# Dunmore Quarry – Modification 9

## Response to Submissions

Prepared for Boral Resources (NSW) Pty Ltd I August 2017

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Dunmore Quarry | Modification 9

Croome West Pit

Prepared for Boral Resources (NSW) Pty Ltd | 17 August 2017

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# Response to Submissions

Final

Report J16050RP4 | Prepared for Boral Resources (NSW) Pty Ltd | 17 August 2017

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|---|---|---|---|
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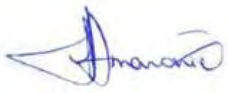
| Signature |  | Signature |  |
| Date | 17August 2017 | Date | 17 August 2017 |



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# 1 Introduction

## 1.1 Project overview

Dunmore Quarry (the quarry) is located on Tabbita Road, Dunmore in the Shellharbour local government area (LGA) - refer to Figures 1.1 and 1.2. It is owned and operated by Boral Resources (NSW) Pty Ltd (Boral). The location of the quarry can be seen in Figures 1.1 and 1.2.

Hard rock has been extracted from the quarry for about 95 years. The quarry has an extensive and high quality resource, and due to its ability to rail product into the Sydney metropolitan market, is a key asset for Boral. At the current extraction rate of 160,000 – 170,000 tonnes per month (tpm), it is estimated that these rock reserves will be exhausted by November 2017.

To enable continued operation of the quarry, it is proposed to extend the existing Croome Farm Pit by approximately 13.74 hectares (ha) to enable extraction within the 'Croome West Pit'. All other aspects of the approved operations will remain the same (ie operating hours, employee numbers, production rates and traffic generation). The proposed Croome West Pit can be seen in Figure 1.3.

Assuming an average extraction rate of 2 million tonnes per annum (Mtpa), extraction of the Croome West Pit will allow the quarry to continue extracting hard rock up to 2034.

The application is Modification 9 and is referred to in this document as 'the proposed modification'. An application for Modification 8 was approved by the Department of Planning and Environment (DPE) under delegation from the NSW Minister for Planning on 17 November 2016. Modification 8 allows for the removal of overburden within the Croome Farm Pit and its use to create a visual and acoustic bund around the proposed Croome West Pit (subject of this application). Construction of this bund has commenced and is expected to be completed by October 2017.

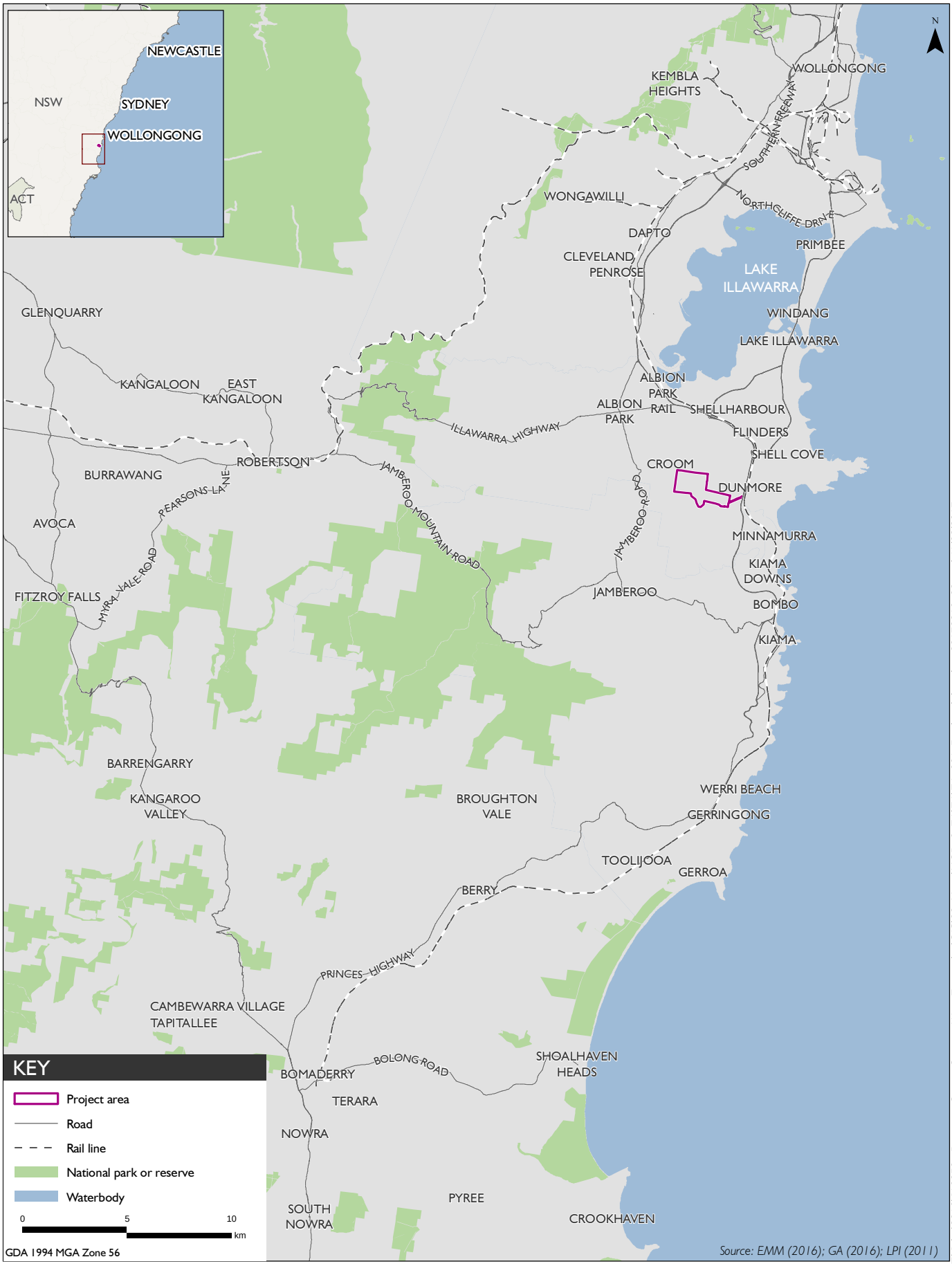
## 1.2 The application

Approval for the proposed modification is being sought under section 75W of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Under Clause 8(8) of the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation), a development consent relating to State significant development (SSD) that was granted by the NSW Minister for Planning under Part 4 of the EP&A Act before 1 August 2005 is taken to be an approval under Part 3A Act, for the purposes of a modification only, and section 75W of the EP&A Act applies to any modification of such a consent. Under section 75W, the request for the Minister's approval for a modification is to be lodged with the Secretary of the DPE.

The *Dunmore Quarry – Modification 9 Environmental Assessment* (EA) was prepared by EMM Consulting Pty Ltd (EMM 2017), with input from a range of specialists. The EA was prepared in accordance with the requirements of the DPE's Resource Assessments and Compliance division (DPE-RAC) and other government agencies, including Shellharbour City Council (the council).

The EA was submitted to DPE-RAC and placed on public exhibition for four weeks from 20 March 2017 to 10 April 2017.

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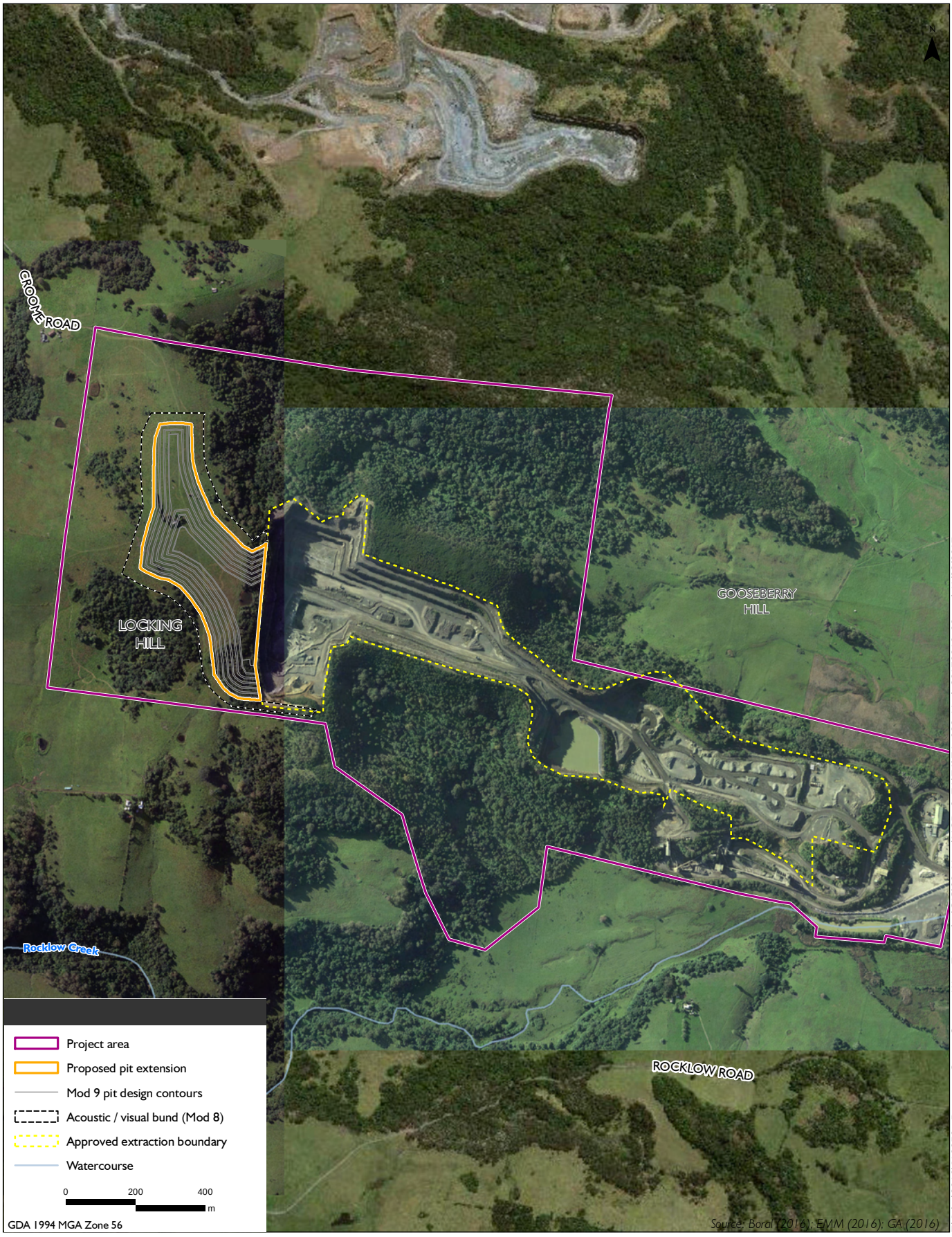
EMM

**Regional context**
Dunmore Quarry Modification 9
Response to submissions
Figure 1.1


EMM

**Locality plan**
Dunmore Quarry Modification 9
Response to submissions
Figure 1.2




**Proposed modification (Croome Farm West Pit)**

Dunmore Quarry Modification 9
Response to submissions
Figure 1.3

## 1.3 Submissions received

Following public exhibition of the EA, six submissions were received from the following government agencies:

- NSW Department of Planning and Environment – Division of Resources and Mining (DPE-RM);
- Environment Protection Authority (EPA);
- Department of Primary Industries (DPI);
- Office of Environment and Heritage (OEH);
- Heritage Council of New South Wales (HC); and
- NSW Rural Fire Service (RFS).

No submissions were received from the council or from the local community.

None of the submissions received object to the proposed modification. One submission, from DPE-RM, was provided in support.

On 19 April 2017, DPE-RAC wrote to Boral requesting a report be prepared that responds to the matters raised in the submissions regarding the proposed modification. DPE's letter also stated that in preparing responses, Boral should pay particular attention to matters outlined in an attachment to the letter, including matters relating to noise, water, biodiversity and resources.

This Response to Submissions (RTS) report has been prepared to address this requirement. Responses to matters raised by DPE-RAC have also been addressed in this report.

Notwithstanding the above, two submissions, from the HC and RFS, did not raise any concerns with the proposed modification and provided recommended conditions of approval. Boral has reviewed and accepted these recommended conditions, and as such, responses to these submissions have not been provided in this document.

## 1.4 Response format

In this RTS, a response to has been provided to each of the matters raised by the relevant government agency, as follows.

Matter

*The matter raised by the relevant government agency has been stated in italics.*

Response

A response is provided to the matter raised by the relevant government agency in non-italics.

Responses to matters raised by DPE are provided in Chapter 2; responses to matters raised by the EPA are provided in Chapter 3; responses to matters raised by DPI are provided in Chapter 4; and responses to matters raised by OEH are provided in Chapter 5.

# 2 Department of Planning and Environment

## 2.1 Introduction

Correspondence from two divisions within DPE were provided to Boral. The first was a submission from DPE-MR dated 7 April 2017. The second was a letter from DPE-RAC division dated 19 April 2017.

The letter from DPE-RAC requested a report be prepared that responds to the matters raised in the submissions regarding the proposed modification. DPE-RAC's letter also stated that in preparing responses, Boral should pay particular attention to matters outlined in an attachment to the letter, including matters relating to noise, water, biodiversity and resources.

This chapter responds to the matters outlined in the attachment to the letter from DPE-RAC and the submission from DPE-MR.

## 2.2 DPE-RAC

### 2.2.1 Noise

Matter

*State whether the noise model includes inputs from noise generated from the processing area (e.g. crushing and screening) and rail loadout area. If not, expand the noise model to include these noise sources and provide an updated description of the predicted noise levels relative to the noise criteria and proposed mitigation measures.*

Response

The noise model undertaken for the proposed modification did not include noise sources or inputs from the processing and rail loading area. This was because noise generated by the proposed modification is concentrated in the west of the quarry, whereas noise generated in the eastern part of the quarry will not increase beyond existing operation.

The noise model has been updated to include noise generated by the existing operations at the processing and rail load loading area. Table 2.1 below summarises the predicted worst case noise levels for each assessment location. The noise model adopted worst case mobile plant locations and therefore provide the highest noise levels expected. It is unlikely that the scenarios represented by the noise model would often occur (ie the number of fixed and mobile plant items working simultaneously in the same, most exposed, location is unlikely).

The results indicate that, with noise from the processing and rail loading area included in the noise modelling, noise levels from the whole of the quarry including Stage 3 of the proposed modification are generally consistent with those reported in the noise assessment. Marginal predicted changes of 1 dB shown at six locations (assessment locations AB, D, F, G, T and Z) are due to rounding, with actual changes being less than 1 dB. Similarly, a marginal 2 dB change at one location (assessment location S) is considered plausible as contributions from existing operations are expected to be relatively higher at this location.

## Table 2.1 Predicted worst case noise levels

| Assessment location | Draft EPL limits, dB, $L_{Aeq,15minute}$ | | | Predicted worst case noise level, dB, $L_{Aeq,15minute}$ | | Change, dB | Suggested EPL limits, dB, $L_{Aeq,15minute}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day | Evening | Shoulder | Noise assessment | Revised | | Day | Evening | Shoulder |
| AA | 38 | 38 | 38 | 38 | 38 | 0 | 38 | 38 | 38 |
| AB | 35 | 35 | 35 | 35 | 36 | +1 | 36 | 36 | 36 |
| AC | 35 | 35 | 35 | <35 | <35 | 0 | 35 | 35 | 35 |
| AD | 35 | 35 | 35 | <35 | <35 | 0 | 35 | 35 | 35 |
| D | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |
| F | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |
| G | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |
| K | 49[1] | 44[1] | 47[1] | <35 | 44 | N/A[2] | 49[1] | 44[1] | 47[1] |
| O | 49[1] | 44[1] | 47[1] | <35 | 39 | N/A[2] | 49[1] | 44[1] | 47[1] |
| S | 35 | 35 | 35 | <35 | 37 | +2 | 37 | 37 | 37 |
| T | 35 | 35 | 35 | <35 | 36 | +1 | 36 | 36 | 36 |
| Z | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |

*Notes:* 1. *Current development consent noise limits.*

2. *Noise modelling in the original noise assessment did not include noise from the processing or rail loading area, which is the main noise source at these locations.*

### Matter

*Provide the current measured noise levels at the closest residential properties to the south and west of the quarry including at locations D, F, G, S and Z, as shown in Figure 2.1 of the EA Noise Assessment Report. If no monitoring under current operating conditions is available at any or all of these locations, provide the predicted noise levels under current operations at these locations.*

### Response

There are no measured noise levels at the closest residential properties to the south and south-west of the quarry. Table 2.1 below summarises the predicted noise levels for current operations at assessment locations to the south and west as requested. It should be noted that the noise model has adopted worst case plant locations and therefore provides the highest noise levels expected. It is unlikely that the scenarios represented by the noise model would often occur (ie the number of plant items working simultaneously in the same, most exposed, location is unlikely).

## Table 2.2 Current predicted operational noise levels

| Assessment location | Predicted noise levels, dB, $L_{Aeq,15minute}$ | | |
|---|---|---|---|
| | Calm | Adverse | Inversion |
| AA | 32 | 34 | 34 |
| AB | 27 | 30 | 30 |
| AC | 29 | 31 | 31 |
| AD | 32 | 34 | 34 |
| D | 34 | 36 | 36 |

**Table 2.2 Current predicted operational noise levels**

| Assessment location | Predicted noise levels, dB, $L_{Aeq,15minute}$ | | |
|---|---|---|---|
| | Calm | Adverse | Inversion |
| F | 33 | 36 | 36 |
| G | 34 | 37 | 37 |
| S | 35 | 37 | 37 |
| T | 33 | 35 | 35 |
| Z | 34 | 37 | 37 |

Matter

*Provide a description of the risks identified due to the proximity of blasting activities to nearby residences and private properties (for instance, the risk of flyrock from blasting with residents at locations D, Z and G and their associated landholdings) and proposed blast management measures to mitigate the impacts.*

Response

With the implementation of routine blast management procedures contained within the quarry's *Blast Management Plan* (Boral 2008), the risk of impacts associated with blasting activities to nearby residences and properties is considered very low, including impacts associated with air blast overpressure, ground vibration, flyrock, fumes and dust.

In relation to air blast overpressure and ground vibration, the noise and vibration assessment that accompanied the EA in Modification 9 (Appendix E), overpressure and vibration levels provided in the assessment were calculated with a maximum instantaneous charge (MIC) of 100 kg (which is the historic average used at the quarry and practical quantity to be used for the proposed Croome West Pit). No exceedances of overpressure or vibration criteria were predicted. Overpressure and vibration levels using an MIC of 200kg (double the historical quarry average) was also assessed with a marginal overpressure exceedance predicted at assessment location D during stage 3. However, this predicted exceedance is in the range that is allowed for 5% of blasts in every 12 months.

Blasts are currently monitored at the McParland property (owned by Boral), which is approximately 500 m from the quarry's existing disturbance boundary (and a similar distance to assessment locations D, Z and G from the proposed Croome West Pit disturbance boundary during stage 3). A total of 63 blasts were conducted throughout the 2015-2016 annual environmental monitoring report (AEMR) reporting period. All blasts were compliant with airblast overpressure and ground vibration blasting criteria.

Notwithstanding the above, the quarry designs its blasts in accordance with predictive site laws which are based on statistical analysis of previous blast results, the monitors distance from the blast and the MIC. If required, the MIC can be reduced to ensure that air blast overpressure and ground vibration is reduced.

The generation of fly rock, fumes and dust is managed by incorporating appropriate controls in blast designs. These controls include design of stemming lengths and stemming materials to minimise the potential for generating fly rock. Adequate burden, which is the distance from a charge to a free face, is maintained to minimise the risk of generating fly rock due to face bursting. These measures are used to ensure there is no damage to property, equipment or power lines from flyrock. In certain situations, crushed rock stemming will be used to improve stemming confinement and hence reduce the chance of flyrock and elevated blast overpressure.

Any unusual level of fly rock generated by blasting, with the potential to cause a safety risk will be noted for each blast. This information will be used to continually re-assess the adequacy of blast design controls in reducing the generation of fly rock.

### 2.2.2 Water

Matter

*Having regard to DPI's comment regarding the continued use of the Site Water Balance and the Groundwater Monitoring Program to inform water licensing requirements, provide a discussion of the proposed approach to identify all water "take", including but not limited to, the groundwater inception identified at the Lower Dam.*

Response

Section 8 of the revised surface water assessment (Rev H) contained in Appendix A discusses the water licensing requirements for the existing and proposed quarry operation and provides detailed information regarding:

- licencing requirements for the capture of surface water runoff in the quarry's water management dams; and
- licencing requirements for the water take from the Rocklow Creek Alluvium via groundwater ingress into the Lower Dam.

Section 8 revised surface water assessment (Rev H) identifies that a water access licence is required for any water take from the Rocklow Creek Alluvium via groundwater ingress into the Lower Dam. Boral has submitted a registration of interest with DPI-Water and will continue to consult with DPI-Water to establish appropriate licensing arrangements.

### 2.2.3 Biodiversity

Matter

*In reference to the request from OEH to provide offset calculations, provide offset calculations to quantify the exact offset likely to be generated as a result of the proposed removal of threatened Illawarra Zieria individuals.*

Response

A total of 162 Illawarra Zieria (*Zieria granulata*) individuals are proposed to be removed as part of the proposed modification. In principle agreement with OEH includes offsetting the species at a ratio greater than 1:1 to ensure a net gain. To date the offset ratio has not been negotiated.

In order to inform the offset ratio, species credit calculations were conducted for Illawarra Zieria. This was based on a simulated approach using the *Framework for Biodiversity Assessment* (FBA) calculator (OEH 2014), by an accredited assessor (Eugene Dodd, Assessor 191). As no native plant community types (PCT) will be impacted by the proposed modification, no ecosystem credits are required. However, to generate the required species credits in the calculator, PCT 720 Bracelet Honey-myrtle - Australian Indigo dry shrubland on volcanics, southern Sydney Basin Bioregion; was used. This PCT was selected as it occurs in close proximity to the project area and is known habitat for the Illawarra Zieria.

A major project development calculation was used to determine the number of credits required to offset the loss of 162 Illawarra Zieria under the FBA. A total of 2,268 species credits were generated (refer to Appendix B for the credit report).

A trial and error approach was used to determine the number of Illawarra Zieria required to create 2,258 species credits at a simulated BioBank site. Initially, 162 individuals were entered into the calculator, assuming a 1:1 ratio between the number of plants impacted (162) and the number of individual required to generate the offset. This did not generate sufficient credits; with only 1,150 species credits generated (refer to Table 2.3).

**Table 2.3 Number of species credits generated by hypothetical BioBank site**

| Number of Illawarra Zieria at simulated BioBank site | Credits generated | Planting ratio required to meet credits generated |
|---|---|---|
| 162 | 1,150 (insufficient) | 1:1 |
| 324 | 2,300 (slightly in excess) | 2:1 |

A 2:1 ratio (324:162) was found to generate sufficient credits (2,300) to compensate for the 2,268 species credits required by project (Table 2.3 and Appendix C).

The above calculations are based on a simulated BioBank site where the species credits would be generated by extant individuals. The proposed species credits for the proposed modification are based on planting the species within a rehabilitated area, and therefore it is recommended that an offset ratio of 3:1 is used for this scenario. This higher ratio would allow for mortality of up to a third of plants, while still achieving a suitable offset requirement in accordance with the FBA. Planting of Illawarra Zieria within the rehabilitated parts of the project area has been highly successful, with many large shrubs persisting and natural regeneration occurring from planted individuals through self seeding.

Matter

*Provide a description of the consideration given to the potential for resource sterilisation in proposed of biodiversity offset areas.*

Response

The current biodiversity offset area for the quarry is located to the south of the extraction area, on land which does not have any hard rock resource. At this stage, the offsets for Modification 8 and 9 have not been determined. This will form part of a package of work to be undertaken in due course, however, a key consideration will be to ensure that offsets do not sterilise hard rock resource that may be extracted in the future.

### 2.2.4 Resource

Matter

*State whether past resource assessments, including a description of the methods used to assess the size and quality of the resources, are available. If so, include this information in the RTS report. If this information cannot be included, provide a rationalisation for why not.*

Response

A resource assessment of the Croome West Pit was undertaken by Boral in 2014. This assessment provides details on the methods used to assess the size and the quality of the hard rock resource. This assessment is considered to be commercially sensitive and therefore has not been provided in this RTS. However, it will be provided separately to DPE-RAC as a commercial in confidence document.

## 2.3 Resources and Mining division

Matter

*GSNSW* [NSW Department of Planning & Environment – Division of Resources & Mining, Geological Survey of New South Wales] *has reviewed the Environmental Impact Statement (EIS) for the proposed modification and notes that the EIS includes an adequate description of the local and regional geological setting however contains no information in relation to the methods used to assess the size and quality of the resource in the western extension area.*

*GSNSW notes that applications to modify, expand, extend or intensify an existing consent that has already been adequately reported in publicly available documents, may restrict detailed documentation to the additional resources to be extracted, if accompanied by a summary of past resource assessments and past production.*

*GSNSW considers it is the best interest of the proponent and the community to fully assess the resource to be extracted and it would be helpful to append or reference such past resources assessments (if they are not deemed commercial-in-confidence) in the EIS.*

Comment

As stated above, a resource assessment of the Croome West Pit will be provided separately to DPE-RAC as a commercial in confidence document.

Matter

*The Division of Resources and Mining collects data on the quantity of construction materials produced annually throughout the State. Forms are sent to all operating quarries at the end of each financial year for this purpose. The statistical data collected is of great value to Government and industry in planning and resource management, particularly as a basis for analysing trends in production and for estimating future demand for particular commodities or in particular regions. Production data may be published in aggregate form, however production data for individual operations is kept strictly confidential.*

*In order to assist in the collection of construction material production data, the proponent should be required to provide (or continue to provide) annual production data for the site as a condition of any new or amended development consent.*

Comment

Boral provide details on the quantity of hard rock produced at the quarry on an annual basis to DPR-MR. Therefore, it is not necessary to include a condition in the consent requiring this data be provided.

Matter

*GSNSW notes that the proponent is planning a detailed assessment of potential biodiversity impacts of the proposed development including an appropriate biodiversity offset strategy. GSNSW requests that the proponent give consideration to avoiding potential resource sterilisation in the choice of any biodiversity offset areas.*

Comment

As previously stated, the current biodiversity offset area for the quarry is located to the south of the extraction area, on land which does not have any hard rock resource. At this stage, the offsets for Modification 8 and 9 have not been determined. This will form part of a package of work to be undertaken in due course, however, a key consideration will be to ensure that offsets do not sterilise hard rock resource that may be extracted in the future.

# 3 Environment Protection Authority

## 3.1 Introduction

The EPA provide a submission on 10 April 2017. The submission provides comments on the proposed modification in relation to EPA regulation, air quality, noise and water quality. These matters are addressed below.

## 3.2 Regulation

Comment

*The proponent must comply with the Protection of the Environment Operations Act (POEO) Act 1997 and any associated regulations at all times. This includes the Environment Protection Licence (EPL) for the premises (EPL No 77). In exercising these licensing functions the EPA will take into consideration Section 45 of the POEO Act.*

Response

Boral notes the EPA's comment.

## 3.3 Air quality

Comment

*The EPA considers that Modification 9 provides an opportunity to revisit the ambient monitoring requirements in place at the Boral Quarry. The EPA has been advising DPE and hard rock quarry operators in the Shellharbour LGA (including Boral) on the use of real-time dust monitoring as part of recent development modifications. The use of real-time air quality monitors can assist quarry operators to better understand and respond to activities that might generate dust and assist with day to day environmental management decisions. Real-time monitors can be used in Trigger Action Response Plans (TARPs) where quarries can respond promptly to dust emissions by scheduling water carts, stockpile sprays and modifying their production activities. Quarries currently rely mainly on dust deposition gauges (DDG) and some hi-volume air samplers (HVAS) which can provide high quality information about particle concentrations. Both DDG and HVAS are valid and recognised techniques however the time required for collection and analysis places limitations in their ability to inform day to day management decisions.*

Response

It is Boral's view that there is no justification for implementing real-time dust monitoring at the quarry. Predicted air quality impacts at all receptors surrounding the quarry are low.

Notwithstanding the above, Boral will install a real-time dust monitor for the quarry in accordance with the EPA's request. The location and operational parameters of the monitor will be provided within the air quality management plan to be prepared for the quarry. Given the results of the air quality assessment (ie predicted compliance with air quality criteria at all private receptors), it is requested that Boral be provided 12 months from the time of approval to prepare and submit the air quality management plan.

Comment

*The Air Quality Impact Assessment (AQIA) has been conducted in broad agreement with 'Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales'. The AQIA predicted the proposed expansion will comply with all air quality impact assessment criteria, with the exception of dust deposition, which is predicted to exceed the cumulative annual criterion at two residences owned by Boral. The AQIA assesses fugitive particulate emissions from stockpiles, crushing and screening equipment, drilling and blasting, and unsealed roads using USEPA AP42 values. Emissions from diesel combustion by trucks and mobile equipment were also included in the assessment.*

Response

Boral notes the EPA's comment.

Comment

*The EPA has reviewed the Air Quality Impact Assessment, and recommends the following conditions of approval be included if development consent is granted.*

*Air Quality Management Plan*

1. *For all emission sources at the site the proponent must prepare an air quality management plan that includes, but is not limited to:*

    - *Site specific benchmarking of emission controls with best management practice*
    - *Key performance indicator(s);*
    - *Monitoring method(s), including real-time particulate monitoring to inform management plans;*
    - *Location, frequency and duration of monitoring;*
    - *Record keeping;*
    - *Response mechanisms; and*
    - *Compliance reporting.*

2. *The air quality management plan must be implemented prior to the commencement of any dust generating activities associated with the proposed modification.*

*Dust*

3. *All operations and activities occurring at the premises must be carried out in a manner that prevents and minimises the emission of air pollutants from the premises; and*

4. *The premises must be maintained in a manner that prevents and minimises the emission of air pollutants.*

Response

Boral agrees to the preparation of an air quality management plan for the site as requested by the EPA, however, as stated above, based on the results of the air quality assessment (ie predicted compliance with air quality criteria at all private receptors), it is requested that Boral be provided 12 months from the time of approval to prepare and submit the air quality management plan.

Boral also agrees to the inclusion of the EPA's recommended conditions relating to the management of dust. Notwithstanding this, it is noted that the quarry's development consent currently includes a condition (Condition 23) which has the same intention as the recommended conditions. It states that "The Applicant must minimise and/or prevent the emission of dust from the site."

## 3.4 Noise

### Comment

*The EPA has reviewed the Dunmore Quarry – Modification 9 Noise Assessment (NA) prepared by EMM Consulting. In summary, EPA considers the report to be adequate to derive recommended EPL noise limits (see below).*

*In reference to the NA prediction model, it appears that noise generated by the existing operations at the processing area, such as the crushing and screening plant, has not been included. It also appears that the NA also does not include noise from any rail loadout operations (if applicable). The EPA recommends that the proponent recalculate the figures in the Noise Agreement, including all activities on the premises, and determine if this changes the derived noise limit figures.*

### Response

As previously discussed, the noise model undertaken for the proposed modification did not include noise sources or inputs from the processing and rail loading area.

The noise model has been updated to include noise generated by the existing operations at the processing and rail load loading area. Table 3.1 below summarises the predicted worst case noise levels for each assessment location. The noise model adopted worst case mobile plant locations and therefore provide the highest noise levels expected. It is unlikely that the scenarios represented by the noise model would often occur (ie the number of fixed and mobile plant items working simultaneously in the same, most exposed, location is unlikely).

The results indicate that, with noise from the processing and rail loading area included in the noise modelling, noise levels from the whole of the quarry, including Stage 3 of the proposed modification, are generally consistent with those reported in the noise assessment. Marginal predicted changes of 1 dB shown at six locations (assessment locations AB, D, F, G, T and Z) are due to rounding, with actual changes being less than 1 dB. Similarly, a marginal 2 dB change at one location (assessment location S) is considered plausible as contributions from existing operations are expected to be relatively higher at this location.

**Table 3.1 Predicted worst case noise levels**

| Assessment location | Draft EPL limits, dB, $L_{Aeq,15minute}$ | | | Predicted worst case noise level, dB, $L_{Aeq,15minute}$ | | Change, dB | Suggested EPL limits, dB, $L_{Aeq,15minute}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day | Evening | Shoulder | Noise assessment | Revised | | Day | Evening | Shoulder |
| AA | 38 | 38 | 38 | 38 | 38 | 0 | 38 | 38 | 38 |
| AB | 35 | 35 | 35 | 35 | 36 | +1 | 36 | 36 | 36 |
| AC | 35 | 35 | 35 | <35 | <35 | 0 | 35 | 35 | 35 |
| AD | 35 | 35 | 35 | <35 | <35 | 0 | 35 | 35 | 35 |
| D | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |
| F | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |

**Table 3.1 Predicted worst case noise levels**

| Assessment location | Draft EPL limits, dB, $L_{Aeq,15minute}$ | | | Predicted worst case noise level, dB, $L_{Aeq,15minute}$ | | Change, dB | Suggested EPL limits, dB, $L_{Aeq,15minute}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day | Evening | Shoulder | Noise assessment | Revised | | Day | Evening | Shoulder |
| G | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |
| K | 49[1] | 44[1] | 47[1] | <35 | 44 | N/A[2] | 49[1] | 44[1] | 47[1] |
| O | 49[1] | 44[1] | 47[1] | <35 | 39 | N/A[2] | 49[1] | 44[1] | 47[1] |
| S | 35 | 35 | 35 | <35 | 37 | +2 | 37 | 37 | 37 |
| T | 35 | 35 | 35 | <35 | 36 | +1 | 36 | 36 | 36 |
| Z | 39 | 39 | 39 | 39 | 40 | +1 | 40 | 40 | 40 |

*Notes:* 1. *Current development consent noise limits.*

2. *Noise modelling in the original noise assessment did not include noise from the processing or rail loading area, which is the main noise source at these locations.*

Comment

*The EPA notes that predicted operational noise level from Stage 3 are expected to exceed the Voluntary Land Acquisition and Mitigation Policy's mitigation criteria during adverse weather conditions at locations 'D', 'F', 'G' and 'Z'. Real time management of operations, as described in Section 5.1 of the NA, will be required during Stage 3 to ensure that activities are restricted to the lower shelves of the extraction pit during adverse weather conditions, which are expected to occur during the morning shoulder and evening time periods.*

Response

Operational management at the quarry will adopt real time weather data collected by the site's automatic weather station (AWS) to manage this issue during, for example, assessable easterly winds.

Comment

*The EPA recommends the following conditions if development consent is granted.*

*General*

*The acoustic bund around the perimeter of the project site, constructed as described in Modification 8, must be retained for the duration of the Modification 9 project consent.*

*Limited Conditions*

*L6.1 Noise generated at the premises must not exceed the noise limits in the Table below. The location references are from the Dunmore Quarry – Modification 9 Noise Assessment prepared by EMM Consulting (Report J16050NRP1 Ver 2 dated 28/9/2016).*

| Location | Grid Reference (Map Grid of Australia 1994, Zone 56) | | NOISE LIMITS dB(A) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | Day $L_{Aeq}$ (15 minute) | Evening $L_{Aeq}$ (15 minute) | Night $L_{Aeq}$ (15 minute) | Shoulder $L_{Aeq}$ (15 minute) | Night $L_{A1}$ (1 minute) | Shoulder $L_{A1}$ (1 minute) |
| *AA* | 297979 | 6169974 | 38 | 38 | 38 | 38 | | |
| *D* | 298183 | 6169201 | 39 | 39 | 39 | 39 | 45 | 45 |
| *F* | 298285 | 6169804 | 39 | 39 | 39 | 39 | | |
| *G* | 298176 | 6169349 | 39 | 39 | 39 | 39 | | |
| *Z* | 298173 | 6169276 | 39 | 39 | 39 | 39 | | |
| *All other non-associated residential receivers* | | | 35 | 35 | 35 | 35 | | |

*(Note: proponent to confirm the grid references of all assessed receivers above).*

*L6.2 For the purpose of condition L6.1;*

- *Day is defined as the period from 7am to 6pm Monday to Saturday and 8am to 6pm Sunday and Public Holidays.*
- *Evening is defined as the period 6pm to 10pm.*
- *Night is defined as the period from 10pm to 6am Monday to Saturday and 10pm to 8am Sunday to Public Holidays.*
- *Shoulder is defined as the period from 6am to 7am Monday to Saturday.*

*L6.3 The noise limits set out in condition L6.1 apply under all meteorological conditions except for the following:*

*a) Wind speeds greater than 3 metres/second at 10 metres above ground level.*

*b) Stability category F temperature inversion conditions and wind speeds greater than 2 metres/second at 10 metres above ground level; or*

*c) Stability category G temperature inversion conditions.*

*L6.4 For the purpose of condition L6.3:*

*a) Data recorded by a meteorological station installed on site must be used to determine meteorological conditions; and*

*b) Temperature inversion conditions (stability category) are to be determined by the sigma-theta method referred to in Part E4 of Appendix E to the NSW Industrial Noise Policy.*

*L6.5 To determine compliance:*

*a) With the Leq (15 minute) noise limits in condition L6.1, the noise measurement equipment must be located:*

- *approximately on the property boundary, where any dwelling is situated 30 metres or less from the property boundary closest to the premises; or*
- *within 30 metres of a dwelling facade, but not closer than 3m, where any dwelling on the property is situated more tyhan 30 metres from the property boundary closest to the premises; or, where applicable*
- *within approximately 50 metres of the boundary of a National Park or a Nature Reserve.*

*b) With the LA1 (1 minute) noise limits in condition L6.1, the noise measurement equipment must be located within 1 metre of a dwelling facade.*

*c) with the noise limits in condition L6.1, the noise measurement equipment must be located:*

- *at the most affected point at a location where there is no dwelling at the location; or*
- *at the most affected point within an area at a location prescribed by conditions L6.5(a) or L6.5(b).*

*L6.6 A non-compliance of condition L6.1 will still occur where noise generated from the premises in excess of the appropriate limit is measured:*

- *at a location other than an area prescribed by conditions L6.5(a) and L6.5; and/or*
- *at a point other than the most affected point at a location.*

*L6.7 For the purpose of determining the noise generated at the premises the modification factors in Section 4 of the NSW Industrial Noise Policy must be applied, as appropriate, to the noise levels measured by the noise monitoring equipment.*

*<u>M8 Requirements to Monitor Noise</u>*

*M8.1 To assess compliance with Condition L6.1, attended noise monitoring must be undertaken in accordance with Conditions L6.5 and:*

*a) Noise from the premises must be measured annually via attended noise surveys at potentially affected residences, including Location K Stocker Residence (as described elsewhere in the licence). The noise monitoring should be conducted during the period when it is known that noise propagation from the premises will be at its worst, that is, generally winter conditions.*

*<u>Reporting Conditions</u>*

*<u>R4 Noise Monitoring Report</u>*

*A noise compliance assessment report must be submitted to the EPA within 30 days of the completion of the yearly monitoring. The assessment must be prepared by a suitably qualified and experienced acoustical consultant and include:*

*a) an assessment of compliance with noise limits presented in Condition L6.,1; and*

*b) an outline of any management actions taken within the monitoring period to address any exceedences of the limits contained in Condition L6.1.*

*Additions to Definition of Terms of the licence*

- *NSW Industrial Noise Policy – the document entitled "New South Wales Industrial Noise Policy published by the Environment Protection Authority in January 2000."*
- *Noise – 'sound pressure levels' for the purposes of conditions L6.1 to L6.7.*

*The EPA recommend that DPE consider adding the above Conditions of Consent, including the requirement that Boral review and update the Noise Management Plan for the Dunmore Quarry.*

Response

Boral agrees with the suggested conditions regarding noise and noise management. Notwithstanding the above, it is requested that the noise limits provided in the table are amended to reflect the updated modelling results which include operations on the eastern side of the quarry as stated in Table 3.1.

## 3.5 Water quality

### 3.5.1 General

The EPA's submission covers three areas relating to water quality, including the impact assessment, water balance, and erosion and sediment control. The submission states:

*The EA does not appear to provide adequate information to identify and appropriately manage the risks to receiving waterways. Additional information and clarification is required to inform the EPA's considerations consistent with s45 of the POEO Act. In particular, the proponent should:*

- *characterise the discharge to understand the pollution likely to be caused by the development, including contamination of surface water from groundwater ingress;*
- *assess the potential impact of the development on the environmental values of the receiving waters;*
- *consider practical measures to minimise pollution and mitigate potential impacts.*

*Additionally if the proposed development is approved the EPA will vary the licence to include limits for key pollutants of concerns and to switch off limits for managed overflow. It is also recommended that Boral update the Water Management Plan to reflect the modification.*

Each of these matters are addressed below in response to more specific comments from the EPA.

### 3.5.2 Impact assessment

Comment

1. *The EA does not adequately characterise discharges, so it is unclear what pollution could occur due to the development. The frequency of discharges is also not provided.*

   *The water balances show that the groundwater inflows to the lower dam are substantial (over 150 ML in median rainfall year). The Groundwater Assessment indicates elevated concentrations of a range of pollutants, including EC, arsenic, zinc, ammonia, oxides of nitrogen, total nitrogen, and total phosphorous. Given the substantial groundwater inflows, these pollutants are likely to be elevated in discharges from sediment retention basins.*

   *The proponent should characterise controlled discharges and managed overflows from the premises in terms of the median and maximum expected concentrations of all pollutants present that pose a risk of non-trivial harm to human health and the environment. This should be informed by a risk profile of the pollutants potentially mobilised from activities on the premises, including those present in groundwater inflows. The potential impact of discharges on environmental values should be assessed with reference to relevant ANZECC (2000) trigger values. The proponent should also quantify the loads of pollutants expected to be discharged and consider potential load related impacts on Rocklow Creek and Minnamurra River.*

Response

A surface water characterisation assessment (SWCA) has been undertaken and is documented in Section 4.4 of the revised surface water assessment (Rev H) contained in Appendix A. The SWCA is informed by three to four samples collected from the quarry's water management dams, identified groundwater discharge locations and receiving water locations. Accordingly, the water quality data is expected to reliably characterise the quality of all surface and groundwater discharges from the quarry's water management system.

Refer to Section 4.4 of the surface water assessment (Rev H) for detailed information on the sampling program, results and analysis.

Comment

2. *The Environmental Assessment (EA) does not adequately consider the environmental values of the receiving waterways or assess the potential impact of discharges on these values. The NSW Water Quality Objectives (WQO's) are the agreed environmental values and long-term goals for assessing and managing the likely impact of activities on surface and groundwater in NSW. The NSW WQO's are the environmental values of the ANZECC Guidelines and hate water quality that supports those values. They set out:*

   a. *the community's values and uses for our waterways;*
   b. *a range of water quality indicators and numerical criteria (trigger values) to help assess whether the current condition of our waterways supports those values and uses.*

   *The WQO's for uncontrolled streams in the Illawarra are protection of aquatic ecosystems, visual amenity, primary and secondary contract recreation, livestock water supply, irrigation water supply, and homestead water supply.*

*The proponent should identify the environmental values of the receiving waters affected by the discharges, assess the significance of any impacts on those environmental values and consider the practical measures that could be taken to restore or maintain those environmental values.*

Response

A SWCA has been undertaken and is documented in Section 4.4 of the revised surface water assessment (Rev H) contained in Appendix A. The SWCA compares all water quality results to trigger levels that were established for slightly disturbed ecosystems using the information and methods documented in the ANZECC (2000) guidelines.

### 3.5.3 Water balance

Comment

3. *The EA states "Runoff from the Croome West Pit and existing Croome Farm Pit will accumulate in the existing pit sump which will be dewatered to the Middle Dam after a runoff event. Water stored in the Middle Dam will be either used to supply process water or discharged to the Bioretention Swale when water quality is suitable." This is not captured in the water balance schematics.*

   *The proponent should confirm whether water will be transferred between the Middle Dam and the Bioretention Swale.*

Response

The revised surface water assessment (Rev H) contained in Appendix A is informed by water level and quality monitoring and further site inspections and documents a revised interpretation of the existing water management system. The bioretention swale and associated controlled discharge regime is no longer considered to be part of the quarry's water management system. This is because historically the bioretetion swale has not been used as infiltration from the bioretention swale seeps back into the Lower Dam.

Refer to Section 4 of the surface water assessment (Rev H) for further information on the revised interpretation of the existing water management system.

Comment

4. *The surface water assessment notes "the calculations presented in Table 5-1 assume that there is no ingress of flood waters from Rocklow Creek into the Lower Dam during a 5-day, 95th percentile rainfall event", however the EA notes that there is sometimes ingress (though the event is not specified).*

   *The proponent should clarify how the Lower Dam will be designed and constructed to prevent ingress of flood waters from Rocklow Creek during rainfall events up to a 5-day, 95th percentile storm.*

Response

The revised surface water assessment (Rev H) contained in Appendix A includes a review of the sedimentation treatment functionality of the Lower Dam. This review was informed by water level

monitoring data and identified a number of issues with the existing dam. Boral is proposing to substantially modify the dam and its operating procedures.

The proposed changes will improve the sedimentation treatment effectiveness of the Lower Dam by:

- significantly reducing the frequency of Rocklow Creek surface water inflows;
- increasing the sedimentation treatment volume to exceed the calculated Guideline Volume; and
- enabled dewatering of the sedimentation treatment volume to the Middle Dam to reduce the frequency and magnitude of Lower Dam overflows.

Once the proposed dam modifications are implemented it is expected that the Lower Dam will broadly be operated in accordance with the operating principles described in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008). The modified dam will also broadly comply with development consent conditions 31 and 33, which requires the dam to capture and treat all runoff from storm events up to and including the 5 day 95th percentile rainfall event.

Refer to Section 5.1.1 of the revised surface water assessment (Rev H) for further information on the proposed modifications to the Lower Dam.

Comment

5. *The surface water assessment provides dam management options but selection of a preferred strategy has been deferred while monitoring is completed. The proposal options vary significantly in the volume of controlled discharges (381 ML/yr? In option 1, ~240 ML/yr? In option 2). Figure 21 and Figure 22 depicting proposed water balances under dry and median years are the same and Figure 22 contradicts Figure 24.*

   *The proponent should:*

   - *Review and replace Figure 21/22 with correct figures and confirm predicted volume of controlled discharges under each option.*
   - *Provide a timeline for selecting the preferred strategy.*
   - *Describe the how the risks and impacts from the different options vary and how these would be managed/mitigated.*

Response

The revised surface water assessment (Rev H) contained in Appendix A documents a revised interpretation of the existing water management system. The water balance model has been reconfigured to reflect the revised understanding of the existing water management system. The water balance model was also applied to assess the effectiveness of proposed improvements to the existing water management system and changes due to Modification 9.

The revised water balance model results are substantially different to those documented in the version of the surface water assessment (Rev F) contained in the EA. Accordingly, all water balance results documented in the surface water assessment (Rev F) should be disregarded.

Comment

6. *There are no water balance for the future scenario when the Croome West Pit is excavated to a similar level as the Croome Farm Pit final void and the water holding potential is reduced. Without this, the likely scale or impact of any increased discharges cannot be assessed.*

   *The proponent should include a water balance and commentary, including identification and management for any increased risk, regarding the future scenario when the site's water holding potential is reduced.*

Response

The revised water balance model documented in revised surface water assessment (Rev H) contained in Appendix A assumes that water accumulated in the pit will be dewatered to the Middle Dam when the Middle Dam storage is less than 60% full. Accordingly, it is not proposed to permanently store water in the Upper Dam. Boral will maintain an appropriate in-pit water management solution to manage pit flooding risks throughout the quarry life.

Comment

7. *The report notes that values in the water balance model were adjusted to achieve similar water use rates to those reported in the Dunmore Quarry WMP (Evans & Peck, 2008).*

   *The proponent should clarify whether the water use rates in the 2008 Water Management Plan are still relevant or if water use has changed or will change under the proposal and how (if) this will impact the water balance model.*

Response

The revised surface water assessment (Rev H) contained in Appendix A is informed by revised estimates of process water use that have been provided by Boral. Refer to Section 4.2.4 of the revised surface water assessment (Rev H) for further information.

### 3.5.4 Erosion and sediment control

Comment

1. *It is unclear whether erosion and sediment controls will align with the practices and principles in Managing Urban Stormwater: Soils and Construction, Vol. 2E, Mines and Quarries (DECC, 2008). The sediment basin sizing calculations are not included in the specialist report. The EA states there will be a 'large volume' available for sedimentation treatment in the upper dam.*

   *The proponent should confirm if the erosion and sediment controls align with best practice management for a long term quarry and define the volume available for sedimentation treatment in the upper dam.*

Response

Appendix D of the revised surface water assessment (Rev H) provides sediment basin sizing calculations that have been undertaken using the methods documented in *Managing Urban Stormwater: Soils and Construction, Vol. 2E, Mines and Quarries* (DECC, 2008). These calculations confirm that following the

proposed modifications to the Lower Dam, all three of the quarry's water management dams will provide sedimentation treatment volumes that are consistent with the above guideline and development consent condition 31, which requires sedimentation dams to be sized to capture and treat all runoff from storm events up to and including the 5 day 95$^{th}$ Percentile rainfall event.

Refer to Section 5.1 of the revised surface water assessment (Rev H) for further information on the proposed modifications to the Lower Dam.

Comment

2. *The EA identifies the presence of subsoil which is sodic, dispersive, strongly to extremely acid and with high levels of exchangeable aluminium. Erosion and runoff of this soil could increase turbidity, acidity and aluminium levels in downstream waters.*

   *The proponent should outline how exposed subsoil will be managed to prevent or minimise risks to water quality.*

Response

The soils assessment contained in Appendix H of the EA for the proposed modification states that the entire B horizon is moderately sodic and has an unstable Ca:Mg ratio. As such, it has been recommended that this subsoil not be used in rehabilitation of the quarry at a later stage.

As stated in Section 15.5 of the EA, it is proposed to update the quarry's rehabilitation management plan (RMP) to take into account the rehabilitation strategy for the proposed Croome West Pit identified in Chapter 15 of the EA. The management of the sodic subsoil will be detailed as part of this update.

# 4 Department of Primary Industries

Comment

*The EA states that agricultural land in the vicinity of the proposal is used for grazing and rural residential purposes. There is no mention of the significant cropping activity undertaken on Croome Road, Croome Vale Road and Jamberoo Road for hay and silage making. There are also dairy cows on Croome Vale Road, however it is unclear whether dairying still operates in this area. Such agricultural activities should be included in the EA and any strategies to reasonably avoid or mitigate impacts on those activities addressed. Any possible cumulative effects to agricultural enterprises should also be addressed.*

Response

Whilst dairying was historically undertaken on the land where the Croome West Pit is proposed, this agricultural activity was ceased more than 20 years ago. The land is currently only used for the agistment of horses. Horse agistment will continue to occur in this area, however, the land available will be reduced.

Other than a reduction in the area of land available for horse grazing, there will be no direct or indirect impacts on any agricultural activities surrounding the quarry as a result of the proposed modification. As such, no strategies to avoid or mitigate impacts are considered necessary.

Comment

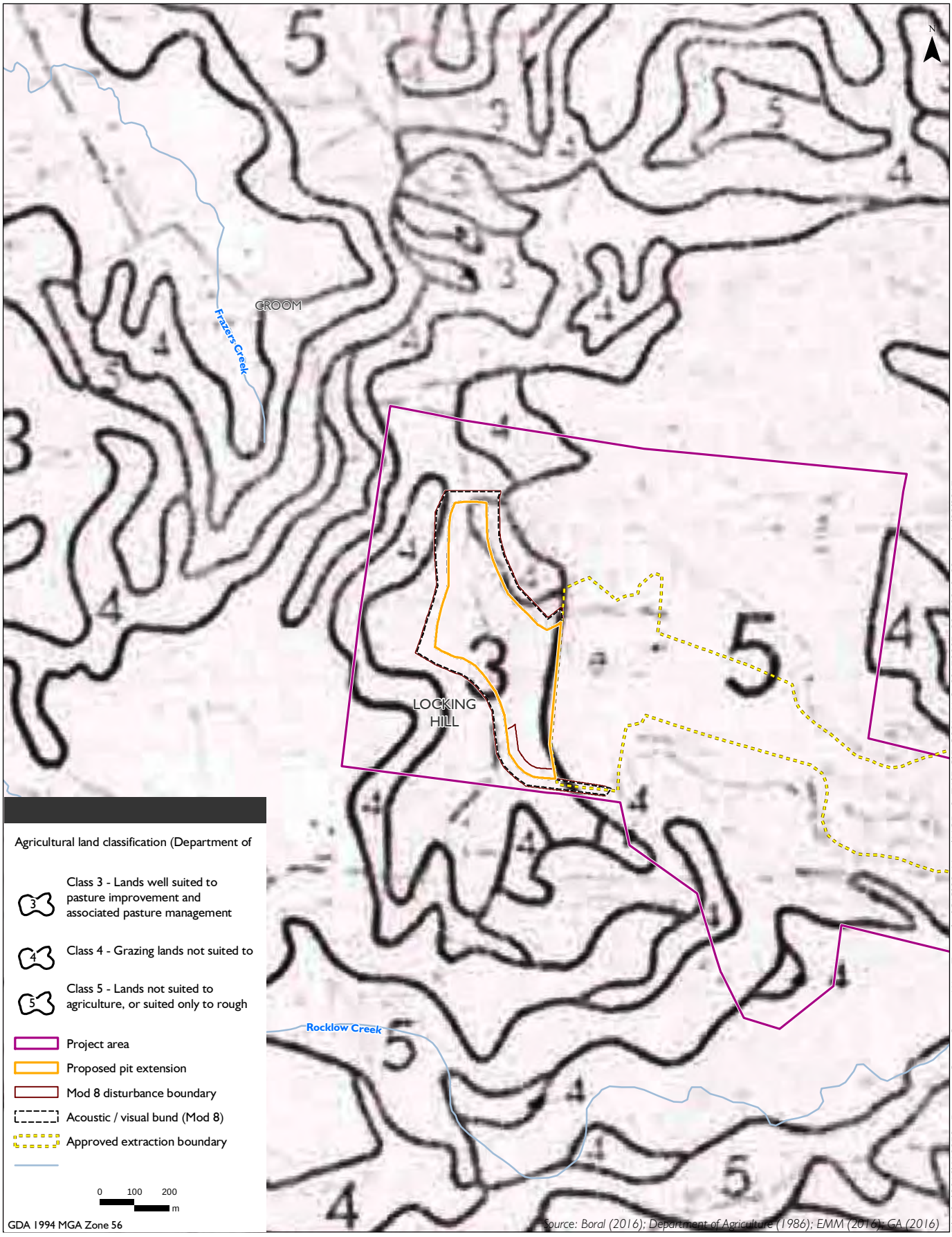
*The agricultural land classification of the agricultural land proposed to be used for the quarry should also be stated.*

Response

NSW agriculture uses the *Agricultural Land Classification, Agfact AC.25* (NSW Agriculture 2002) which is a five class system used to classify land in terms of its suitability for general agricultural use.

Agricultural land classification mapping has been undertaken for the Illawarra region by the Department of Agriculture at a scale of 1:50000. The quarry is located within the coverage of the Kiama map (Hindle and NSW Department of Agriculture 1986) (Figure 4.1). The study area (the proposed Croome West Pit) is located within an eastern area mapped as agricultural land class 5 adjacent to an area mapped as agricultural class 3 to the west. A description of Class 3 and Class 5 land sourced from the Agfact AC.25 is provided below:

> **Class 3**
>
> Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate because of edaphic factors or environmental constraints. Erosion hazard, soil structural breakdown or other factors including climate may limit the capacity for cultivation, and soil conservation or drainage works may be required.
>
> Class 3 lands have generally moderate levels of social, economic or physical limitations, restricting the extent of arable agriculture. For example, erosion hazard, soil structural breakdown or other factors including climate may limit the capacity for cultivation, and soil conservation or drainage works may be required. However, a high to very high level of one




EMM

**Agricultural land classes**

Dunmore Quarry Modification 9

Response to submissions

Figure 4.1

particular characteristic may result in an area being classified as Class 3 even where other limitations are absent. Class 3 lands are characteristically lands with the following features:

- productivity is high for locally adapted pastures and moderate for crops well suited to the area;
- access to local and export markets is satisfactory;
- local and regional infrastructure to support extensive forms of agriculture is present, and a ready supply of suitable labour is available;
- potential for land use conflict with neighbours as a result of standard agricultural practices may restrict agricultural activities;
- slopes are level to moderately inclined;
- soils are moderately deep to shallow;
- the land has moderate to limited suitability for cultivation, so cultivation is only sustainable in rotation with pastures;
- the soil profile is well drained to imperfectly drained;
- erosion hazard is low to high, so intensive measures of soil conservation may be required to control erosion in the long term;
- soil physical and chemical properties may limit crop and pasture productivity;
- recurrent extremes of climate may affect productivity;
- potential economic losses due to flooding are moderate, in the long term; and
- the level of economic constraint from factors such as weeds, site contamination, standing timber and feral animals is moderate.

**Class 5**

Land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors which preclude land improvement.

Class 5 lands suffer extreme limitations for agricultural production. These limitations may be one of, or a combination of the following features:

- productivity levels for all types of agricultural crops and pastures are very low;
- access to local and export markets may be very restricted by location;
- local infrastructure to support extensive forms of agriculture may be absent, as may suitable labour resources;
- extremes of slope can be expected. • The land is unsuitable for cultivation. The soil profile is very poorly drained;
- erosion hazard is extreme, and economic control using conventional soil conservation measures is impractical;

- soil physical and chemical properties present an extreme limitation to the growth of agricultural plant species;
- recurrent extremes of climate may seriously affect productivity;
- potential economic losses due to flooding are high, in the long term; and
- the level of economic constraint from factors such as weeds, site contamination, standing timber and feral animals is very high to extreme.

In order to provide a comprehensive assessment of the agricultural land classification of the study area the results of the soil survey undertaken (EMM 2016) have been assessed against the limitations outlined above for the agricultural land classification class.

The study area is surrounded by grazing land and associated rural residential properties. Historically the area has been used for dairy farming. The western side of the study area is currently cleared and is used for horse grazing.

Elevation generally declines from the study area, located along the upper surface of the north-west - south-east orientated ridge formed by Locking Hill and Gooseberry Hill at 164 m AHD towards the eastern edge of the quarry where the elevation is 10 m AHD. The slopes on the eastern edge of the study area provide a restriction for cultivation and grazing.

Acidic-Sodic, Eutrophic Dermosols were the dominant soil type identified in the study area. The chemistry analysis results for test pit one showed the soil presented extreme acidity in the B horizon, poor fertility, higher exchangeable sodium percentage in the B horizon and restrictive cation exchange capacity (CEC) and calcium to magnesium ratio (Ca:Mg). This assessment was based on agricultural industry benchmarks for soil sufficiency (Baker and Eldershaw 1993, Department of the Environment and Resource Management (DERM) 2011, Peverill, Sparrow and Reuter 1999).

For the eastern side of the study area, the slope and soil chemical restrictions identified by the soil survey are consistent with the Class 5 classification as mapped, as the acidity provides an extreme limitation to plant growth within the study area. The western boundary of the study area may be classified as Class 3 agricultural land however would be best suited to grazing of pasture or improved pasture as cultivation may be slightly restricted by slope and soil chemistry.

Comment

*The proponent should outline any impacts to water use on agriculture and mitigation measures as required.*

Response

The proposed modification will not have any impact on water available for use by agricultural enterprises surrounding the quarry. A detailed description of water impacts of the proposed modification is provided in Chapter 3.

Comment

*The proponent should include a biosecurity (weeds) risk assessment outlining the likely risks and a biosecurity (weed) response plan to deal with identified risks. A contingency plan should address any failures and include monitoring and mitigation measures in weed management plans.*

Response

The following section provides a risk assessment for priority weed species recorded within the project area. While some mitigation measure are provided, it is considered more appropriate to update the existing *Flora And Fauna Management Plan* (FFMP) for the quarry, with a biosecurity response plan, detailed monitoring schedules and mitigation measures. This will be provided following project approval (if approved).

Species recorded within the project area were cross-referenced against priority weeds listed under the NSW *Biosecurity Act 2015* for the south-east NSW region (NSW WeedWise). The south-east NSW region includes Shellharbour local government area in which the quarry is located. Listed priority weeds and the appropriate measure and landholder duties required are provided in Table 4.1.

**Table 4.1 Priority weeds recorded within the project area**

| Species | Type of measure | Duty |
|---|---|---|
| All plants | General biosecurity duty | All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable. |
| Blackberry<br>*Rubus fruticosus* species aggregate | Mandatory measure | Must not be imported into the State or sold. |
| Fireweed<br>*Senecio madagascariensis* | Mandatory measure | Must not be imported into the State or sold. |
| | Regional recommended measure | Whole region: Land managers should mitigate the risk of new weeds being introduced to their land. Within the exclusion area the plant should be eradicated from the land and the land kept free of the plant. Shellharbour council area is within a core infestation area and therefore is not included within the exclusion zone. |
| Lantana<br>*Lantana camara* | Mandatory measure | Must not be imported into the State or sold. |
| | Regional recommended measure | Whole region: Land managers should mitigate the risk of new weeds being introduced to their land. Within the exclusion area the plant should be eradicated from the land and the land kept free of the plant. Shellharbour council area is within a core infestation area and therefore is not included within the exclusion zone. |

The proposed modification may affect the prevalence of weed species via several mechanisms. These have been considered in a risk assessment table (Table 4.2), which is specific to the lifecycle and dispersal characterises of the priority weed species.

## Table 4.2 Risk assessment of priority weeds recorded within the project area

| Potential risk factor | Species specific information | Project risk | Mitigation measures | Project risk after mitigation |
|---|---|---|---|---|
| **Lantana (*Lantana camara*)** | | | | |
| Propagation from seed | Readily propagates from seed dispersed by terrestrial and volant species. Potential for seeds to be transported in soil and on machinery during construction works. After works are completed a net loss of Lantana will have occurred, reducing the amount of local seed production. | Moderate | Hygiene controls for machinery and other equipment, especially while clearing Lantana infested area.<br>Disposal of cleared material in landfill or treated appropriately (eg heat) prior to repurposing. | Low |
| Vegetative propagation | Lantana rarely propagates vegetatively, though stockpiling material should be avoided. | Low | As above | Low |
| Introduction of species to new areas | Shoalhaven council area is part of core infestation area with frequent colonisation of the weed where even moderate disturbance has occurred. Spread of seed by birds is the primary cause, with project impacts likely to be relatively negligible. | Low | As above | Low |
| Colonisation of intact native vegetation | Native vegetation within proximity of the works are likely to be already impacted by Lantana or have resisted infestation due to both biotic and abiotic factors. | Low | As above | Low |
| Colonisation of adjacent agricultural land | This species is not a problematic agricultural weed and is easily controlled by a variety of methods (aided by the lack of native canopy and shrub species) | Low | As above | Low |
| Colonisation of new habitats created by the project (especially bund revegetation). | This species is able to colonise new habitats relatively rapidly via spread in bird droppings. It poses a threat to native plant cover and diversity. It has the potential to smother Illawarra Zieria offset planting. | High | As above and; vigilant monitoring is required within revegetation areas to detect and control plants before they seed. This is particularly important before the native species fully establish. Weed control should be highly targeted to prevent any impact to native species, especially Illawarra Zieria offset planting. | Low |
| **Blackberry (*Rubus fruticosus* species aggregate)** | | | | |
| Propagation from seed | Readily propagates from seed dispersed by both terrestrial and volant species. Potential for seeds to be transported in soil and on machinery during construction works. After works are completed a net loss of Blackberry will have occurred, reducing the amount of local seed production. | Moderate | Hygiene controls for machinery and other equipment, especially while clearing Lantana infested area.<br>Disposal of cleared material in landfill or treated appropriately (eg heat) prior to repurposing. | Low |

**Table 4.2 Risk assessment of priority weeds recorded within the project area**

| | | | | |
|---|---|---|---|---|
| Vegetative propagation | Blackberry frequently propagates vegetatively; therefore it is important to avoid spreading or stockpiling part of the plant. | Moderate | As above | Low |
| Introduction of species to new areas | Blackberry is not prevalent within the immediate proximity of the project area. It is therefore important that the project does not contribute to spread of the species, especially in wetter areas and where disturbance has occurred. | Moderate | As above | Low |
| Colonisation of intact native vegetation | Intact native vegetation within proximity of the project area has shown to be relatively resilient to the weed. However disturbed native vegetation and edges of habitat are likely to be susceptible to invasion. | Moderate | As above | Low |
| Colonisation of adjacent agricultural land | This species has the potential to become a problematic agricultural weed due to its ability to regenerate from rootstock. In addition to reducing the area of suitable grazing land it can also trap sheep due to its recurved thorns. | Moderate | As above | Low |
| Colonisation of new habitats created by the project (especially bund revegetation). | This species is able to colonise new habitats relatively rapidly via spread in bird droppings. It poses a threat to native plant cover and diversity. It has the potential to smother Illawarra Zieria offset planting. | High | As above and; vigilant monitoring is required within revegetation areas to detect and control plants before they seed. This is particularly important before the native species fully establish. Weed control should be highly targeted to prevent any impact to native species, especially Illawarra Zieria offset planting. | Low |
| **Fireweed (*Senecio madagascariensis*)** | | | | |
| Propagation from seed | Produces a very high number of wind dispersed seeds which readily propagate, especially in cleared areas or grassland where disturbance has led to reduced competition. Potential to spread the species during clearance works and mobilise seed during transport of material offset. | Moderate | Hygiene controls for machinery and other equipment, especially while clearing infested grassland areas.<br>Disposal of cleared material in landfill or treated appropriately (eg heat) prior to repurposing. Cover load during transportation, to minimise spread of windborne seeds. The latter is not required if no seed material is present. | Low |
| Vegetative propagation | This species is not known to regenerate vegetatively. | Low | N/A | Low |
| Introduction of species to new areas | Sheelharbour council area is part of core infestation area with frequent colonisation of the weed in disturbed areas. Spread of seed by wind over is the primary dispersal mechanism. In comparison with wind dispersal project impacts are likely to be relatively negligible. | Moderate | Hygiene controls for machinery and other equipment, especially while clearing infested grassland areas.<br>Disposal of cleared material in landfill or treated appropriately (eg heat) prior to repurposing. Cover load during transportation, to minimise spread of seeds. The latter is not required if no seed material is present. | Low |

**Table 4.2 Risk assessment of priority weeds recorded within the project area**

| | | | | |
|---|---|---|---|---|
| Colonisation of intact native vegetation | Native vegetation within proximity of the works is likely to be already impacted by the species or have resisted infestation due to both biotic and abiotic factors. | Low | As above | Low |
| Colonisation of adjacent agricultural land | This species has the potential to become a problematic agricultural weed due to its very high dispersal capacity and large number of seeds produced. Fireweed contains pyrrolizidine alkaloids that are toxic to livestock and causes liver damage. Hay, silage and grain that is contained with fireweed plants or their seeds can also be toxic (Weedwise 2017). | Moderate | As above | Low |
| Colonisation of new habitats created by the project (especially bund revegetation). | This species is able to colonise new habitats rapidly via wind dispersal of seed. It is unlikely to outcompete native species once they are established however,may pose a problem during establishment of revegetation area. | Moderate | As above and; vigilant monitoring is required within revegetation areas to detect and control plants before they seed. This is particularly important before the native species fully establish. Weed control should be highly targeted to prevent any impact to native species, especially Illawarra Zieria offset planting. | Low |

The risk of heightened weed dispersal is likely to be at its highest during the clearing of vegetation where there is the potential for spread of propagules. The implementation of appropriate weed control measures during this period will substantially reduce the risk of weed dispersal.

Of particular importance is personnel, vehicle and equipment hygiene, preventing the spread of propagules coming onto the project area, moving within the project area and transporting material offsite. Vigilance will also be required in the native revegetation of the bund areas, especially before native species fully establish. Early monitoring and treatment of weeds is vital to prevent establishment of weed which would cause reduced biodiversity and require more onerous management at a later date.

Illawarra Zieria is proposed to be planted within revegetation areas. Therefore, it is important that weeds are controlled to prevent smothering of this threatened species. The project will remove an area of revegetation which has a high occurrence of weed species, particularly Lantana. If managed appropriately, the project will result in a net reduction of weed species, removing a source of seed material, which is currently dispersing through natural mechanisms. Furthermore the revegetation areas provide an opportunity to create habitat with a low prevalence of weed, providing best practice methods are followed.

Comment

*The Site Water Balance and the Groundwater Monitoring Program should continue to give due consideration to any water licensing requirements which may result from the reviews and to account for all water "take" by the quarry operations accordingly.*

Response

Details on the site water balance and groundwater monitoring program are provided in Chapter 3. This provides information on the likely water take by the quarry which can be used by Boral to obtain relevant licences and licence allocations under the NSW *Water Management Act 2000*.

# 5 Office of Environment and Heritage

## 5.1 Introduction

OEH provide a submission on 10 April 2017. The submission provides comments on the proposed modification in relation to biodiversity, Aboriginal cultural heritage and water management. These matters are addressed below.

## 5.2 Biodiversity

Comment

*Our office is supportive of the proposed offset strategy approach in principle, however it is preferable that that offset calculations from the biobank simulation be provided prior to approval. This is in order to quantify the exact offset likely to be generated as a result of proposed removal of all threatened Illawarra Ziera individuals. Should the modification be approved, conditions requiring submission of the finalised offset strategy within 12 months and appropriate security for the offsets should be imposed. Our preferred option in the longer term for suitable offsets for future extraction proposals remains establishment of a biobanking site, as suggested by Action 4.2.2 of the ISRP 2015. Our office remains available to provide further assistance in this regard.*

Response

This matter is addressed in Chapter 2.

## 5.3 Aboriginal cultural heritage

Comment

*It is our understanding that an AHIP is not required, as the transitional Part 3A provisions under the Environmental Planning and Assessment Act 1979 removes the requirement for approvals under s.90 of the National Parks and Wildlife Act 1974.*

*An Aboriginal Heritage Management Plan (AHMP) should instead be developed for Modification 9. The AHMP must include Aboriginal community consultation procedure, archaeological salvage excavation methodology (as per Kelleher Nightingale Consultants, 2017, Appendix E), long term management procedure for Aboriginal objects recovered during the archaeological excavations and a procedure for unanticipated finds including Aboriginal objects and Aboriginal skeletal remains during the operation of the quarry. We request that the draft AHMP for Modification 9 is provided to OEH for review.*

Response

A draft AHMP has been prepared in accordance with OEH's request and requirements and is attached at Appendix D. It has been prepared by Kelleher Nightingale Consulting, which prepared the Aboriginal cultural heritage assessment for the proposed modification.

## 5.4 Water Management

Comment

*We recommend that DPE as consent authority and the proponent ensure that existing water management conditions are strictly adhered to with regard to increased surface water flows and runoff, or in the event that unanticipated groundwater flows are encountered.*

*The Environmental Assessment details that the Water Management Plan will be revised to reflect the results of the water balance modelling and with any amendments to the existing water management system. It is advisable that if the quarry modification is approved, prior to the commencement of works, the amended Water Management Plan be submitted for review.*

Response

This matter has been addressed in Chapter 2.

# 6 Conclusion

The EA for the proposed modification was placed on public exhibition for four weeks from 20 March 2017 to 10 April 2017. Following public exhibition of the EA, six submissions were received from government agencies. No submissions were received from the council or from the local community.

None of the submissions received object to the proposed modification. One submission, from DPE-RM, was provided in support.

On 19 April 2017, DPE-RAC wrote to Boral requesting a report be prepared that responds to the matters raised in the submissions regarding the proposed modification. DPE's letter also stated that in preparing responses, Boral should pay particular attention to matters outlined in an attachment to the letter, including matters relating to noise, water, biodiversity and resources.

This RTS report has been prepared to address this requirement. Responses to matters raised by DPE-RAC have also been addressed in this report.

As part of this RTS, an updated surface water assessment (refer to Appendix A) of the proposed modification has been prepared to address all comments made by government agencies in relation to surface water management and impacts. In addition, an Aboriginal heritage management plan (refer to Appendix D) has also been prepared in response to a request from OEH to address management of impacts to Aboriginal cultural heritage with the project area.

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# Appendix A

## Revised surface water assessment

# Dunmore Hard Rock Quarry
# Modification 9
# Surface Water Assessment

**For: Boral Resources (NSW) Pty Ltd**

**August 2017**

PROJECT INFORMATION

**Project Name:** Dunmore Hard Rock Quarry: Modification 9: Surface Water Assessment

**Project Number:** PA1331

**Report for:** Boral Resources (NSW) Pty Ltd

## PREPARATION, REVIEW AND AUTHORISATION

| Revision # | Date | Prepared by | Reviewed by | Approved for Issue by |
|---|---|---|---|---|
| A | 6.9.2016 | Chris Kuczera | Ben Patterson | Draft for Review |
| B | 12.9.2016 | Chris Kuczera | Ben Patterson & EMM | Draft for Review |
| C | 12.12.2016 | Chris Kuczera | Ben Patterson | Ben Patterson |
| D | 19.12.2016 | Chris Kuczera | Ben Patterson, Boral & EMM | Ben Patterson |
| E | 7.2.2017 | Chris Kuczera | Ben Patterson, Boral & EMM | Ben Patterson |
| F | 14.2.2017 | Chris Kuczera | Ben Patterson, Boral & EMM | Ben Patterson |
| G | 2.8.2017 | Chris Kuczera | Chris Kuczera | Draft for Review |
| H | 17.8.2017 | Chris Kuczera | Chris Kuczera, Boral & EMM | Ben Patterson |

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# EXECUTIVE SUMMARY

This report documents a Surface Water Assessment of a proposed modification at the Dunmore Hard Rock Quarry. The proposed modification seeks to expand the Croome Farm Pit by approximately 14.4ha to enable extraction within the Croome West Pit. There are no changes proposed to the production rates, existing quarry infrastructure or process water demands. The Croome West Pit will increase the contributing catchment area to the quarry's water management system, which will result in higher runoff volumes reporting to the existing water management dams.

This Surface Water Assessment addresses the following assessment requirements that have been provided by the NSW Government's Department of Planning and Environment (DP&E):

- A detailed assessment of the potential impacts of the development on the quantity and quality of regional water supplies, regional water supply infrastructure and affected licensed water users and basic landholder rights.
- A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.

## *Report Background and Framework*

An Environmental Assessment for Modification 9 was submitted to the DP&E in February 2017. The Surface Water Assessment report issue Rev F was included in this submission. This Surface Water Assessment identified some significant departures from the water management system that is documented in the quarry's Water Management Plan (Arcadis, 2016). This was recognised prior to the submission of the Environment Assessment in February 2017.

In November 2016, Boral installed water level loggers at three key locations with the intention of using this data to reliably characterise the functionality of the existing water management system and calibrate a site water balance model. At the time of preparing the Surface Water Assessment (Rev F) there was insufficient data available to reliably characterise the functionality of the existing surface water management system. This was acknowledged in the report.

This revised Surface Water Assessment is informed by water level and water quality monitoring and further site inspections and documents a revised interpretation of the existing water management system.

A review of the existing water management system was also undertaken. This review identified that the Lower Dam is not adequately providing its intended sedimentation treatment function. As a result Boral is proposing to modify the dam and it operational procedures. In addition, Boral are proposing to preferentially source process water from the Middle Dam, rather than the Lower Dam to increase the volume of process water that is sourced from the quarry's water management system, reducing receiving water impacts. These proposed modifications are not associated with Modification 9 but are documented in this report.

For the purposes of assessing Modification 9 impacts, proposed changes to improve the existing water management system have been separated from the impact assessment, with the following scenarios described and assessed separately in this report:

- **Existing Conditions**: Refers to the existing water management system that is described in **Section 4**.

- **Existing Conditions with Improvements**: Applies the proposed modifications to the Lower Dam and changes to the process water extraction regime to the Existing Conditions scenario.

- **Modification 9**: Applies Modification 9 changes to the Existing Conditions with Improvements scenario.

## *Revised Interpretation of the Existing Water Management System*

The revised interpretation of water management system is diagrammatically described in the **Figure E1** and discussed in detail in **Section 4** of this report.

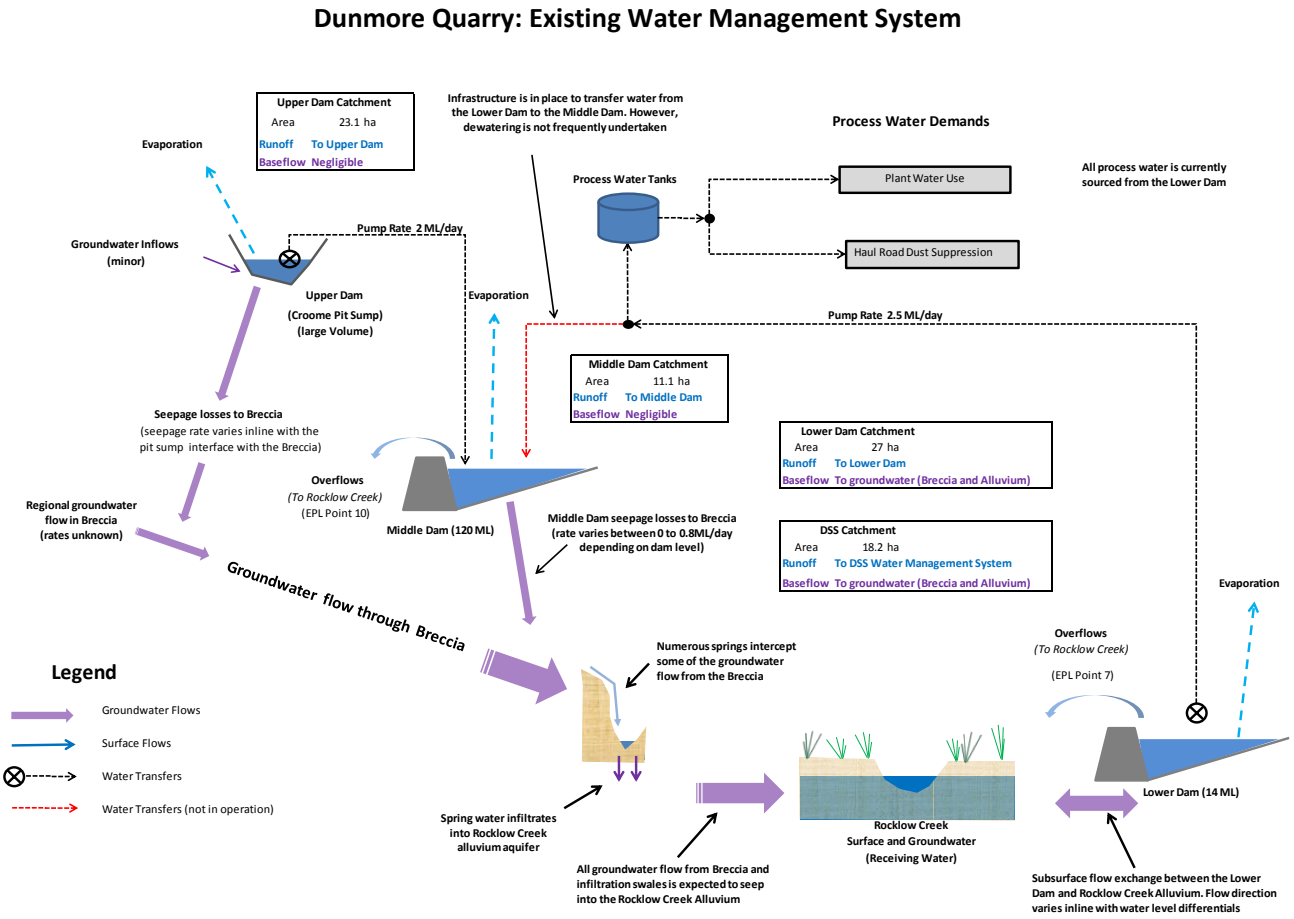


**Figure E1** – *Existing Water Management System*

As described in **Figure E1**, the surface water management system interfaces with a permeable breccia rock layer and the Rocklow Creek Alluvium groundwater system. These interfaces are described further below.

### Interface with Permeable Breccia Layer

The majority of the historic extraction areas have been quarried down to the top of a breccia rock layer that sits between low permeability latite rock layers. Breccia is a permeable sedimentary rock. The breccia layer receives water that seeps from the Middle Dam at rates of up to 0.8 ML/day. As a result of the high seepage rates, the Middle Dam has received runoff from its own 11.1 ha catchment plus all water dewatered from the Croome Farm Pit (which has 23.1 ha catchment) and

has never overflowed or required dewatering. Accordingly, all outflows from the dam have been via seepage and evaporation losses.

Groundwater is interpreted to flow through the breccia on top of the low permeability latite rock layer. Substantial seepage from the breccia layer occurs to the north of the material processing plant area where the breccia outcrops. This is referred to as the Breccia Spring throughout this report. The seepage currently concentrates into a small water fall that spills into an infiltration swale. Water from the swale is interpreted to infiltrate into the Rocklow Creek Alluvium. No direct connection to the Lower Dam is expected. Breccia Spring flows are interpreted to be the quarry's primary discharge mechanism.

**Interface with Rocklow Creek Alluvium**

It is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Historically all process water has been extracted from the Lower Dam which has been excavated into the Rocklow Creek Floodplain. The majority of the process water extracted from the Lower Dam is expected to be drawn from the adjoining Rocklow Creek Alluvium via groundwater ingress into the dam.

## *Water Quality Characterisation*

Water quality sampling was undertaken to characterise the quality of water in the quarry's water management dams, Breccia Spring flows and receiving water. The monitoring identified elevated Nitrate and Copper levels in most water management dam and the Breccia Spring samples. The elevated concentrations of both Nitrate and Copper are interpreted to be associated with the weathering of quarry rock that has naturally occurring elevated levels of both analytes. To support this hypothesis, Boral has compared geochemical data from Dunmore Quarry rock to rock from other Boral quarries. This analysis is provided in **Appendix B**.

As discussed earlier, Breccia Spring flows are considered to be one of the quarry's primary surface water discharge mechanisms. An assessment of potential receiving water impacts was undertaken by comparing the Breccia Spring and receiving water quality results. This assessment concluded that the Breccia Spring flows are resulting in elevated Nitrate and Copper levels in the immediate mixing zone (within Rocklow Creek), with no elevated Nitrate and Copper levels identified in other downstream sampling locations. Refer to **Section 4.4** of this report for further information.

## *Identified Issues with the Existing Water Management System*

A review of the existing water management system has identified the following issues:

- The Lower Dam is not adequately providing its intended sedimentation treatment function. This is due to connectivity with the Rocklow Creek surface and groundwater systems and the sedimentation treatment volume being undersized. Boral is proposing to modify the dam to rectify these identified issues. This is discussed further below.

- The Breccia Spring flows have been identified as being the quarry's primary discharge mechanism. This discharge mechanism is not regulated by the quarry's existing Environment Protection Licence.

- Groundwater inflows into the Lower Dam are not currently licenced.

Boral proposes to consult with the NSW Environment Protection Authority and the Department of Primary Industries – Water (DPI-Water) to rectify the above-mentioned licensing issues.

## *Proposed Improvements to the Existing Water Management System*

Following a review of the existing water management system, Boral is proposing to implement the following improvements:

- The Lower Dam will be substantially modified to improve its sedimentation treatment functionality. The modifications include relocating and raising the dam's spillway, increasing the sedimentation treatment volume and implementing a dewatering regime. Once the proposed dam upgrades are implemented it is expected that the Lower Dam will broadly be operated in accordance with the operating principles described in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008).

- Process water will be preferentially sourced from the Middle Dam to reduce extraction from the Lower Dam and associated groundwater ingress into the Lower Dam from the Rocklow Creek Alluvium. Process water extraction from the Middle Dam will also reduce Middle Dam leakage rates and associated Breccia Spring flows.

It is noted that these improvements are proposed to improve the effectiveness of the existing water management system and are not associated with Modification 9.

## *Impact Assessment*

The existing and proposed water management systems were assessed against relevant consent conditions and other key benchmarks to identify potential impacts. Potential impacts are described as follows:

- **Surface Water Quantity Impacts**: The proposed Croome West Pit is expected to permanently reduce the contributing catchment area to Rocklow Creek by up to 13.8ha and Frazers Creek by 1.7ha. This change in catchment extents is considered to be unavoidable but will result in a minor reduction in stream flows in the downstream receiving waters. The resulting impacts are expected to be negligible given that both Rocklow and Frazer Creeks have significant catchment areas. DPI-Water has advised that there are no licensed surface water users in the immediate receiving waters downstream of the quarry site. Hence, no impacts to existing surface water users are expected.

- **Groundwater Quantity Impacts:** it is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Process water use is not expected to increase as a result of the proposed modification. Historically all process water has been extracted from the Lower Dam, with the majority of the water expected to have been drawn from the Rocklow Creek Alluvium via groundwater ingress into the dam. Boral is proposing to reconfigure the process water extraction regime to preferentially source water from the Middle Dam rather than then Lower Dam. This combined with the Croome Farm West Pit extension is expected to materially reduce the volume of groundwater that is taken from the Rocklow Creek Alluvium via groundwater ingress into the Lower Dam.

- **Receiving Water Quality Impacts**: Water balance model results presented in **Section 5.3** of this report indicate that Middle Dam seepage volumes are predicted to be maintained at existing levels, with the additional dewatering requirements from the Upper Dam being fully offset by preferentially sourcing process water from the Middle Dam. This indicates that Modification 9 (when combined with the proposed improvements to the existing water management system) will not result in a material increase in Breccia

Spring flows and associated Nitrate and Copper loads to receiving waters. Accordingly, Modification 9 is not expected to result in any material receiving water quality impacts.

## *Assessment of Cumulative Impacts*

**Section 7** of this report discusses cumulative impacts associated with a potential 4ha extension of the Sydney Trains Extraction Area. This assessment concluded that the potential extension could result in a modest (7 to 8%) increase in the volume of surface water that requires management in Boral's water management system. This is expected to result in a moderate increase in discharge volumes from the Breccia Spring flows and Lower Dam overflows. It is expected that these impacts could be partially or fully mitigated if process water use is increased as a result of the Sydney Trains operation and appropriate water storages are established. No other material impacts to Boral's water management system are expected. Potential impacts on Boral's water management system from the proposed 4ha extension to the Sydney Trains Extraction Area can be addressed in more detail when more data is available.

## *Water Licensing Provisions*

It is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Historically all process water has been extracted from the Lower Dam, with the majority of the water expected to have been drawn from the Rocklow Creek Alluvium via groundwater ingress into the dam. No Water Access Licence has been established for this water take. Boral acknowledges that a Water Access Licence is required for any water take from the Rocklow Creek Alluvium and will consult with DPI-Water to establish appropriate licencing arrangements.

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# ABBREVIATIONS

| | |
|---|---|
| **AHD** | *Australian Height Datum* |
| **AR&R** | *Australian Rainfall and Runoff (1987)* |
| **Blue Book** | *An Erosion and Sediment Control Guideline titled Managing Urban Stormwater: Soils and Construction (Landcom, 2004)* |
| **BoM** | *Bureau of Meteorology* |
| **$C_v$** | *Volumetric Runoff Coefficients* |
| **DO** | *Dissolved Oxygen* |
| **DP&E** | *NSW Government's Department of Planning and Environment* |
| **DPI Water** | *NSW Government's Department of Primary Industries - Water* |
| **EC** | *Electrical Conductivity* |
| **EIS** | *Environmental Impact Statement* |
| **EMM** | *EMM Consulting Pty Limited* |
| **EMP** | *Environmental Management Plan* |
| **EPA** | *NSW Environment Protection Authority* |
| **EPL** | *Environment Protection Licence* |
| **IEAust** | *Institution of Engineers Australia* |
| **ML** | *Megalitre* |
| **Mtpa** | *Million tonnes per annum* |
| **OEH** | *NSW Government's Office of Environment and Heritage* |
| **PET** | *Potential Evapotranspiration* |
| **POEO Act** | *Protection of the Environment Operations Act 1997* |
| **RHDHV** | *Royal HaskoningDHV* |
| **SWCA** | *Surface Water Characterisation Assessment* |
| **The Quarry** | *Dunmore Quarry* |
| **TSS** | *Total Suspended Solids* |
| **WAL** | *Water Access Licence* |
| **WM Act** | *Water Management Act 2000* |
| **WMP** | *Water Management Plan* |

# 1 INTRODUCTION

Dunmore Hard Rock Quarry ('the quarry') is located at the end of Tabbita Road, Dunmore, in the Shellharbour local government area. It is owned and operated by Boral Resources (NSW) Pty Ltd ('Boral'). This Surface Water Assessment has been prepared to accompany an application to modify (Modification 9) the existing development consent for the quarry (Development Consent 470-11-2003) under Section 75W of the NSW *Environmental Planning and Assessment Act 1979* ('the proposed modification').

It is estimated that approved rock reserves at the quarry will be exhausted by the end of 2017. To enable continued operation of the quarry, it is proposed to extend the existing Croome Farm Pit by approximately 14.4 ha to enable extraction within the 'Croome West Pit'. **Figure 1** shows the proposed Croome West Pit. All other aspects of the approved operations will remain the same (i.e. operating hours, employee numbers, production rates, traffic generation, etc).

Construction of an acoustic/visual bund around the perimeter of the pit and associated disturbance is subject to a separate modification to Development Consent 470-11-2003 (Modification 8).

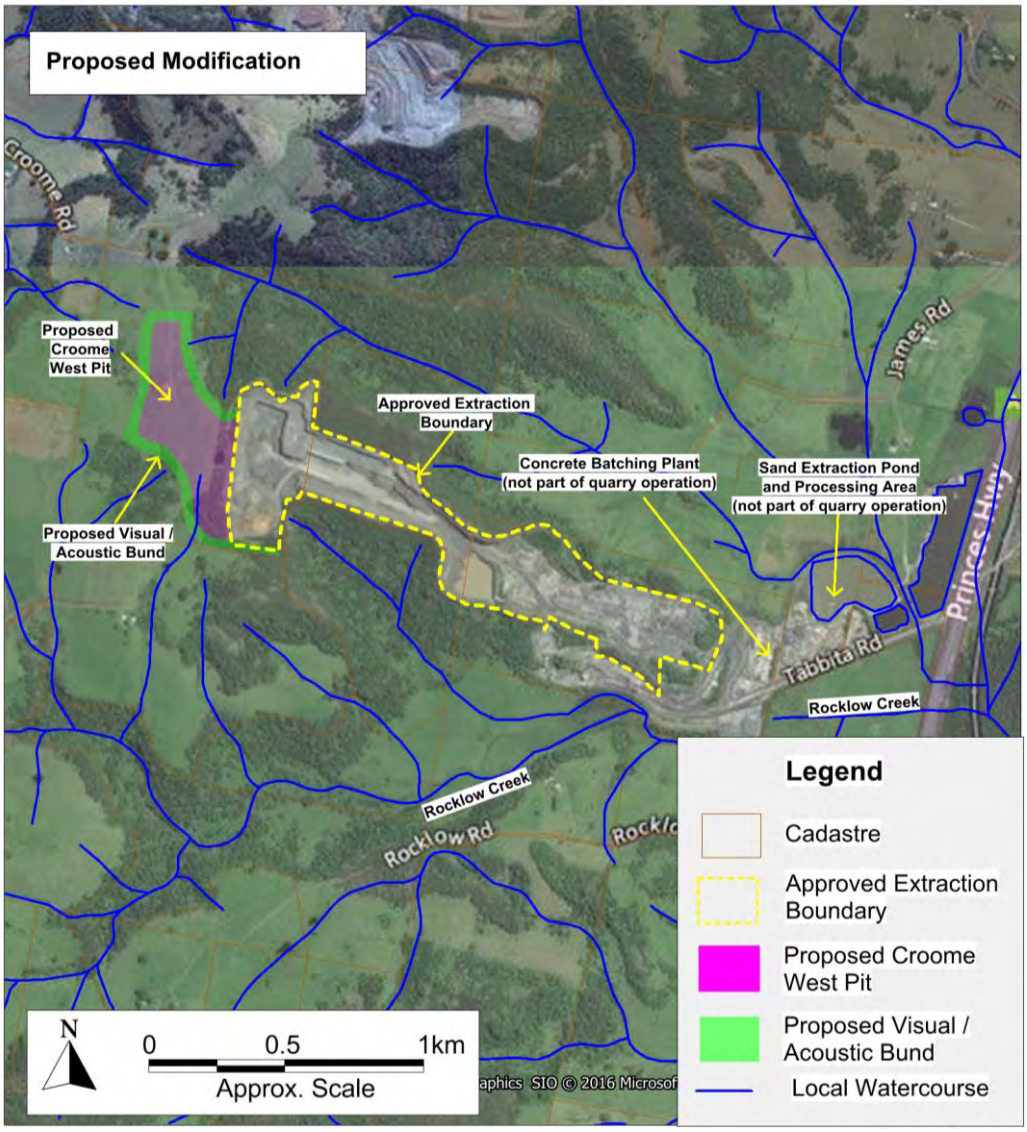


**Figure 1** – *Proposed Croome West Pit*

## 1.1 Assessment Background and Framework

An Environmental Assessment for Modification 9 was submitted to the DP&E in February 2017. The Surface Water Assessment report issue Rev F was included in this submission. This Surface Water Assessment identified some significant departures from the water management system that is documented in the quarry's Water Management Plan. This was recognised prior to the submission of the Environment Assessment in February 2017.

In November 2016, Boral installed water level loggers at three key locations with the intention of using this data to reliably characterise the functionality of the existing water management system and calibrate a site water balance model. At the time of preparing the Surface Water Assessment (Rev F) there was insufficient data available to reliably characterise the functionality of the existing surface water management system. This was acknowledged in the report.

This revised Surface Water Assessment is informed by water level and quality monitoring and further site inspections and documents a revised interpretation of the existing water management system. Key departures from the previously documented water management system are discussed qualitatively in **Section 4.6** of this report.

A review of the existing water management system was also undertaken. This review identified that the Lower Dam is not adequately providing its intended sedimentation treatment function. As a result Boral is proposing to modify the dam and its operational procedures. In addition, Boral is proposing to preferentially source process water from the Middle Dam, rather than the Lower Dam to increase the volume of process water that is sourced from the quarry's water management system, reducing receiving water impacts. These proposed modifications are not associated with Modification 9 but are documented in this report.

For the purposes of assessing Modification 9 impacts, proposed changes to improve the existing water management system have been separated from the impact assessment, with the following scenarios described and assessed separately in this report:

- **Existing Conditions**: Refers to the existing water management system that is described in **Section 4**.
- **Existing Conditions with Improvements**: Applies the proposed modifications to the Lower Dam and changes to the process water extraction regime to the Existing Conditions scenario.
- **Modification 9**: Applies Modification 9 changes to the Existing Conditions with Improvements scenario.

## 1.2 Report Overview

This report documents the Surface Water Assessment that has been prepared for the Modification 9. The report is structured as follows:

- **Section 2** discuses statutory requirements and relevant guidelines.
- **Section 3** reviews the existing surface water environment at the quarry site.
- **Section 4** describes the existing surface water management system and includes information on water level and water quality monitoring data.
- **Section 5** describes proposed changes to the surface water management system and presents water balance results.
- **Section 6** summarises the predicted surface water impacts associated with the proposed modification.
- **Section 7** discusses cumulative impacts associated with a potential 4ha extension to the existing Sydney Trains Extraction Area.
- **Section 8** discusses water licencing requirements for the existing operation.
- **Section 9** details a revised monitoring plan and provides a summary of additional actions and contingency measures.

# 2 ASSESSMENT FRAMEWORK

This section provides a summary of environmental assessment requirements, existing operating conditions and relevant water management plans and guidelines. This information is used as a basis for the assessment and is cross-referenced in subsequent sections of this report.

## 2.1 Assessment Requirements

The NSW Government's Department of Planning and Environment (DP&E) has provided the following assessment requirements for the proposed modification:

- A detailed assessment of the potential impacts of the development on the quantity and quality of regional water supplies, regional water supply infrastructure and affected licensed water users and basic landholder rights.
- A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.

No assessment requirements from other government agencies were provided.

## 2.2 Agency Submissions

The Surface Water Assessment (rev F) was reviewed by government agencies. All agency comments are addressed in a separate response to submissions document. However, additional information is provided in this revised Surface Water Assessment to address the following agency comments:

- The NSW Environment Protection Authority (EPA) requested that the Surface Water Assessment is informed by surface water quality characterisation.
- The Department of Primary Industries – Water (DPI - Water) requested further information on the potential water take from the Lower Dam and associated water licencing implications.

## 2.3 Review of Existing Operating Conditions

This section reviews consent and operating licence conditions that are relevant to surface water management at the quarry.

### *Consent Conditions*

The quarry operates under modified development consent that was approved by the NSW Minister of Planning. **Table 2-1** provides a summary of the existing water management related consent conditions and notes the relevance of each condition to this assessment.

***Table 2-1** – Summary of water management related conditions of consent*

| Condition of Consent | Condition | Relevance to this Assessment |
|---|---|---|
| **28** | Except as may be expressly provided by an Environment Protection Licence, the Applicant shall comply with section 120 of the Protection of the Environment Operations Act 1997 during the carrying out of the development. | **Relevant** - addressed in **Section 6** |
| **28A** | The Applicant must ensure that is has sufficient water for all stages of the development, and if necessary, adjust the scale of quarrying operations to match its available water supply. | **Relevant** - addressed in **Section 6** |
| **29** | Except as may be expressly provided by an Environmental Protection Licence, the Applicant shall ensure that the discharges from any licenced discharge point/s comply with the following concentration limits:<br>• TSS – 50 mg/l<br>• PH 6.5 to 8.5 | **Relevant** - addressed in **Section 6** |
| **30** | In each Annual Review, the Applicant must:<br>a) re-calculate the site water balance for the development<br>b) provide information on evaporation losses, dust suppression, dam storage levels and implications of obtaining any water supplies from off-site; and<br>c) evaluate water take against licensing requirements. | **Not Relevant** -Applicable to ongoing management and compliance. |
| **31** | The Applicant shall ensure that the stormwater management system for the development is designed, constructed and operated to capture and treat polluted waters from storm event(s) of up to and including the 5-day, 95th percentile rainfall event. | **Relevant** -addressed in **Section 6** |
| **32** | The Applicant shall ensure that the basins in the stormwater management system are managed in accordance with the operating principles within the revised Water Management Plan prepared by Evans and Peck, dated April 2008, or any subsequent Water Management Plan approved by the Secretary, to maintain the required storm water storage volume. | **Relevant** -addressed in **Section 6** |
| **33** | By 18 May 2008, or as otherwise agreed to by the Secretary, the Applicant shall, to the satisfaction of the EPA and the Secretary:<br>a) modify the existing dam at the site to create a dam with an increased capacity offline from Rocklow Creek;<br>b) construct new dams within the Quarry of sufficient capacity so that water quality at condition 29 can be met for all rainfall events up to and including the 5 day duration 95$^{th}$ percentile rainfall event.<br>c) ensure the discharge and overflow points of the dam do not cause erosion at the point of discharge/overflow;<br>d) rehabilitate and stabilize the banks of the dam; and<br>e) ensure the integrity of the dam would not be compromised by any flooding in Rocklow Creek; | **Relevant** -addressed in **Section 5** |

| Condition of Consent | Condition | Relevance to this Assessment |
|---|---|---|
| 34 | Prior to carrying out any of these works, the Applicant shall prepare a Dam Upgrade Plan in consultation with the EPA, and to the satisfaction of the Secretary. This plan must include:<br>a) the detailed design and specifications of the proposed works, which have been certified by a practicing registered engineer;<br>b) an erosion and sediment control plan for the proposed works, that is consistent with the requirements in the Department of Housing's Managing Urban Stormwater: Soils and Construction manual;<br>c) a vegetation and rehabilitation plan, setting out how the banks of the dam would be rehabilitated and stabilized;<br>d) an acid sulfate soil management plan that is consistent with the NSW Acid Sulfate Soil manual;<br>e) a construction program for the proposed works; and<br>f) a program setting out how the modified dam and associated revegetation works would be maintained during the life of the development.<br>The Applicant must implement the approved management plan as approved from time to time by the Secretary. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| 35 | Within 1 month of completing the construction works in the Dam Upgrade Plan, the Applicant shall submit an as-executed report, certified by a practicing registered engineer, to the satisfaction of the EPA and Secretary. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| 36 | The Applicant must not use flocculants on the site. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| 38 | Within 18 months of the date of this consent, the Applicant shall carry out the following works to the satisfaction of EPA and the Secretary:<br>Workshop and Fuel Storage Area<br>a) desilt drains and culverts upstream of the workshop to limit flooding;<br>b) construct a first flush collection basin to capture and store the first 13mm of run-off from the external service bays before it is treated by the oil/water separator; and<br>c) bund and roof the drum storage area;<br>Magazine Area<br>a) reinstate drain through access road to magazines to direct stormwater flows to the main drain; | **Not Relevant** – This consent condition is being addressed separately by Boral |
| 39 | Impervious bunds must be constructed around all fuel, oil and chemical storage areas and the bund volume must be large enough to contain 110 per cent of the volume held in the largest container. The bund must be designed and installed in accordance with the requirements of the EPA Environment Protection Manual Technical Bulletin Bunding and Spill Management. | **Not Relevant** – This consent condition is being addressed separately by Boral |

| Condition of Consent | Condition | Relevance to this Assessment |
|---|---|---|
| **40** | The Applicant shall measure:<br>a) the volume of water discharged from the site via licenced discharge points;<br>b) water use on the site;<br>c) water transfers across the site;<br>d) dam and water structure storage levels;<br>The Applicant shall monitor:<br>a) discharged from the licence discharge point/s of the development;<br>b) upstream and downstream of the development;<br>i. monitor flows in Rocklow Creek; and<br>ii. monitor regional groundwater levels and quality;<br>to the satisfaction of the EPA and the Secretary. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| **41** | Within 12 months of the date of this consent, the Applicant shall prepare a Site Water Management Plan for the development, in consultation with the DPI - Water, and to the satisfaction of the Secretary. This plan must include:<br>a) the predicted site water balance;<br>b) an Erosion and Sediment Control Plan;<br>c) a Surface Water Monitoring Program<br>d) a Ground Water Monitoring Program; and<br>e) an Integrated Water Management Strategy.<br>The Applicant must implement the approved management plan as approved from time to time by the Secretary. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| **42** | The Erosion and Sediment Control Plan shall:<br>a) be consistent with the requirements of the Department of Housing's Managing Urban Stormwater: Soils and Construction manual;<br>b) identify activities that could cause soil erosion and generate sediment;<br>c) describe measures to minimize soil erosion and the potential for the transport of sediment to downstream waters;<br>d) describe the location, function, and capacity of erosion and sediment control structures; and<br>e) describe what measures would be implemented to maintain the structures over time. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| **43** | The Surface Water Monitoring Program shall include:<br>a) detailed baseline data on surface water flows and quality in Rocklow Creek;<br>b) surface water impact assessment criteria;<br>c) a program to monitor surface water flows and quality in Rocklow Creek;<br>d) a program to monitor bank and bed stability in Rocklow Creek; and<br>e) a program to monitor the effectiveness of the Erosion and Sediment Control Plan. | **Not Relevant** – This consent condition is being addressed separately by Boral |

| Condition of Consent | Condition | Relevance to this Assessment |
|---|---|---|
| **44** | The Ground Water Monitoring Program shall include:<br>a) detailed baseline data on ground water levels and quality, based on statistical analysis;<br>b) ground water impact assessment criteria; and<br>c) a program to monitor regional ground water levels and quality. | **Not Relevant** – This consent condition is being addressed separately by Boral |
| **45** | The Integrated Water Management Strategy shall:<br>a) explore a range of options for a sustainable resource alternative for water supply to the site;<br>b) identification of all possible and available sources of water;<br>c) consistency with Government Water Reform initiatives and policies;<br>d) quality of water to meet usage requirements including any possible effects on product;<br>e) costs of supply;<br>f) health and environmental impacts;<br>g) legislative requirements;<br>h) assessment of the feasibility, benefits and costs of options;<br>i) a process to identify and evaluate preferred options for implementation; and<br>j) the identification of a timetable for implementation of the selected options. | **Not Relevant** – This consent condition is being addressed separately by Boral |

## *Existing Environment Protection Licence*

Environment Protection Licence (EPL) 77 applies to the quarry. This EPL includes five reference points (referred to as EPL Points) for which specific discharge and monitoring conditions are applied. The five EPL points are located in **Figure 2**. **Table 2-2** provides a summary of discharge and monitoring conditions for each EPL point.

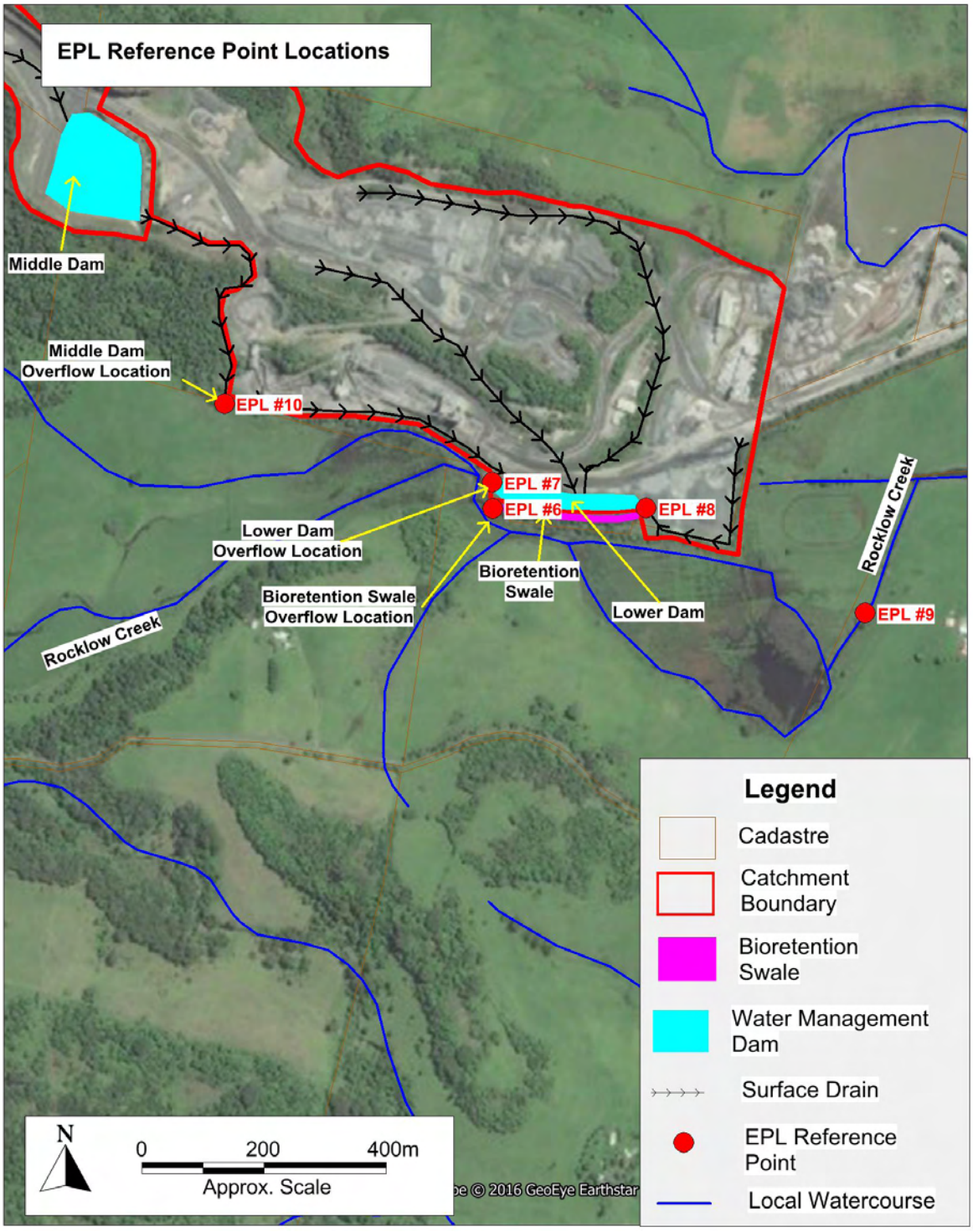


***Figure 2*** *– Water related EPL points*

***Table 2-2** – EPL Discharge and Monitoring Conditions*

| EPL Point | Description | EPL Discharge Conditions | EPL Monitoring Conditions | | |
|---|---|---|---|---|---|
| | | | Parameters | Monitoring Frequency | Sampling Method |
| 6 | Discharge from the Biofiltration Swale to Rocklow Creek. | TSS concentration less than 50 mg/l | Conductivity | Daily during discharge | In situ |
| | | | Flow | Continuous | Gauging |
| | | | Oil and Grease | Daily during discharge | Visual Inspection |
| | | | pH | Daily during discharge | In situ |
| | | | TSS | Daily during discharge | Grab Sample |
| | | | Turbidity | Daily during discharge | In situ |
| 7 | Uncontrolled discharge from the Lower Dam Spillway. | Nil | Conductivity | Daily during discharge | In situ |
| | | | Oil and Grease | Daily during discharge | Visual Inspection |
| | | | pH | Daily during discharge | In situ |
| | | | TSS | Daily during discharge | Grab Sample |
| | | | Turbidity | Daily during discharge | In situ |
| 8 | Effluent quality monitoring | Nil | Conductivity | Monthly | In situ |
| | | | Oil and Grease | Monthly | Visual Inspection |
| | | | pH | Monthly | In situ |
| | | | TSS | Monthly | Grab Sample |
| | | | Turbidity | Monthly | In situ |
| 9[1] | Rocklow Creek receiving water monitoring location | Nil | Conductivity | Monthly | In situ |
| | | | Oil and Grease | Monthly | Visual Inspection |
| | | | pH | Monthly | In situ |
| | | | TSS | Monthly | Grab Sample |
| | | | Turbidity | Monthly | In situ |
| 10 | Uncontrolled discharge from the Middle Dam Spillway. | Nil | Conductivity | Daily during discharge | In situ |
| | | | Oil and Grease | Daily during discharge | Visual Inspection |
| | | | pH | Daily during discharge | In situ |
| | | | TSS | Daily during discharge | Grab Sample |
| | | | Turbidity | Daily during discharge | In situ |

Note 1: EPL 77 does not specify any monitoring requirements for EPL Point 9. Monitoring conditions for this point are based on Boral's existing monitoring program.

EPL 77 also includes the following water related operating conditions:

- **Condition O4.2**: The stormwater management system is to be managed and operated in accordance with the operating principles of the revised Water Management Plan prepared by Evans and Peck, dated April 2008.
- **Condition O4.3**: The stormwater management system must be maintained at its design capacity. In this regard, the licensee must inspect the drainage system and associated

stormwater infrastructure every three months and following heavy rainfall and arrange routine maintenance as required. Inspection sheets certifying the work has been completed and detailed actions arising from the inspections must be kept in accordance with the requirements of this licence.

- **Condition O4.4**: Any proposal for a change of flocculant other than those specified in the report titled Dunmore Quarry Response to Water Management Issues, prepared by Environmental Resources Management Australia (February 2004), requires EPA approval and may require an appropriate eco-toxicological risk assessment to the satisfaction of the EPA. The flocculants nominated in the abovementioned report were Aluminium Sulphate and Ferric Chloride.

- **Condition O4.5**: Impervious bunds must be constructed around all fuel, oil and chemical storage areas and the bund volume must be larger enough to contain 110% of the volume held in the largest container.

## 2.4 Water Management Plan

The Consent Conditions that are summarised in **Table 2-1** make reference to a Water Management Plan (WMP) for the quarry was prepared by Evans & Peck in 2008. The WMP included a description of the water management system (in 2008) and a site water balance. The WMP recommended a number of water management improvement works to respond to concerns raised by the Department of Environment and Conservation.

An updated WMP was finalised by Arcadis in September 2016 and was approved by DP&E on 5 December 2016. The updated WMP incorporates a similar water management strategy and water balance to the 2008 WMP, but includes updated water management actions, monitoring and reporting requirements and exceedance protocols.

As discussed in **Section 1.2**, this Surface Water Assessment has identified some significant departures from the water management system that is documented in both the Evans & Peck (2008) and Arcadis (2016) WMPs. Accordingly, these plans have limited relevance to this Surface Water Assessment.

## 2.5 Applicable Polices and Guidelines

There are a number of legislative and guidance documents for water resource management and assessment in NSW. The following policies, plans and guidelines have been considered in this assessment.

### *Water Plans and Statutory Provisions*

***Water Sharing Plan for the Greater Metropolitan Region Unregulated Water Sources 2011***

Water Access Licences (WALs) in the quarry area are administered by the *Water Sharing Plan for the Greater Metropolitan Unregulated Water Sources 2011*. The Water Sharing Plan is administered on the basis of catchment scale Water Sources. The quarry is located within the Illawarra Rivers Water Source. The licensing provisions of the *Water Management Act 2000* (WM Act) are also applicable to the plan area.

The Water Sharing Plan is administered by the Department of Primary Industries – Water (DPI Water). **Section 8** addresses the water licensing requirements for the quarry.

### *Protection of the Environment Operations Act 1997*

The *Protection of the Environment Operations Act 1997 (POEO Act)* establishes the NSW environmental regulatory framework and includes licensing requirements for certain activities. EPLs for water discharge are administered by the EPA under the POEO Act.

## *Guidelines*

### *Australian Rainfall and Runoff*

*Australian Rainfall and Runoff* (IEAust, 2016) is a document published by the Institution of Engineers, Australia. This document has been prepared to provide practitioners with the best available information on design flood estimation and is widely accepted as a design guideline for all flood and stormwater related investigation and design in Australia.

### *Erosion and Sediment Control Guidelines*

There are numerous guidelines which document best practice for erosion and sediment control. The following NSW government guidelines are typically referred to when developing Erosion and Sedimentation Control Plans for mines and quarries:

- *Managing Urban Stormwater: Soils and Construction- Volume 1 (Landcom, 2004*) – This guideline is often referred to as the 'Blue Book'.
- *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008).

Specifically, these guidelines detail calculation methodologies to size sedimentation basins.

### *Bunding and Spill Management Guidelines*

The following NSW Government guidelines detail best practice storage, handling and spill management procedures for liquid chemicals:

- *Liquid Chemical Storage, Handling and Spill Management: Review of Best Practice Regulation* (DECC, 2005).
- *Storing and Handling Liquids: Environmental Protection: Participant's Manual* (DECC, 2007).

### *Australian Guidelines for Water Quality Monitoring and Reporting – ANZECC, 2000*

These guidelines are the benchmark documents of the National Water Quality Management Strategy which is used for comparison of water quality monitoring data throughout Australia.

### *NSW Guidelines for Controlled Activities on Waterfront Land (NOW)*

This guideline reference refers to a series of guidelines that provide information on the design and construction of a controlled activity, and other ways to protect waterfront land.

# 3 EXISTING CONDITIONS

This section provides a description of the existing surface water environment in the vicinity of the quarry. The existing surface water management system is described separately in **Section 4**.

## 3.1 Climatic Data

This section reviews available climatic information and establishes representative climatic databases for the quarry site.

### 3.1.1 Rainfall Records

There are a number of Bureau of Meteorology (BoM) operated rainfall gauges that provide rainfall records in the vicinity of the quarry. Rainfall records from three local gauges were selected for analysis. These gauges are located in **Plate 3-1** and were selected as they are either located in close proximity to the quarry and / or have extended rainfall records. The quarry also operates a weather station. This weather station has a limited rainfall record which is not analysed in this section. However, recent data from this station has been used to inform water balance calibration and data analysis that are discussed in subsequent sections of this report.


**Figure 3** – *Local Rainfall Gauges*

**Table 3-1** presents key information and statistical data from the three gauges shown in **Figure 3**.

**Table 3-1** – *Rainfall Statistics from Local Gauges*

| Statistics | Kiama Bowling Club (68038) | Albion Park Post Office (68000) | Stockyard Mountain (68154) |
|---|---|---|---|
| Rainfall Record | 1897 to 2011 | 1892 to present | 1898 to 1919 |
| Distance from quarry | 8.5km to the South-East | 5km to the North-West | 1.5km to the South |
| Elevation (m AHD) | 10 | 8 | 90 |
| Average Rainfall (mm/year) | 1248 | 1103 | 1024 |
| Lowest Annual Rainfall (mm/year) | 602 | 469 | 563 |
| 5th Percentile Rainfall (mm/year) | 779 | 608 | 653 |
| 10th Percentile Rainfall (mm/year) | 834 | 656 | 669 |
| Median Rainfall (mm/year) | 1160 | 1064 | 939 |
| 90th Percentile Rainfall (mm/year) | 1740 | 1660 | 1306 |
| 95th Percentile Rainfall (mm/year) | 1916 | 1820 | 1639 |
| Highest Annual Rainfall (mm/year) | 2715 | 2604 | 1724 |

*Source: Bureau of Meteorology*

The three rainfall records presented in **Table 3-1** correlate well indicating that there is no substantial spatial variation in rainfall characteristics in the vicinity of the quarry. A representative long term daily rainfall time series was prepared using daily rainfall records from the Kiama Bowling Club (BoM:68038), Albion Park Post Office (BoM: 680000) and an additional local gauge. Preference was given to the data from the Kiama Bowling Club (BoM:68038) with data from the other gauges used to fill gaps in the BoM 68038 record. This rainfall time series was used for water balance modelling that is discussed in **Section 5**. Annual rainfall totals between 1900 and 2015 are shown in **Figure 4**.

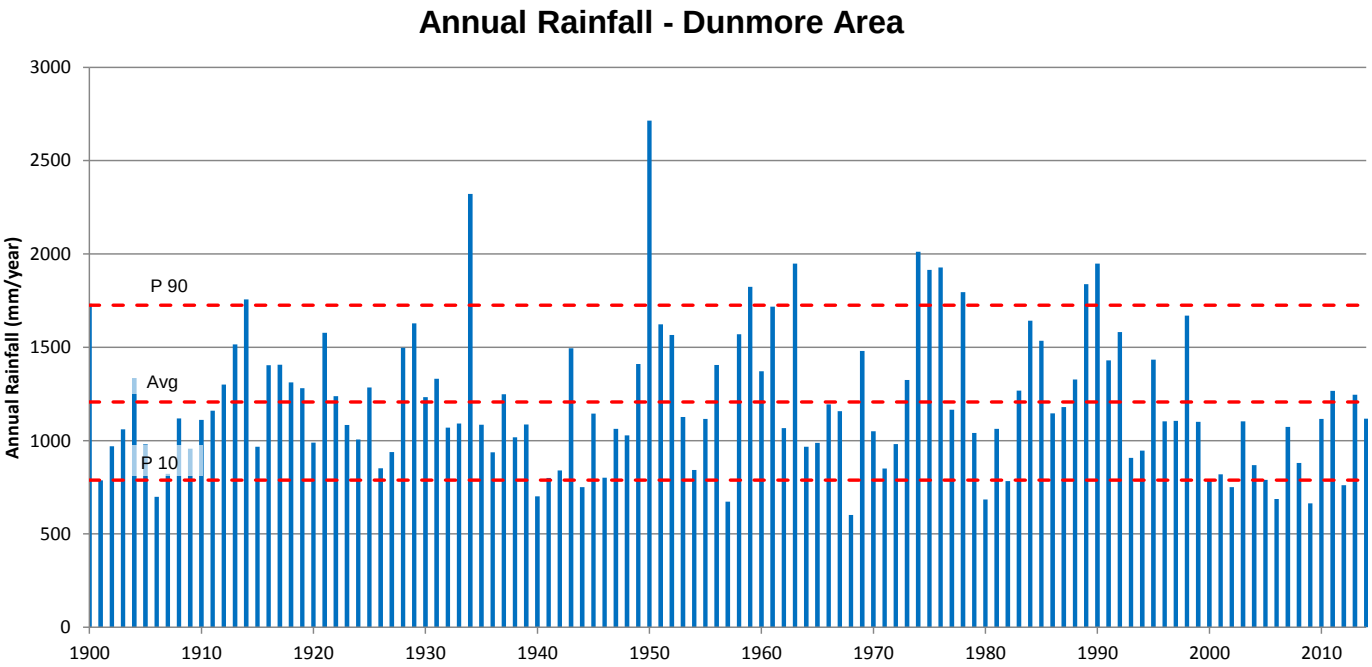


***Figure 4*** *– Annual rainfall totals for the Dunmore Area*

**Figure 5** plots the average and 10th and 90th Percentile monthly rainfall depths calculated from the Kiama Bowling Club (BoM:68038) record. The chart clearly demonstrates the high variability in monthly rainfall across all seasons.

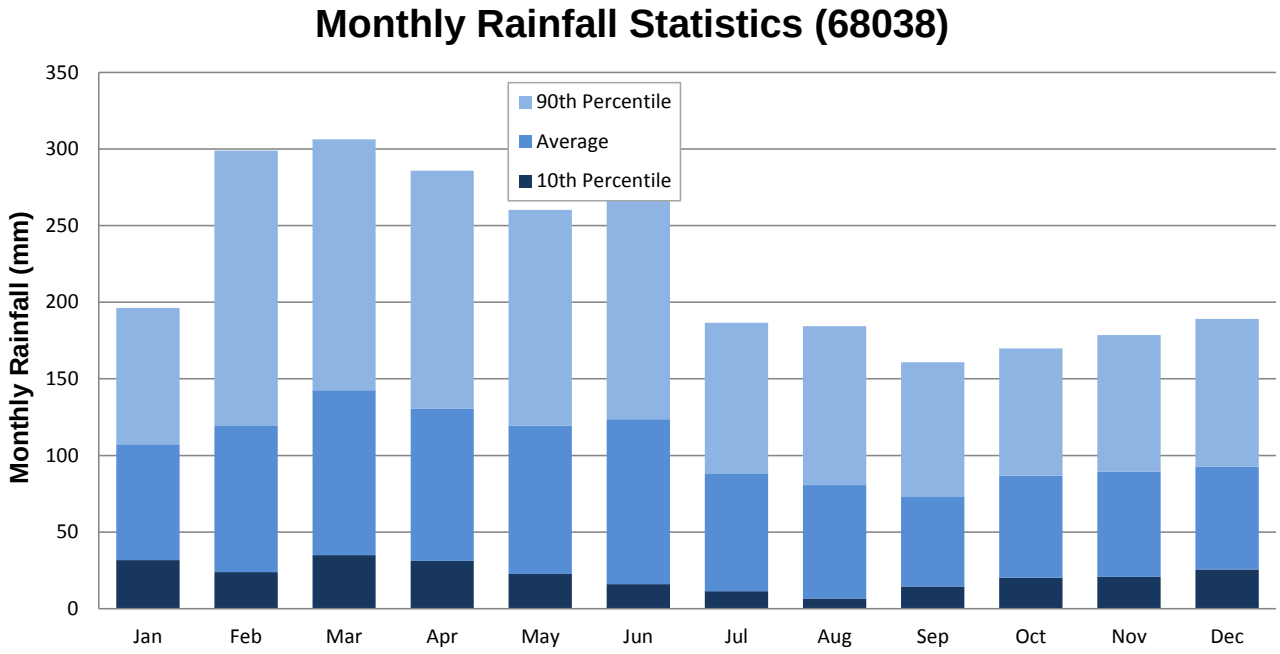


**Figure 5** – *Monthly rainfall statistics at Kiama Bowling Club (68038)*

### 3.1.2 Evaporation Data

**Table 3-2** presents the average monthly pan evaporation and Areal Potential Evaporation (PET) rates at the quarry. This information was extracted from the monthly climate maps provided by the BoM and indicates that the pan evaporation rate is approximately 50% higher than the average annual rainfall depth.

**Table 3-2** - *Average monthly evaporation and PET data*

| Month | Average Monthly Pan Evaporation | Average Areal Potential Evapotranspiration |
|---|---|---|
| | (mm/month) | (mm/month) |
| January | 196 | 170 |
| February | 160 | 129 |
| March | 143 | 117 |
| April | 111 | 76 |
| May | 82 | 50 |
| June | 72 | 37 |
| July | 78 | 38 |
| August | 110 | 55 |
| September | 133 | 76 |
| October | 167 | 119 |
| November | 177 | 145 |
| December | 207 | 155 |
| **Annual** | **1638** | **1159** |

*Source: Bureau of Meteorology*

## 3.2 Local Watercourses

The quarry is located centrally within the Rocklow Creek Catchment. Rocklow Creek has an estimated 21km$^2$ catchment area and generally flows in an easterly direction towards the ocean. Land uses within the catchment comprise a combination of native vegetation, cleared agricultural land and extractive industries. There are a number of quarries (including the quarry) and sand extraction operations located in the northern portion of the catchment.

The quarry is licensed to discharge surface water into Rocklow Creek at three locations, which are all located in the south-eastern portion of the quarry (refer to **Section 4** for further information on discharge locations). Downstream of the quarry, Rocklow Creek flows into an ephemeral waterbody and through low lying agricultural land before passing under the Princes Highway. Downstream of the Princes Highway the creek joins the Minnamurra Estuary, 1500m upstream of its outlet to the Pacific Ocean.

The western most portion of the Croome West Pit area is located within the upper extent of the Frazers Creek Catchment. Frazers Creek drains to the west towards the township of Albion Park, before flowing into the Macquarie Rivulet. The Macquarie Rivulet is a major tributary to Lake Illawarra.

**Figure 6** locates the abovementioned watercourses relative to the project area.

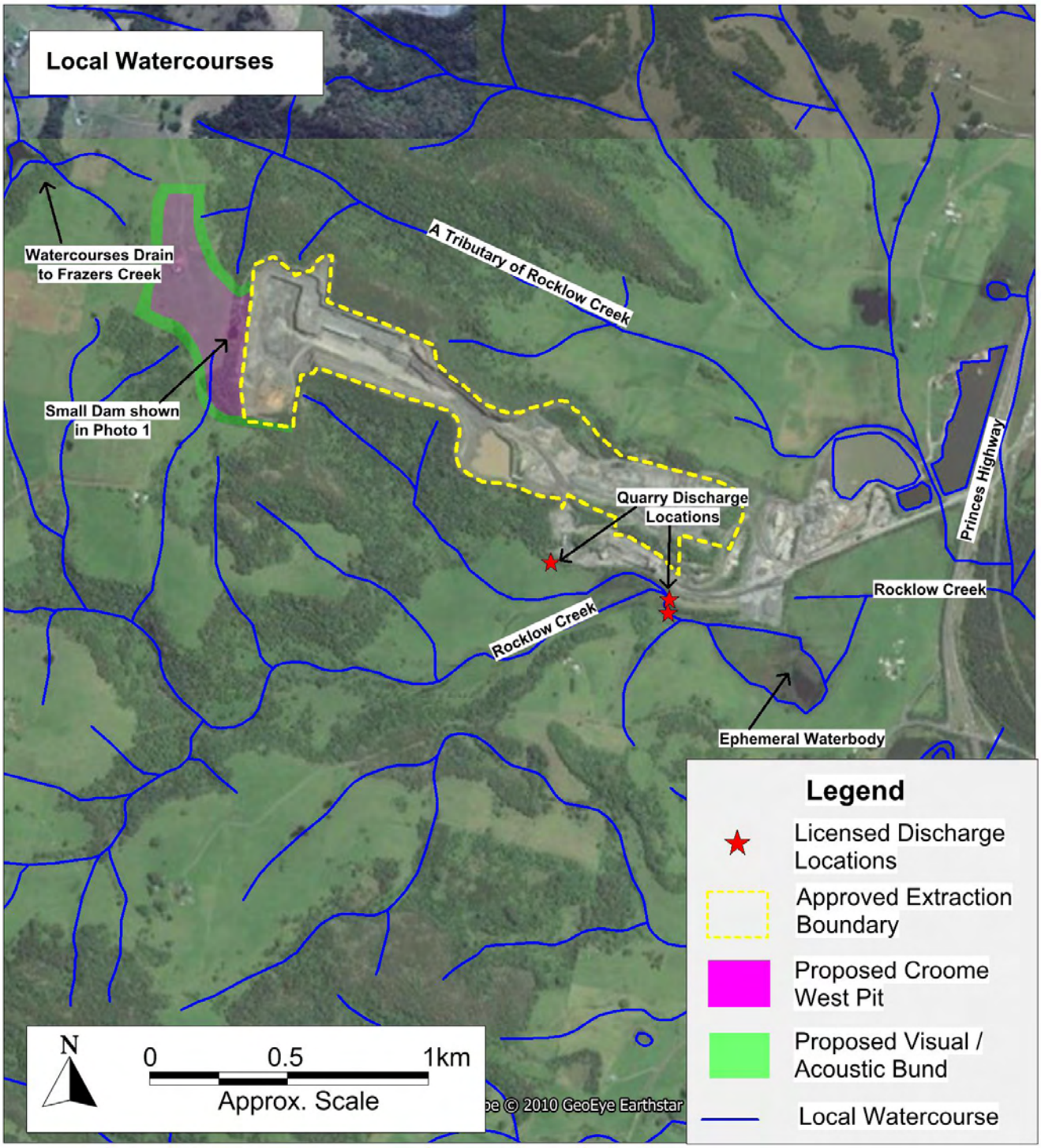


***Figure 6*** *– Local Watercourses*

Drainage within the proposed Croome West Pit area is characterised by a number of discrete ephemeral drainage lines that drain to the north, south and west (as indicated in **Figure 6**). There is a small dam located immediately to the west of the existing pit within the Croome West Pit area. This dam currently overflows into the pit. A photograph of the dam is shown as **Photo 1**.

**Photo 1** – *An existing dam located immediately to the west of the existing pit.*

## 3.3 Local Water Users

RHDHV contacted the DPI Water to request information on local licensed water users downstream of the quarry on either Rocklow or Frazer Creeks. DPI-Water advised that there is only one WAL (No. 25152), which is owned by Boral. WAL 25152 authorises a bywash dam and a 100 mm pump for mining purposes with a linked WAL of 227 ML/yr.

# 4 EXISTING WATER MANAGEMENT SYSTEM

This section describes the existing water management system and is structured as follows:

- **Section 4.1** introduces terminology used to describe the surface water management system.
- **Section 4.2** describes the existing surface water management system.
- **Section 4.3** presents and discusses water level monitoring data
- **Section 4.4** presents and discusses surface water characterisation data.
- **Section 4.5** provides information on local soil conditions.
- **Section 4.6** describes key departures from the water management system that is documented in the quarry's current WMP (Arcadis, 2016).

Proposed changes to the water management system are discussed separately in **Section 5**. Water balance results for existing and proposed conditions are also documented in **Section 5.**

## 4.1 Definitions

Surface water within the quarry has been differentiated into the following categories based on water quality and intended use:

- **Clean Water** – refers to surface water runoff from catchments that are undisturbed, relatively undisturbed or fully rehabilitated following disturbance. Clean water can be discharged from the site with no treatment.
- **Dirty Water** – refers to surface water runoff from the quarry's pit, haul roads, emplacement and product stockpiles and processing areas. Dirty water is likely to contain elevated suspended sediment levels and requires sedimentation treatment prior to release.
- **Process Water** - refers to water used by the quarry operation for haul road dust suppression and plant water use.
- **Breccia Spring Water** – refers to groundwater seepage from a permeable breccia rock layer that interfaces with the surface water management system.
- **Rocklow Creek Alluvium** (or sand aquifer) – refers to the Rocklow Creek alluvial aquifer that comprises a permeable sand medium. As with most alluvial groundwater systems, the groundwater is connected to the surface water in Rocklow Creek.
- **Wastewater –** refers to wastewater generated from the onsite amenities such as toilets and showers. Wastewater contains human waste and associated pathogens.

## 4.2 Existing Surface Water Management System

This section describes the existing water management system and should be read in conjunction with the following Figures:

- **Figure 7** diagrammatically describes the functionality of the water management system.
- **Figure 8** shows an overview of the existing water management system depicting catchment extents, the size and locations of water management dams and site discharge locations.
- **Figure 9** provides detailed information on the water management system in the eastern portion of the quarry.

The following sections provide further information on the catchment areas, water management dams, process water uses, water transfers and site discharge mechanisms.

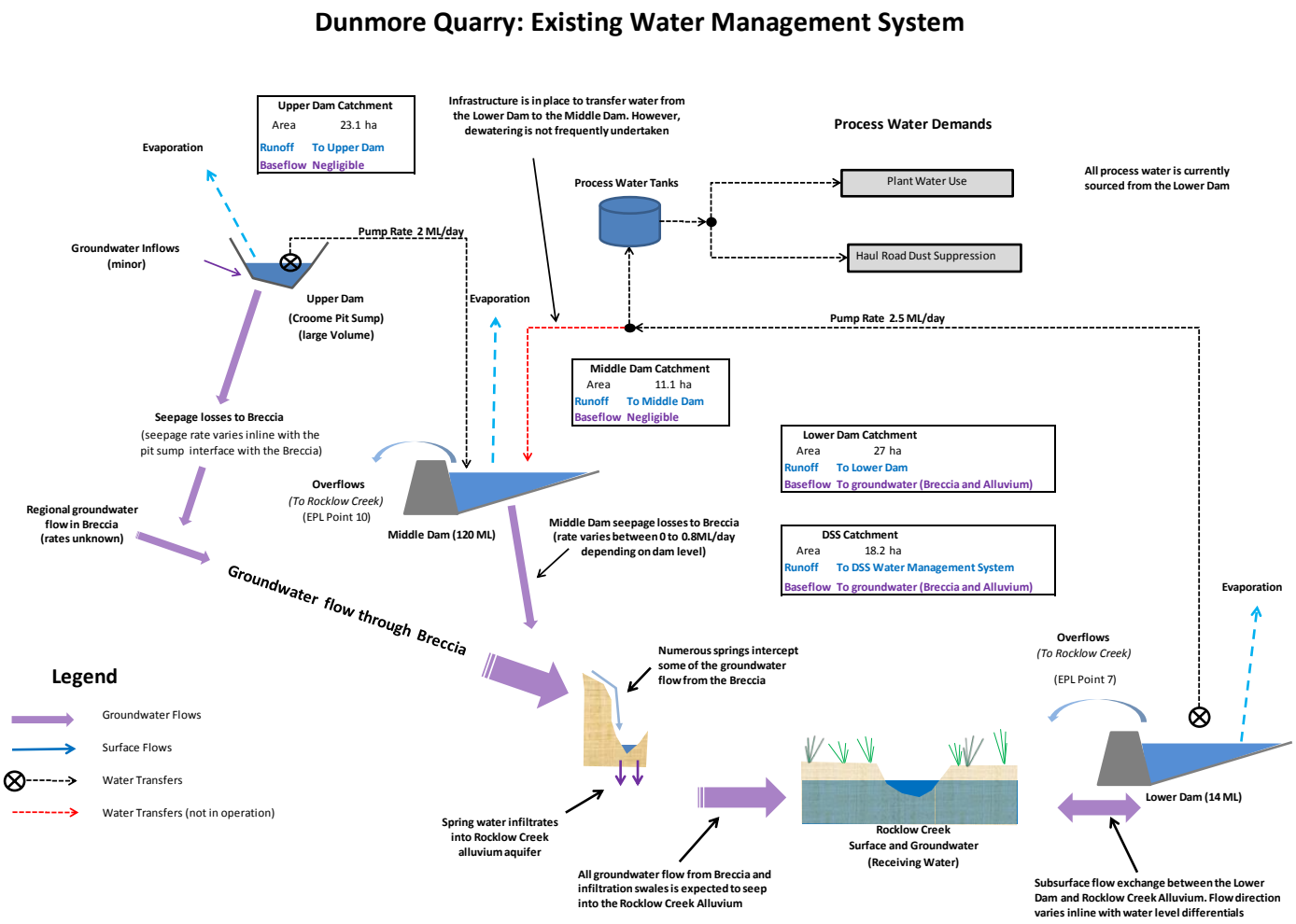


***Figure 7** – Existing Water Management System*

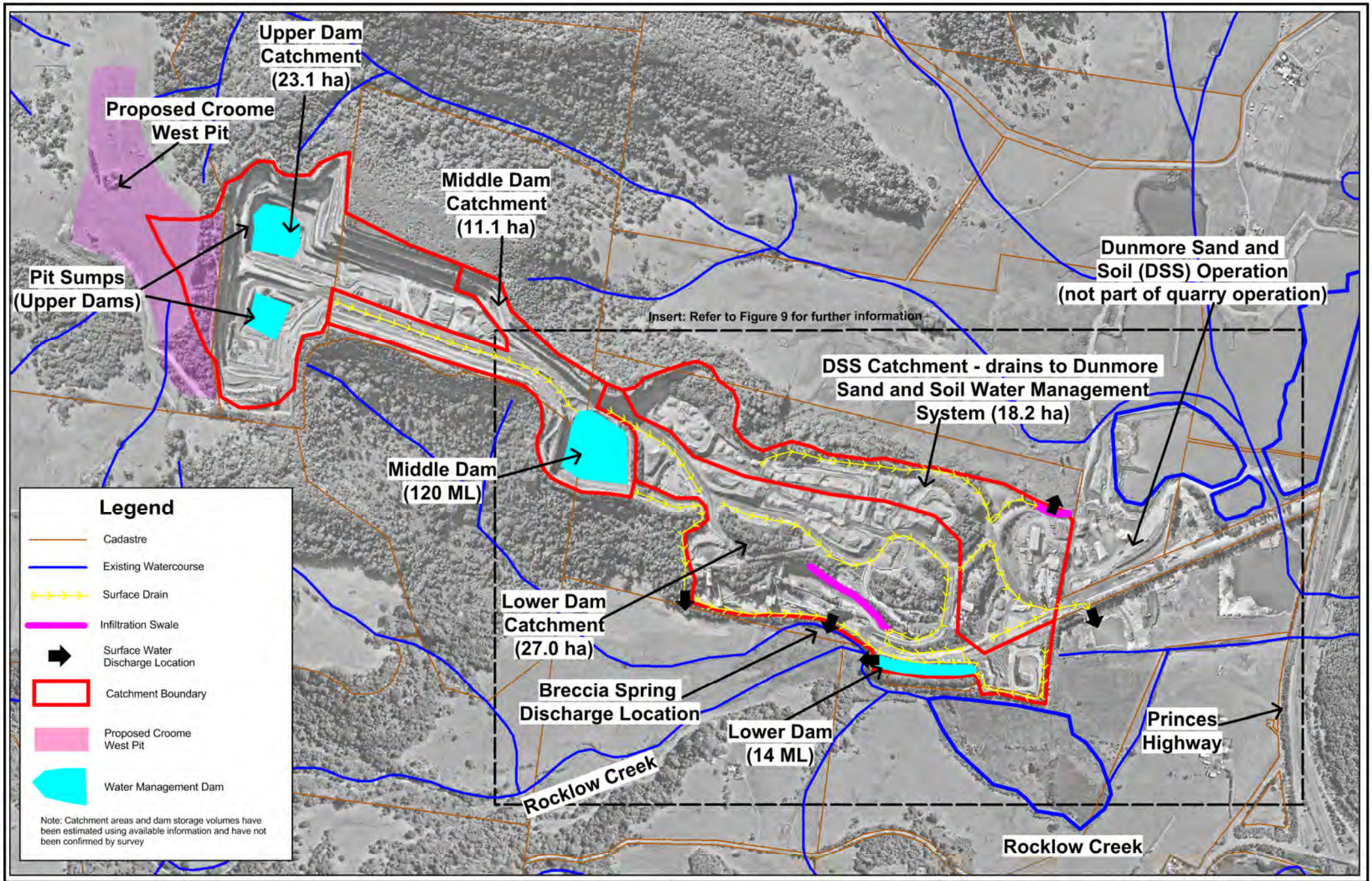


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**Figure 8** Surface Water Management Plan: Overview

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0 125 250m
Approx. Scale

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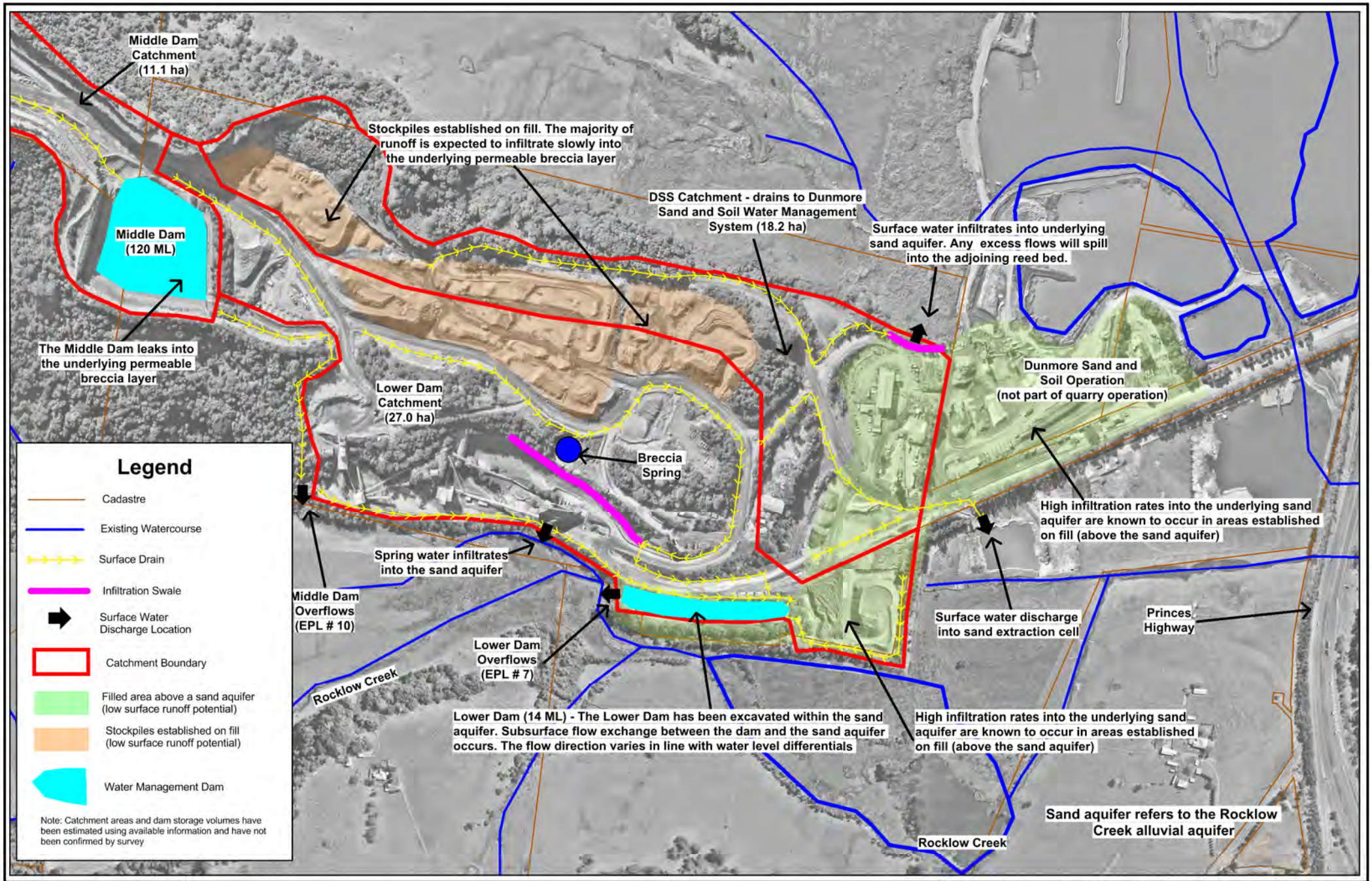


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**Figure 9** Surface Water Management System: Detailed View

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0 75 150m
Approx. Scale

NORTH

### 4.2.1 Geology Overview

Geology within the quarry is characterised by the three latite (an igneous hard rock) layers that are referred to as the Upper, Middle and Lower Lava Flows. Latite is the resource that is extracted by the quarry operation. Operations to date have only extracted the Upper and Middle Lava Flow resources. A layer of breccia (a permeable sedimentary rock) is located between the Middle and Lower Lava Flows. Accordingly, the majority of the historic extraction area has been quarried down to the top of this breccia layer. The breccia layer is understood to slope to the east and outcrops at numerous locations around the periphery of the historic extraction area. **Figure 10** shows a conceptual section of the existing Croome Farm and proposed Croome West Pits and explains the geological setting.

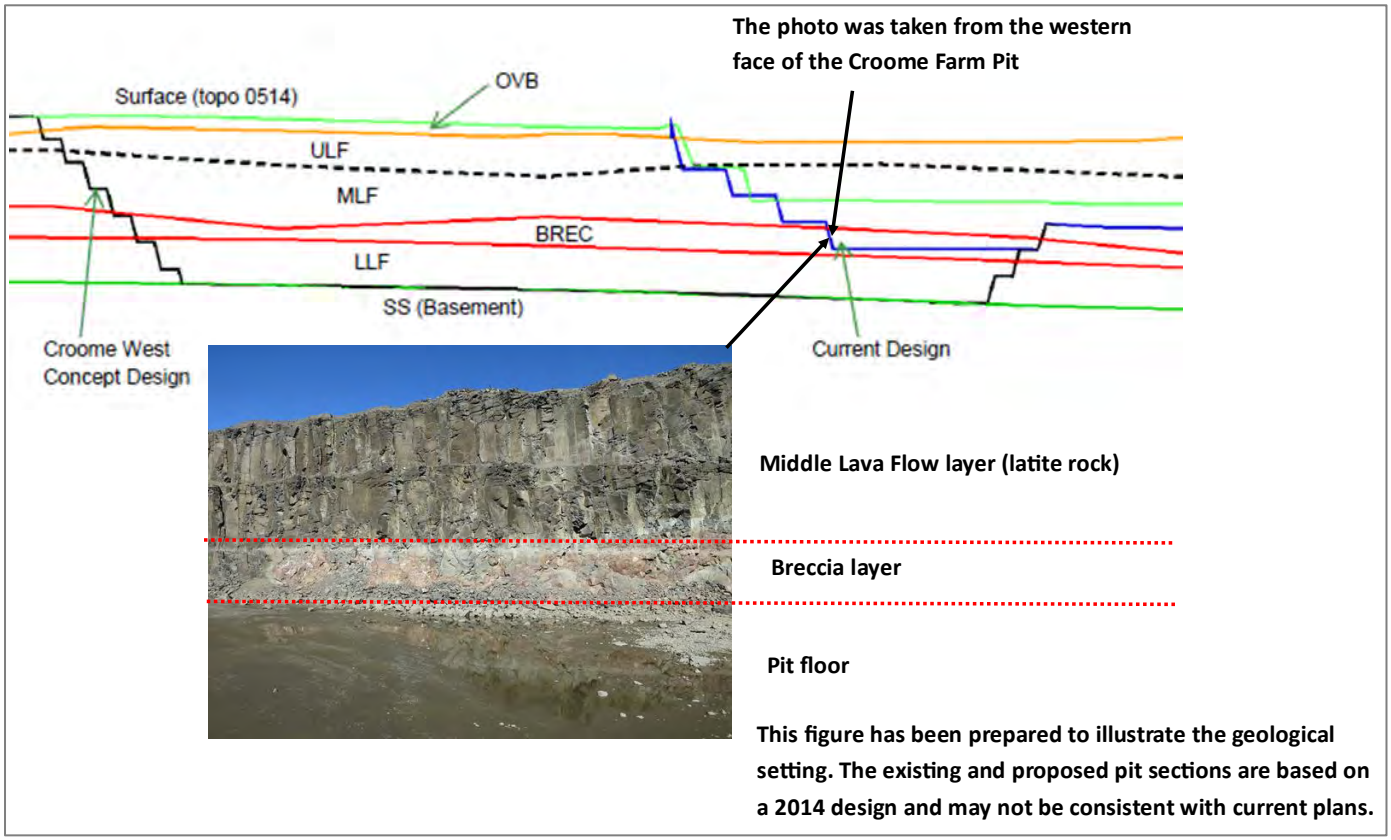


**Figure 10** – *Geology overview*

The breccia layer is interpreted to have significant connectivity with the quarry's surface water management system due to its permeability and positioning. In particular:

- The existing Croome Farm Pit has been quarried down to the top of the breccia (as shown in **Figure 10**). Accordingly, when the pit sump is holding substantial water, some lateral seepage into the breccia is expected to occur.
- The Middle Dam has been established on top of the breccia and is known to leak vertically into the underlying breccia at rates of up to 0.8 ML/day. This is discussed further in **Section 4.3**.
- Significant portions of the Lower Dam and DSS Catchment areas have been quarried down to the breccia. Base flow from these areas is expected to infiltrate directly into the underlying breccia, reducing the potential for surface water runoff.

As noted above, the breccia layer slopes to the east and outcrops at numerous locations around the periphery of the historic extraction area. Groundwater is interpreted to flow through the breccia on top of the low permeability Lower Lava Flow latite rock layer. Substantial seepage from the breccia layer occurs to the north of the material processing plant area where the breccia outcrops. The seepage currently concentrates into a small water fall that spills into an infiltration swale that is located to the north-east of the plant. Water from the swale is interpreted to infiltrate under the adjoining haul road (which is constructed on fill) into the Rocklow Creek Alluvium. No direct connection to the Lower Dam is expected. The water fall (which is also referred to as the Breccia Spring) and swale locations are indicated in **Figure 9**. **Photos 2** and **3** show the water fall and the infiltration swale.

**Photo 2** *on the left shows the Breccia Spring waterfall (looking north) and* **Photo 3** *on the right shows the infiltration swale (looking east)*

### 4.2.2 Catchment Areas

There are four defined catchments within the quarry's water management area. **Figure 8** shows the extent of each catchment and the location of key surface drains. **Table 4-1** provides a summary of the key characteristics of each catchment. The annual runoff coefficient (Cv) for each catchment that was adopted for water balance modelling (discussed in **Section 5**) is also provided for context.

**Table 4-1** – *Existing Catchment Characteristics*

| Name | Area | Land-use | Annual Runoff Coefficient (Cv) |
|---|---|---|---|
| Upper Dam Catchment | 23.1 ha | Comprises rock extraction and in pit processing areas, pit sumps, haul roads and stockpiles. There is a 3 ha clean water catchment located to the west of the pit that contributes runoff to the pit. | **0.49** |
| Middle Dam Catchment | 11.1 ha | Comprises remnant quarry workings and haul roads. | **0.67** |
| Lower Dam Catchment | 27.0 ha | The Lower Dam Catchment includes:<br>• 5.7 ha of haul roads which are expected to have a high runoff potential.<br>• 21.3 ha of stockpiles and vegetated areas that primarily sit on top of the breccia layer and are expected to have a low runoff potential. | **0.44** |
| DSS Catchment | 18.2 ha | Comprises numerous haul roads, site administration and work shop areas and numerous stockpile and vegetated areas. The DSS Catchment is expected to have similar hydrological characteristics to the Lower Dam Catchment | **0.44** |

### 4.2.3 Water Management Dams

The water management system includes three water management dams and a bioretetion swale. The location of the three dams is indicated in **Figure 8**. **Table 4-2** provides a summary of the key characteristics of each control.

***Table 4-2*** – *Existing Water Management Dams*

| Storage | Function | Volume[1] | Overflows to |
|---|---|---|---|
| Lower Dam | Stores and treats runoff from the Lower Dam Catchment. Process water is currently extracted from the Lower Dam. | 14 ML | Rocklow Creek (EPL Point 7) |
| Middle Dam | Stores and treats runoff from the Middle Dam Catchment and receives water pumped from the Upper Dam. As noted in **Section 4.2.1**, the Middle Dam leaks into the underlying breccia layer at rates of up to 0.8 ML/day. | 120 ML plus 30 ML for sediment storage. | Rocklow Creek (EPL Point 10) |
| Upper Dam | The Upper Dam is a pit sump that receives runoff from the Upper Dam Catchment. | Very large (greater than 500 ML), but dewatered following rainfall. | Middle Dam (but unlikely to ever overflow due to the large dam volume) |
| Biorention Swale | This control is not currently used but it was intended to be a controlled discharge arrangement that would treat water pumped from the Lower Dam. | Designed to treat up to 7ML/day of water pumped from the Lower Dam | Rocklow Creek (EPL Point 6) |

**Note 1**: Dam volumes have been estimated by RHDHV from LiDAR survey and site observations. No detailed survey has been undertaken.

Photographs of the Lower Dam, Middle Dam and Croome Farm Pit Sump (Upper Dam) are shown in **Photos 4**, **5** and **6** respectively.

**Photo 4** – *shows the Lower Dam (looking west)*

**Photo 5** – *shows the Middle Dam (looking east)*

**Photo 6** – *shows the southern portion of the Croome Farm Pit (looking east)*

### 4.2.4 Process Water Uses

The quarry operation uses process water for:

- Haul road dust suppression; and
- Dust suppression within the processing plant.

**Table 4-3** provides details for each of the above process water uses. Estimated annual water use volumes established from water balance modelling (discussed in **Section 5**) are also provided for context.

**Table 4-3** – *Process Water Use Profiles*

| Process Water Use | Description | Annual Water Use[1] |
|---|---|---|
| Haul road dust suppression | The site operates a 50KL water cart 5 ½ days per week. Typical daily use rates during dry conditions are:<br>• 1.6 ML 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 75 KL/day. | Constant at 27 ML/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 Sundays.

The operation has not historically experienced water shortages due to the Lower Dam's connectivity with the Rocklow Creek Alluvium.

### 4.2.5 Site Discharge Locations

**Figures 7, 8** and **9** identify six discharge locations / mechanisms from the quarry's water management system. **Table 4-4** describes the key characteristics of each discharge location.

**Table 4-4** – *Surface Water Discharge Locations*

| Location | Mechanism | Description | EPL Point |
|---|---|---|---|
| Overflows from the Lower Dam Spillway | Dam Overflows | Overflows occur to Rocklow Creek when the dam water level exceeds the spillway crest level. | EPL Point 7 |
| Overflows from the Middle Dam Spillway | Dam Overflows | Overflows occur to Rocklow Creek when the dam water level exceeds the spillway crest level. Boral has advised that the Middle Dam has never spilled. | EPL Point 10 |
| Discharge from the Bioretention Swale | Controlled Discharge | The bioretention swale was intended to treat and release water pumped from the Lower Dam. The bioretetion system has not been used and is not considered to be part of the quarry's water management system. | EPL Point 6 |
| Breccia Spring | Groundwater seepage | As discussed in **Section 4.2.1**, groundwater flows from the breccia layer infiltrate into the Rocklow Creek Alluvium via an infiltration swale that is located to the east of the processing plant. | Not licensed |
| Seepage from the Lower Dam | Seepage through dam embankment and floor | Some seepage from the Lower Dam into the adjoining Rocklow Creek Alluvium is expected to occur when the dam level is higher than the adjoining aquifer level. | Not licensed |
| DSS Water Management System | Runoff into the adjoining DSS Water Management Area | Runoff from the DSS Catchment enters the DSS water management system. | Not licensed |

### 4.2.6 Operating Principles

Historically, the water management system has been operated using the following principles:

1) Process water is extracted from the Lower Dam via pumping. Historically, the Lower Dam has been replenished by groundwater ingress from the Rocklow Creek Alluvium.
2) The Middle and Upper Dams capture runoff from their respective catchment areas. The Upper Dam is dewatered to the Middle Dam on an as needed basis.
3) Accumulated water in the Middle Dam is allowed to seep into the underlying breccia. Boral has advised that no water has ever been pumped out of or spilled from the Middle Dam, demonstrating that this has been an effective method for managing runoff volumes from the Middle and Upper Dam Catchments.

## 4.3 Water Level Data

Boral engaged Environmental Earth Services to install continuous water level loggers in the Middle and Lower Dams and in Rocklow Creek upstream from the Lower Dam Spillway. It is noted that the Rocklow Creek logger was installed in a groundwater monitoring bore and effectively measures Rocklow Creek groundwater and surface water levels. The loggers were programmed to record water pressure on an hourly basis. Environmental Earth Services calculated water levels (in m AHD) from the water pressure data. The location of the loggers is shown in **Figure 11**.

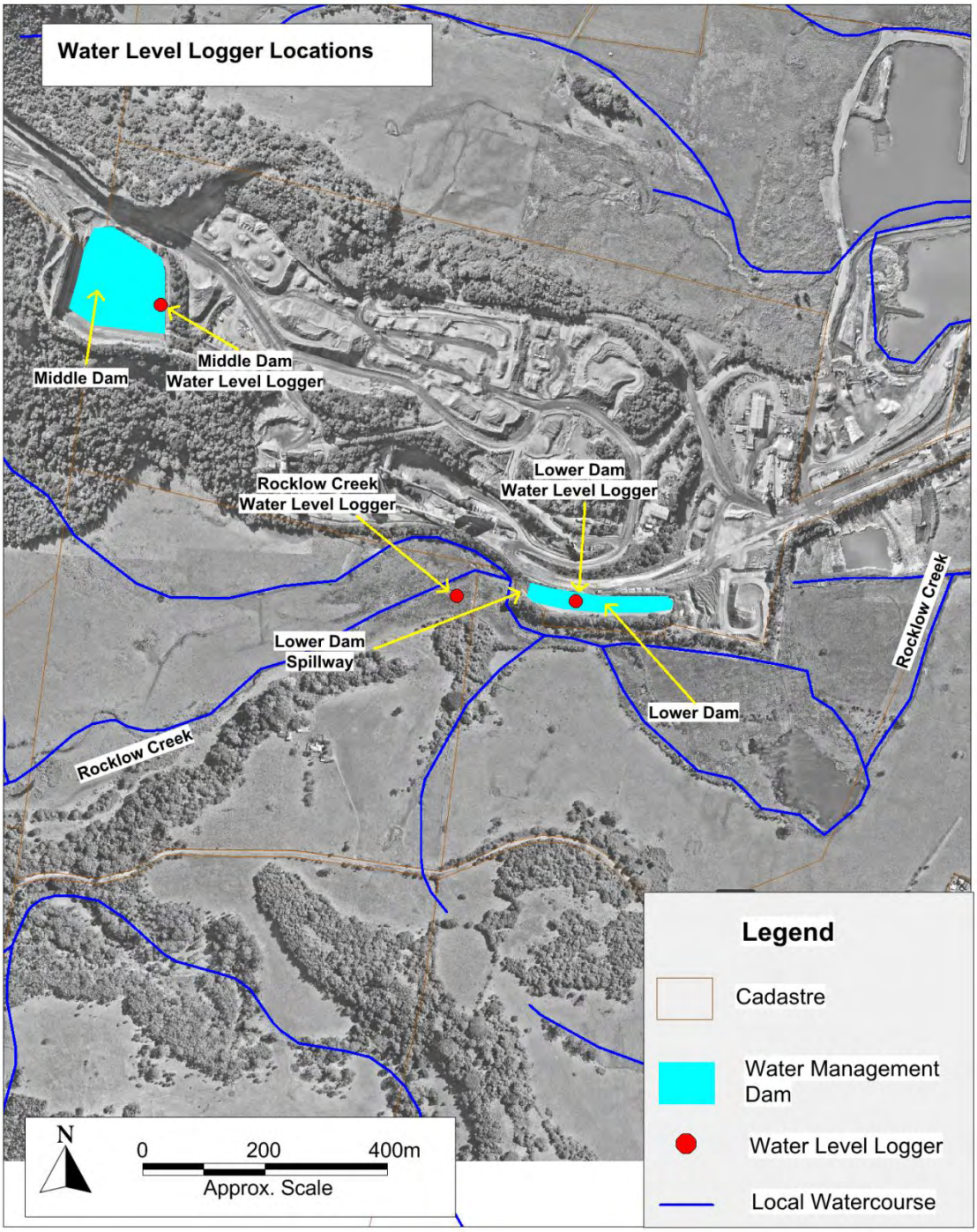


***Figure 11*** *– Level Logger Location*

The loggers were installed on 17 November 2016 and data was retrieved on 10 Mary 2017 (a 174 day period). The November to early February portion of the period was characterised by unusually hot conditions, with below average rainfall. A significant amount of rainfall occurred in late February and throughout March, with 654mm recorded at the quarry's weather station over a 42 day period. More than half of the rainfall over this period occurred during the following two major rainfall events:

- 7 February 2017 event comprised 173 mm over a 24 hour period. 132 mm of this rainfall occurred over a 2 hour period, which is similar to the 100 year Average Recurrence Interval (ARI) rainfall intensity for a 2 hour duration rainfall event (AR&R, 2016).
- 16 March 2017 event comprised 190 mm over a 24 hour period. 117 mm of this rainfall occurred over a 2 hour period, which is similar to the 50 year ARI rainfall intensity for a 2 hour duration rainfall event (AR&R, 2016). This rainfall event produced a significant flood in Rocklow Creek.

**Figure 12** plots the daily rainfall and evaporation rates that were recorded at the quarry's weather station over the period.

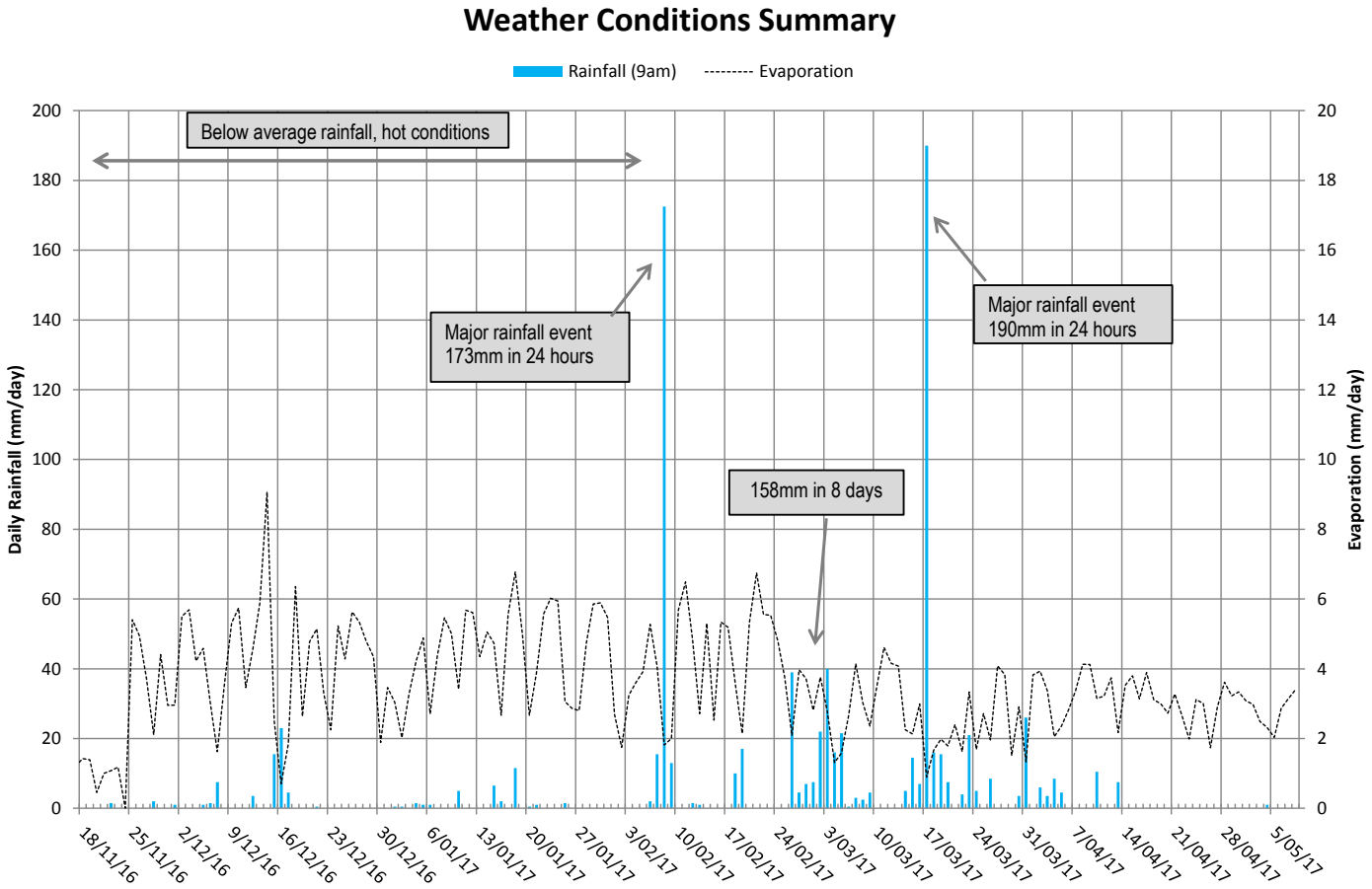


**Figure 12** – *Weather Conditions Summary*

Data from the water level loggers has been used to improve the general understanding of the functionality of the water management system and to provide specific information on:

- The extent and nature of connectivity between the Lower Dam and Rocklow Creek Alluvium.
- The extent and nature of flood water ingress from Rocklow Creek into the Lower Dam.

- Seepage rates from the Middle Dam.
- Runoff volumes into the Lower and Middle Dams.

The water level data is presented in the following summary charts:

- **Figure 13** compares the Lower Dam and Rocklow Creek level data over the period.
- **Figure 14** compares the Lower Dam and Rocklow Creek level data during the 7 February 2017 event.
- **Figure 15** compares the Lower Dam and Rocklow Creek level data during the 16 March 2017 event.
- **Figure 16** shows the Middle Dam data over the period.

The water level data is discussed below the charts.

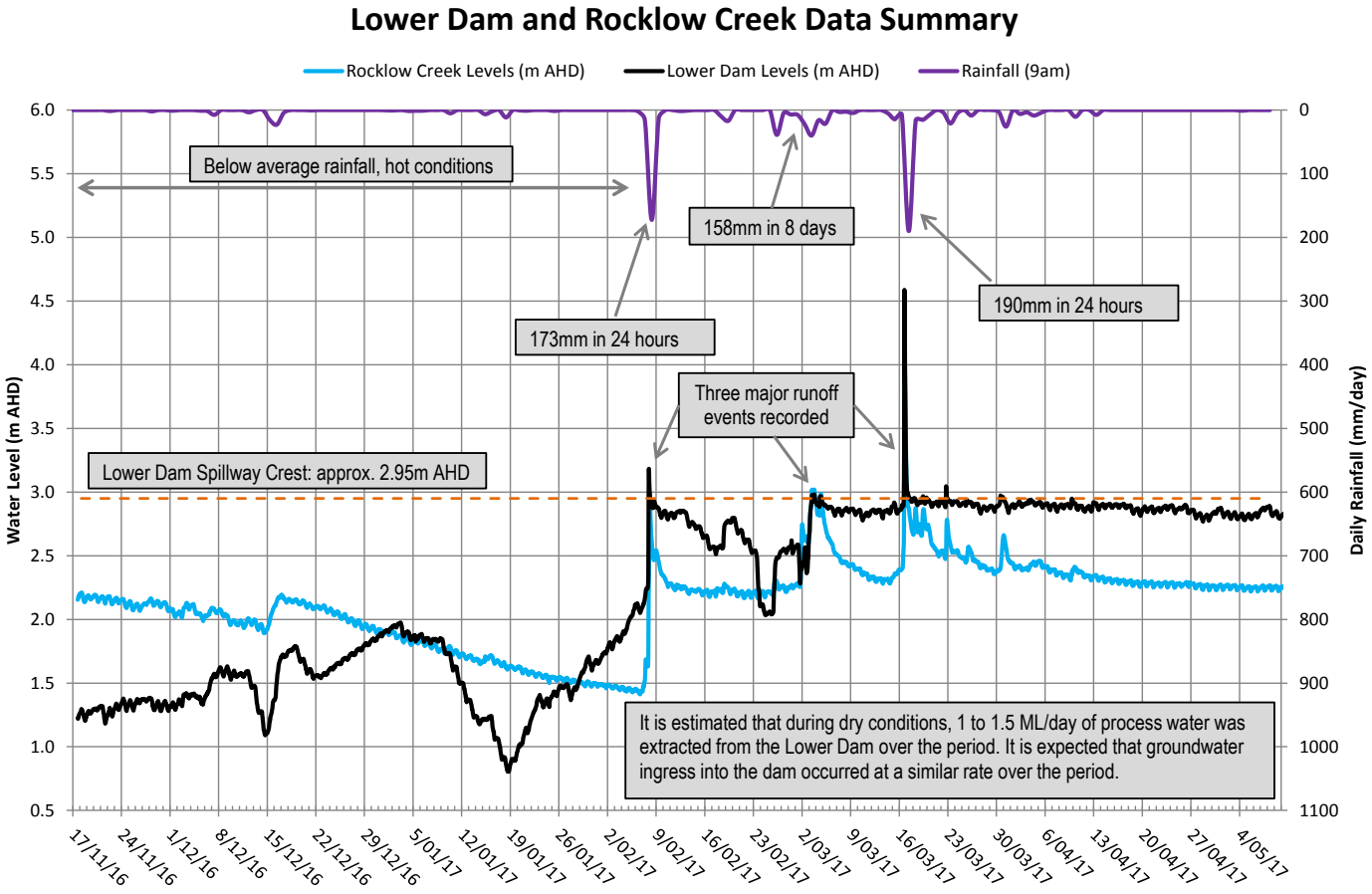


**Figure 13** – *Water Level Data: Lower Dam and Rocklow Creek (Summary Chart)*

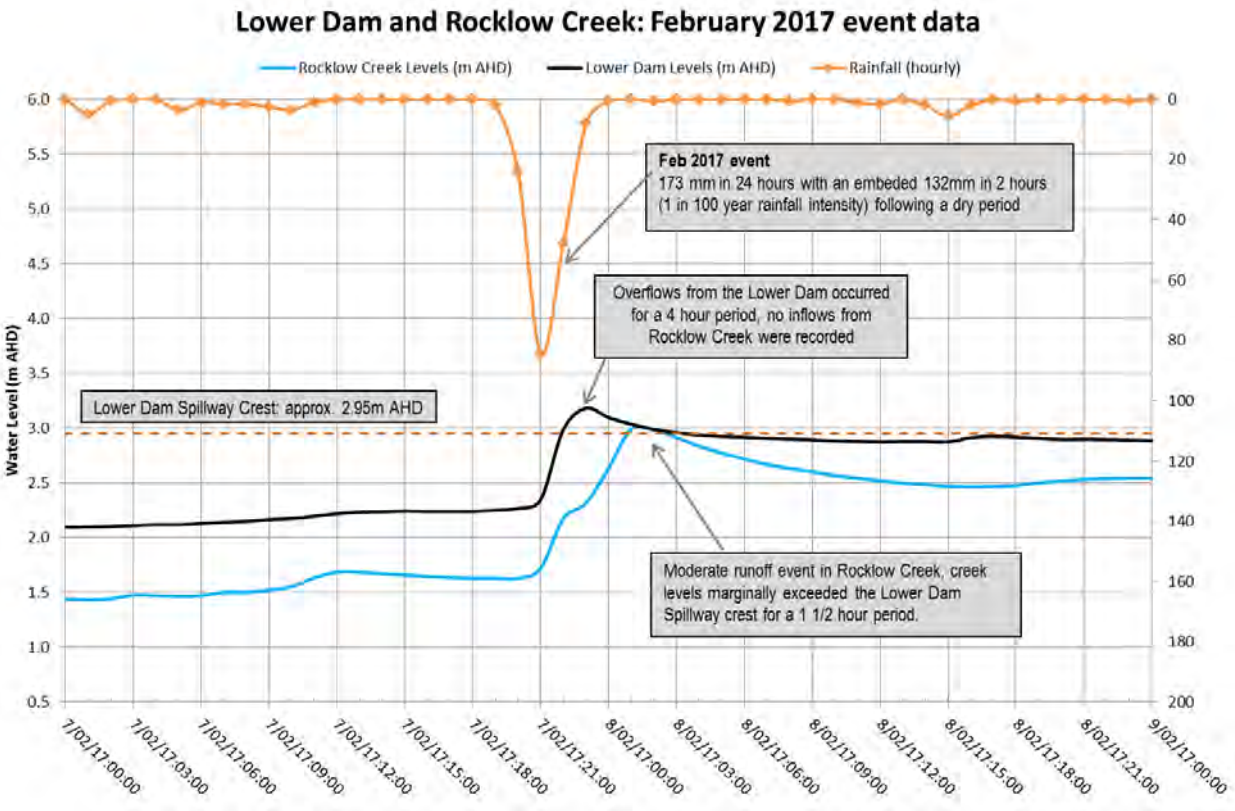


**Figure 14** – *Water Level Data: Lower Dam and Rocklow Creek (7 February 2017 Event)*

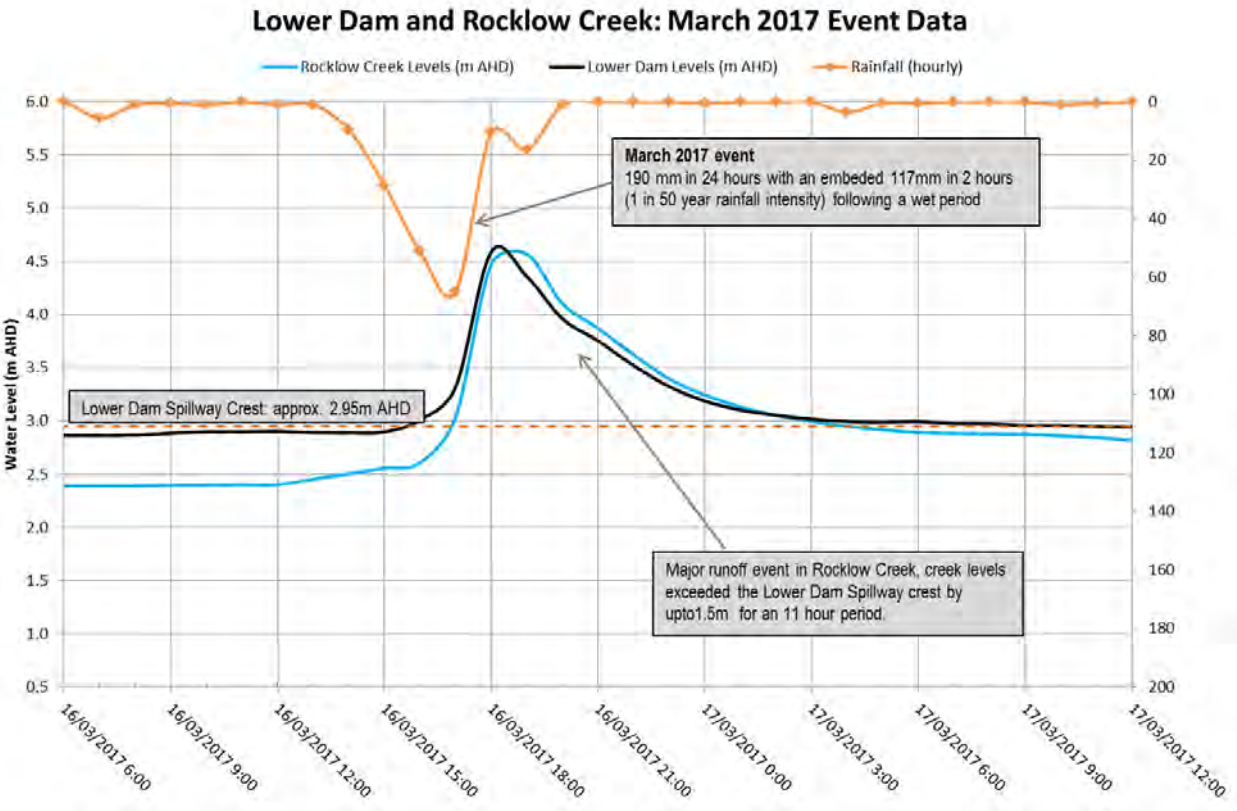


**Figure 15** – *Water Level Data: Lower Dam and Rocklow Creek (16 March 2017 Event)*

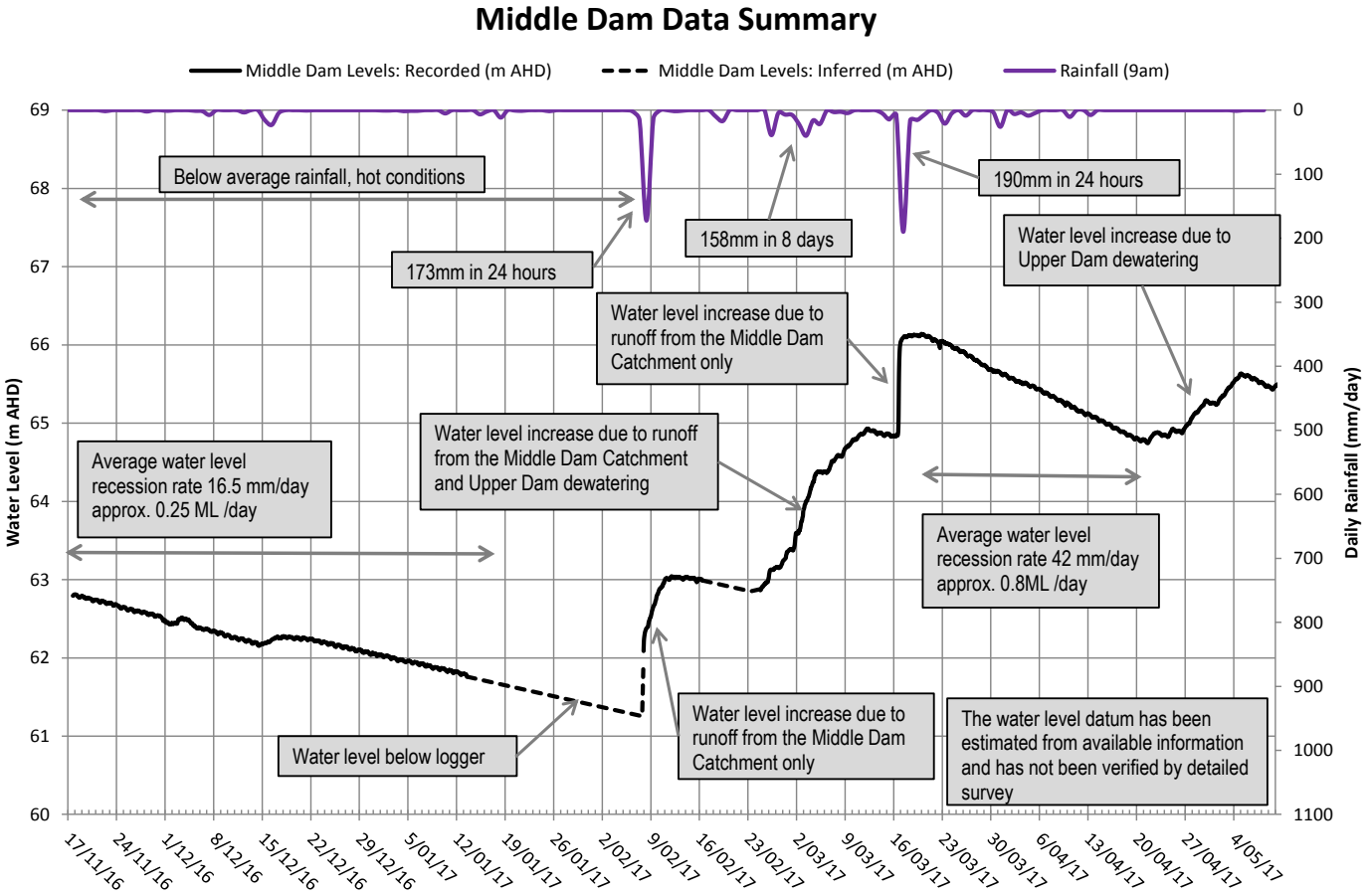


**Figure 16** – *Water Level Data: Middle Dam*

## *Lower Dam and Rocklow Creek Data Review*

The following trends can be established from the Rocklow Creek and Lower Dam water level data:

- With reference to **Figure 13** the Lower Dam and Rocklow Creek levels show a strong correlation during dry and wet conditions. Considering that 1 to 1.5 ML/day of process water was extracted from the Lower Dam during the dry portions of the period, it can be concluded that similar rates of groundwater ingress into the dam occurred.

- Comparison of Lower Dam and Rocklow Creek levels indicates that the potential to dewater the Lower Dam to the Middle Dam to improve the Lower Dam's sedimentation treatment function is limited by the connectivity to the Rocklow Creek groundwater system. It is expected that the potential for dewatering would be limited to a Lower Dam level of 2m AHD or the adjoining Rocklow Creek level, whichever is greater. Any additional dewatering beyond this threshold is likely to result in additional groundwater ingress from the Rocklow Creek alluvium replenishing the dewatered volume. This would effectively add volume to the quarry's water management system and would be counterproductive.

- Rocklow Creek levels exceeded the Lower Dam spillway crest level for short periods of time on three occasions over the period. It is expected that the elevated Rocklow Creek levels would have resulted in some mixing of Rocklow Creek and Lower Dam waters within the Lower Dam. Some of the combined waters would have flowed out of the Lower Dam back into Rocklow Creek on the falling limb of the Rocklow Creek hydrograph. With reference to **Figure 15** the data from the 16 March 2017 event recorded a significant

flood in Rocklow Creek with floodwaters exceeding the Lower Dam spillway crest by more than 1.5 m. The recurrence interval of this event has not been calculated. However, it is expected to have been at least a 20 year ARI event.

### *Middle Dam Data Review*

The following trends can be established from the Middle Dam water level data that is presented in **Figure 16**:

- There were two clear periods of water level recession. The first period occurred from mid-November 2016 to mid–January 2017 and comprised an average recession rate of 16.5 mm/day. Following adjustment for evaporation losses, a seepage loss rate of 0.25 ML/day was calculated for this period as a function of the estimated level / surface area characteristics of the dam. The second recession period occurred in April 2017, following significant rainfall in March. A seepage loss rate of 0.8 ML/day was calculated for this period, demonstrating that the dam seepage rate into the underlying breccia rock increases with dam water level.

- The water level data includes well defined water level responses to the significant runoff events that occurred in late February and March 2017. Periods of inflows from Upper Dam dewatering were also captured. This information was used to calibrate rainfall runoff models for the Middle and Upper Dam Catchments.

## 4.4 Surface Water Quality Characterisation

A Surface Water Characterisation Assessment (SWCA) has been undertaken using water quality data from the following monitoring programs:

- **WMP Monitoring** – comprises water quality data from the quarry's ongoing water quality monitoring program that is undertaken in accordance with the WMP.

- **SWCA Monitoring** – comprises additional water quality data that has been collected to inform a SWCA.

This section presents and discusses both data sets and should be read in conjunction with **Figure 17** which shows sampling locations for both programs.

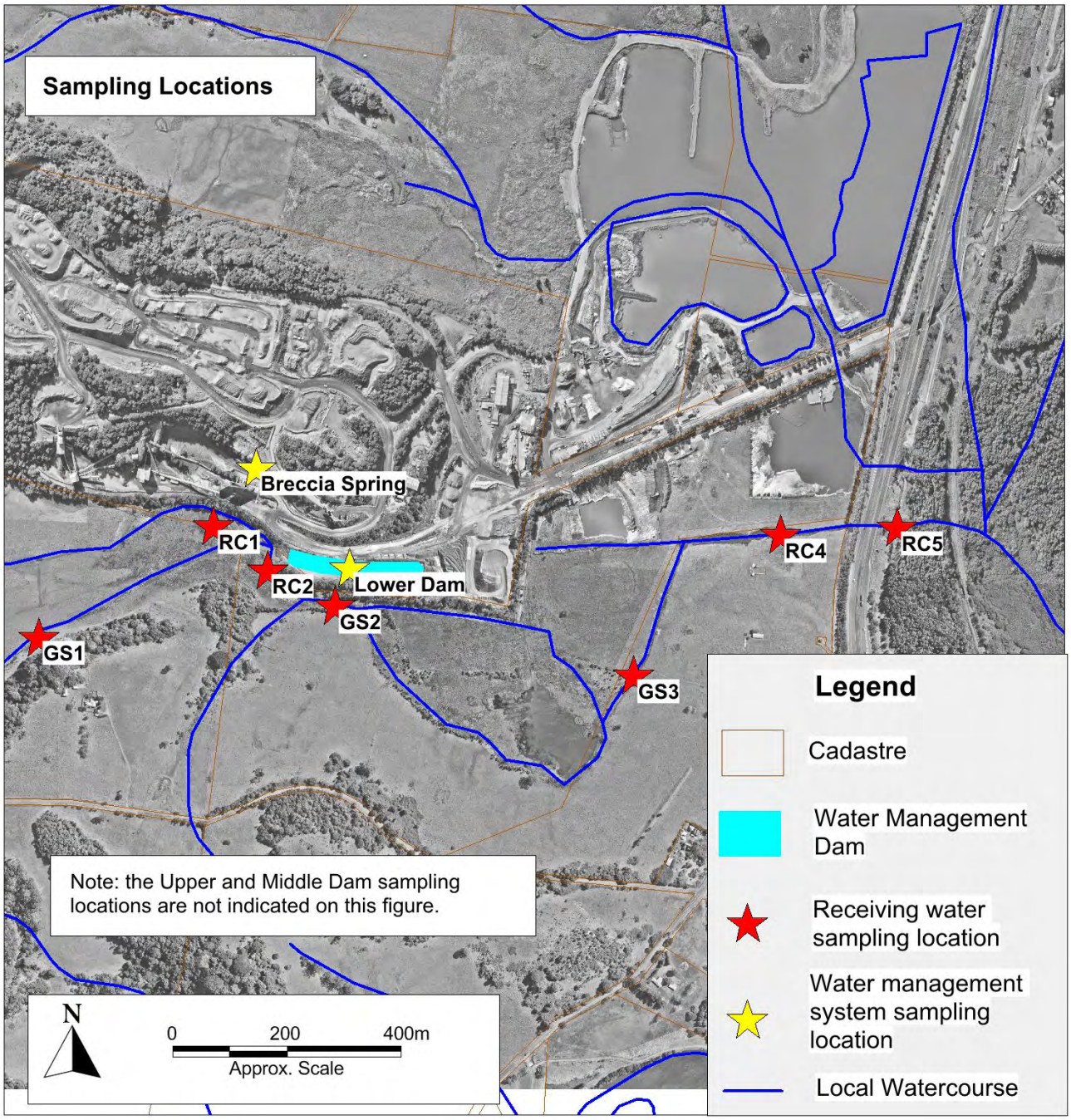


**Figure 17** – *Water Quality Sampling Locations*

### 4.4.1 WMP Monitoring Data

Boral has been monitoring water quality for a number of years in accordance with the quarry's WMP and EPL conditions. The monitoring program includes sampling from the Lower Dam and Rocklow Creek on a monthly basis and from all EPL points on a daily basis during discharge. **Table 4-5** provides an overview of the monitoring program

**Table 4-5** – WMP *Surface Water Monitoring Program Overview*

| EPL Point | Description | EPL Discharge Conditions | EPL Monitoring Conditions | | |
|---|---|---|---|---|---|
| | | | Parameters | Monitoring Frequency | Sampling Method |
| 6 | Discharge from the Biofiltration Swale to Rocklow Creek. | TSS concentration less than 50 mg/l | Conductivity | Daily during discharge | In situ |
| | | | Flow | Continuous | Gauging |
| | | | Oil and Grease | Daily during discharge | Visual Inspection |
| | | | pH | Daily during discharge | In situ |
| | | | TSS | Daily during discharge | Grab Sample |
| | | | Turbidity | Daily during discharge | In situ |
| | | | Comprehensive[2] | Every 6 months | Laboratory |
| 7 | Uncontrolled discharge from the Lower Dam Spillway. | Nil | Conductivity | Daily during discharge | In situ |
| | | | Oil and Grease | Daily during discharge | Visual Inspection |
| | | | pH | Daily during discharge | In situ |
| | | | TSS | Daily during discharge | Grab Sample |
| | | | Turbidity | Daily during discharge | In situ |
| 8 | Lower Dam Monitoirng | Nil | Conductivity | Monthly | In situ |
| | | | Oil and Grease | Monthly | Visual Inspection |
| | | | pH | Monthly | In situ |
| | | | TSS | Monthly | Grab Sample |
| | | | Turbidity | Monthly | In situ |
| | | | Comprehensive[2] | Every 6 months | Laboratory |
| 9[1] | Rocklow Creek receiving water locations (GS1, GS2 and GS3) | Nil | Conductivity | Monthly | In situ |
| | | | Oil and Grease | Monthly | Visual Inspection |
| | | | pH | Monthly | In situ |
| | | | TSS | Monthly | Grab Sample |
| | | | Turbidity | Monthly | In situ |
| | | | Comprehensive[2] | Every 6 months | Laboratory |
| 10 | Overflows from the Middle Dam Spillway. | Nil | Conductivity | Daily during discharge | In situ |
| | | | Oil and Grease | Daily during discharge | Visual Inspection |
| | | | pH | Daily during discharge | In situ |
| | | | TSS | Daily during discharge | Grab Sample |
| | | | Turbidity | Daily during discharge | In situ |

**Note 1**: EPL 77 does not specify any monitoring requirements for EPL Point 9. Monitoring conditions for this point are based on Boral's existing monitoring program.

**Note 2**: Comprehensive analysis refers to monitoring of the following analytes: TDS, TN, TP As, Cd, Ni, Pb and Zn.

**Table 4-6** (overleaf) presents a statistical summary of the water quality results. Results are compared to relevant trigger values from the ANZECC (2000) Guidelines and relevant EPL and consent conditions. All monitoring data is presented in table form in **Appendix A**. It is noted that:

- No data has been provided by Boral for discharge from the Biofiltration Swale (EPL Point 6) or discharge from the Middle Dam Spillway (EPL Point 10). Boral has advised that this is due to no discharges occurring from these EPL points during the monitoring period.
- Consent Condition 29 only applies to site discharge. Hence, this condition is not applicable to results from within the Lower Dam or receiving water locations.
- Results from the bi-annual comprehensive sampling within the Lower Dam and receiving water locations (GS1, GS2 and GS3) are not included in this report as:
  - Organic Nitrogen (i.e. Nitrogen as TKN) has been monitored instead of Total Nitrogen. Accordingly, the nitrogen results are of limited relevance; and
  - Laboratory analysis of the metals (As, Cd, Ni, Pb and Zn) has been undertaken for total metal concentrations (rather than dissolved) using a limit of reporting that is an order of magnitude higher than most trigger levels. Accordingly, the metal results are of limited relevance

All results are discussed in **Section 4.5.1**.

**Table 4-6** – WMP *Surface Water Monitoring Results Summary*

| | | | | Lower Dam | | Receiving Water | |
|---|---|---|---|---|---|---|---|
| **Analyte** | **Relevant Trigger Value** | **Relevant Consent Condition** | **Statistic[3]** | **Within Dam** | **Dam Overflow (EPL #7)** | **Upstream of Lower Dam** | **Downstream of Lower Dam** |
| **Field Measurements** | | | | | | | |
| **pH** | 6.5 – 8.0[1] | 6.5 - 8.5[2] | Samples[4] | 102 | 12 | 10 | 8 |
| | | | 90%ile or Max | 8.5 | 8.1 | 7.3 | 7.5 |
| | | | Avg | 7.7 | 7.6 | 6.9 | 7.0 |
| | | | 10%ile or Min | 6.7 | 7.0 | 6.3 | 6.4 |
| **DO (mg/L)** | - | - | Samples[4] | 102 | 11 | 9 | 7 |
| | | | 90%ile or Max | 9.3 | 8.6 | 8.5 | 6.8 |
| | | | Avg | 7.9 | 6.3 | 6.1 | 5.2 |
| | | | 10%ile or Min | 5.3 | 4.5 | 4.4 | 3.8 |
| **EC (µS/cm)** | 125 - 2200[1] | - | Samples[4] | 101 | 10 | 9 | 8 |
| | | | 90%ile or Max | 827 | 480 | 360 | 297 |
| | | | Avg | 565 | 367 | 264 | 251 |
| | | | 10%ile or Min | 378 | 297 | 200 | 209 |
| **Turbidity** | 6 - 50[1] | - | Samples[4] | 102 | 12 | 10 | 8 |
| | | | 90%ile or Max | 767 | 1675 | 174 | 141 |
| | | | Avg | 271 | 659 | 118 | 75 |
| | | | 10%ile or Min | 53 | 67 | 11 | 20 |
| **Laboratory Results** | | | | | | | |
| **pH** | 6.5 – 8.0[1] | 6.5 - 8.5[2] | Samples[4] | 106 | 13 | 10 | 7 |
| | | | 90%ile or Max | 8.5 | 8.3 | 7.1 | 7.1 |
| | | | Avg | 8.1 | 7.7 | 6.7 | 6.7 |
| | | | 10%ile or Min | 7.7 | 6.8 | 6.1 | 6.4 |
| **EC (µS/cm)** | 125-2200[1] | - | Samples[4] | 106 | 13 | 10 | 7 |
| | | | 90%ile or Max | 835 | 423 | 379 | 329 |
| | | | Avg | 555 | 351 | 268 | 263 |
| | | | 10%ile or Min | 362 | 290 | 184 | 190 |
| **Turbidity** | 6 - 50[1] | - | Samples[4] | 106 | 13 | 10 | 7 |
| | | | 90%ile or Max | 380 | 658 | 204 | 30 |
| | | | Avg | 158 | 363 | 74 | 20 |
| | | | 10%ile or Min | 35 | 65 | 16 | 10 |
| **TSS (mg/L)** | - | 50[2] | Samples[4] | 106 | 13 | 10 | 8 |
| | | | 90%ile or Max | 210 | 345 | 299 | 30 |
| | | | Avg | 80 | 181 | 130 | 21 |
| | | | 10%ile or Min | 16 | 22 | 9 | 13 |
| **Oil and Grease (mg/L)** | - | - | Samples[4] | 49 | 6 | 6 | 1 |
| | | | 90%ile or Max | 1 | 2 | 2 | 2 |
| | | | Avg | 1 | 1 | 2 | 2 |
| | | | 10%ile or Min | 1 | 1 | 1 | 2 |

Shading denotes ANZECC (2000) trigger value has been exceeded

Red Text denotes consent condition exceeded.

**Note 1**: ANZECC Trigger Values for physical & chemical stressors for South-East Australia for slightly disturbed ecosystems (Low land River) adopted.

**Note 2**: Consent Condition 29 only applies to site discharge. Hence, this condition is not applicable to results from within the Lower Dam or receiving water locations.

**Note 3**: Maximum and minimum values are reported when the number of samples is less than 10. 10th and 90th Percentiles are reported when the number of samples is 10 or greater.

**Note 4**: Data provided by Boral from monitoring undertaken between January 2010 and April 2016 has been summarised in this table. RHDHV have not verified the reliability or completeness of the data provided.

### 4.4.2 SWCA Monitoring

Boral has implemented an additional water quality monitoring program to inform a SWCA. The objectives of the additional monitoring are to:

- Expand the analytes tested to include nutrients and a full suite of dissolved metals.
- Expand the sampling locations to include the Middle and Upper Dams, Breccia Spring and additional receiving water locations.

The sampling program has progressively been expanded in response to initial results. At the time of writing this report a total of six sampling rounds have been completed. However, the results from the initial two sampling rounds were impacted by some laboratory issues and are of limited use. **Table 4-7** provides detailed information on the sampling context for each of the five sampling rounds and **Table 4-8** lists the SWCA analytes.

**Table 4-7** – *SWCA Sampling Context*

| Sample Date | Sampled Locations | Rainfall Context | Breccia Spring Flows | Comments |
|---|---|---|---|---|
| 7 June 2017 | • Lower Dam<br>• Middle Dam<br>• Upper Dam<br>• Receiving Water (GS2) | **Wet Weather Sample –** 34 mm of rainfall[1] occurred prior to sampling | Flow conditions were similar to those shown in **Photo 2**. | Some of the results are of limited value due to the following laboratory issues:<br>• Limits of reporting for some metals are above relevant trigger levels.<br>• Two sets of Nitrogen results were provided for the same samples.<br>• Metal concentrations were reported as total instead of dissolved.<br>These issues did not affect the Breccia Spring sample that was collected on 16 June 2017. |
| 14 and 15 June 2017 | • Lower Dam<br>• Middle Dam<br>• Upper Dam<br>• Receiving Water (GS2)<br>• Breccia Spring | **After Wet Weather Sample –** sample was collected 5 days after a wet weather event | | |
| 28 June 2017 | • Lower Dam<br>• Middle Dam<br>• Upper Dam<br>• Breccia Spring<br>• Receiving Water (GS1& GS2) | **Dry Weather Sample** | | No issues were encountered during this sampling round. |
| 17 July 2017 | • Lower Dam<br>• Middle Dam<br>• Upper Dam<br>• Breccia Spring<br>• Receiving Water (GS1, GS2, GS3, RC1, RC2, RC4 & RC5) | **Dry Weather Sample** | | No issues were encountered during this sampling round. |
| 4 August 2017 | | **Wet Weather Sample –** 21 mm of rainfall[1] occurred prior to sampling | | No issues were encountered during this sampling round. |

Note 1: rainfall was recorded that the quarry's weather station.

Sampling analytes were established in consultation with the EPA. Each sample was tested for the analytes that are listed in **Table 4-8**.

***Table 4-8*** *– SWCA sampling analytes*

| | Analytes Proposed |
|---|---|
| **General** | • pH<br>• Electrical Conductivity (EC)<br>• Total Suspended Solids (TSS)<br>• Turbidity<br>• Total Hardness (Ca $CO_3$) |
| **Nutrients** | • Ammonia, Nitrate, Nitrate, Nitrate + Nitrate ($NO_x$), Organic Nitrogen (TKN) and Total Nitrogen (TN)<br>• Reactive and Total Phosphorus (TP) |
| **Dissolved Metals** | • Metals (Al, As, Ag, B, Ba, Co, Cu, Cr, Cd, Pb, Mn, Ni, Zn, Fe, Hg, Se) |

The SWCA results have been compared to relevant EPL conditions and ANZECC (2000) trigger values for slightly to moderately disturbed ecosystems. Hardness adjustments were made for the Copper trigger value using the methods provided in ANZECC (2000). Low reliability trigger levels were established for Barium and Cobalt using the methods recommended in ANZECC (2000).

The SWCA results are presented in **Table 4-9**. All results are discussed in **Section 4.5.1**.

***Table 4-9*** *: SWCA Results Table*

| Analyte and Units | | EPL Condition | ANZECC Trigger Values | | Limit of Reporting | 7 June 2017 (Wet Weather Sample) | | | | 14 - 15 June 2017 (After Wet Weather Sample) | | | | | 28 June 2017 (Dry Weather Sample) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lowland River[1] | Toxicants[2] | | Upper Dam | Middle Dam | Lower Dam | GS2 | Upper Dam | Middle Dam | Lower Dam | GS2 | Breccia Spring | Upper Dam | Middle Dam | Lower Dam | Breccia Spring | GS 1 | GS 2 |
| **General Analytes** | | | | | | | | | | | | | | | | | | | | |
| Electrical Conductivity (EC) | (µ/s) | | 200-300 | | 1 | **308** | **315** | **497** | **490** | **328** | **337** | **578** | **491** | NS | **317** | **327** | **515** | **521** | **334** | **408** |
| pH | - | 6.5-8.5 | 6.5-8.0[1] | | 0.1 | 8.4 | 8.4 | 8.3 | 8.1 | 8.2 | 8.4 | 8.2 | 7.9 | 8.4 | **8.8** | **8.6** | 8.1 | **8.3** | 7.9 | 6.6 |
| Turbidity | (NTU) | | 6-50[1] | | 1 | 38 | 33 | **140** | **270** | 37 | 28 | 50 | 45 | 3 | NS | NS | NS | NS | NS | NS |
| Total Suspended Solids | (mg/l) | 50 | | | 5 | 28 | 24 | **85** | **233** | 20 | 22 | 40 | 33 | 6 | 14 | 5 | 44 | 6 | <5 | 177 |
| Total Hardness ($CaCO_3$) | (mg/l) | - | | | 1 | 35 | 42 | 126 | 124 | 39 | 46 | 117 | 118 | 121 | 20 | 36 | 111 | 113 | 75 | 89 |
| **Nitrogen Results** | | | | | | | | | | | | | | | | | | | | |
| Ammonia as N | (mg/l) | | 0.02 | 0.9 | 0.01 | NR | NR | NR | NR | NR | NR | NR | NR | <0.01 | <0.01 | 0.01 | 0.01 | <0.01 | <0.01 | **0.210** |
| Nitrate as N | (mg/l) | | | 0.7 | 0.01 | NR | NR | NR | NR | NR | NR | NR | NR | **5.06** | **2.39** | **4.64** | **3.13** | **4.13** | 0.05 | <0.01 |
| Nitrite as N | (mg/l) | | | | 0.01 | NS | NS | NS | NS | NS | NS | NS | NS | <0.01 | 0.11 | 0.01 | 0.01 | 0.04 | <0.01 | <0.01 |
| Oxidised Nitrogen (as $NO_x$) | (mg/l) | | 0.04 | | 0.05 | NS | NS | NS | NS | NS | NS | NS | NS | **5.06** | **2.50** | **4.65** | **3.14** | **4.17** | **0.05** | <0.01 |
| Organic Nitrogen (as TKN) | (mg/l) | | | | 0.1 | NS | NS | NS | NS | NS | NS | NS | NS | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.3 | 0.9 |
| Total Nitrogen (TN) | (mg/l) | | 0.35 | | 0.1 | NS | NS | NS | NS | NS | NS | NS | NS | **5.6** | **3.0** | **5.2** | **3.7** | **4.9** | **0.4** | **0.9** |
| **Phosphorous Results** | | | | | | | | | | | | | | | | | | | | |
| Reactive Phosphorous | (mg/l) | | 0.020 | | 0.05 | NS | NS | NS | NS | NS | NS | NS | NS | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorous (TN) | (mg/l) | | 0.025 | | **0.05** | **0.09** | **0.08** | **0.28** | **0.22** | **0.1** | **0.09** | **0.24** | **0.27** | **0.02** | **0.06** | **0.04** | **0.28** | **0.07** | **0.03** | **0.22** |
| **Dissolved Metals** | | | | | | | | | | | | | | | | | | | | |
| *Aluminium (Al)* | (mg/l) | | | 0.055 | 0.01 | NR | NR | NR | NR | NR | NR | NR | NR | <0.01 | **0.060** | 0.040 | 0.010 | <0.01 | <0.01 | <0.01 |
| *Arsenic (As)* | (mg/l) | | | 0.0132 | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.001 | 0.008 | 0.008 | 0.002 | 0.001 | <0.001 | <0.001 |
| *Barium (Ba)* | (mg/l) | | | 0.008^^ | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | 0.004 | <0.001 | <0.001 | 0.003 | 0.004 | **0.031** | **0.016** |
| *Boron (B)* | (mg/l) | | | 0.37 | 0.05 | NR | NR | NR | NR | NR | NR | NR | NR | NS | **0.49** | 0.30 | 0.26 | 0.30 | <0.05 | <0.05 |
| *Cadmium (Cd)* | (mg/l) | | | 0.0002 | 0.0001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| *Cobalt (Co)* | (mg/l) | | | 0.003^^ | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Copper (Cu)* | (mg/l) | | | 0.0043^ | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | **0.008** | **0.005** | **0.006** | **0.006** | **0.007** | 0.001 | 0.001 |
| *Chromium (Cr)* | (mg/l) | | | 0.001 | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Manganese (Mg)* | (mg/l) | | | 1.9 | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | 0.001 | 0.001 | <0.001 | 0.008 | 0.001 | 0.05 | 0.121 |
| *Mercury (Hg)* | (mg/l) | | | 0.00006 | 0.0001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| *Nickel (Ni)* | (mg/l) | | | 0.011 | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Lead (pb)* | (mg/l) | | | 0.0034 | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 |
| *Selenium (Se)* | (mg/l) | | | 0.011 | 0.01 | NR | NR | NR | NR | NR | NR | NR | NR | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| *Silver (Ag)* | (mg/l) | | | 0.0005 | 0.001 | NR | NR | NR | NR | NR | NR | NR | NR | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Zinc (Zn)* | (mg/l) | | | 0.08 | 0.005 | NR | NR | NR | NR | NR | NR | NR | NR | NS | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| *Iron (Fe)* | (mg/l) | | | | 0.05 | NR | NR | NR | NR | NR | NR | NR | NR | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.08 | 0.11 |

***Note 1*** *: Default trigger value for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems as defined in Table 3.3.2 of the ANZECC 2000 guidelines have been applied as the relevant trigger value.*

***Note 2*** *: Trigger values for slightly-moderately disturbed systems as defined in Table 3.4.1 of the ANZECC 2000 guidelines have been applied have been applied as the relevant trigger value.*

*^ denotes a hardness adjustment was applied to the trigger value using a hardness of 113 mg/l (typical value for Breccia Spring water quality)*

*^^ denotes that a low reliability trigger value was established using the methods recommended in ANZECC (2000)*

***NS*** *denotes Not Sampled*

***NR*** *denotes lab reliability issues were encountered*

***Table 4-9*** *: SWCA Results Table Continued*

| Analyte and Units | | EPL Condition | ANZECC Trigger Values | | Limit of Reporting | 17 June 2017 (Dry Weather Sample) | | | | | | | | | | | 4 August 2017 (Wet Weather Sample) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lowland River[1] | Toxicants[2] | | Upper Dam | Middle Dam | Lower Dam | Breccia Spring | GS 1 | GS 2 | GS 3 | RC1 | RC2 | RC4 | RC5 | Upper Dam | Middle Dam | Lower Dam | Breccia Spring | GS 1 | GS 2 | GS 3 | RC1 | RC2 | RC4 | RC5 |
| **General Analytes** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Electrical Conductivity (EC) | (µ/s) | | 200-300 | | 1 | **407** | **341** | **551** | **520** | **346** | **445** | **603** | **818** | **434** | **5770** | **7950** | **332** | **338** | **509** | **511** | **334** | **515** | **734** | **599** | **452** | **686** | **2440** |
| pH | - | 6.5-8.5 | 6.5-8.0[1] | | 0.1 | **8.5** | **8.8** | **8.4** | **8.4** | 7.2 | 6.9 | 7 | 7.2 | 7.2 | 7.8 | 7.5 | 8.6 | **8.6** | **8.3** | **8.3** | 7.9 | 7.5 | 7.3 | 7.7 | 7.5 | 7.4 | 7.6 |
| Turbidity | (NTU) | | 6-50[1] | | 1 | 27 | 11 | 37 | 3 | 4 | 18 | 17 | 15 | 17 | 8 | 5 | **289** | 19 | 144 | 21 | 3.2 | 8.9 | 23 | **60.5** | 8 | 12 | 6 |
| Total Suspended Solids | (mg/l) | 50 | | | 5 | 6 | <5 | 15 | 22 | <5 | 39 | 19 | <5 | 18 | 10 | <5 | **119** | 32 | 47 | **80** | <5 | 18 | 23 | **51** | 9 | 12 | 23 |
| Total Hardness ($CaCO_3$) | (mg/l) | - | | | 1 | 30 | 35 | 110 | 106 | 64 | 88 | 107 | 192 | 90 | 555 | 842 | 25 | 39 | 108 | 109 | 64 | 108 | 151 | 129 | 95 | 722 | 2620 |
| **Nitrogen Results** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ammonia as N | (mg/l) | | 0.02 | 0.9 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | **0.1** | <0.01 | <0.01 | <0.01 | <0.01 | 0.010 | 0.020 | 0.020 | 0.020 | <0.01 | **0.030** | **0.02** | **0.020** | **0.020** | **0.090** | **0.06** |
| Nitrate as N | (mg/l) | | | 0.7 | 0.01 | **7.40** | **4.05** | **2.96** | **3.96** | 0.03 | 0.06 | 0.50 | **3.73** | <0.01 | 0.06 | 0.10 | **2.71** | **4.1** | **2.71** | **3.82** | 0.02 | <0.01 | 0.05 | 0.01 | 0.32 | 0.06 | 0.10 |
| Nitrite as N | (mg/l) | | | | 0.01 | 0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 | 0.02 | 0.06 | <0.01 | <0.01 | <0.01 | 0.08 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Oxidised Nitrogen (as $NO_x$) | (mg/l) | | 0.04 | | 0.05 | **7.41** | **4.05** | **2.97** | **3.96** | 0.03 | **0.06** | **0.50** | **3.73** | <0.01 | 0.06 | **0.1** | **2.79** | **4.1** | **2.72** | **3.82** | 0.02 | <0.01 | **0.05** | 0.01 | **0.32** | **0.06** | **0.1** |
| Organic Nitrogen (as TKN) | (mg/l) | | | | 0.1 | 0.9 | 0.5 | 0.5 | 0.5 | 0.3 | 0.8 | 1.9 | 1.0 | 0.6 | 1.1 | 0.9 | 0.5 | 0.6 | 0.3 | 0.3 | 0.2 | 1.8 | 2.7 | 1.3 | 0.6 | 1.4 | 0.6 |
| Total Nitrogen (TN) | (mg/l) | | 0.35 | | 0.1 | **8.3** | **4.6** | **3.5** | **4.5** | **0.3** | **0.9** | **2.4** | **4.7** | **0.6** | **1.2** | **1.0** | **3.3** | **4.7** | **3.0** | **4.1** | 0.2 | **1.8** | **2.8** | **1.3** | **0.9** | **1.5** | **0.7** |
| **Phosphorous Results** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reactive Phosphorous | (mg/l) | | 0.020 | | 0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.010 | <0.01 | <0.01 | <0.01 | <0.01 | 0.010 | 0.010 | <0.01 | **0.30** | <0.01 | 0.01 | **0.03** | <0.01 | <0.01 |
| Total Phosphorous (TN) | (mg/l) | | 0.025 | | 0.05 | **0.18** | **0.04** | **0.12** | **0.05** | **0.03** | **0.11** | **0.31** | **0.13** | **0.17** | **0.11** | **0.07** | **1.14** | **0.10** | **3.00** | **0.31** | **0.040** | 0.020 | **0.300** | **0.280** | **0.170** | **0.140** | **0.08** |
| **Dissolved Metals** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Aluminium (Al)* | (mg/l) | | | 0.055 | 0.01 | **0.070** | **0.070** | 0.010 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | **0.050** | **0.070** | 0.020 | 0.010 | <0.01 | <0.01 | <0.01 | 0.020 | <0.01 | <0.01 | <0.01 |
| *Arsenic (As)* | (mg/l) | | | 0.0132 | 0.001 | 0.008 | 0.007 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.006 | 0.008 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Barium (Ba)* | (mg/l) | | | 0.008^^ | 0.001 | <0.001 | <0.001 | 0.003 | 0.003 | **0.025** | **0.019** | **0.023** | **0.016** | **0.023** | **0.031** | **0.034** | <0.001 | 0.001 | 0.003 | 0.003 | **0.023** | **0.022** | **0.036** | **0.015** | **0.022** | **0.038** | **0.048** |
| *Boron (B)* | (mg/l) | | | 0.37 | 0.05 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.46** | 0.28 | 0.27 | 0.28 | 0.05 | 0.08 | 0.12 | 0.09 | 0.06 | **0.52** | **1.81** |
| *Cadmium (Cd)* | (mg/l) | | | 0.0002 | 0.0001 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| *Cobalt (Co)* | (mg/l) | | | 0.003^^ | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | **0.003** | <0.001 | <0.001 | 0.001 | <0.001 |
| *Copper (Cu)* | (mg/l) | | | 0.0043^ | 0.001 | **0.008** | **0.006** | 0.004 | 0.004 | <0.001 | 0.001 | 0.002 | 0.004 | 0.002 | 0.002 | 0.001 | **0.006** | **0.006** | **0.006** | **0.006** | <0.001 | 0.002 | 0.002 | **0.009** | 0.002 | 0.002 | 0.001 |
| *Chromium (Cr)* | (mg/l) | | | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Manganese (Mg)* | (mg/l) | | | 1.9 | 0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.079 | 0.053 | 0.278 | 0.021 | 0.224 | 0.181 | 0.152 | 0.003 | <0.001 | 0.010 | 0.002 | 0.093 | 0.13 | 0.554 | 0.106 | 0.182 | 0.281 | 0.181 |
| *Mercury (Hg)* | (mg/l) | | | 0.00006 | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| *Nickel (Ni)* | (mg/l) | | | 0.011 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Lead (pb)* | (mg/l) | | | 0.0034 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Selenium (Se)* | (mg/l) | | | 0.011 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| *Silver (Ag)* | (mg/l) | | | 0.0005 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| *Zinc (Zn)* | (mg/l) | | | 0.08 | 0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| *Iron (Fe)* | (mg/l) | | | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.10 | 0.13 | 0.38 | <0.05 | 0.14 | 0.25 | 0.19 | <0.05 | <0.05 | <0.05 | <0.05 | 0.10 | 0.35 | 0.45 | 0.23 | 0.34 | 0.09 | <0.05 |

***Note 1****: Default trigger value for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems as defined in Table 3.3.2 of the ANZECC 2000 guidelines have been applied as the relevant trigger value.*

***Note 2****: Trigger values for slightly-moderately disturbed systems as defined in Table 3.4.1 of the ANZECC 2000 guidelines have been applied have been applied as the relevant trigger value.*

*^ denotes a hardness adjustment was applied to the trigger value using a hardness of 113 mg/l (typical value for Breccia Spring water quality)*

*^^ denotes that a low reliability trigger value was established using the methods recommended in ANZECC (2000)*

***NS*** *denotes Not Sampled*

***NR*** *denotes lab reliability issues were encountered*

### 4.4.3 Water Quality Results Discussion

This section reviews the water quality results from the WMP and SWCA monitoring programs. It is important to note that only sample results from the Breccia Spring flows and Lower Dam overflows (EPL #7) provide information on water quality of site discharge. All other samples were collected from within water management dams or receiving water locations.

The following sections discuss the water quality results.

## *General Trends – WMP Monitoring Data*

The following key trends can be interpreted from the WMP monitoring data that is presented in **Table 4-6**:

- Measured Electrical Conductivity in the Lower Dam ranges between 300 to 830 µS/cm, which is elevated above the ANZECC (2000) trigger range of 200-300 µS/cm and the typical receiving water range of 180-350 µS/cm. It is noted that Rocklow Creek becomes tidal shortly downstream of the Lower Dam.
- Recorded pH within the water management dams is generally within the 6.5 to 8.5 range that is specified in Consent Condition 29.
- Elevated turbidity levels (i.e. greater than 50 NTU) have been consistently measured in the Lower Dam and in discharge from the Lower Dam.
- Recorded TSS in overflows from the Lower Dam Spillway exceeded the 50 mg/l discharge criteria (Consent Condition 29) in 9 out of 13 samples, indicating that the Lower Dam is not providing effective sedimentation treatment.
- The calculated 10$^{th}$ Percentile TSS concentration in the Lower Dam of 16 mg/l indicates that sedimentation processes effectively reduce TSS concentrations in the Lower Dam over time.
- No elevated Oil and Grease concentrations were identified in any sample.

## *General Trends – SWCA Monitoring Data*

The following key trends can be interpreted from the SWCA monitoring data that is presented in **Table *4-9***:

- Nitrate concentrations within the water management dams and Breccia Spring samples ranged between 2.4 to 7.4 mg/l, above the ANZECC (2000) trigger value of 0.7 mg/l. This is discussed further below.
- Copper concentrations were marginally above the ANZECC (2000) trigger value of 0.0043 mg/l (after hardness adjustment) in most of the water management dam samples and in all Breccia Spring samples. This is discussed further below.
- Aluminium was marginally elevated above the ANZECC (2000) trigger level of 0.0055 mg/l in three Upper Dam samples and two Middle Dam sample. Aluminium was below detection levels in all Lower Dam, Breccia Spring and receiving water samples.

- Boron was marginally elevated above the ANZECC (2000) trigger level of 0.370 mg/l in two Upper Dam samples. All other samples retuned concentrations that were below the ANZECC (2000) trigger level.

- Some receiving water samples returned concentrations of Barium that were elevated relative to a low reliability trigger level of 0.008 mg/l. All samples from the water management dams and the Breccia Spring flows returned Barium concentrations that were below this low reliability trigger level, indicating that Barium concentrations in Rocklow Creek are generally higher than in the water management dams.

- All samples of Arsenic, Cadmium, Cobalt, Chromium, Manganese, Mercury, Nickle, Lead, Selenium, Silver and Zinc were either below detection limits or the ANZECC (2000) trigger levels.

## *Nitrate and Copper Results*

The SWCA monitoring identified elevated Nitrate and Copper levels in most water management dam and the Breccia Spring samples. The elevated concentrations of both Nitrate and Copper are interpreted to be associated with the weathering of quarry rock that has naturally occurring elevated levels of both analytes. To support this hypothesis, Boral has compared geochemical data from Dunmore Quarry rock to rock from other Boral quarries. This analysis is provided in **Appendix B**.

As discussed earlier in this section, Breccia Spring flows are considered to be one of the quarry's primary surface water discharge mechanisms. The Breccia Spring flows are interpreted to originate from Middle Dam seepage and base flows into the breccia from the general quarry area. The Middle Dam water level data presented in **Figure 16** demonstrates that seepage from the Middle Dam will occur for a number of months following a rainfall period. For this reason, dry weather conditions present the greatest potential for Breccia Spring flows to impact the water quality of Rocklow Creek. This is because the constant flows from the Breccia Spring will have less opportunity for mixing or dilution with Rocklow Creek stream and groundwater flows.

The SWCA monitoring results that are presented in **Table *4-9*** include Nitrate and Copper results from three samples from the water management dams, four Breccia Spring samples and two to three samples from seven receiving water locations. **Table *4-10*** provides a summary of all Nitrate and Copper results.

The water quality results provided in **Table *4-10*** indicate that the Breccia Spring flows contain Nitrate concentrations ranging from 3.8 to 5.1 mg/l and copper concentrations ranging from 0.004 to 0.008 mg/l. Two near field receiving water samples (RC1) returned similar concentrations, indicating that the Breccia Spring flows enter the Rocklow Creek surface and groundwater system near the RC1 sampling location. Sampling was undertaken at five additional receiving water locations that are located at varying distances downstream of the RC1 location. Results from all of these samples returned Nitrate and Copper concentrations that were below ANZECC (2000) trigger levels and similar to the results from the GS1 sampling location, which is located upstream of the Breccia Spring inflow location. These results indicate that the Breccia Spring flows are only resulting in elevated Nitrate and Copper levels in the immediate mixing zone (around the RC1 sampling location). Possible explanations for this include:

- Nitrate and Copper concentrations are being readily removed by biochemical processes in the Rocklow Creek riparian zone. This is consistent with expectations given that Rocklow Creek is a wetland and wetlands are typically used to treat nutrients and metals.

- Some surface and groundwater from the RC1 sampling location may flow into the Lower Dam via subsurface flow to replenish water extracted from the Lower Dam for process water uses. This would reduce the potential for water from the RC1 sampling location to flow to downstream sampling locations.

**Table 4-10** – Nitrate *and Copper Results Summary Table*

| Sample ID | Sample Context | Number of Samples | Nitrate Results | Copper Results |
|---|---|---|---|---|
| **Units** | | | (mg/l) | (mg/l) |
| **ANZECC (2000) Trigger Value** | | | 0.7 | 0.0043 |
| **Water Management Dam Results** | | | | |
| **Upper Dam** | Water Management Dam | 3 | **2.4** to **7.4** | **0.005** to **0.008** |
| **Middle Dam** | Water Management Dam | 3 | **4.1** to **4.6** | **0.006** |
| **Lower Dam** | Water Management Dam | 3 | **2.7** to **3.1** | 0.004 to **0.006** |
| **Breccia Spring Results** | | | | |
| **Breccia Spring** | Water sampled from Breccia Spring waterfall | 4 | **3.8** to **5.1** | 0.004 to **0.008** |
| **Receiving Water Results** | | | | |
| **GS1** | Upstream of the Breccia Spring and other discharge locations. | 3 | 0.02 to 0.05 | BD to 0.001 |
| **RC1** | Adjacent to the Breccia Spring | 2 | 0.01 to **3.7** | 0.004 to **0.009** |
| **RC2** | 150m downstream of the Breccia Spring seep, adjacent to the Lower Dam Spillway | 2 | BD to 0.32 | 0.002 |
| **GS2** | 270m downstream of the Breccia Spring seep, adjacent to the Lower Dam | 3 | DB to 0.06 | 0.001 to 0.002 |
| **GS3** | 1km downstream of the Breccia Spring seep. | 2 | 0.05 to 0.5 | 0.002 |
| **RC4** | 1.5km downstream of the Breccia Spring seep, adjacent to DSS extraction area | 2 | 0.06 | 0.002 |
| **RC5** | Downstream of Princess Highway | 2 | 0.10 | 0.001 |

**BD** denotes concertation is below detection limits.

**Bold** denotes trigger value exceeded.

## 4.5 Local Soil Conditions

Evans and Peck reviewed local soil conditions when preparing the 2008 Water Management Plan. The review concluded that:

- Sediment sampling from the Quarry Dam (presumed to be the Lower Dam) indicated that sediment within the dam was consistent with Type C to Type F material.
- The quarry is located within the Bombo Soil landscape, which is classified as Type F soils.

In addition, as discussed in **Section 4.4**, water quality results indicate that sedimentation processes effectively reduce TSS concentrations in the Lower Dam, indicating that limited Type D material (dispersive material) enters the basin. Accordingly, for the purposes of this assessment, it is assumed that soils within the quarry area are Type F soils.

## 4.6 Departures from WMP

The current WMP for the quarry operation was prepared by Arcadis in September 2016 and was approved by DP&E on 5 December 2016. This WMP documented a similar water management strategy and water balance to a WMP that was prepared by Evans & Peck in 2008, but includes updated water management actions, monitoring and reporting requirements and exceedance protocols.

The revised interpretation of the existing water management system that is described in this section has identified the following significant departures from the water management system that is documented in quarry's current WMP (Arcadis, 2016):

- **Changes to Catchment Areas**: The contributing catchment areas to the Upper, Middle and Lower Dams that are described in **Figure 8** are considerably different to those documented in the WMP. In addition, the 18.2 ha catchment that contributes runoff to the DSS Water Management System was not identified in the WMP.
- **Changes to the Lower Dam Volume**: The Lower Dam volume is reported in the WMP as having a 28 ML volume. The dam's volume is estimated to be 14ML.
- **Controlled Discharge Regime**: The WMP describes a controlled discharge regime that treats water extracted from the Lower Dam in a bioretention swale. The infrastructure for this system has been constructed. However, it is has not been historically used as infiltration from the bioretention swale infiltrates back into the Lower Dam. Accordingly, the bioretention swale and associated controlled discharge regime is not considered to be part of the water management system.
- **Operating Procedures and Water Balance Results**: The WMP did not identify or assess seepage from the Middle Dam or groundwater ingress into the Lower Dam. Both of these groundwater interfaces are important aspects of the water management system. Accordingly, the associated operating principals and water balance results are considered to not be representative of the quarry's water management system.

# 5 PROPOSED SURFACE WATER MANAGEMENT CHANGES

This section describes and assesses the following proposed changes to the existing water management system:

- **Proposed Improvements to the Existing Water Management System** – Following a review of the existing water management system, Boral are proposing to:
  - Modify the Lower Dam to improve its sedimentation treatment functionality.
  - Preferentially source process water from the Middle Dam to reduce extraction from the Lower Dam and associated groundwater ingress into the Lower Dam from the Rocklow Creek Alluvium. Process water extraction from the Middle Dam will also reduce Middle Dam leakage volumes and associated Breccia Spring flows.

  It is noted that these improvements are proposed to improve the effectiveness of the existing water management system and are not associated with Modification 9.

- **Changes due to Modification 9 -** Modification 9 seeks to extend the Croome Farm Pit by approximately 14.4 ha to enable extraction within the Croome West Pit. There are no changes proposed to the production rates or existing quarry infrastructure. The Croome West Pit will increase the contributing catchment area to the quarry's water management system, which will result in higher runoff volumes to the existing water management dams.

In order to separate the potential impacts and benefits associated with the above-mentioned changes, the following scenarios are described and assessed separately in this section:

- **Existing Conditions**: Refers to the existing water management system that is described in **Section 4**.
- **Existing Conditions with Improvements**: Applies the proposed upgrades to the Lower Dam and changes to the process water extraction regime to the Existing Conditions scenario.
- **Modification 9**: Applies Modification 9 changes to the Existing Conditions with Improvements scenario.

This section documents the proposed changes to the surface water management system and is structured as follows:

- **Section 5.1** describes proposed improvements to the existing surface water management system.
- **Section 5.2** describes proposed changes to the water management system associated with Modification 9.
- **Section 5.3** details a site water balance for the Existing Conditions, Existing Conditions with Improvements and Modification 9 scenarios.

Potential impacts associated with Modification 9 are discussed separately in **Section 6**. Water licencing requirements are discussed in **Section 8**.

## 5.1 Proposed Improvements to the Existing System

Following a review of the existing water management system, Boral are proposing to:

- Modify the Lower Dam to improve its sedimentation treatment functionality.
- Preferentially source process water from the Middle Dam to reduce extraction from the Lower Dam and associated groundwater ingress into the Lower Dam from the Rocklow Creek Alluvium. Process water extraction from the Middle Dam will also reduce Middle Dam leakage rates and associated Breccia Spring flows.

It is noted that these improvements are proposed to improve the effectiveness of the existing water management system and are not associated with Modification 9.

The following sections describe the proposed changes and should be read in conjunction with **Figure 18** which describes the functionality of the Existing Conditions with Improvements water management system.

**Dunmore Quarry: Existing Conditions with Improvements: Water Management System**

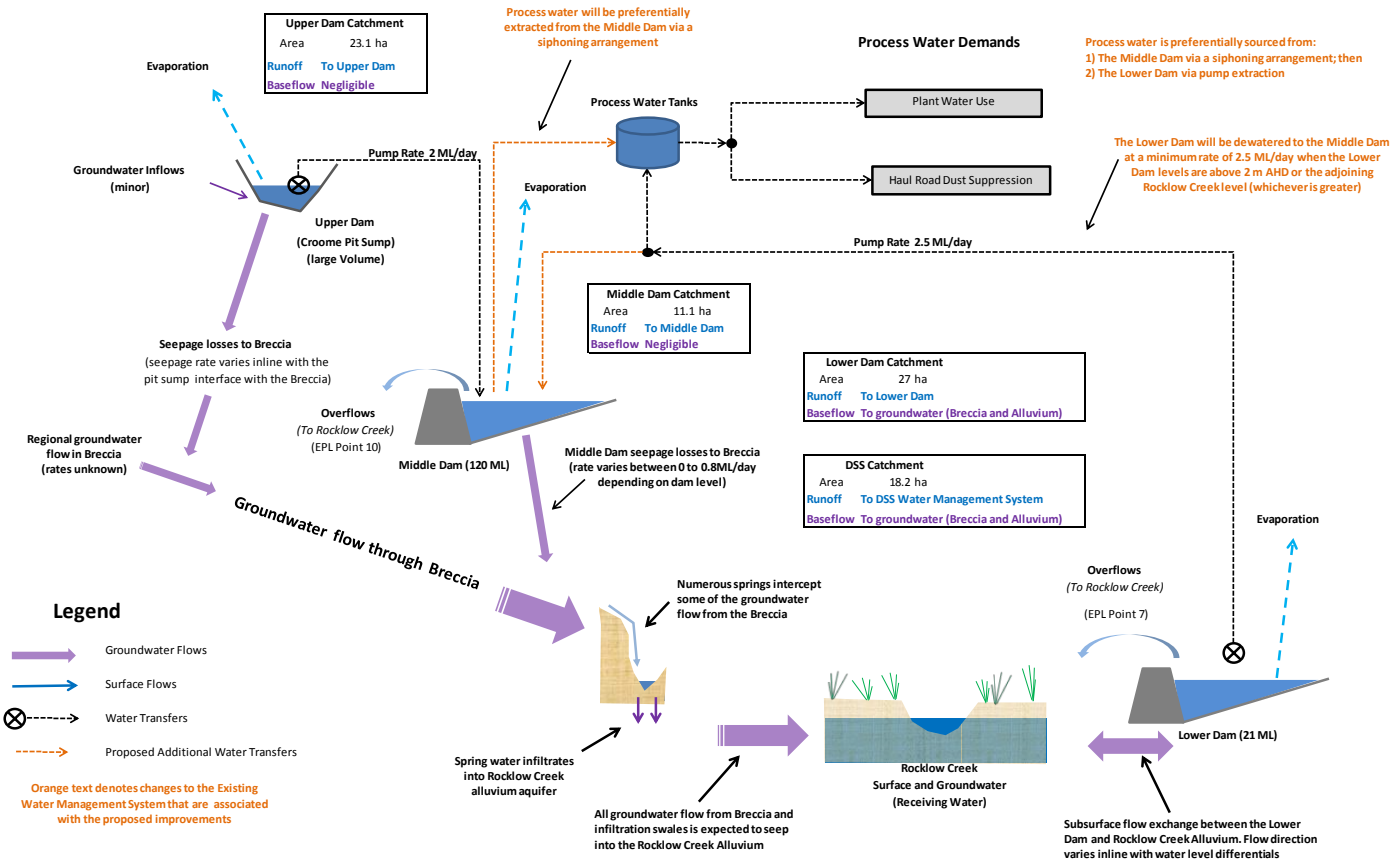


**Figure 18** – *Existing Conditions with Improvements: Water Management System*

### 5.1.1 Proposed Lower Dam Upgrades

As committed to in Surface Water Assessment (Rev F), a review of the functionality of the Lower Dam has been completed. This review was initiated for the following reasons:

- As discussed in **Section 4.4**, the recorded TSS concentrations in overflows from the Lower Dam exceeded the 50 mg/l discharge criteria (Consent Condition 29) in 9 out of 13 samples.
- Flood waters from Rocklow Creek are known to periodically inundate the Lower Dam. This is evidenced by the water level data presented in **Section 4.3**.
- Subsurface flow exchange occurs between the Lower Dam and the Rocklow Creek Alluvium aquifer. This connectivity limits the potential to dewater the Lower Dam below the adjoining aquifer level as any volume removed from the dam will quickly be replenished by additional groundwater inflows.
- Consent Condition 33 requires that Boral modify the Lower Dam to create a dam with an increased capacity that is offline from Rocklow Creek.

The review was informed by:

- A site inspection.
- Analysis of the Lower Dam and Rocklow Creek water level data that is presented **Section 4.3**.
- Sedimentation dam volume calculations that were undertaken applying the methods provided in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008). The 5 day 95$^{th}$ Percentile rainfall depth was adopted for calculations as required in Consent Condition 31. Resulting volumes are referred to as the Guideline Volumes. Refer to **Appendix D** for calculations.
- Hydraulic modelling of a Rocklow Creek runoff event that occurred on 16 March 2017.

The review concluded that:

- The Lower Dam can be dewatered to 2m AHD or the adjoining Rocklow Creek level (whichever is greater). Any further dewatering would result in groundwater inflows entering the dam. Accordingly, the sedimentation treatment volume of the dam is taken as the volume above 2m AHD.
- The water quality function of the Lower Dam is constrained by an undersized sedimentation treatment volume and the above-mentioned dewatering constraints. **Table 5-2** compares the existing sedimentation treatment volume to the guideline volume.
- Inflows from Rocklow Creek are likely to occur during any material Rocklow Creek runoff event. Hydraulic modelling of the 16 March 2017 runoff event indicated that a 1m variation in water levels would have occurred between the upstream and downstream extents of the dam. This is because of the constriction in the creek's floodplain adjacent to the dam. Hydraulic model results are provided in **Appendix C**.

A number of upgrades and revised operating procedures are proposed to improve the Lower Dam's sedimentation treatment function. These measures are summarised in **Table 5-1** and are shown in

**Figure 19**. **Table 5-2** compares the sedimentation treatment and storage volumes afforded by the existing and proposed dam to the calculated Guideline Volumes.

***Table 5-1*** *– Proposed Lower Dam Modifications*

| Proposed Change | Outcome |
|---|---|
| Relocate the dam's spillway to the southern side of the dam, where Rocklow Creek levels are expected to be lower during material runoff events. | • Significantly reduce the frequency of Rocklow Creek floodwaters inundating the Lower Dam. |
| Extend the eastern portion of the dam by 4,000 $m^2$. The dam extension area will be excavated to 2m AHD and is expected to be an ephemeral macrophyte zone. | • Provide and additional 4ML of storage above 2m AHD<br>• Improve the water quality treatment function of the dam. |
| The relocated spillway will have an invert level of 3.3m AHD, which will be 300 mm higher than the existing level. | • Reduce the frequency of Rocklow Creek floodwaters inundating the Lower Dam.<br>• Provide an additional 3 ML of storage above 2m AHD |
| Following a runoff event, the Lower Dam will be dewatered to 2m AHD or the adjoining Rocklow Creek levels (whichever is greater). Dewatering will occur via pumping to the Middle Dam at a minimum rate of 2.5 ML/day. | • The sedimentation treatment volume will be dewatered within 5 days as recommended in relevant guidelines. |

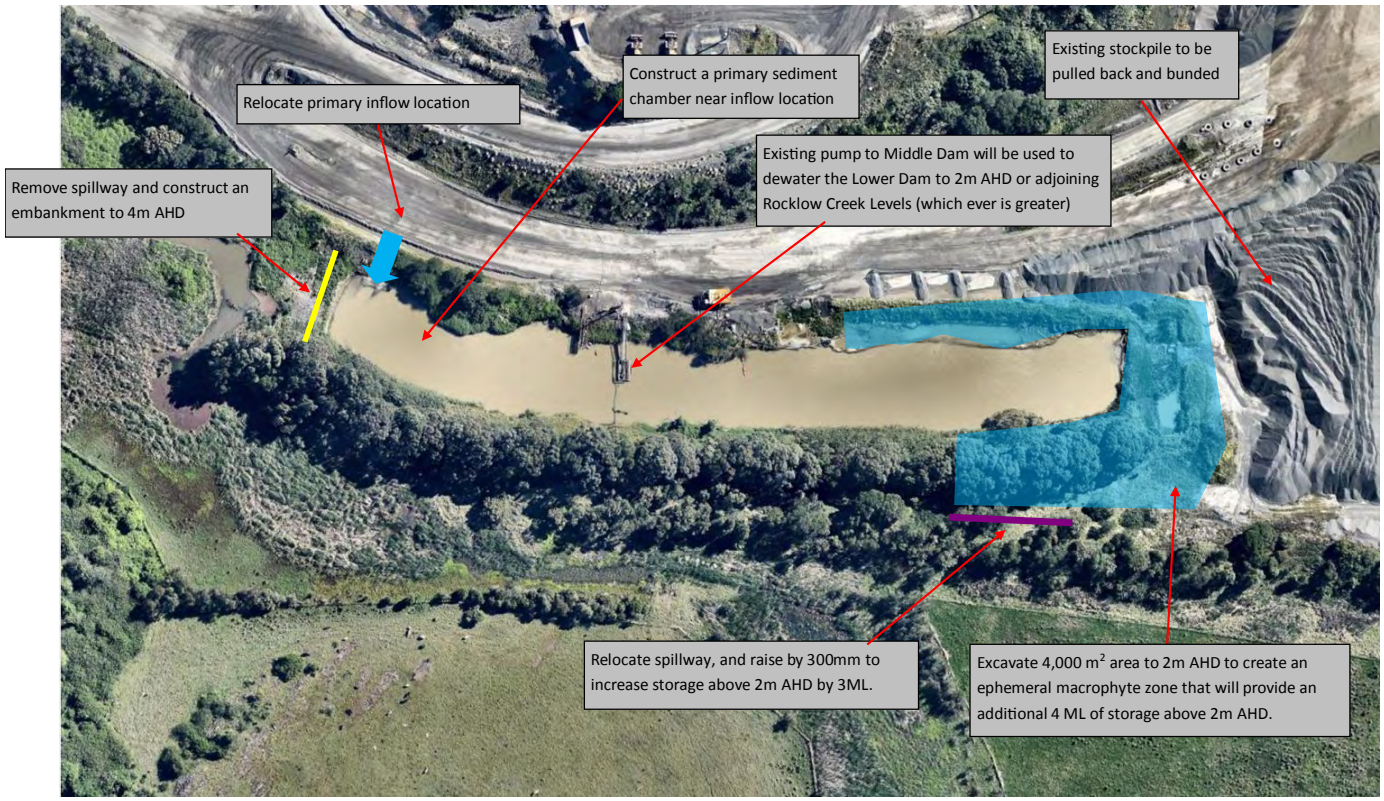


**Figure 19** - *Proposed Lower Dam Modifications*

***Table 5-2** – Lower Dam Storage Volumes*

| | Lower Dam Storage Characteristics | | | Guideline Volumes[2] | | |
|---|---|---|---|---|---|---|
| | Sedimentation Treatment Volume[1] | Sediment Storage Volume | Total Storage | Sedimentation Treatment Volume[1] | Sediment Storage Volume | Guideline Volumes Achieved |
| **Existing** | 6.2 ML | 7.8 ML | 14.0 ML | 12.5 ML | 6.3 ML | No |
| **Post Upgrade** | 13.2 ML | 7.8 ML | 21.0 ML | 12.5 ML | 6.3 ML | Yes |

Note 1: Sedimentation Treatment Volume is taken as the dam volume above 2m AHD.
Note 2: Guideline Volume refers to a dam volume that was calculated applying the methods provided in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008). The 5 day 95$^{th}$ Percentile rainfall depth was adopted for calculations as required in Consent Condition 31. Refer to **Appendix D** for calculations

The proposed changes will improve the sedimentation treatment effectiveness of the Lower Dam by:

- Significantly reducing the frequency of Rocklow Creek surface water inflows.
- Increasing the sedimentation treatment volume to exceed the calculated Guideline Volume; and
- Enabling dewatering of the sedimentation treatment volume to the Middle Dam to reduce the frequency and magnitude of Lower Dam overflows.

Once the proposed dam upgrades are implemented it is expected that the Lower Dam will broadly be operated in accordance with the operating principles described in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008). The upgraded dam will also broadly comply with Consent Conditions 31 and 33, which requires the dam to capture and treat all runoff from storm events up to and including the 5 day 95$^{th}$ percentile rainfall event.

### 5.1.2 Proposed Changes to Process Water Source

As discussed in **Section 4.2.4**, it is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Historically all process water has been extracted from the Lower Dam, with the majority of the water expected to have been drawn from the Rocklow Creek Alluvium via groundwater ingress into the dam.

It is proposed to preferentially source process water from the Middle Dam. This is expected to result in the following water management benefits:

- A reduction in seepage volumes from the Middle Dam and associated Breccia Spring flows. This will be due to the increased dewatering rates associated with process water extraction resulting in generally lower Middle Dam levels.
- A reduction in the volume of water that is extracted from Lower Dam will reduce associated groundwater ingress into the Lower Dam from the adjoining Rocklow Creek Alluvium.

Boral proposed to source process water from the Middle Dam via a siphoning arrangement. A pump out system would also be effective. It is assumed that the proposed extraction system will access

the upper 70% of the dam volume. Process water will continue to be extracted from the Lower Dam when the Middle Dam is less than 30% full.

## 5.2 Changes due to Modification 9

As discussed earlier in this section, Modification 9 seeks to extend the Croome Farm Pit by approximately 14.4 ha to enable extraction within the Croome West Pit. There are no changes proposed to the production rates, existing quarry infrastructure or process water demands. The Croome West Pit will increase the contributing catchment area to the quarry's water management system by an estimated 15.5 ha. This has been calculated as follows:

- An increase of 14.4ha associated with the Croome West Pit area.
- An increase of 4.1ha associated with the inner portion of the proposed visual and acoustic bund and any offset between the bund and the pit.
- Less 3ha of catchment area within the proposed Croome West Pit area that currently drains to the existing pit (Refer to **Figure 8** for existing catchment extents).

The increase in contributing catchment area will result in higher runoff volumes reporting to the existing water management dams.

Surface water runoff from both the existing Croome Farm Pit and proposed Croome West Pit will accumulate in the final void of the Croome Farm Pit. Boral have advised that initially the final void can hold a large volume of water while the Croome West Pit is excavated at higher levels. However, in the final years of the quarry plan, the water holding potential will be reduced as the Croome West Pit is excavated to levels below the existing Croome Farm Pit final void. Accordingly, it is assumed that water accumulation in the Croome Farm Pit final void will be managed as follows:

- During rainfall events, all runoff from the 38.6 ha contributing catchment area will accumulate in the pit sump. The pit sump will have a significant capacity, but will generally be dewatered when possible to minimise pit flooding risks.
- Water will be pumped from the void to the Middle Dam at an approximate rate of 2 ML/day rate when the Middle Dam level is less than 60% full.

All water transferred from the Croome Farm Pit to the Middle Dam will be via a fully enclosed conduit. This will avoid any potential scour or erosion impacts on Sydney Trains owned land, which is located between the two water storages.

The Croome West Pit is not expected to materially change any aspect of the existing water management system in the Middle and Lower Dam Catchments or the existing process water use profiles.

**Figure 20** describes the functionality of the Modification 9 water management system. **Figure 21** presents an associated surface water management plan that depicts catchment extents, the locations of water management dams and site discharge locations.

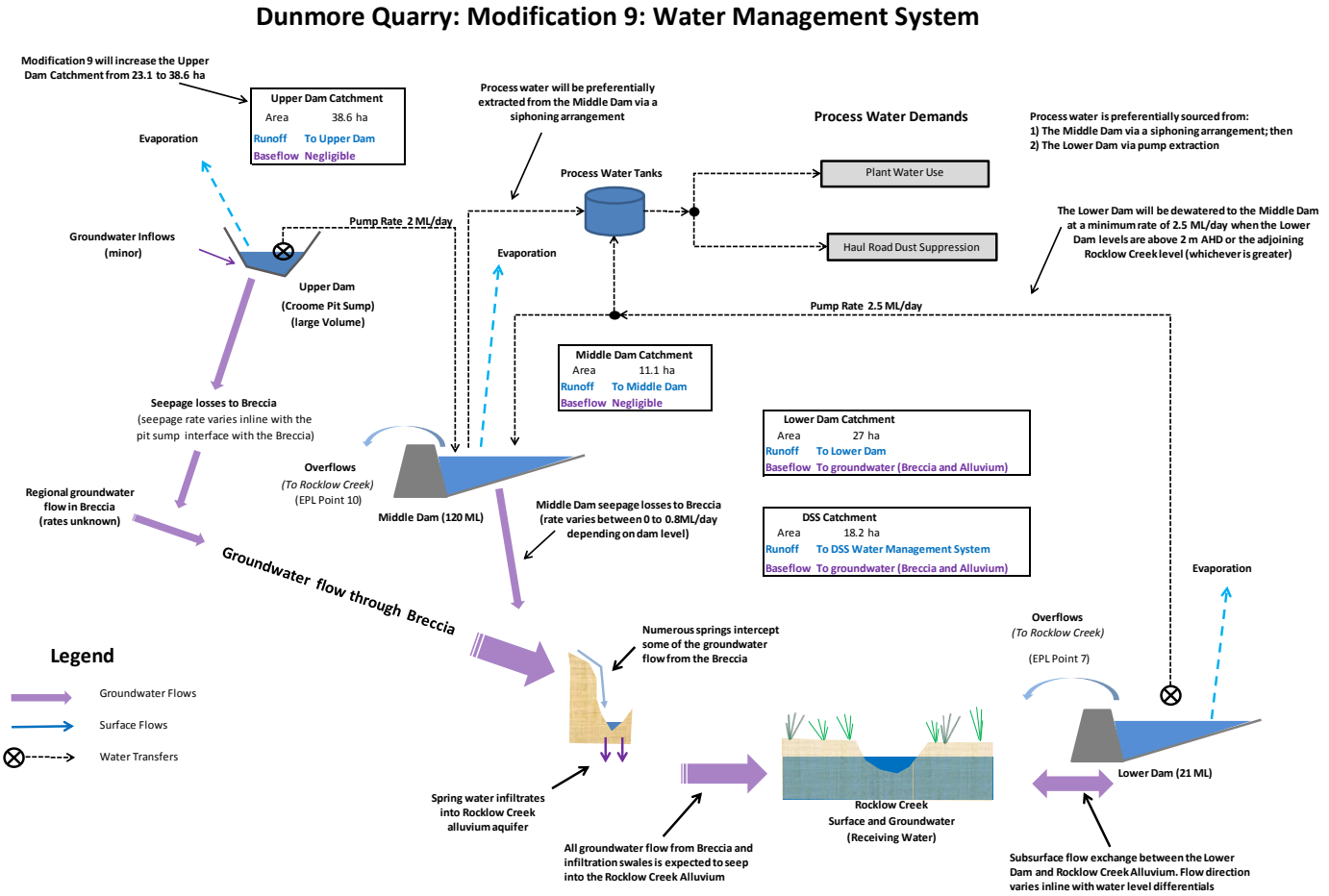


**Figure 20** – *Modification 9: Water Management System*

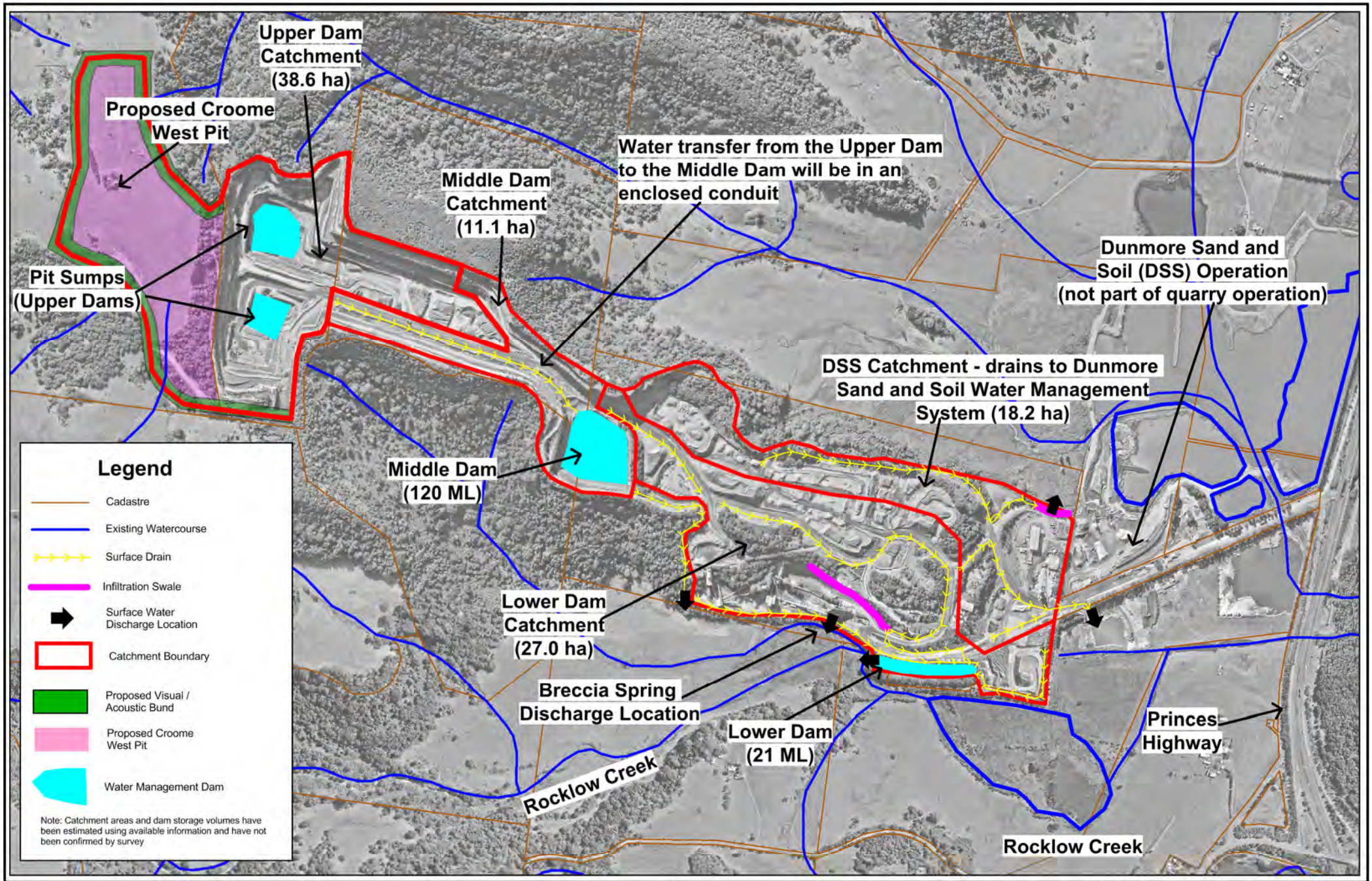


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**Figure 21** Modification 9Surface Water Management Plan

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0 125 250m
Approx. Scale

NORTH

## 5.3 Site Water Balance

A site water balance model was developed for the Existing Conditions, Existing Conditions with Improvements and Modification 9 scenarios. The objectives of the water balance models are to:

- Assess the frequency and volume of all site discharge mechanisms.
- Estimate volumes of groundwater ingress into the Lower Dam.
- Assist in the determination of water licensing requirements; and

This section details the modelling approach, assumptions and results.

### 5.3.1 Modelling Approach

The water balance model was established using a Visual-Basics Programme that has been developed independently by RHDHV. The model applies a continuous simulation methodology that simulates the performance of each scenario under a range of climatic conditions. The key features of the model are described below:

- The model runs on a daily time-step and requires daily rainfall and evaporation rates as model inputs. The model results are available on a daily time step, but are reported as annual averages to simplify the results presentation.
- The model runs as a continuous simulation and applies a long term (116 year) rainfall record that includes a wide range of embedded dry and wet periods as well as major flood events. The model results are processed to provide a statistical representation of the performance of each surface water management system, under a full range of climatic conditions.
- Results are presented in flow chart format for typical dry (10$^{th}$ Percentile), median (50$^{th}$ Percentile) and wet (90$^{th}$ Percentile) years. Select results such as dam overflows are also presented as summary charts.

The model was broadly calibrated using the water level data that is presented in **Section 4.3**.

### 5.3.2 Model Assumptions

This section details the assumptions applied to the water balance model.

#### *Climatic Data*

In order to facilitate a comprehensive assessment of a range of climatic conditions, a 116 year simulation period was adopted for the water balance model based on the available rainfall record. This simulation period applies the constructed daily rainfall record that is described in **Section 3.1**. The average monthly evaporation and potential evapotranspiration rates listed in **Table 3-2** were applied to the model.

#### *Calculation of Runoff*

The SIMHYD rainfall / runoff model was applied to simulate the rainfall runoff response from the catchments within the quarry's surface water management system. SIMHYD is one of the most commonly used rainfall runoff models in Australia and has been extensively tested using data from across Australia (*Chiew, 2005*).

The water level data presented in **Section 4.3** recorded changes in dam levels associated with a number of rainfall events of varying intensity and duration. Runoff volumes were calculated where possible from this data. The calculated runoff volumes were used to inform the parametrisation of the SIMHYD model for each catchment. The resulting average volumetric runoff coefficients ($C_v$) for each catchment are:

- **Upper Dam Catchment** – $C_v$ 0.49 or 49% of rainfall.
- **Middle Dam Catchment** – $C_v$ 0.69 or 69% of rainfall.
- **Lower Dam Catchment** – $C_v$ 0.44 or 44% of rainfall.
- **DSS Catchment** – $C_v$ 0.44 or 44% of rainfall.

These $C_v$ values are consistent with typical values for a hard rock quarry. It is noted that SIMHYD calculates runoff on a daily time step, as a function of soil moisture storage. Hence, $C_v$ for any given rainfall event will generally be below the long term average $C_v$ during dry conditions (due to the soils being dry before the event) and above the long term average $C_v$ during wet conditions when the soils are close to saturated before the event. This represents the effects of antecedent soil moisture conditions when calculating daily runoff.

## *Process Water Demands*

The process water demands documented in **Section 4.2.4** were applied equally to all scenarios.

Haul road dust suppression demands were calculated on a daily time step by applying the following equation:

$$DSupp(t) = \Big(\big(Evap(t) - Rain(t)\big) + LossFactor\Big) \times (Area \times 10)$$

Where:

*DSupp(t) = Daily water use for haul road dust suppression (KL/day)*

*Evap(t) = Daily pan evaporation (mm/day)*

*Rain(t) = Daily rainfall (mm/day)*

*Loss Factor = Daily loss factor (mm/day)*

*Area = Area of active haul road or stockpile (ha)*

A daily loss factor of 3 mm/day and an application area of 12.5 ha produced a good representation of the typical daily summer and winter application rates that are reported in **Table 4-3** (following correction for the 5 ½ days of operation per week).

Plant water use was applied at a constant rate of 70 KL/day in the water balance model.

## *Water Management Dams*

The Upper, Middle and Lower Dams are included in the model for each scenario. The storage volumes for each dam are consistent with the stated volume in the relevant water management figures for each scenario. It is noted that for the Existing Conditions with Improvements and Modification 9 scenarios, the upgraded Lower Dam volume of 21ML was applied to the model.

The level / storage characteristics for each dam were estimated by RHDHV from LiDAR levels and aerial photos.

## *Evaporation Losses*

Evaporation losses will occur from all water storages. The model calculates evaporation losses on a daily time step as a function of:

- **Evaporation Rates** - the average monthly evaporation rates provided in **Table 3-2** were applied to the water balance model. A Pan Coefficient of 0.7 was applied to all evaporation loss calculations from water management dams.
- **Dam Surface Area -** is a function of the dam stage (or level) and the level / volume properties of the storage. The water balance model calculates the surface area at each daily time step based on the water level and estimated level / area characteristics for each storage.

## *Middle Dam Seepage Losses*

**Section 4** established that the Middle Dam leaks into the underlying breccia rock at rates of up to 0.8 ML/day. Accordingly, seepage losses from the Middle Dam are a key component of the water balance. Middle Dam seepage rates were calculated from the water level data presented in **Figure 16**. This was done by calculating the change in dam storage volume for each day over the period. Days from which there was no influence from runoff or Upper Dam dewatering were selected for further analysis. The selected daily change in storage volumes were adjusted for a calculated evaporation loss rate, with the remaining loss assumed to be associated with dam seepage. **Figure 22** shows the resulting daily seepage loss estimates.

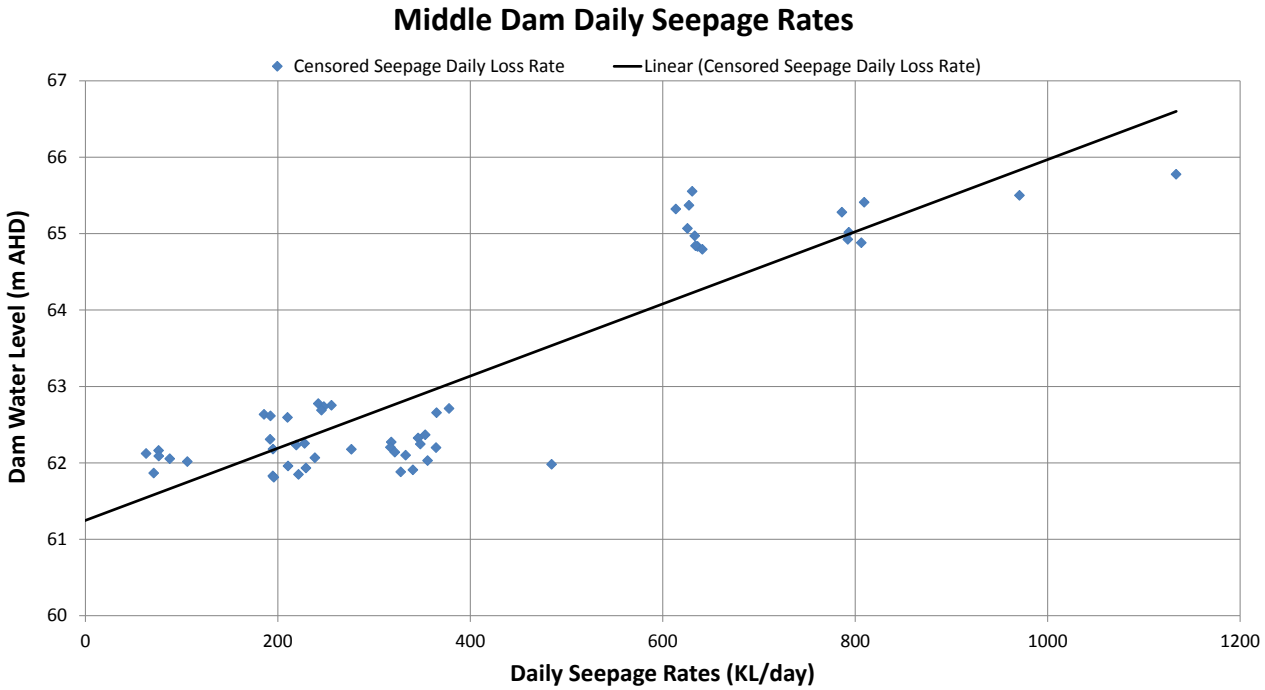



**Figure 22** –*Middle Dam Daily Seepage Loss Rates*

Seepage losses from the Middle Dam were applied to the water balance using a linear water level / seepage rate relationship indicated by the trend line in **Figure 22**.

## *Upper Dam Seepage Losses*

There is no data available to estimate lateral seepage losses from the Upper Dam into the breccia layer. However, it is expected that rates would be substantially lower than the Middle Dam rates as the seepage would occur laterally rather than vertically, and would therefore be driven by less head. For the purposes of water balance modelling, seepage was assumed to occur at a nominal rate when the pit sump volume exceeds 10 ML.

For the Modification 9 scenario, no seepage losses from the Upper Dam were assumed to occur as it is proposed to quarry through the breccia layer to extract the Lower Lava Flow resource.

## *Lower Dam Seepage*

Seepage from the Lower Dam into the adjoining Rocklow Creek Alluvium is expected to occur for short periods of time when the dam level is higher than the adjoining Rocklow Creek surface / groundwater levels. For the purposes of water balance modelling it was assumed that seepage from the dam occurs at a rate of 200 KL/day when the dam's water level is above 2.5m AHD.

## *Groundwater Ingress into the Lower Dam*

As discussed in **Section 4.2.4**, it is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Historically all process water has been extracted from the Lower Dam, with the majority of the water expected to have been drawn from the Rocklow Creek Alluvium via groundwater ingress into the dam. For the purposes of water balance modelling, it is assumed that groundwater ingress into the Lower Dam is equivalent to the volume of process water extracted from the dam when the dam's water level is below 2m AHD.

## *Groundwater Pit Inflows*

Groundwater inflows into the pit are expected to negligible over the life of the quarry. **Table 5-3** provides estimated inflow rates that were established as part of the Groundwater Assessment (EMM, 2016).

**Table 5-3** – *Groundwater Inflow Rates*

| Quarry Stage | Average Pit Seepage Rates (ML/year) |
|---|---|
| Existing Conditions | 0.01 |
| Mod 9 – Stage 1 | 0.80 |
| Mod 9 – Final Pit | 0.07 |

Note: Groundwater inflow rates sourced from the Groundwater Assessment (EMM, 2016)

## *Water Transfers*

Water transfers between storages, demands and sources are controlled using transfer rules that are based on storage levels, demand requirements and source availability. For the Existing Conditions scenario, the operating principles documented in **Section 4.2** were applied. For the Existing Conditions with Improvements and Modification 9 scenarios the proposed amendments discussed in **Sections 5.1** and **5.2** were applied.

### 5.3.3 Water Balance Results

This section documents site water balance results for the three scenarios assessed. For each scenario results are presented in flow chart form for typical dry (10th Percentile), median (50th Percentile) and wet (90th Percentile) rainfall years. The flow charts show total water movements over the year. ***Table 5-4*** provides a figure schedule for the water balance results. Water balance results are discussed at the end of this section.

**Table 5-4** – *Water Balance Results Figure Schedule*

| Scenario | Dry Year | Median Year | Wet Year |
|---|---|---|---|
| Existing Conditions | **Figure 23** | **Figure 24** | **Figure 25** |
| Existing Conditions with Improvements | **Figure 26** | **Figure 27** | **Figure 28** |
| Modification 9 | **Figure 29** | **Figure 30** | **Figure 31** |

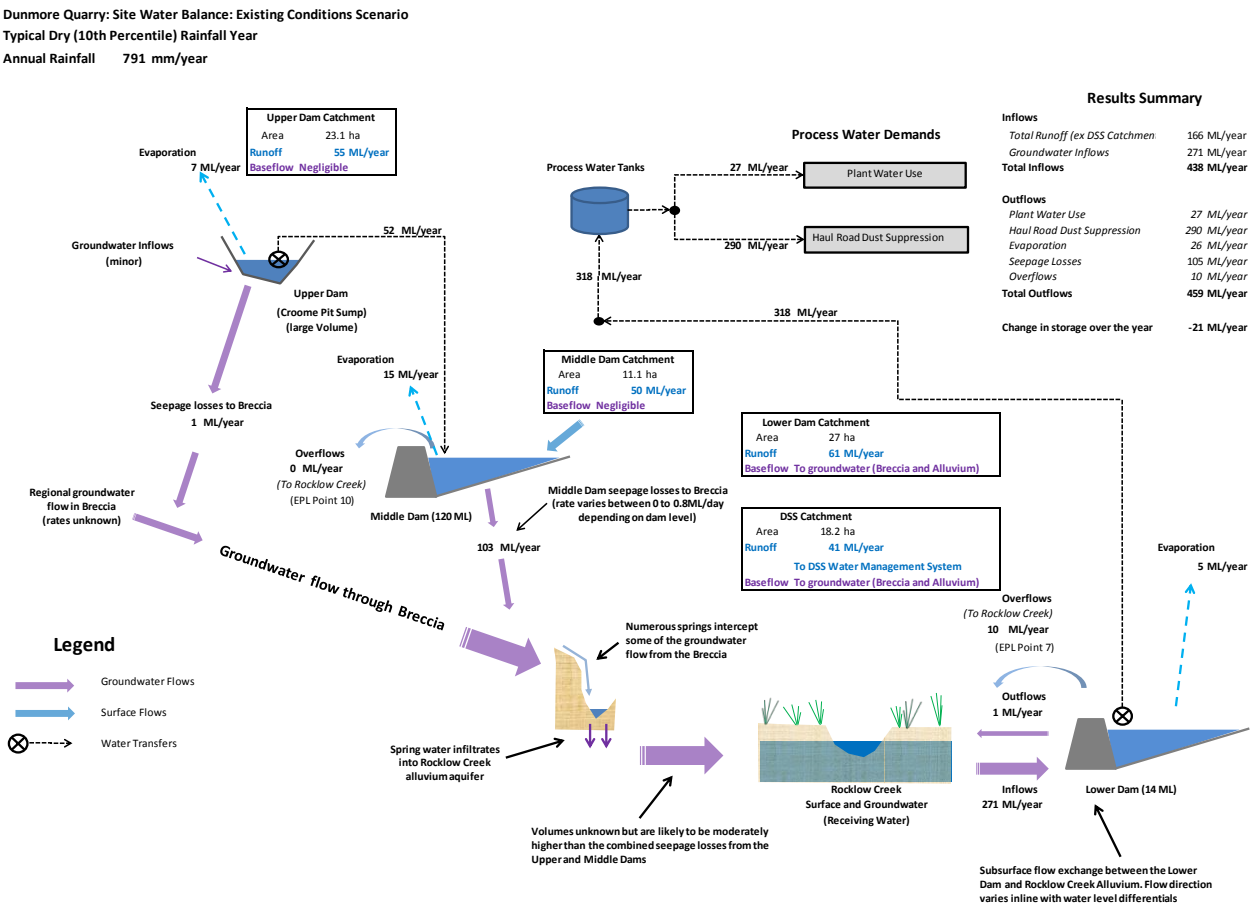



**Figure 23** – *Existing Conditions Scenario: Typical Dry Year Results*

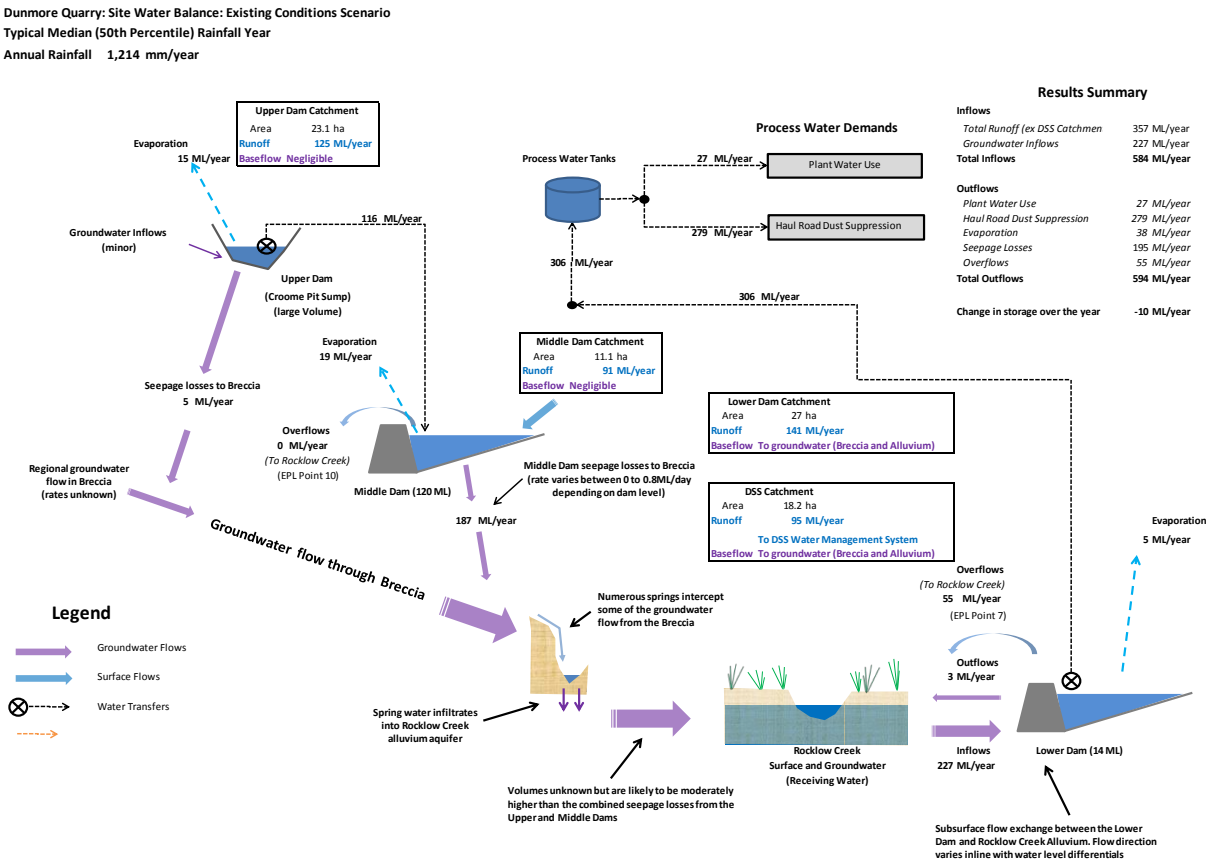



**Figure 24** – *Existing Conditions Scenario: Typical Median Year Results*

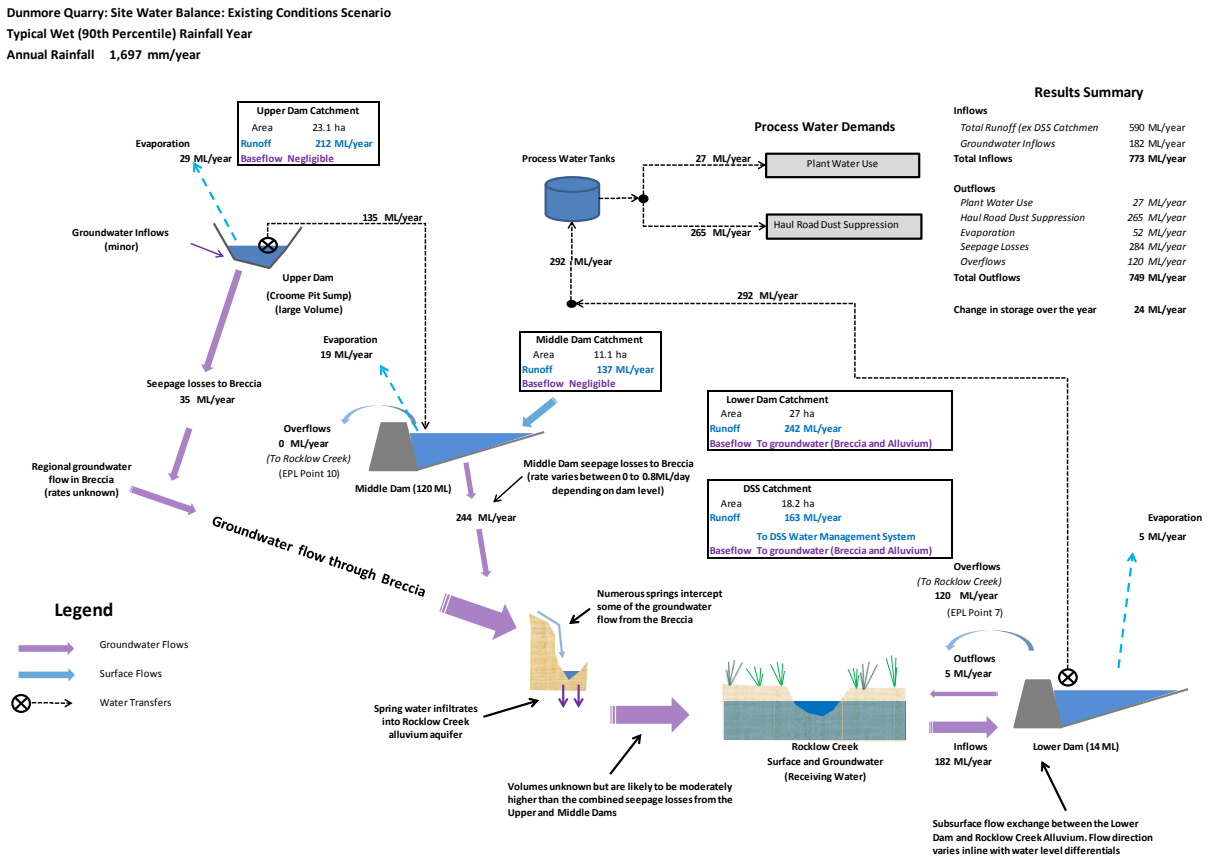



**Figure 25** – *Existing Conditions Scenario: Typical Wet Year Results*

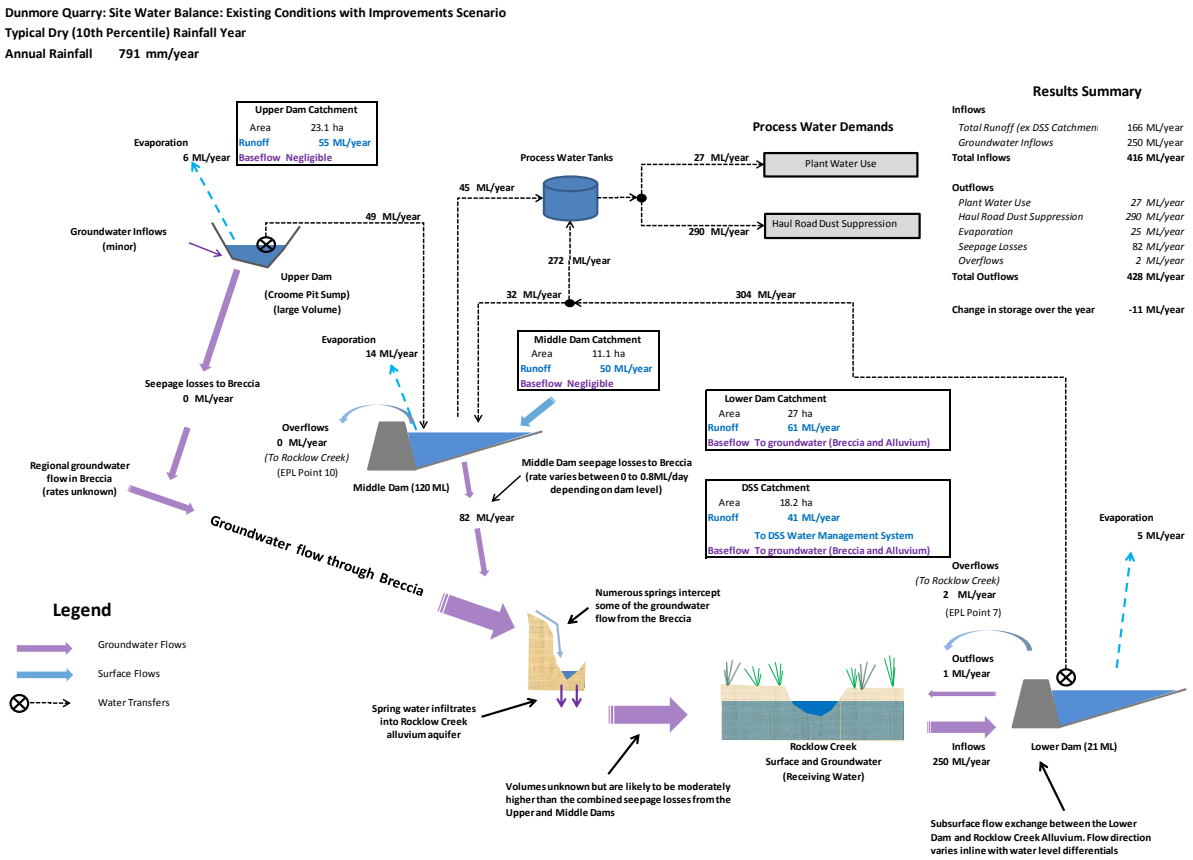



**Figure 26** – *Existing Conditions with Improvements Scenario: Typical Dry Year Results*

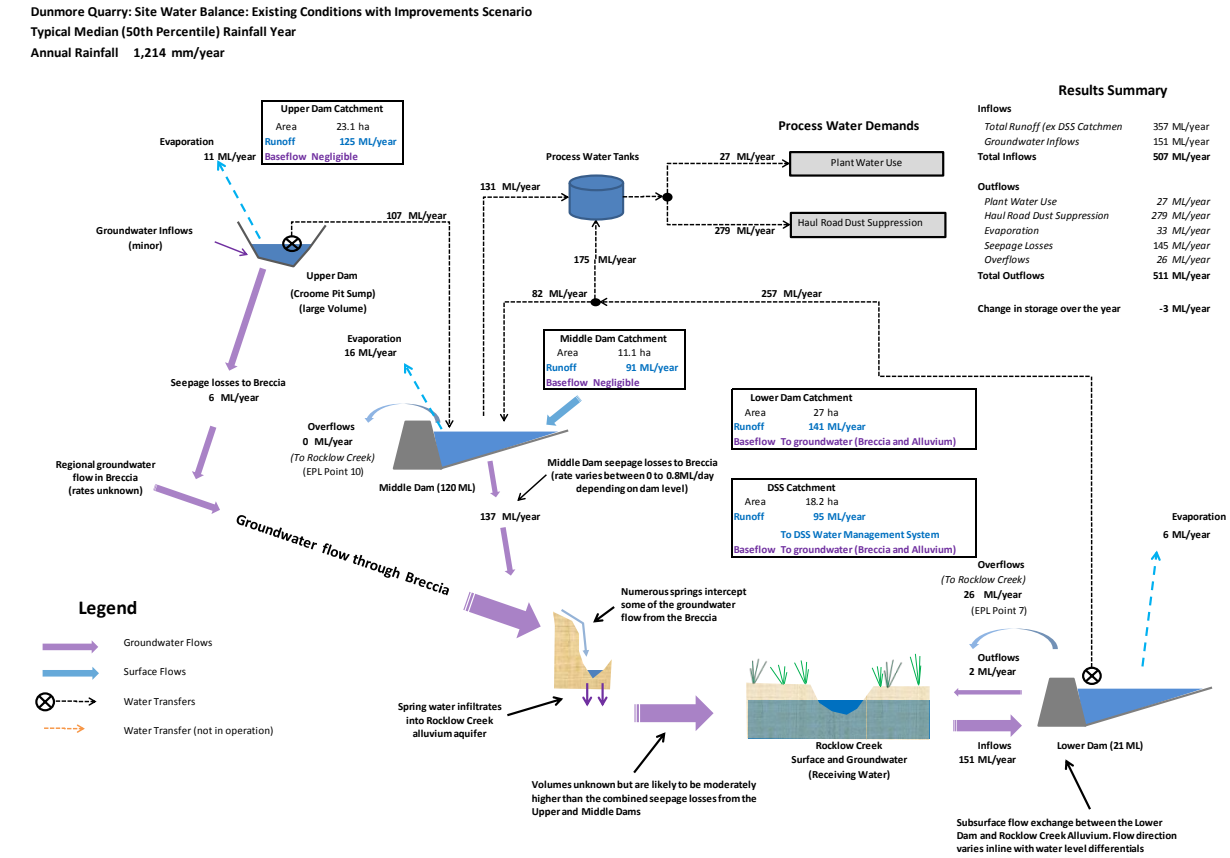



**Figure 27** - *Existing Conditions with Improvements Scenario: Typical Median Year Results*

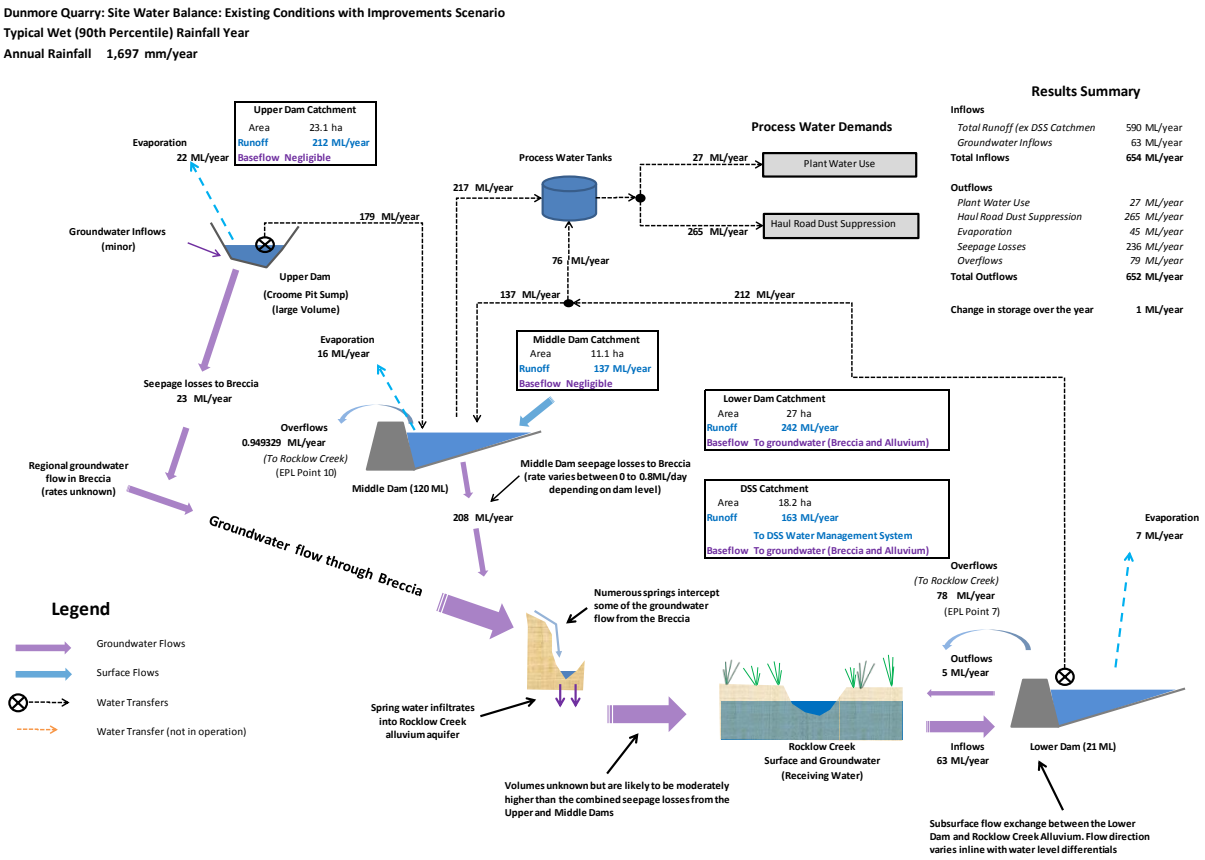



***Figure 28*** – Existing *Conditions with Improvements Scenario*: Typical *Wet* Year *Results*

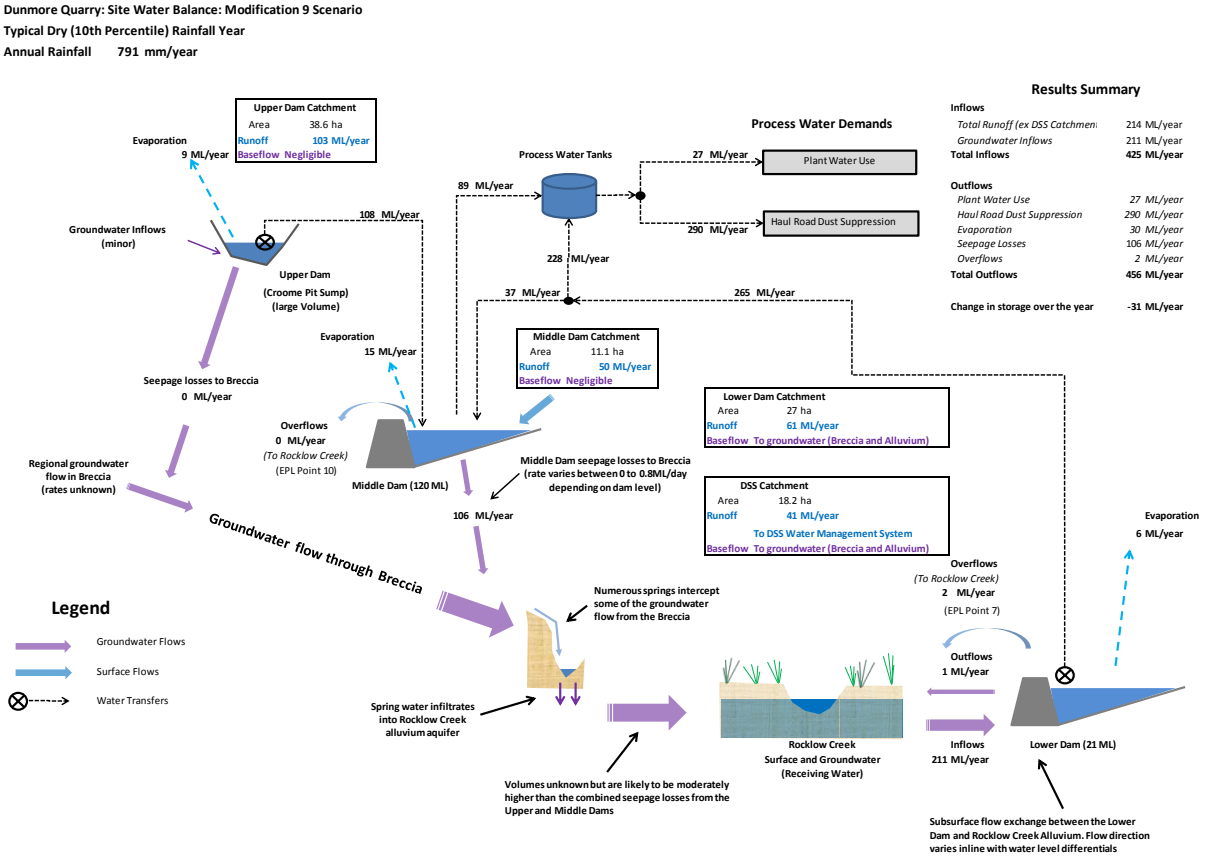



**Figure 29** – *Modification 9 Scenario: Typical Dry Year Results*

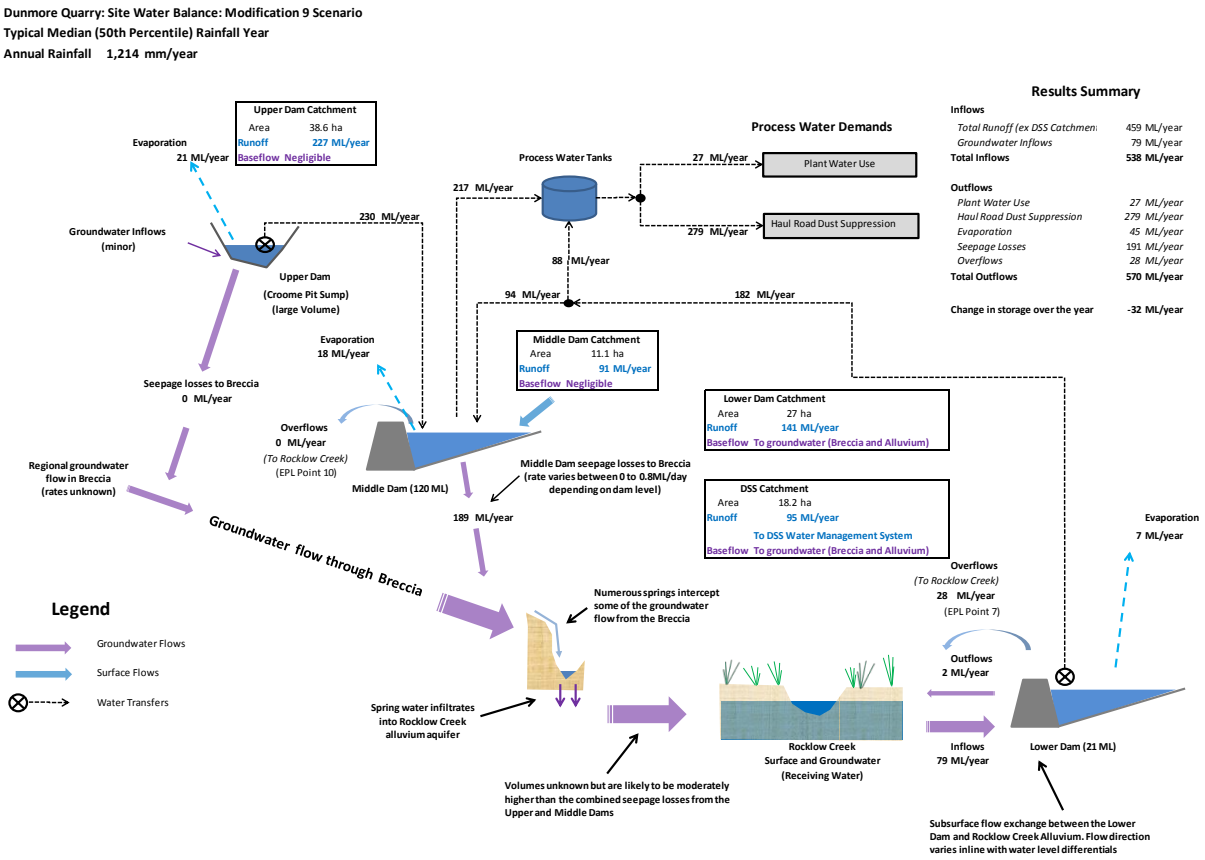



**Figure 30** - *Modification 9 Scenario: Typical Median Year Results*

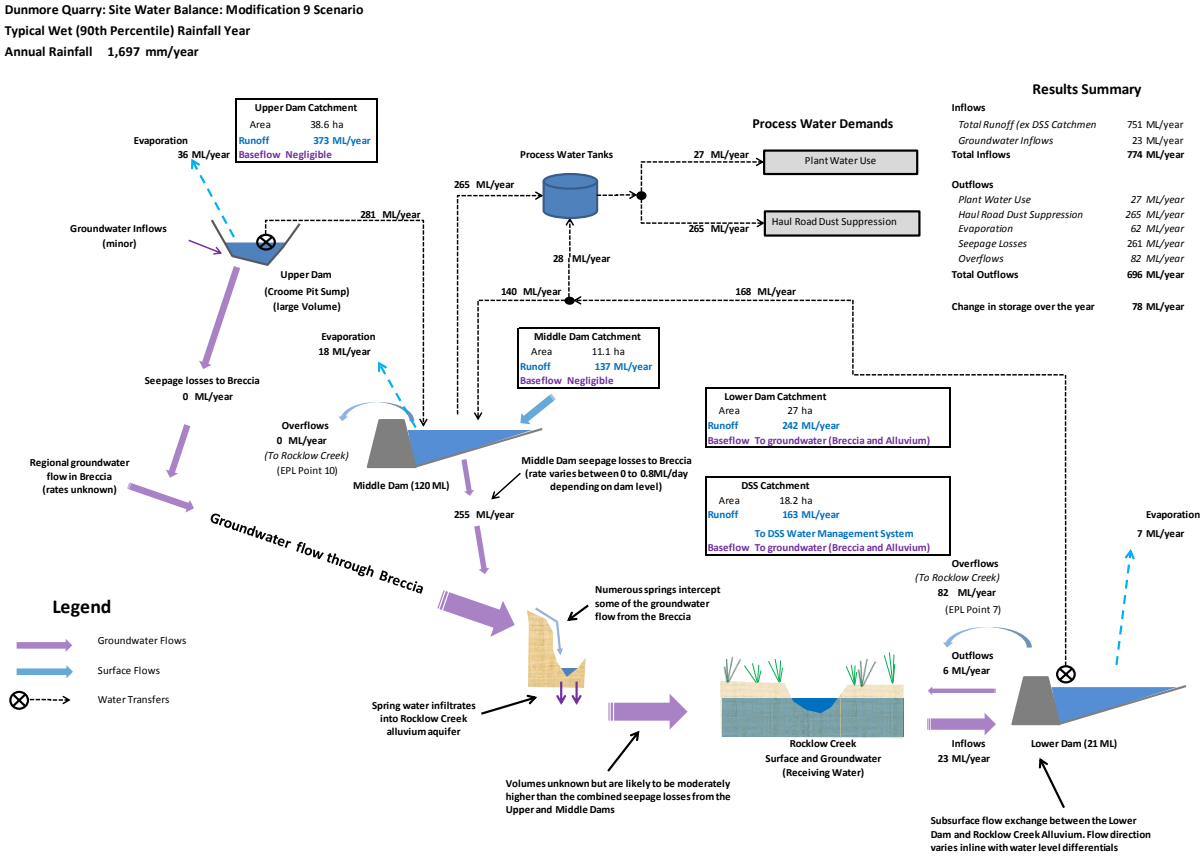



**Figure 31** - *Modification 9 Scenario: Typical Wet Year Results*

## *Water Balance Results Summary Charts*

The following percentile charts compare key results from the three water balance scenarios:

- **Figure 32** compares the predicted annual overflow volumes from the Lower Dam (EPL #7).
- **Figure 33** compares the predicted Middle Dam seepage volumes.
- **Figure 34** compares the predicted Lower Dam groundwater ingress volumes.

The results are discussed following the figures.

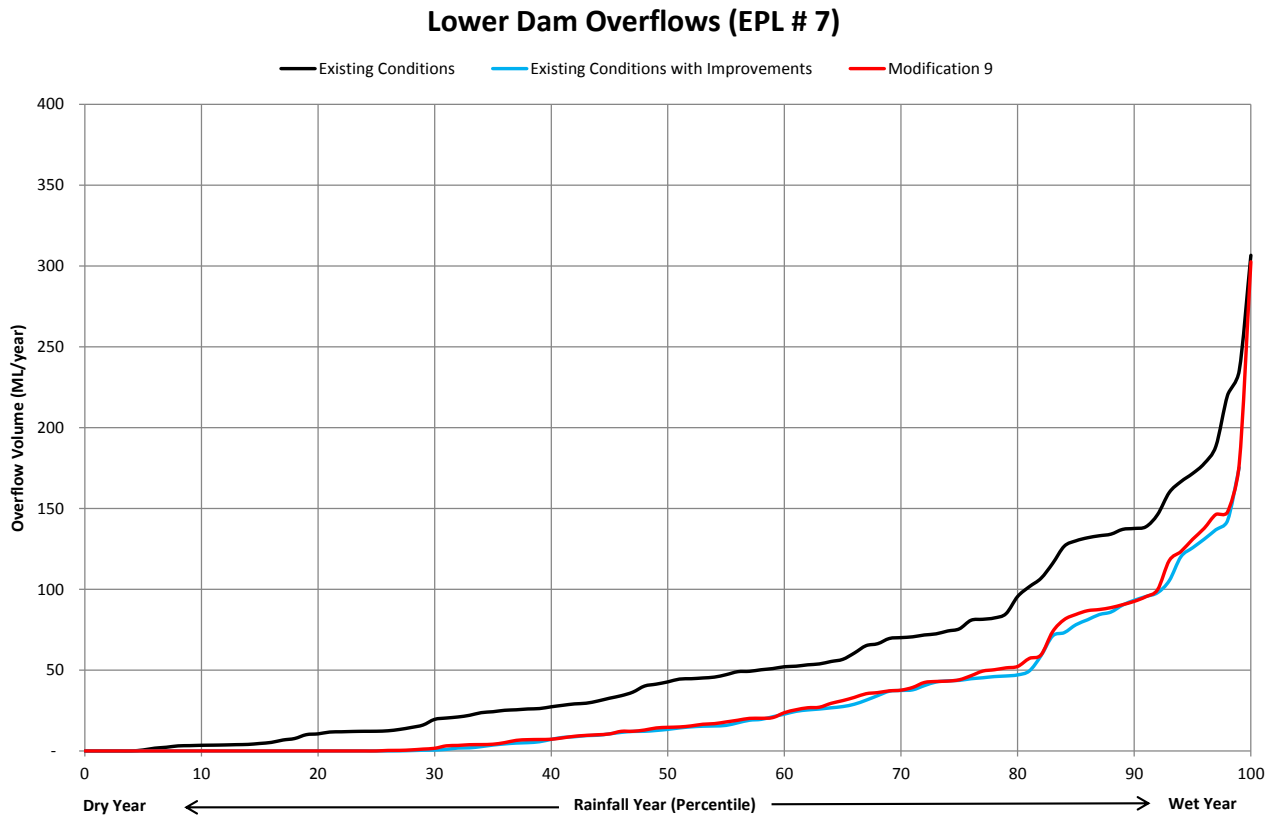



**Figure 32** – *Predicted Lower Dam overflows (EPL# 7)*

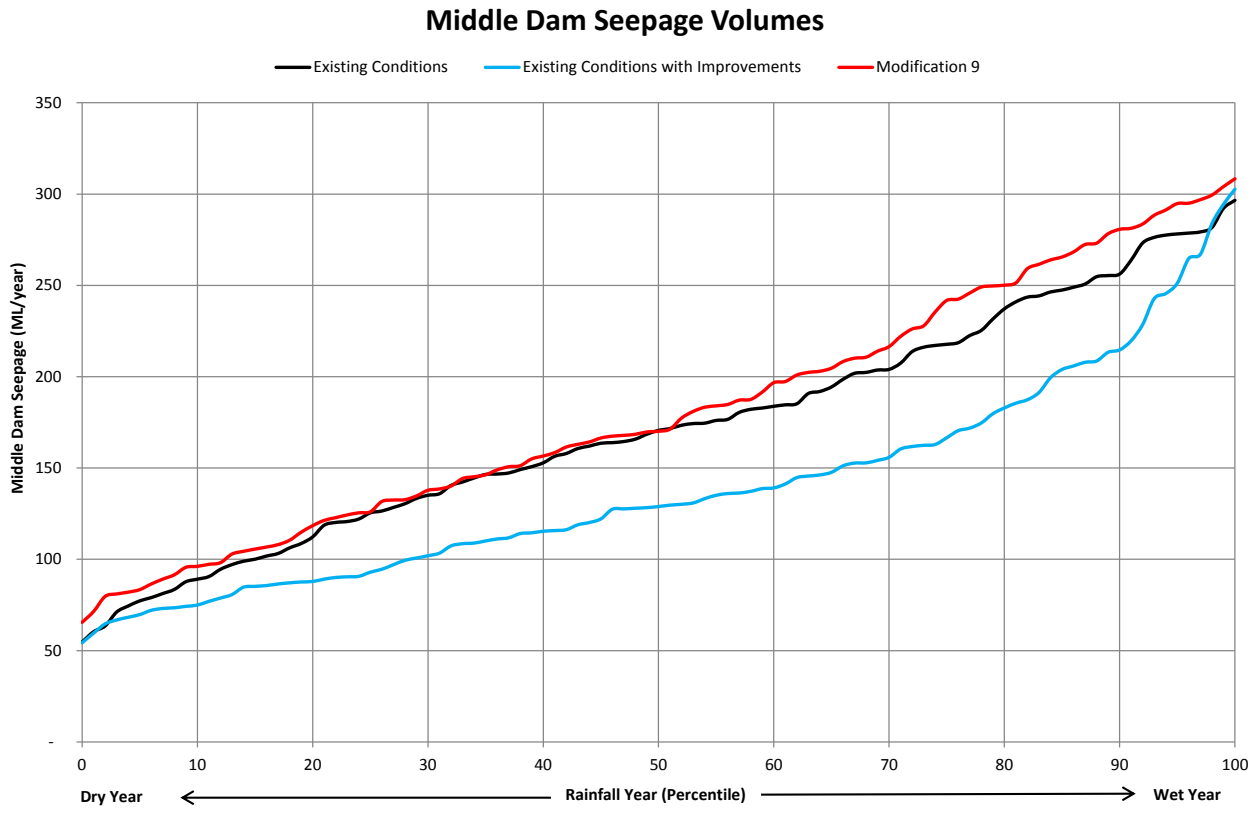



**Figure 33** – *Predicted Middle Dam Seepage Volumes*

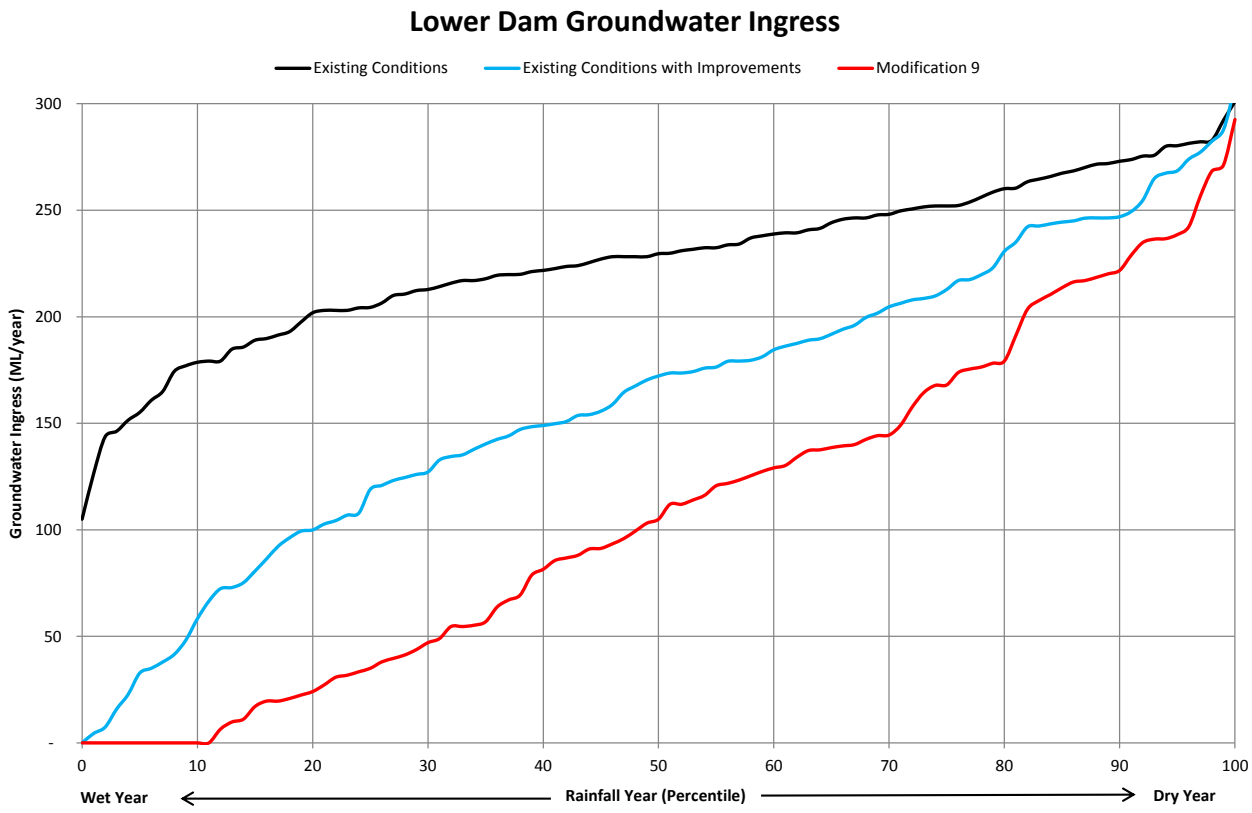



**Figure 34** – *Lower Dam Groundwater Ingress Volumes*

### 5.3.4 Results Discussion

This section discusses the key water balance results.

## *Discharge Characteristics*

Water balance model results indicate that for all three scenarios, discharge from the quarry's water management system will occur via Breccia Spring flows, Lower Dam overflows and runoff from the DSS Catchment into the DSS Water Management System. Model results indicate that overflows from the Middle Dam will occur occasionally during extreme rainfall events (i.e. once every 20 years).

Volumetrically, predicted seepage losses from the Middle Dam (which is a key contributor to Breccia Spring flows) are higher than the Lower Dam overflows and runoff volumes from the DSS Catchment, indicating that the Breccia Spring flows are the quarry's primary discharge mechanism.

## *Lower Dam Groundwater Ingress*

Model results for all scenarios indicate that groundwater ingress into the Lower Dam is a key source of water. The reliance on this water source increases in drier conditions. If this arrangement was not in place the quarry would require access to an alternative local groundwater resource to meet process water needs during dry conditions.

## *Drought Security*

Historically the operation has not experienced water shortages due to the Lower Dam's connectivity with the Rocklow Creek Alluvium. It is expected that the proposed water management improvements and establishment of the Croome Farm West Pit will improve the overall drought security by reducing reliance on groundwater inflows and increasing the overall runoff volumes into the water management system.

## *Changes due to Proposed Water Management Improvements*

As discussed in **Section 5.1**, Boral is proposing to implement the following improvements to the existing water management system:

- Upgrade the Lower Dam to improve its sedimentation treatment functionality.
- Reconfigure the process water extraction regime to preferentially source water from the Middle Dam rather than then Lower Dam. This will reduce groundwater ingress into the Lower Dam and reduce Middle Dam seepage rates and associated Breccia Spring flows.

Water balance results indicate that collectively these initiatives are predicted to:

- Reduce overflows from the Lower Dam by more than 50% in most years (**Figure 32**).
- Reduce Middle Dam seepage volumes by between 20 and 30% in most years (**Figure 33**). This will result in a commensurate reduction in Breccia Spring flow volumes.
- Reduce groundwater ingress into the Lower Dam by between 10% (dry year) and 70% (wet year) (**Figure 34**).

## *Changes due to Modification 9*

Modification 9 seeks to extend the Croome Farm Pit by approximately 14.4 ha to enable extraction within the Croome West Pit. There are no changes proposed to the production rates, existing quarry infrastructure or process water demands. The Croome West Pit will increase the contributing catchment area to the quarry's water management system by an estimated 15.5 ha.

Water balance results for the Modification 9 scenario (which includes the proposed improvements to the existing water management system) indicate that:

- Modification 9 will not impact the functionality of the Lower Dam, with no material change to the overflow regime for the Existing Conditions with Improvements Scenario predicted (**Figure 32**). This enables the benefits of the Lower Dam improvement works to be fully realised under a Modification 9 scenario.

- The Middle Dam seepage volumes are predicted to be maintained at existing levels, with the additional dewatering requirements from the Upper Dam being fully offset by preferentially sourcing process water from the Middle Dam. This indicates that Modification 9 (when combined with the proposed improvements to the existing water management system) will not result in a material increase in Breccia Spring flows and associated Nitrate and Copper loads that are discussed in **Section 4.4**.

- Modification 9 will result in a further reduction in groundwater ingress volumes into the Lower Dam, with a 100% reduction predicted in wet years and a 20% reduction predicted in dry years. This reduction is due to the increased availability of process water from the Middle Dam due to the increase in dewatering volumes from the Upper Dam.

In summary, water balance model results indicate that when combined with the proposed water management improvements, Modification 9 will have a neutral to beneficial impact on the receiving water through:

- Reducing the frequency and magnitude of overflows from the Lower Dam.

- Maintaining Breccia Spring discharge volumes and associated Nitrate and Copper loads at existing levels.

- Reducing the volume of groundwater ingress into the Lower Dam.

# 6 PREDICTED IMPACTS AND COMPLIANCE RISK ASSESSMENT

This section discusses predicted surface water impacts associated with the proposed modification and documents a compliance risk assessment.

## 6.1 Surface Water Quantity Impacts

The proposed Croome West Pit will have a footprint of 14.4 ha and the visual and acoustic bund will have a footprint of 5.7 ha. Collectively these works will disturb 20.1 ha of land. **Figure 35** shows the location of these works relative to the existing catchment extents.

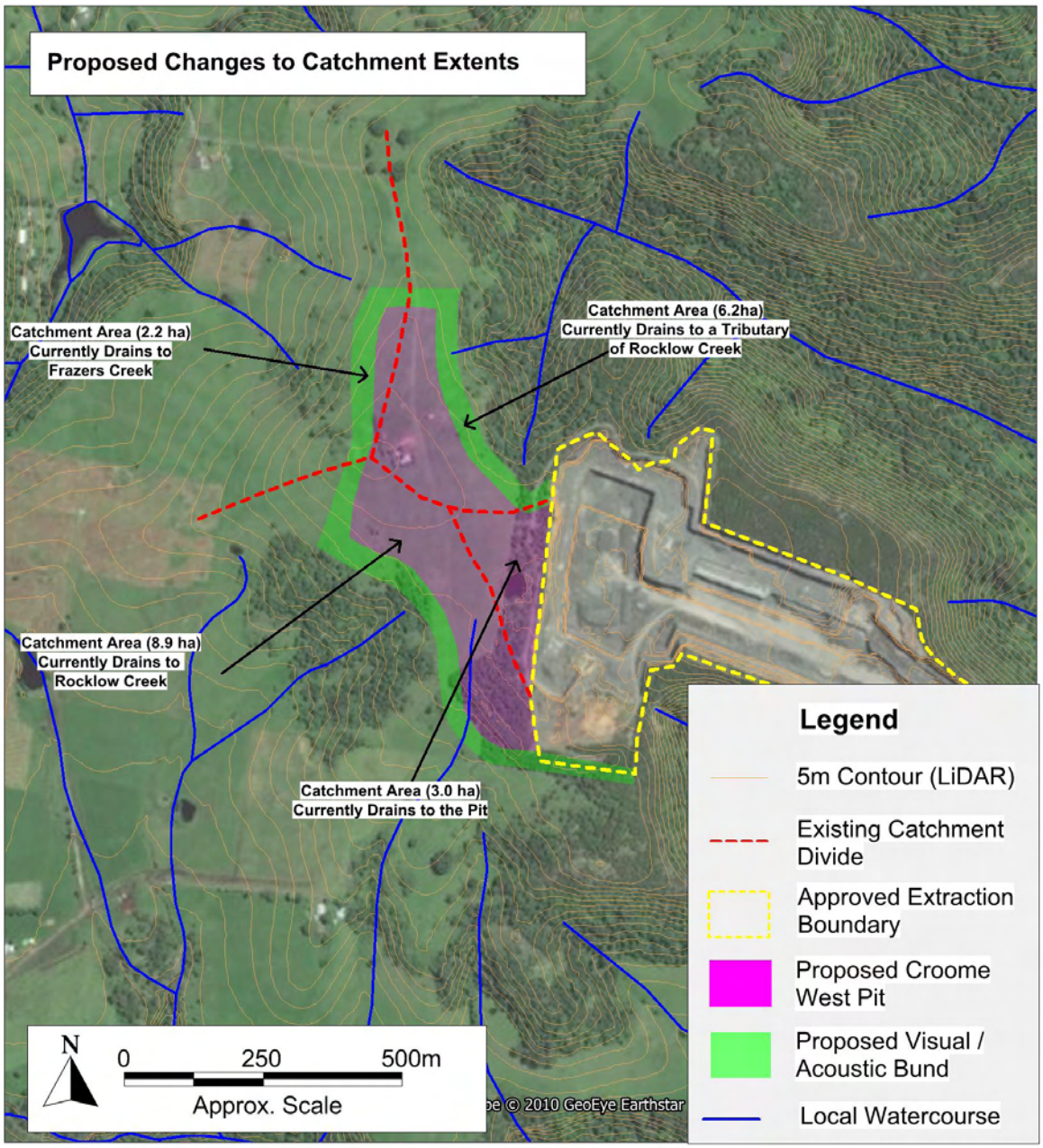



**Figure 35** – *Proposed Changes to Catchment Extents*

As indicated in **Figure 35** the existing topography within the Croome West Pit area falls to the north and south into the Rocklow Creek Watershed, to the west into the Frazers Creek Catchment and to the east into the existing Croome Farm Pit. All runoff from the Croome West Pit area and the inner portion of the berm will be permanently diverted into the quarry's water management system. Accordingly, the proposed works are expected to permanently reduce the contributing catchment area to Rocklow Creek by up to 13.8ha and Frazers Creek by up to 1.7ha. This change in catchment extents is considered to be unavoidable but will result in a minor reduction in stream flows in the downstream receiving waters. The resulting impacts are expected to be negligible given that both Rocklow and Frazer Creeks have significant catchment areas.

DPI-Water has advised that there are no licensed surface water users in the immediate receiving waters downstream of the quarry site. Hence, no impacts to existing surface water users are expected.

## 6.2 Groundwater Quantity Impacts

As discussed in **Section 4.2.4**, it is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Historically all process water has been extracted from the Lower Dam, with the majority of the water expected to have been drawn from the Rocklow Creek Alluvium via groundwater ingress into the dam. Boral is proposing to reconfigure the process water extraction regime to preferentially source water from the Middle Dam rather than then Lower Dam. Extraction from the Lower Dam will only occur when the Middle Dam level is below 30%. This is expected to materially reduce the volume of groundwater that is taken from the Rocklow Creek Alluvium via groundwater ingress into the Lower Dam.

Modification 9 will result in a further reduction in groundwater ingress volumes into the Lower Dam as the additional runoff volume from the Croome West Pit will increase the volume of water available in the Middle Dam for process water use. Water balance results presented in **Section 5.3** indicate that Modification 9 (when combined with the proposed improvements to the existing water management system) will result in a 100% reduction groundwater take from the Rocklow Creek Alluvium in wet years and a 20% reduction in dry years.

Water licencing provisions are discussed separately in **Section 8**.

## 6.3 Receiving Water Quality Impacts

The proposed modification seeks to expand the Croome Farm Pit by approximately 14.4ha to enable extraction within the Croome West Pit. There are no changes proposed to the production rates, existing quarry infrastructure or process water demands. The Croome West Pit will increase the contributing catchment area to the quarry's water management system, which will result in higher runoff volumes reporting to the Upper Dam and Middle Dam (via dewatering of the Upper Dam).

**Section 4** established that under existing conditions, all water that accumulates in the Middle Dam seeps into the underlying breccia rock and contributes to the Breccia Spring flows that are interpreted to seep into the Rocklow Creek Alluvium at a location near the quarry's material processing plant. Water quality data presented in **Section 4.4** established that the Breccia Spring flows contain elevated Nitrate and Copper concentrations. Accordingly, there is potential for the increase in pit dewatering volumes to the Middle Dam associated with the establishment of the Croome West Pit, to increase Nitrate and Copper loads entering the Rocklow Creek Alluvium.

However, Boral is proposing to reconfigure the process water extraction regime to preferentially source water from the Middle Dam rather than then Lower Dam. This will reduce Middle Dam seepage rates and associated Breccia Spring flows. Water balance model results presented in

**Section 5.3** indicate that the Middle Dam seepage volumes are predicted to be maintained at existing levels, with the additional dewatering requirements from the Upper Dam being fully offset by preferentially sourcing process water from the Middle Dam. This indicates that Modification 9 (when combined with the proposed improvements to the existing water management system) will not result in a material increase in Breccia Spring flows and associated Nitrate and Copper loads to receiving waters. Accordingly, Modification 9 is not expected to result in any material receiving water quality impacts.

## 6.4 Relevant Consent Conditions Compliance Risk Assessment

**Table 2-1** included a summary of the eighteen water management related consent conditions. Six conditions (numbers 28, 28A, 29, 31, 32 and 33) were considered to be relevant to this surface water assessment. The remaining conditions relate to either the ongoing management of the existing operation or legacy issues and are not considered to be relevant to the assessment of impacts associated with the proposed modification.

**Table 6-1** reproduces the above-mentioned relevant consent conditions and assesses compliance risks associated with the proposed water management system.

**Table 6-1** – *Assessment of Relevant Consent Conditions*

| Condition of Approval | Relevant Consent Condition | Assessment of Compliance Risk |
|---|---|---|
| **28** | Except as may be expressly provided by an Environment Protection Licence, the Applicant shall comply with section 120 of the Protection of the Environment Operations Act 1997 during the carrying out of the development. | As discussed in **Section 6.3**, the proposed modification is not expected to result in any material receiving water quality impacts. The SWCA presented in **Section 4.4** identified elevated Nitrate and Copper levels in Breccia Spring discharges from the quarry's water management system. These discharges are not currently licensed under the Protection of the Environment Operations Act 1997.<br><br>Boral propose to consult with the EPA to establish appropriate licencing arrangements. |
| **28A** | The Applicant must ensure that is has sufficient water for all stages of the development, and if necessary, adjust the scale of quarrying operations to match its available water supply. | Historically the operation has not experienced water shortages due to the Lower Dam's connectivity with the Rocklow Creek Alluvium. It is expected that the proposed water management improvements and establishment of the Croome Farm West Pit will improve the overall drought security by reducing reliance on groundwater inflows and increasing the overall runoff volumes into the water management system. |
| **29** | Except as may be expressly provided by an Environmental Protection Licence, the Applicant shall ensure that the discharges from any licenced discharge point/s comply with the following concentration limits:<br>• TSS – 50 mg/l<br>• PH 6.5 to 8.5 | Water quality monitoring results presented in **Table 4-6** indicate that uncontrolled overflows from the Lower Dam (EPL #7) recorded TSS concentrations greater than 50 mg/l on a number of occasions, indicating that the existing system does not comply with this condition. As discussed in **Section 5**, Boral are proposing to modify the Lower Dam to improve its sedimentation treatment functionality. |
| **31** | The Applicant shall ensure that the stormwater management system for the development is designed, constructed and operated to capture and treat polluted waters from storm event(s) of up to and including the 5-day, 95th percentile rainfall event. | **Section 5.1** reviewed the functionality of the Lower Dam. This review identified that the Lower Dam does not contain sufficient sedimentation treatment volume to comply with Consent Condition 31. , Boral are proposing to modify the Lower Dam to improve its sedimentation treatment functionality. These modifications will increase sedimentation treatment volume to comply with this Consent Condition. |
| **32** | The Applicant shall ensure that the basins in the stormwater management system are managed in accordance with the operating principles within the revised Water Management Plan prepared by Evans and Peck, dated April 2008, or any subsequent Water Management Plan approved by the Secretary, to maintain the required storm water storage volume. | This Surface Water Assessment has identified some significant departures from the water management system that is document in both the Evans & Peck (2008) and current Arcadis (2016) site Water Management Plans. Accordingly, Consent Condition 32 requires review. |

| Condition of Approval | Relevant Consent Condition | Assessment of Compliance Risk |
|---|---|---|
| **33** | By 18 May 2008, or as otherwise agreed to by the Secretary, the Applicant shall, to the satisfaction of the EPA and the Secretary:<br>a) modify the existing dam at the site to create a dam with an increased capacity offline from Rocklow Creek;<br>b) construct new dams within the Quarry of sufficient capacity so that water quality at condition 29 can be met for all rainfall events up to and including the 5 day duration 95$^{th}$ percentile rainfall event.<br>c) ensure the discharge and overflow points of the dam do not cause erosion at the point of discharge/overflow;<br>d) rehabilitate and stabilize the banks of the dam; and<br>e) ensure the integrity of the dam would not be compromised by any flooding in Rocklow Creek; | **Section 5.1** reviewed the functionality of the Lower Dam. This review identified that the:<br>• Lower Dam does not contain sufficient sedimentation treatment volume to comply with Consent Condition 31.<br>• Inflows from Rocklow Creek occur during any material Rocklow Creek runoff event.<br>Boral are proposing to modify the Lower Dam and its operational procedures to improve its sedimentation treatment functionality. The modifications include relocating and raising the dam's spillway, increasing the sedimentation treatment volume and implementing a dewatering regime. Once the proposed dam upgrades are implemented it is expected that the Lower Dam will broadly be operated in accordance with the operating principles described in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008). The upgraded dam will also broadly comply with Consent Conditions 31 and 33, which requires the dam to capture and treat all runoff from storm events up to and including the 5 day 95$^{th}$ percentile rainfall event. |

# 7 CUMULATIVE IMPACTS

Sydney Trains owns Lot 1 DP 100295, which is located to the east of the existing Croome Farm Pit. Extraction of material from this lot commenced in 1986. The resulting quarry workings are referred to as the RailCorp Extraction Area. Sydney Trains has indicated to Boral that they plan to extend the RailCorp Extraction Area to the north, increasing the extraction footprint by approximately 4ha. **Figure 36** shows the extent of land owned by Sydney Trains as well as the existing and potential future RailCorp Extraction Areas.

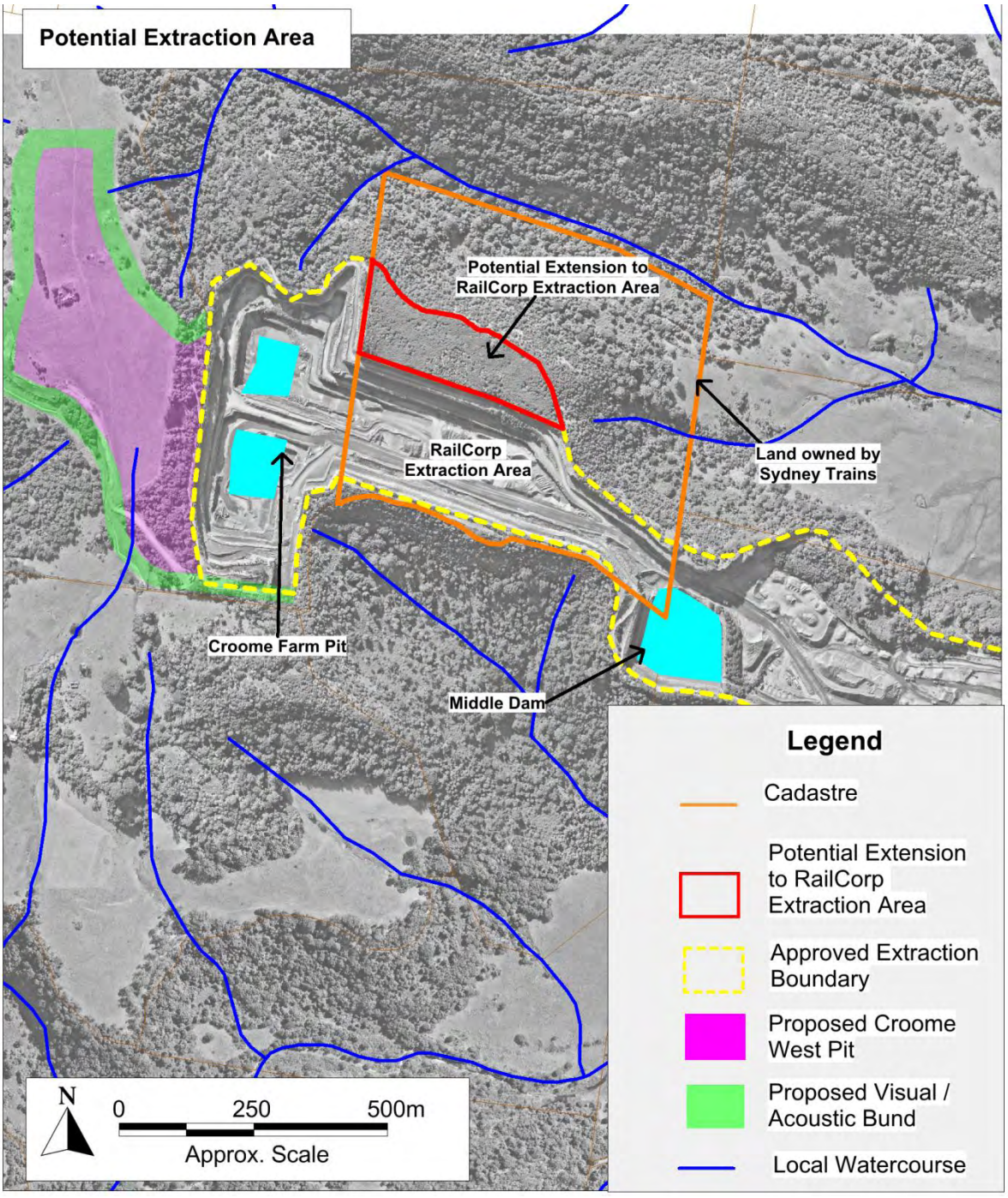



**Figure 36** – *Sydney Trains landholdings and existing and potential extraction areas*

The proposed 4ha extension of the RailCorp Extraction Area may increase the volume of surface water that will require management. A cumulative impact assessment has been undertaken to establish any implications to the functionality of the quarry's proposed water management system. This section documents the cumulative impact assessment and is structure as follows.

- **Section 7.1** documents water balance modelling that has been undertaken to assess a RailCorp Extraction Area extension scenario (RailCorp scenario).
- **Section 7.2** provides a summary of cumulative impacts.

It is noted that an extension of the RailCorp Extraction Area does not form part of Modification 9 and any extension proposal will be subject to separate environmental approvals.

## 7.1 Water Balance Modelling

The Modification 9 scenario water balance model was modified to assess a RailCorp Extraction Area extension scenario. The only change to the model was to increase the contributing catchment area to the Middle Dam from 11.1 to 15.1ha to represent a 4ha expansion of the RailCorp Extraction Area. As there is currently no information available regarding any proposed stormwater controls or quarry plans for the expansion area, it was conservatively assumed that:

- No additional water storage will be established within Sydney Trains owned land. However, it is expected that Sydney Trains will establish water management controls that are consistent with industry best practice; and
- There will be no increase in process water usage.

Model results are compared to the Modification 9 scenario results and are presented in the following formats:

- **Flow Chart Format** - Results are summarised in flow chart format for typical dry (10$^{th}$ Percentile), median (50$^{th}$ Percentile) and wet (90$^{th}$ Percentile) rainfall years. Flow charts are provided in **Appendix E.**
- **Table Summary** – Key changes to the Modification 9 scenario results are summarised in **Table 7-1**.

**Table 7-1** – *RailCorp Scenario Water Balance Summary Table*

| | Units | Modification 9 Scenario | | | RailCorp Scenario[1] | | | Relative Change | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Rainfall Year | | | Rainfall Year | | | Rainfall Year | | |
| | | Dry | Median | Wet | Dry | Median | Wet | Dry | Median | Wet |
| **Total Catchment Area** | (ha) | 95 | | | 99 | | | 4 or 4.2% | | |
| **Total Runoff Volume** [2] | (ML/year) | 214 | 459 | 751 | 232 | 492 | 800 | 18 or 8% | 33 or 7% | 49 or 7% |
| **Middle Dam Seepage** | (ML/year) | 106 | 189 | 255 | 114 | 204 | 266 | 8 or 8% | 15 or 8% | 11 or 4% |
| **Lower Dam Overflows** | (ML/year) | 2 | 28 | 82 | 2 | 29 | 92 | No change | 1 or 4% | 10 or 12% |
| **Lower Dam Groundwater Ingress** | (ML/year) | 211 | 79 | 23 | 200 | 63 | 17 | -11 or (5%) | -16 or (20%) | -6 or (26%) |

**Note 1**: The RailCorp Scenario refers to the potential 4ha extension of the RailCorp Extraction Area
**Note 2**: Total runoff volume excludes runoff from the DSS Catchment

### *Results Discussion*

Water balance model results for the RailCorp Extraction Area extension scenario indicate that:

- A 4ha increase in the RailCorp Extraction Area would result in a 4.2% increase in the contributing catchment area to the surface water management system. This will result in a 7 to 8% increase in runoff volumes that require management in Dunmore Quarry's water management system. The increase in runoff volume is greater than the increase in catchment area as the Middle Dam Catchment has a higher than average runoff coefficient (as discussed in **Section 4.2.2**).

- The increase in runoff volumes will result in the following changes to the Modification 9 scenario water balance results:

  - Middle Dam Seepage rates will increase by 4.0% (wet year) to 8.0% (dry year). This will result in a commensurate increase in Breccia Spring flows and associated Nitrate and Copper loads.

  - Lower Dam overflows will increase by up to 12% in wet years due to reduced opportunities to dewater the Lower Dam to the Middle Dam.

  - Groundwater ingress into the Lower Dam is expected to reduce by 5% (dry years) to 26% (wet years). This is due to the increased availability of water in the Middle Dam for process water use.

## 7.2 Summary of Cumulative Impacts

It is expected that the impacts identified in **Section 7.1** could be partially or fully mitigated if process water use is increased as a result of the RailCorp operation and appropriate water storages are established. No other material impacts to Boral's water management system are expected.

Potential impacts on Boral's water management system from the proposed 4ha extension to the RailCorp Extraction Area can be addressed in more detail when more data is available.

# 8 WATER LICENSING AND ACCOUNTING

This section discusses the water licensing requirements for the existing and proposed quarry operation.

## 8.1 Water Licensing Framework

Water licensing for Dunmore Quarry is regulated by the *WM Act*. WALs in the Rocklow Creek Catchment are administered by the *Water Sharing Plan for the Greater Metropolitan Unregulated Water Sources 2011*, which is a legal instrument of the *WM Act*. The Water Sharing Plan is administered on the basis of catchment scale water sources. The project area is located within the Illawarra Rivers Water Source.

## 8.2 Water Licensing Requirements

This section describes water licensing requirements associated with the capture of runoff into the quarry's water management dams and groundwater ingress into the Lower Dam.

### *Surface Water Management Dams*

The Surface Water Management Plan presented in **Section 4** established that the majority of surface water runoff from the quarry site, for both existing and proposed conditions, is captured in either the Upper Dam (or pit sump), Middle Dam or Lower Dam. Captured water is either used within the quarry operation, lost to evaporation or seepage or discharged to receiving waters.

The capture of surface water runoff in the above-mentioned dams is considered to be excluded works under *Water Management (General) Regulation 2011, Schedule 1, item 3 (dams solely for the capture, containment or recirculation of drainag*e). Accordingly, no WALs are required for the capture of surface water in the quarry's water management dams.

### *Lower Dam Groundwater Ingress*

As discussed in **Section 4.2.4**, it is estimated that the quarry operation uses between 291 to 318 ML of process water a year. Historically all process water has been extracted from the Lower Dam, with the majority of the water expected to have been drawn from the Rocklow Creek Alluvium via groundwater ingress into the dam. No WAL has been established for this water take.

Boral are proposing to reconfigure the process water extraction regime to preferentially source water from the Middle Dam rather than the Lower Dam. Extraction from the Lower Dam will only occur when the Middle Dam level is below 30%. This is expected to materially reduce the volume of groundwater that is taken from the Rocklow Creek Alluvium via groundwater ingress into the Lower Dam.

Modification 9 will result in a further reduction in groundwater ingress volumes into the Lower Dam as the additional runoff volume from the Croome West Pit will increase the volume of water available in the Middle Dam for process water use. Water balance results presented in **Section 5.3** indicate that Modification 9 (when combined with the proposed improvements to the existing water management system) will result in a 100% reduction in groundwater take from the Rocklow Creek Alluvium in wet years and a 20% reduction in dry years.

Notwithstanding, groundwater ingress into the Lower Dam will continue to be an important supply of water for the quarry operation. If this arrangement was not in place the quarry would require access to an alternative local groundwater resource to meet process water needs during dry conditions.

**Table 8-1** provides a summary of the estimated groundwater ingress volumes for each water balance scenario.

**Table 8-1** – *Estimated Lower Dam Groundwater Ingress Volumes*

| Water Balance Scenario | Estimated Groundwater Ingress into the Lower Dam | | | |
|---|---|---|---|---|
| | Extreme Dry Year[2] | Typical Dry Year[1] | Typical Median Year[1] | Typical Wet Year[1] |
| Existing Conditions | Up to 300 ML/year | 271 ML/year | 227 ML/year | 182 ML/year |
| Existing Conditions with Improvements | Up to 300 ML/year | 250 ML/year | 151 ML/year | 63 ML/year |
| Modification 9 | Up to 300 ML/year | 211 ML/year | 79 ML/year | 23 ML/year |

Note 1: Annual flow volumes are sourced from the water balance flow charts presented in **Section 5.3.3**.
Note 2: Annual flow volumes are sourced from **Figure 34**.

Boral acknowledges that a WAL is required for any water take from the Rocklow Creek Alluvium and has submitted a registration of interest with DPI-Water. Boral will continue to consult with DPI-Water to establish appropriate licensing arrangements.

# 9 MONITORING AND CONTINGENCY MEASURES

## 9.1 Surface Water Monitoring Plan

Boral proposes to revise the existing surface water monitoring plan that is documented in the current WMP and is summarised in **Table 4-5**. The revised plan will reflect the revised interpretation of the water management system functionality and receiving water quality risks.

The revised plan will include:

- Continuation of monitoring of site rainfall and other climatic conditions.
- Continuation of monitoring of Rocklow Creek, Lower and Middle Dam water levels and overflows.
- Weekly monitoring of daily process water use volumes.
- Monitoring of all water extracted from the Lower Dam for process water use.
- Quarterly baseline water quality monitoring from all water management dams, Breccia Spring flows and select receiving water locations.
- Bi-annual wet weather water quality monitoring from all water management dams, Breccia Spring flows and select receiving water locations.

The objective of the monitoring plan is to collect data to enable:

- The occurrence, duration and volume of site discharges to be estimated.
- The quality of surface water within the quarry's water management system and receiving waters to be progressively characterised.
- The site water balance model to be progressively updated (as required).
- Compliance with EPL and consent conditions to be assessed.

A provisional surface water monitoring plan is described in the following tables:

- **Table 9-1** details the framework of a provisional plan, which will be finalised when the quarry's WMP is updated.
- **Table 9-2** lists analytes that will be monitored. It is noted that is not proposed to monitor analytes that were consistently below detection limits in the SWCA monitoring results that are presented in **Section 4.4.2.**

**Table 9-1** – *Provisional Surface Water Monitoring Plan Framework*

| Aspect | Objective | Monitoring Locations | Monitoring Description |
|---|---|---|---|
| **Rainfall Monitoring** | To accurately record site rainfall. This information can be used to calibrate the site water balance model and demonstrate compliance with rainfall related consent conditions. | • Current weather station location. | Boral will continue to operate the onsite weather station that is capable of measuring rainfall. |
| **Process Water Monitoring** | Boral will measure and record process water use volumes on a weekly basis. This information can be used to progressively improve the reliability of water balance model calibration. | • Water cart use<br>• All other process water uses. | Weekly process water use volumes are to be recorded either by a cumulative flow meter or a daily tanker load count. Process water usage is to be maintained in a spread sheet. |
| **Lower Dam Process Water Use** | Boral will measure and record the volumes of water extracted from the Lower Dam for process water use. This data will be used to estimate groundwater ingress volumes into the Lower Dam. | • Lower Dam | A cumulative flow meter will be installed to record the volumes of water extracted from the Lower Dam for process water use. The flow meter will be read on a weekly basis. |
| **Water Level Monitoring** | To continuously record the water levels in Rocklow Creek and the Lower and Middle Dams. This data can be used to demonstrate the functionality of the water management system and estimate discharge and runoff characteristics. | • Rocklow Creek<br>• Lower Dam<br>• Middle Dam | Boral will continue to operate the water presser sensors that have been installed in Rocklow Creek and the Lower and Middle Dams. Data will be downloaded on a 6 monthly basis and reviewed annually. |
| **Water Quality Monitoring**<br><br>**(Quarterly)** | To monitor the quality of water within quarry's water management system and receiving water locations during dry weather conditions. | • Upper, Middle and Lower Dams<br>• Breccia Spring<br>• Receiving water locations (GS1, GS2, GS3, RC1 and RC2) | Monitoring is to be undertaken via grab samples at each location. Samples are to be collected during dry weather conditions on a quarterly basis. |
| **Water Quality Monitoring**<br><br>**(wet weather conditions)** | To monitor the quality of water within quarry's water management system and receiving water locations during wet weather conditions. | | Monitoring is to be undertaken via grab samples at each location. Samples are to be collected during wet weather conditions and 3 to 5 days after rainfall.<br>This sampling regime will be undertaken twice annually.<br>Wet weather conditions are defined as 50mm or more rainfall occurring within the 48 hour period prior to sampling. |

***Table 9-2 –*** *Surface Water Quality Monitoring Plan: Analytes Proposed*

| | Proposed Analytes |
|---|---|
| **General** | • pH<br>• Electrical Conductivity (EC)<br>• Total Suspended Solids (TSS)<br>• Turbidity<br>• Total Hardness (Ca $CO_3$) |
| **Nutrients** | • Ammonia, Nitrate, Nitrate, Nitrate + Nitrate ($NO_x$), Organic Nitrogen (TKN) and Total Nitrogen (TN)<br>• Reactive and Total Phosphorus (TP) |
| **Dissolved Metals** | • Metals (Al, B, Cu) |

## 9.2 Summary of Additional Investigations and Contingency Measures

***Table 9-3*** provides a summary of additional investigations and **Table 9-4** outlines contingency measures that could be implemented.

**Table 9-3** – *Summary of Additional Investigations and Actions.*

| Item | Trigger / Timing | Outcomes |
|---|---|---|
| Consult with DPI-Water to establish water licencing arrangements for the quarry operation. | During the Modification 9 EIS process | Establish appropriate water licensing arrangements for water take from the Rocklow Creek Alluvium via groundwater ingress into the Lower Dam. |
| Consult with the EPA to revise EPL conditions | During the Modification 9 EIS process | Revise the EPL conditions to reflect the additional discharge locations / mechanisms and water quality risks that have been identified in this Surface Water Assessment. |
| Revise the Water Management Plan | The WMP will be updated following approval of Modification 9. | A detailed description of the water management system, operating procedures and monitoring and reporting requirements. |

**Table 9-4** – *Summary of Contingency Measures*

| Item | Trigger / Timing | Outcomes |
|---|---|---|
| Surface water quality | If water quality monitoring indicates that overflows or discharges from the quarry exceed relevant EPL and consent conditions. | Boral will undertake an investigation to establish the likely cause of the underperformance of the water management system and will implement necessary measures to mitigate the identified underperformance. |
| Process water shortages | If the process water sources discussed in the report are unable to provide sufficient water to meet operation requirements. | If process water shortfalls occur, Boral will:<br>• Identify alternative water sources and consult with DPI-Water to establish appropriate water licensing arrangements.<br>• Use mains water for plant dust suppression.<br>• Use chemical dust suppressants for haul road and stockpile dust suppression. |

# 10 REFERENCES

1) *ARCADIS (2016), 'Dunmore Hard Rock Quarry Project: Water Management Plan (Rev Final – 03)'*

2) *Chiew, F.H.S and Siriwardena, L (2005), 'Estimation of SIMHYD Parameter Values for Application in Ungauged Catchments'*

3) Department of Environment and Conservation NSW (2005), *'Environmental Compliance Report: Liquid Chemical Storage, Handling and Spill Management: Part B Review of Best Practice and Regulation'*

4) Department of Environment and Climate Change NSW (2008), *'Managing Urban Stormwater: Soils and Construction Volume 2E Mines and Quarries'*

5) Department of Environment and Climate Change NSW (2007), *'Storing and Handling Liquids: Environmental Protection: Participant's Manual'*

*6)* Evans and Peck (2008)*, 'Dunmore Quarry Draft Water Management Plan'*

*7)* EMM (2016), *'Dunmore Quarry Modification 9: Groundwater Assessment'*

8) Institution of Engineers Australia (2016), '*Australian Rainfall and Runoff – A Guide to Flood Estimation'*

9) Landcom (2004), '*Managing Urban Stormwater: Soils and Construction Volume 1 4th Edition'.*

# APPENDIX A – SURFACE WATER QUALITY MONITORING RESULTS

| | Lower Dam Results (EPL #8) | | | | | | | | | Lower Dam Results Overflow Results (EPL #7) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Field Test Results | | | | Laboratory Results | | | | | Field Test Results | | | | Laboratory Results | | | | |
| | pH | DO | EC | Turbidity | pH | EC | Turbidity | TSS | Oil and Grease | pH | DO | EC | Turbidity | pH | EC | Turbidity | TSS | Oil and Grease |
| Unit | | mg/L | µS/cm | NTU | | µS/cm | NTU | mg/L | mg/L | | mg/L | µS/cm | NTU | | µS/cm | NTU | mg/L | mg/L |
| Limit of Reporting | 0.1 | | 1 | | 0.1 | 1 | | < 2 | 1 | 0.1 | | 1 | | 0.1 | 1 | | < 2 | 1 |
| ANZECC Trigger Values for physical & chemical stressors for south-east Australia for slightly disturbed ecosystems (Lowland River) | 6.5 - 8 | | 125 - 2200 | 6 - 50 | 6.5 - 8 | 125 - 2200 | 6 - 50 | | | 6.5 - 8 | | 125 - 2200 | 6 - 50 | 6.5 - 8 | 125 - 2200 | 6 - 50 | | |
| Consent Condition (no. 29) | N/A | | | | N/A | | | N/A | | 6.5 to 8.5 | | | | 6.5 to 8.5 | | | 50 | |
| 30/07/2010 | 7.0 | 6.9 | 841 | 52 | 7.70 | 851 | 40 | 14 | <1 | | | | | | | | | |
| 31/08/2010 | 6.8 | 9.6 | 802 | 49 | 7.80 | 803 | 25 | 16 | <1 | | | | | | | | | |
| 15/09/2010 | 6.7 | 5.6 | 557 | 220 | 7.30 | 597 | 100 | 17 | <1 | 6.3 | 4.5 | 302 | 54 | 6.7 | 377 | 31 | 26 | <1 |
| 30/09/2010 | 7.0 | 9.2 | 724 | 34 | 8.00 | 712 | 10 | 10 | <1 | | | | | | | | | |
| 29/10/2010 | 7.5 | 6.4 | 715 | 51 | 7.70 | 701 | 27 | 11 | <1 | | | | | | | | | |
| 30/11/2010 | 7.8 | 8.5 | 619 | 151 | 7.50 | 591 | 55 | 40 | <1 | | | | | | | | | |
| 1/12/2010 | 7.6 | 6.3 | 564 | 380 | 7.80 | 543 | 24 | 85 | <1 | 7.0 | 3.2 | 338 | 17 | 6.4 | 326 | 9 | 10 | <1 |
| 2/12/2010 | 7.7 | 5.0 | 491 | 277 | 7.60 | 481 | 250 | 73 | <1 | 8.1 | 6.4 | 478 | 273 | 7.6 | 461 | 200 | 21 | <1 |
| 22/12/2010 | 7.7 | 6.9 | 654 | 72 | 7.50 | 630 | 40 | 10 | <1 | | | | | | | | | |
| 2/02/2011 | 6.7 | 4.8 | 694 | 62 | 7.60 | 646 | 36 | 13 | <1 | | | | | | | | | |
| 3/03/2011 | 7.0 | 5.5 | 718 | 85 | 7.80 | 675 | 55 | 21 | <1 | | | | | | | | | |
| 20/03/2011 | | | | | 7.60 | 437 | 280 | 61 | 3.8 | | | | | 7.6 | 431 | 260 | 49 | 2.4 |
| 22/03/2011 | | | | | 7.20 | 309 | 320 | 107 | 1.4 | | | | | 7.3 | 315 | 240 | 199 | 1.9 |
| 11/04/2011 | 7.0 | 6.0 | 498 | 95 | 7.80 | 629 | 70 | 12 | <1 | | | | | | | | | |
| 4/05/2011 | 7.3 | 7.2 | 551 | 183 | 7.20 | 485 | 160 | 75 | 1.1 | | | | | | | | | |
| 8/06/2011 | 5.7 | 7.4 | 528 | 157 | 6.95 | 515 | 35 | 57 | 1 | | | | | | | | | |
| 30/06/2011 | 8.0 | 5.5 | 643 | 101 | 8.00 | 608 | 90 | 33 | <1 | | | | | | | | | |
| 22/07/2011 | 7.7 | 5.9 | 401 | 400 | 7.50 | 364 | 370 | 184 | <1 | 7.5 | 6.0 | 392 | 443 | 7.6 | 357 | 650 | 354 | <1 |
| 31/08/2011 | 7.9 | 5.8 | 565 | 200 | 7.60 | 558 | 130 | 80 | <1 | | | | | | | | | |
| 5/10/2011 | 8.2 | 5.7 | 608 | 61 | 7.90 | 587 | 55 | 12 | <1 | | | | | | | | | |
| 31/10/2011 | 7.5 | 6.2 | 515 | 122 | 7.90 | 594 | 110 | 27 | <1 | | | | | | | | | |
| 5/12/2011 | 7.8 | 6.6 | 525 | 81 | 8.00 | 507 | 60 | 27 | <1 | | | | | | | | | |
| 10/01/2012 | 7.4 | 5.6 | 587 | 47 | 7.70 | 605 | 23 | 23 | <1 | | | | | | | | | |
| 30/01/2012 | 8.5 | 5.0 | 478 | 71 | 8.60 | 454 | 65 | 15 | <1 | | | | | | | | | |
| 1/03/2012 | | | | | | | | | | | | | | | | | | |
| 2/03/2012 | 7.5 | 5.9 | 459.00 | 197 | | | | | | 7.6 | 5.8 | 501 | 181 | | | | | |
| 5/04/2012 | 8.0 | 6.5 | 550 | 133 | 7.80 | 532 | 75 | 33 | <1 | | | | | | | | | |
| 24/04/2012 | 7.3 | 6.2 | 479 | 196 | 7.90 | 481 | 85 | 31 | <1 | | | | | | | | | |
| 28/05/2012 | 6.7 | 8.7 | 558 | 135 | 8.00 | 549 | 55 | 30 | 1.2 | | | | | | | | | |
| 29/06/2012 | 6.2 | 10.7 | 522.00 | 94 | 8.10 | 508 | 90 | 20 | <1 | | | | | | | | | |
| 1/08/2012 | 6.3 | 7.9 | 571 | 107 | 8.00 | 533 | 27 | 16 | <1 | | | | | | | | | |
| 30/08/2012 | | | | | 8.20 | 620 | 90 | 69 | <1 | | | | | | | | | |
| 26/09/2012 | 6.6 | 9.1 | 700 | 124 | 8.40 | 687 | 75 | 55 | <1 | | | | | | | | | |
| 7/10/2012 | 6.5 | 6.9 | 825 | 139 | 8.20 | 886 | 80 | 62 | <1 | | | | | | | | | |
| 12/10/2012 | 7.2 | 9.3 | 621 | | 8.60 | 656 | 55 | 33 | <1 | | | | | | | | | |
| 13/10/2012 | 7.1 | 8.9 | 534 | 104 | 8.60 | 560 | 65 | 33 | <1 | | | | | | | | | |
| 26/10/2012 | 8.2 | 5.3 | 593 | 156 | 8.40 | 620 | 85 | 71 | <1 | | | | | | | | | |
| 28/11/2012 | 8.4 | 6.3 | 1154 | 98 | 8.20 | 1082 | 34 | 31 | <1 | | | | | | | | | |
| 19/12/2012 | 8.5 | 7.5 | 1274 | 213 | 8.10 | 1447 | 190 | 285 | <1 | | | | | | | | | |
| 25/12/2012 | 8.1 | 5.4 | 1159 | 148 | 7.90 | 1280 | 85 | 78 | <1 | | | | | | | | | |
| 27/01/2013 | 8.1 | 5.8 | 1434 | 150 | 8.40 | 1148 | 120 | 61 | <1 | | | | | | | | | |
| 29/01/2013 | 7.0 | 7.2 | 374 | 1090 | 8.20 | 402 | 950 | 314 | <1 | | | | | | | | | |
| 30/01/2013 | 8.5 | 7.0 | 431 | 60 | 7.90 | 464 | 250 | 101 | <1 | | | | | | | | | |
| 25/02/2013 | 7.5 | 6.0 | 475 | 342 | 7.90 | 490 | 230 | 58 | <1 | | | | | | | | | |
| 27/02/2013 | 8.0 | 5.8 | 497 | 190 | 8.10 | 327 | 130 | 330 | <1 | | | | | | | | | |
| 1/03/2013 | 7.1 | 6.4 | 470 | 235 | 8.20 | 460 | 230 | 12 | <1 | | | | | | | | | |
| 2/03/2013 | 7.7 | 6.3 | 465 | 184 | 8.20 | 459 | 140 | 32 | <1 | | | | | | | | | |
| 27/03/2013 | 8.0 | 6.1 | 641 | 63 | 8.30 | 620 | 45 | 20 | <1 | | | | | | | | | |
| 3/04/2013 | 8.5 | 6.8 | 624 | 334 | 8.20 | 549 | 21 | 93 | <1 | | | | | | | | | |
| 29/04/2013 | 8.2 | 6.8 | 536 | 80 | 8.30 | 512 | 50 | 19 | <1 | | | | | | | | | |
| 24/05/2013 | 7.3 | 10.4 | 524 | 169 | 8.40 | 486 | 95 | 24 | <1 | | | | | | | | | |
| 29/05/2013 | 7.6 | 9.3 | 520 | 86 | 8.30 | 510 | 60 | 19 | <1 | | | | | | | | | |
| 24/06/2013 | 7.9 | 8.0 | 321 | 1705 | 8.40 | 369 | 55 | 109 | <1 | | | | | | | | | |
| 25/06/2013 | 8.1 | | | 735 | 8.30 | 295 | 530 | 67 | <1 | 8.1 | | | 896 | 8.1 | 307 | 490 | 168 | <1 |
| 26/06/2013 | 7.9 | 8.6 | 271 | 1003 | 8.40 | 298 | 420 | 69 | <1 | 7.9 | 7.0 | 255 | 864 | 8.4 | 290 | 660 | 214 | <1 |
| 27/06/2013 | 7.8 | 8.3 | 384 | 427 | 8.20 | 431 | 160 | 45 | <1 | 8.0 | 7.7 | 393 | 277 | 8 | 379 | 210 | 94 | <1 |
| 1/07/2013 | 8.2 | 7.3 | 455 | 117 | 8.00 | 419 | 75 | 27 | <1 | | | | | | | | | |
| 1/08/2013 | 7.8 | 8.1 | 447 | 3 | 8.30 | 436 | 100 | 19 | <1 | | | | | | | | | |
| 3/09/2013 | 8.7 | 7.5 | 617 | 0 | 8.60 | 556 | 95 | 24 | <1 | | | | | | | | | |
| 15/09/2013 | 8.2 | 8.4 | 527 | 119 | 8.60 | 507 | 90 | 10 | <1 | | | | | | | | | |
| 3/10/2013 | 8.0 | 7.0 | 507 | 214 | 8.30 | 533 | 150 | 45 | <1 | | | | | | | | | |
| 6/11/2013 | 8.1 | 7.9 | 897 | 142 | 8.50 | 1039 | 65 | 44 | 0.7 | | | | | | | | | |
| 11/11/2013 | | 7.5 | 1079 | 128 | 8.50 | 1037 | 85 | 55 | 1.1 | | | | | | | | | |
| 17/11/2013 | 6.9 | 6.5 | 827 | 106 | 8.40 | 750 | 60 | 34 | <0.1 | | | | | | | | | |
| 12/12/2013 | | 8.2 | 840 | 66 | 8.10 | 495 | 75 | 54 | 0.8 | | | | | | | | | |
| 26/12/2013 | | | | | 8.40 | 818 | 180 | 122 | 0.7 | | | | | | | | | |
| 8/01/2014 | 7.9 | | 546 | 123 | 8.60 | 577 | 90 | 57 | 0.5 | | | | | | | | | |
| 13/02/2014 | 7.7 | 6.6 | 114 | 111 | 8.50 | 975 | 60 | 30 | <0.1 | | | | | | | | | |
| 1/03/2014 | 6.8 | 6.6 | 968 | 658 | 8.50 | 892 | 180 | 144 | <0.1 | | | | | | | | | |
| 25/03/2014 | 8.0 | 5.5 | 385 | 20 | 8.50 | 359 | 800 | 419 | 0.3 | | | | | | | | | |
| 26/03/2014 | 7.8 | 4.3 | 369 | 865 | 8.40 | 344 | 590 | 220 | 0.9 | | | | | | | | | |
| 27/03/2014 | 7.7 | 4.4 | 384 | 802 | 8.20 | 343 | 500 | 184 | 0.5 | | | | | | | | | |
| 4/04/2014 | 7.6 | 1.8 | 562 | ** | 8.20 | 456 | 160 | 74 | 0.7 | | | | | | | | | |
| 5/05/2014 | 7.2 | 5.9 | 663 | 97 | 8.40 | 509 | 60 | 54 | 1.1 | | | | | | | | | |
| 3/06/2014 | 6.0 | 5.1 | 680 | 85 | 8.40 | 527 | 55 | 45 | 0.6 | | | | | | | | | |
| 2/07/2014 | 6.6 | 7.5 | 664 | 39 | 8.00 | 619 | 28 | 30 | 0.6 | | | | | | | | | |
| 4/08/2014 | 7.5 | 6.9 | 947 | 28 | 8.60 | 986 | 28 | 25 | 1.3 | | | | | | | | | |
| 18/08/2014 | 7.6 | 5.9 | 469 | 771 | 8.30 | 494 | 300 | 213 | 0.8 | | | | | | | | | |
| 19/08/2014 | 7.3 | 5.9 | 369 | 832 | 8.20 | 398 | 340 | 242 | 0.7 | 7.5 | 5.9 | 365 | 1988 | 8.1 | 389 | 380 | 257 | 0.6 |
| 26/08/2014 | 6.8 | 5.1 | 419 | 1989 | 8.30 | 398 | 450 | 181 | 0.7 | | | | | | | | | |
| 27/08/2014 | 7.1 | 5.4 | 347 | 446 | 8.30 | 366 | 390 | 262 | 1.1 | 7.2 | 5.6 | 330 | 455 | 8.3 | 358 | 360 | 249 | 1 |
| 3/09/2014 | 7.9 | 6.0 | 426 | 218 | 8.10 | 436 | 190 | 146 | 0.3 | | | | | | | | | |
| 2/10/2014 | 8.4 | 4.8 | 556 | 91 | 8.10 | 547 | 45 | 33 | 1.1 | | | | | | | | | |
| 15/10/2014 | 8.0 | 5.4 | 421 | 511 | 8.20 | 429 | 330 | 207 | 0.8 | | | | | | | | | |
| 30/10/2014 | 7.9 | 5.8 | 481 | 44 | 8.10 | 493 | 27 | 16 | 1.4 | | | | | | | | | |
| 2/12/2014 | 8.7 | 6.4 | 452 | 425 | 8.40 | 459 | 310 | 118 | 1 | | | | | | | | | |
| 2/12/2014 | 8.7 | 6.4 | 452 | 425 | 8.50 | 453 | 300 | 120 | 1 | | | | | | | | | |
| 22/12/2014 | 7.4 | 6.6 | 491 | 61 | 8.00 | 495 | 41 | 23 | 1 | | | | | | | | | |
| 11/01/2015 | 7.3 | 5.0 | 439 | 236 | 8.00 | 445 | 170 | 81 | 1 | | | | | | | | | |
| 21/01/2015 | 8.3 | 6.1 | 466 | 177 | 8.40 | 478 | 140 | 81 | 0.7 | | | | | | | | | |
| 4/02/2015 | 8.6 | 6.3 | 449 | 79 | 8.00 | 495 | 41 | 23 | 1 | | | | | | | | | |
| 5/02/2015 | 8.2 | 5.5 | 448 | 101 | 8.30 | 451 | 80 | 40 | 0.6 | | | | | | | | | |
| 4/03/2015 | 8.5 | 6.0 | 571 | 64 | 8.30 | 512 | 60 | 38 | 0.7 | | | | | | | | | |
| 21/04/2015 | 8.4 | 9.3 | 323 | 1391 | 8.20 | 328 | 800 | 340 | 1.1 | | | | | | | | | |
| 21/04/2015 | 8.4 | 9.3 | 323 | 1391 | 8.20 | 326 | 800 | 348 | 0.8 | 8.3 | 9.1 | 318 | 1762 | 8.3 | 290 | 850 | 406 | 0.9 |
| 24/04/2015 | 7.9 | 6.9 | | 420 | 8.10 | 385 | 140 | 79 | 1.1 | | | | | | | | | |
| 12/05/2015 | 8.5 | 14.5 | 499 | 90 | 8.30 | 510 | 75 | 62 | 0.8 | | | | | | | | | |
| 10/06/2015 | 8.3 | 15.5 | 538 | 72 | 8.30 | 526 | 40 | 32 | 1.8 | | | | | | | | | |
| 6/07/2015 | 8.1 | 97.7 | 489 | 76 | 8.00 | 489 | 50 | 39 | 0.8 | | | | | | | | | |
| 4/08/2015 | 8.3 | 9.4 | 468 | 114 | 8.30 | 484 | 70 | 45 | 1.5 | | | | | | | | | |
| 27/08/2015 | 7.2 | 7.7 | | 871 | 8.20 | 275 | 390 | 266 | 1.2 | 7.8 | 8.6 | | 695 | 8.2 | 286 | 380 | 308 | 1.1 |
| 1/09/2015 | 7.9 | 8.3 | 378 | 255 | 8.10 | 387 | 190 | 103 | 1.1 | | | | | | | | | |
| 1/10/2015 | 8.5 | 13.5 | 434 | 123 | 8.00 | 415 | 90 | 66 | 0.8 | | | | | | | | | |
| 12/11/2015 | 6.6 | 9.0 | 441 | 65 | 8.60 | 411 | 45 | 33 | 0.9 | | | | | | | | | |
| 2/12/2015 | 8.7 | 7.5 | 477 | 101 | 8.20 | 452 | 55 | 42 | 0.9 | | | | | | | | | |
| 5/01/2016 | 8.0 | 6.2 | 475 | 220 | 7.90 | 430 | 130 | 71 | 0.7 | | | | | | | | | |
| 4/02/2016 | 8.6 | 8.3 | 420 | 159 | 8.20 | 358 | 130 | 83 | 0.9 | | | | | | | | | |
| 10/03/2016 | 7.6 | 7.0 | 444 | 84 | 8.30 | 403 | 45 | 36 | 0.5 | | | | | | | | | |
| 4/04/2016 | 6.8 | 6.6 | 362.0 | 398 | | | | | | | | | | | | | | |
| Statistics | | | | | | | | | | | | | | | | | | |
| Number of Samples | 102 | 102 | 101 | 102 | 106 | 106 | 106 | 106 | 49 | 12 | 11 | 10 | 12 | 13 | 13 | 13 | 13 | 6 |
| 90th Percentile (or Max) | 8.5 | 9.3 | 827 | 767 | 8.5 | 835 | 380 | 210 | 1 | 8.1 | 8.6 | 480 | 1675 | 8.3 | 423 | 658 | 345 | 2 |
| Average | 7.7 | 7.9 | 565 | 271 | 8.1 | 555 | 158 | 80 | 1 | 7.6 | 6.3 | 367 | 659 | 7.7 | 351 | 363 | 181 | 1 |
| 10th Percentile (or Min) | 6.7 | 5.3 | 378 | 53 | 7.7 | 362 | 35 | 16 | 1 | 7.0 | 4.5 | 297 | 67 | 6.8 | 290 | 65 | 22 | 1 |

| | Receiving Water Monitoring Results: Upstream of Lower Dam | | | | | | | | | Receiving Water Monitoring Results: Downstream of Lower Dam | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Field Test Results | | | | Laboratory Results | | | | | Field Test Results | | | | Laboratory Results | | | | |
| | pH | DO | EC | Turbidity | pH | EC | Turbidity | TSS | Oil and Grease | pH | DO | EC | Turbidity | pH | EC | Turbidity | TSS | Oil and Grease |
| Unit | | mg/L | µS/cm | NTU | | µS/cm | NTU | mg/L | mg/L | | mg/L | µS/cm | NTU | | µS/cm | NTU | mg/L | mg/L |
| Limit of Reporting | 0.1 | | 1 | | 0.1 | 1 | | < 2 | 1 | 0.1 | | 1 | | 0.1 | 1 | | < 2 | 1 |
| ANZECC Trigger Values for physical & chemical stressors for south-east Australia for slightly disturbed ecosystems (Upland River) | 6.5 - 8 | | 125 - 2200 | 6 - 50 | 6.5 - 8 | 125 - 2200 | 6 - 50 | | | 6.5 - 8 | | 125 - 2200 | 6 - 50 | 6.5 - 8 | 125 - 2200 | 6 - 50 | | |
| Consent Condition (no. 29) | N/A | | | | N/A | | | N/A | | N/A | | | | N/A | | | N/A | |
| 30/07/2010 | | | | | | | | | | | | | | | | | | |
| 31/08/2010 | | | | | | | | | | | | | | | | | | |
| 15/09/2010 | 6.2 | 6.1 | 264 | 115 | 6.6 | 269 | 16 | 9.4 | <1 | 6.2 | 4.5 | 286 | 78 | 6.5 | 296 | 22 | 14 | <1 |
| 30/09/2010 | | | | | | | | | | | | | | | | | | |
| 29/10/2010 | | | | | | | | | | | | | | | | | | |
| 30/11/2010 | | | | | | | | | | | | | | | | | | |
| 1/12/2010 | 6.9 | 5.96 | 173 | 75 | 6.5 | 185 | 240 | 25.8 | <1 | 7.5 | 4.5 | 324 | 45 | 6.5 | 320 | 22 | 53 | <1 |
| 2/12/2010 | 6.8 | 2.98 | 366 | 84.6 | 6.1 | 375 | 36 | 120 | <1 | 6.8 | 2.9 | 214 | 20 | 6.5 | 207 | 12 | 12 | <1 |
| 22/12/2010 | | | | | | | | | | | | | | | | | | |
| 2/02/2011 | | | | | | | | | | | | | | | | | | |
| 3/03/2011 | | | | | | | | | | | | | | | | | | |
| 20/03/2011 | | | | | | | | | | | | | | | | | | |
| 22/03/2011 | | | | | 6.4 | 412 | 60 | 258 | 2.2 | | | | | 6.5 | 343 | 7.7 | 20 | <1 |
| 11/04/2011 | | | | | | | | | | | | | | | | | | |
| 4/05/2011 | | | | | | | | | | | | | | | | | | |
| 8/06/2011 | | | | | | | | | | | | | | | | | | |
| 30/06/2011 | | | | | | | | | | | | | | | | | | |
| 22/07/2011 | 6.3 | 6.19 | 295 | 59.9 | 5.8 | 254 | 65 | 40.8 | <1 | 6.5 | 5.9 | 201 | 287 | 6.2 | 165 | 30 | 14 | <1 |
| 31/08/2011 | | | | | | | | | | | | | | | | | | |
| 5/10/2011 | | | | | | | | | | | | | | | | | | |
| 31/10/2011 | | | | | | | | | | | | | | | | | | |
| 5/12/2011 | | | | | | | | | | | | | | | | | | |
| 10/01/2012 | | | | | | | | | | | | | | | | | | |
| 30/01/2012 | | | | | | | | | | | | | | | | | | |
| 1/03/2012 | | | | | | | | | | | | | | | | | | |
| 2/03/2012 | 6.7 | | 359 | 62.7 | | | | | | 7.0 | | 251 | 53 | | | | | |
| 5/04/2012 | | | | | | | | | | | | | | | | | | |
| 24/04/2012 | | | | | | | | | | | | | | | | | | |
| 28/05/2012 | | | | | | | | | | | | | | | | | | |
| 29/06/2012 | | | | | | | | | | | | | | | | | | |
| 1/08/2012 | | | | | | | | | | | | | | | | | | |
| 30/08/2012 | | | | | | | | | | | | | | | | | | |
| 26/09/2012 | | | | | | | | | | | | | | | | | | |
| 7/10/2012 | | | | | | | | | | | | | | | | | | |
| 12/10/2012 | | | | | | | | | | | | | | | | | | |
| 13/10/2012 | | | | | | | | | | | | | | | | | | |
| 26/10/2012 | | | | | | | | | | | | | | | | | | |
| 28/11/2012 | | | | | | | | | | | | | | | | | | |
| 19/12/2012 | | | | | | | | | | | | | | | | | | |
| 25/12/2012 | | | | | | | | | | | | | | | | | | |
| 27/01/2013 | | | | | | | | | | | | | | | | | | |
| 29/01/2013 | | | | | | | | | | | | | | | | | | |
| 30/01/2013 | | | | | | | | | | | | | | | | | | |
| 25/02/2013 | | | | | | | | | | | | | | | | | | |
| 27/02/2013 | | | | | | | | | | | | | | | | | | |
| 1/03/2013 | | | | | | | | | | | | | | | | | | |
| 2/03/2013 | | | | | | | | | | | | | | | | | | |
| 27/03/2013 | | | | | | | | | | | | | | | | | | |
| 3/04/2013 | | | | | | | | | | | | | | | | | | |
| 29/04/2013 | | | | | | | | | | | | | | | | | | |
| 24/05/2013 | | | | | | | | | | | | | | | | | | |
| 29/05/2013 | | | | | | | | | | | | | | | | | | |
| 24/06/2013 | | | | | | | | | | | | | | | | | | |
| 25/06/2013 | | | | | | | | | | | | | | | | | | |
| 26/06/2013 | | | | | | | | | | | | | | | | | | |
| 27/06/2013 | | | | | | | | | | | | | | | | | | |
| 1/07/2013 | | | | | | | | | | | | | | | | | | |
| 1/08/2013 | | | | | | | | | | | | | | | | | | |
| 3/09/2013 | | | | | | | | | | | | | | | | | | |
| 15/09/2013 | | | | | | | | | | | | | | | | | | |
| 3/10/2013 | | | | | | | | | | | | | | | | | | |
| 6/11/2013 | | | | | | | | | | | | | | | | | | |
| 11/11/2013 | | | | | | | | | | | | | | | | | | |
| 17/11/2013 | | | | | | | | | | | | | | | | | | |
| 12/12/2013 | | | | | | | | | | | | | | | | | | |
| 26/12/2013 | | | | | | | | | | | | | | | | | | |
| 8/01/2014 | | | | | | | | | | | | | | | | | | |
| 13/02/2014 | | | | | | | | | | | | | | | | | | |
| 1/03/2014 | | | | | | | | | | | | | | | | | | |
| 25/03/2014 | 7.65 | 4.7 | 207 | 26.3 | 6.9 | 185 | 26 | 11 | 1.3 | | | | | | | | | |
| 26/03/2014 | | | | | | | | | | | | | | | | | | |
| 27/03/2014 | | | | | | | | | | | | | | | | | | |
| 4/04/2014 | | | | | | | | | | | | | | | | | | |
| 5/05/2014 | | | | | | | | | | | | | | | | | | |
| 3/06/2014 | | | | | | | | | | | | | | | | | | |
| 2/07/2014 | | | | | | | | | | | | | | | | | | |
| 4/08/2014 | | | | | | | | | | | | | | | | | | |
| 18/08/2014 | | | | | | | | | | | | | | | | | | |
| 19/08/2014 | 7.23 | 6.1 | 235 | 11.1 | 7 | 231 | 65 | 148 | 1.9 | 7.1 | 5.1 | 276 | 19 | 6.9 | 272 | 13 | 18 | 2 |
| 26/08/2014 | | | | | | | | | | | | | | | | | | |
| 27/08/2014 | 7.22 | 5.63 | 216.00 | 11.30 | 7.10 | 218 | 15.0 | 6.7 | 1.7 | 7.2 | 5.6 | 212.0 | 38 | | | | 19 | |
| 3/09/2014 | | | | | | | | | | | | | | | | | | |
| 2/10/2014 | | | | | | | | | | | | | | | | | | |
| 15/10/2014 | | | | | | | | | | | | | | | | | | |
| 30/10/2014 | | | | | | | | | | | | | | | | | | |
| 2/12/2014 | | | | | | | | | | | | | | | | | | |
| 2/12/2014 | | | | | | | | | | | | | | | | | | |
| 22/12/2014 | | | | | | | | | | | | | | | | | | |
| 11/01/2015 | | | | | | | | | | | | | | | | | | |
| 21/01/2015 | | | | | | | | | | | | | | | | | | |
| 4/02/2015 | | | | | | | | | | | | | | | | | | |
| 5/02/2015 | | | | | | | | | | | | | | | | | | |
| 4/03/2015 | | | | | | | | | | | | | | | | | | |
| 21/04/2015 | | | | | | | | | | | | | | | | | | |
| 21/04/2015 | 7.17 | 8.5 | 264 | 25.4 | 7.3 | 373 | 20 | 18 | 1.4 | 7.5 | 8.2 | 240 | 59 | 7.5 | 237 | 31 | 20 | <1 |
| 24/04/2015 | | | | | | | | | | | | | | | | | | |
| 12/05/2015 | | | | | | | | | | | | | | | | | | |
| 10/06/2015 | | | | | | | | | | | | | | | | | | |
| 6/07/2015 | | | | | | | | | | | | | | | | | | |
| 4/08/2015 | | | | | | | | | | | | | | | | | | |
| 27/08/2015 | 7.06 | 8.6 | | 705 | 7 | 177 | 200 | 665 | 1.8 | | | | | | | | | |
| 1/09/2015 | | | | | | | | | | | | | | | | | | |
| 1/10/2015 | | | | | | | | | | | | | | | | | | |
| 12/11/2015 | | | | | | | | | | | | | | | | | | |
| 2/12/2015 | | | | | | | | | | | | | | | | | | |
| 5/01/2016 | | | | | | | | | | | | | | | | | | |
| 4/02/2016 | | | | | | | | | | | | | | | | | | |
| 10/03/2016 | | | | | | | | | | | | | | | | | | |
| 4/04/2016 | | | | | | | | | | | | | | | | | | |
| Statistics | | | | | | | | | | | | | | | | | | |
| Number of Samples | 10 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 6 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 8 | 1 |
| 90th Percentile (or Max) | 7.3 | 8.5 | 360 | 174 | 7.1 | 379 | 204 | 299 | 2 | 7.5 | 6.8 | 297 | 141 | 7.1 | 329 | 30 | 30 | 2 |
| Average | 6.9 | 6.1 | 264 | 118 | 6.7 | 268 | 74 | 130 | 2 | 7.0 | 5.2 | 251 | 75 | 6.7 | 263 | 20 | 21 | 2 |
| 10th Percentile (or Min) | 6.3 | 4.4 | 200 | 11 | 6.1 | 184 | 16 | 9 | 1 | 6.4 | 3.8 | 209 | 20 | 6.4 | 190 | 10 | 13 | 2 |

# APPENDIX B – GEOCHEMICAL ANALYSIS

## Dunmore Quarry

The chart below was prepared in 1999 as a part of the Dunmore Quarry Nusoil project. It is noted that:

- The Total Nitrogen (TN) of the Dunmore dust is 200mg/kg, which is generally higher than concentrations from other quarries; and
- The Copper concentration of the Dunmore dust is 0.03%, which is also generally higher than concentrations from other quarries.

BORAL QUARRY ROCK DUSTS PROPERTY CHART

| Quarry | Dunmore | Kiama | Peats | Currabubula | Byrock | Beryl | Cosgrove | Narangba | Purga | Petrie | Peats | Seaham |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rock Property | | | Ridge | | | | | | | | Ridge | |
| Rock Type | Latite | Latite | Basalt | Quartz Diorite | Basalt | Basalt | Limburgite | Greenstone | | Greenstone | Basalt | Rhyolite |
| pH | 9.70 | 9.70 | 8.00 | 9.10 | 8.40 | 8.40 | 9.00 | 8.90 | 9.40 | 9.20 | 8.00 | 8.50 |
| $Si_2O$(%) | 54.70 | 54.53 | 45.37 | 60.30 | 45.10 | 49.30 | 45.80 | 51.90 | 52.00 | 49.90 | 45.37 | 69.90 |
| $Al_2O_3$(%) | 16.84 | 16.60 | 14.62 | 15.00 | 9.00 | 15.60 | 10.60 | 13.80 | 15.10 | 11.90 | 14.62 | 14.00 |
| $Fe_2O_3$(%) | 8.18 | 7.80 | 12.87 | 5.90 | 11.30 | 12.00 | 13.60 | 12.10 | 11.00 | 10.40 | 12.87 | 2.50 |
| CaO(%) | 7.47 | 7.78 | 10.53 | 4.70 | 7.50 | 8.40 | 11.30 | 6.30 | 6.60 | 8.70 | 10.53 | 1.60 |
| MgO(%) | 3.10 | 2.90 | 9.05 | 0.51 | 8.40 | 7.50 | 7.20 | 4.74 | 8.00 | 8.30 | 9.05 | 0.58 |
| $Na_2O$(%) | 3.41 | 3.35 | 2.82 | 3.10 | 1.00 | 2.00 | 2.10 | 4.20 | 2.26 | 2.00 | 2.82 | 3.00 |
| $K_2O$(%) | 3.97 | 3.88 | 0.82 | 2.30 | 7.10 | 1.20 | 1.00 | 0.60 | 1.15 | 1.20 | 0.82 | 4.30 |
| $TiO_2$(%) | 0.97 | 0.89 | 1.89 | 3.22 | 5.44 | 4.07 | 6.30 | 1.84 | 1.16 | 1.21 | 1.89 | 0.30 |
| $Mn_2O_3$(%) | 0.17 | 0.18 | 0.19 | 0.11 | 0.16 | 0.15 | 0.20 | 0.22 | 0.20 | 0.24 | 0.19 | 0.05 |
| V(%) | ND | ND | ND | <0.05 | <0.05 | <0.05 | | 0.08 | NA | <0.05 | ND | <0.05 |
| Cr(%) | 0.01 | 0.01 | 0.02 | <0.02 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.04 | 0.02 | 0.02 |
| Cu(%) | 0.03 | 0.03 | 0.01 | <0.02 | 0.01 | <0.01 | 0.01 | <0.02 | 0.02 | <0.02 | 0.01 | <0.01 |
| Co(%) | ND | ND | <0.01 | <0.01 | 0.01 | 0.01 | 0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 |
| Pb(%) | ND | ND | ND | 0.01 | <0.01 | <0.01 | 0.03 | <0.01 | 0.01 | <0.01 | ND | <0.01 |
| ZnO(%) | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 |
| L.O.I. | 1.19 | 1.72 | 0.91 | 1.80 | 2.60 | 0.60 | 2.70 | 1.70 | 0.20 | 1.40 | 0.91 | 1.30 |
| *Total (%) | 100.37 | 99.91 | 99.26 | 97.00 | 97.70 | 100.80 | | 97.50 | | 101.30 | 99.26 | 97.60 |
| Total Nitrogen (mg/kg) | 200 | 100 | 200 | 75 | 59 | 75 | <100 | 226.00 | <100 | <50 | 200 | <50 |
| Total Phosphorous (Mg/kg) | 3000 | 2200 | 1300 | 550 | 2950 | 1150 | 4000.00 | 600.00 | 11.00 | 1000.00 | 1300 | 360 |
| CEC (meg/100g) | 3.40 | 14.20 | | 3.80 | 7.60 | 2.40 | 11.20 | 3.70 | 7.30 | 4.20 | | 2.00 |
| Exchange Na (meq/100g) | 0.16 | 0.50 | | 0.46 | 0.40 | 0.20 | 0.90 | 0.27 | 1.50 | 0.35 | | 0.29 |
| Exchange K (meg/100g) | 0.04 | 0.06 | | 0.02 | 0.50 | 0.03 | 0.03 | 0.03 | 0.50 | 0.04 | | 0.02 |
| Exchange Ca (meg/100g) | 2.75 | 8.90 | | 2.75 | 3.20 | 0.47 | 5.40 | 2.35 | 4.30 | 1.10 | | 0.42 |
| Exvchange Mg (meg/100g) | 0.50 | 5.00 | | 0.58 | 3.45 | 1.65 | <100 | 1.05 | 1.00 | 2.70 | | 1.25 |
| Parramagnetic Value (cgs) | 5700 | 5800 | 300 | 2220 | 1350 | 290 | 2750.00 | 800.00 | 1430.00 | 190-220 | 300 | 650 |
| Bulk Density | | 1.55 | 1.7 | | | 1.57 | | | | | 1.7 | 1.42 |
| Laboratory Sample No | | | | 2835 | 3053 | 2871 | | 2593.00 | | | | 2981 |

## Boral National Mineralisation Study – 2005/06

This study was undertaken following an identified issue at Mugga Quarry regarding naturally occurring galena (lead). The table shows the mineralisation results for Boral quarries. Note that copper (Cu) levels are elevated at Dunmore Quarry compared with other Boral quarries.

ZERO HARM TODAY

August 2017

BORAL®

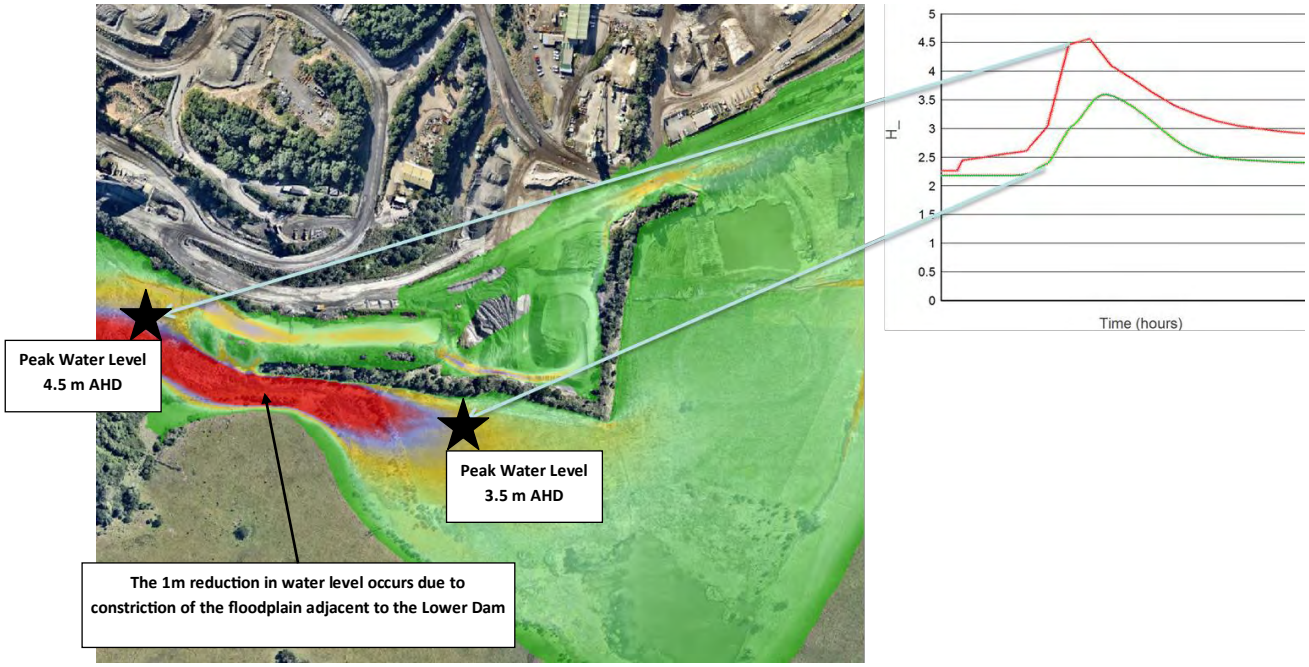
## SUMMARY OF SOIL LABORATORY TEST RESULTS - INORGANICS
## NSW/ACT QUARRIES MINERALISATION RESULTS

| LSN | Sample | Date Sampled | Arsenic | Barium | Beryllium | Cadmium | Colbalt | Chromium | Copper | Manganese | Mercury | Nickel | Lead | Vanadium | Zinc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Unit* | | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* | *mg/kg* |
| | *LOR* | | *2* | *10* | *2* | *0.5* | *5* | *5* | *5* | *5* | *0.1* | *5* | *5* | | *5* |
| | **Threshold Criteria [1, 2 and 3]** | | **100[1], 400[2], 200[3]** | | **20[1], 80[2], 40[3]** | **20[1], 80[2], 40[3]** | **100[1], 400[2], 200[3]** | | **1000[1], 4000[2], 2000[3]** | **1500[1], 6000[2], 3000[3]** | **15[1], 60[2], 30[3]** | **2400[2], 600[1, 3]** | **300[1], 1200[2], 600[3]** | | **7000[1], 28,000[2], 14,000[3]** |
| | **Threshold Criteria [4 and 5]** | | **20[4, 5]** | **300[4]** | | **3[4, 5]** | | **400[4], 50[5]** | **100[4], 60[5]** | **500[4]** | **1[4, 5]** | **60[4, 5]** | **600[4], 300[5]** | | **200[4, 5]** |
| | **Threshold Criteria [6]** | | **30** | | | **1** | | **80** | **80** | | **1** | **50** | **100** | | **300** |
| 83441 | Johns River - 20mm Agg | 16.7.08 | 3.2 | 14.6 | 0.2 | 1.20 | 12.0 | 29.7 | 19.6 | 214.6 | <0.1 | 8.8 | 11.7 | 53.5 | 48.0 |
| 83442 | Johns River - Dust | 16.7.08 | 1.7 | 10.1 | 0.2 | 0.80 | 8.0 | 14.1 | 16.8 | 167.4 | <0.1 | 9.6 | 7.4 | 47.9 | 70.2 |
| 83443 | Culcairn - 20mm Agg | 16.7.08 | 1.3 | 27.1 | 0.3 | 1.10 | 8.8 | 31.8 | 9.3 | 293.9 | <0.1 | 8.0 | 14.2 | 43.1 | 49.9 |
| 83444 | Culcairm - 5mm Dust | 16.7.08 | 2.6 | 34.9 | 0.4 | 1.00 | 8.2 | 14.1 | 9.2 | 243.2 | <0.1 | 5.0 | 14.3 | 40.9 | 40.3 |
| 83317 | Hall - 20mm Agg | 15.7.08 | 5.5 | 31.4 | 0.1 | 0.50 | 3 | 44.9 | 15.2 | 122.4 | <0.1 | 23.5 | 7.1 | 10.4 | 41.1 |
| 83318 | Hall - Dust | 15.7.08 | 4.9 | 21.5 | 0.2 | 0.60 | 4.8 | 23.1 | 9.4 | 183.0 | <0.1 | 22.6 | 5.1 | 16.7 | 42 |
| 83253 | Shadforth - 20mm Agg | 14.7.08 | 1.0 | 21.6 | 0.3 | 0.50 | 4.5 | 15.7 | 16.4 | 192.0 | <0.1 | 10.9 | 5.2 | 12.7 | 36.4 |
| 83254 | Shadforth - Coarse Dust | 14.7.08 | 0.9 | 35.7 | 0.4 | 0.60 | 5.9 | 15.9 | 18.1 | 200.7 | <0.1 | 12.3 | 5.9 | 19.5 | 30.4 |
| 83750 | Talbragar - 20mm B. Metal | 29.7.08 | 0.6 | 15.2 | 0.1 | 2.20 | 31.3 | 36.6 | 37.7 | 517.2 | <0.1 | 141.9 | 14.7 | 65.4 | 59.2 |
| 83751 | Talbragar - Quarry Dust | 29.7.08 | 0.5 | 18.2 | 0.1 | 2.10 | 31.4 | 41.6 | 31.6 | 625.9 | <0.1 | 144.7 | 13.2 | 64.0 | 53.8 |
| 83176 | Beryl - 20mm Blue Metal | 7.7.08 | 0.7 | 20.1 | 0.2 | 0.50 | 28.7 | 26.0 | 22.6 | 442.5 | <0.1 | 98.6 | 16.9 | 46.0 | 52.1 |
| 83177 | Beryl - Quarry Dust | 7.7.08 | 0.4 | 27.5 | 0.2 | 0.60 | 23.1 | 16.2 | 19.2 | 371.1 | <0.1 | 92.5 | 12.4 | 45.2 | 32.5 |
| 83178 | Currabubula - 20mm B.Metal | 11.7.08 | 6.5 | 18.5 | 0.2 | 0.60 | 7.9 | 17.9 | 40.9 | 129.6 | <0.1 | 11.0 | 11.0 | 40.9 | 16.4 |
| 83179 | Currabubula - Mfg. Sand | 11.7.08 | 6.3 | 32.0 | 0.3 | 0.80 | 9.3 | 16.9 | 44.8 | 186.0 | <0.1 | 9.3 | 14.8 | 57.9 | 21.1 |
| 83180 | Peats Ridge - 20mm Agg. | 11.7.08 | 1.6 | 23.0 | 0.5 | 2.20 | 34.9 | 22.7 | 63.1 | 720.9 | <0.1 | 114.4 | 24.9 | 98.3 | 59.9 |
| 83181 | Peats Ridge-B. Quarry Sand | 11.7.08 | 0.7 | 35.1 | 0.5 | 2.40 | 36.3 | 22.8 | 69.4 | 759.0 | <0.1 | 114.3 | 26.3 | 105.1 | 62.2 |
| 83746 | Teven - 20/14mm Basalt Agg. | 29.7.08 | 0.9 | 20.9 | 0.1 | 0.80 | 8.7 | 10.8 | 10.8 | 160.9 | <0.1 | 8.1 | 6.1 | 16.2 | 34.4 |
| 83747 | Teven - Basalt Dust | 29.7.08 | 1.0 | 34.7 | 0.2 | 1.00 | 9.5 | 5.9 | 13.4 | 201.3 | <0.1 | 6.8 | 8.1 | 20.2 | 35.8 |
| 83748 | Teven-20/14mm Argillite Agg. | 29.7.08 | 8.1 | 19.5 | 0.5 | 1.20 | 10.8 | 15.8 | 41.0 | 597.0 | <0.1 | 25.9 | 25.2 | 20.8 | 73.7 |
| 83749 | Teven Argillite Dust | 29.7.08 | 10.4 | 21.5 | 0.7 | 1.00 | 8.5 | 13.8 | 26.8 | 762.3 | <0.1 | 10.7 | 25.7 | 13.2 | 73.3 |
| | Wave Hill - 20mm Agg | 23.7.08 | 0.5 | 39.4 | 0.2 | 0.80 | 10.8 | 32.2 | 21.1 | 374.7 | <0.1 | 48.2 | 7.9 | 29.9 | 45.4 |
| | Wave Hill - Mfg. Sand | 23.7.08 | 0.4 | 39.4 | 0.1 | 1.10 | 13.3 | 32.3 | 27.1 | 594.8 | <0.1 | 54.2 | 9.6 | 34.9 | 58.0 |
| 84043 | Bombala - 20mm Agg | 07.8.08 | 1.1 | 14.7 | 0.4 | 1.60 | 15.0 | 8.9 | 21.7 | 463.1 | <0.1 | 67.8 | 11.5 | 29.4 | 49.9 |
| 84044 | Bombala - Quarry Dust | 07.8.08 | 1.0 | 21.7 | 0.5 | 1.80 | 19.2 | 17.7 | 23.9 | 574.5 | <0.1 | 82.8 | 131.0 | 38.9 | 48.6 |
| 87813 | Marulan - Granodiorite 10mm | 09.12.08 | <0.05 | 84.9 | <0.05 | 1.20 | 8.1 | 19.2 | 22.1 | 181.5 | <0.1 | 9.0 | 14.6 | 62.3 | 36.4 |
| 87814 | Marulan - Granodiorite dust | 09.12.08 | <0.05 | 88.7 | <0.05 | 1.10 | 7.4 | 22.2 | 18.3 | 186.7 | <0.1 | 6.7 | 15.9 | 62.2 | 42.7 |
| 90920 | Marulan - FR | 01.04.09 | 0.27 | 343.10 | 0.29 | 0.96 | 14.01 | 23.14 | 13.97 | 498.50 | <0.1 | 9.38 | 21.96 | 80.84 | 22.00 |
| 90921 | Marulan - SW | 01.04.09 | 0.63 | 104.80 | 0.30 | 0.79 | 15.43 | 17.92 | 16.05 | 263.20 | <0.1 | 8.71 | 18.34 | 87.24 | 27.09 |
| 90922 | Marulan - OB | 01.04.09 | 0.79 | 62.99 | 0.23 | 0.54 | 10.24 | 14.55 | 13.15 | 142.30 | <0.1 | 5.62 | 13.71 | 52.57 | 22.27 |
| 90923 | Marulan - Mard 104 (39.8-41.75) | 01.04.09 | 0.26 | 362.40 | 0.50 | 0.92 | 13.81 | 91.77 | 12.93 | 275.60 | <0.1 | 12.73 | 18.00 | 216.20 | 18.81 |
| 91068 | Dunmore 20mm aggregate | 5.04.09 | 0.15 | 9.87 | 0.69 | 0.70 | 12.21 | 2.21 | 165.00 | 422.60 | <0.1 | 6.01 | 2.65 | 92.93 | 32.48 |
| 91069 | Dunmore dust | 05.04.09 | <0.01 | 8.22 | 0.59 | 0.77 | 12.07 | 1.49 | 181.70 | 367.00 | <0.1 | 5.13 | 2.42 | 94.51 | 31.33 |
| 91675 | DSS - Fine washed concrete sand | 5.04.09 | 1.07 | 10.06 | 0.07 | 0.09 | 0.99 | 2.05 | 4.51 | 27.78 | <0.1 | 1.16 | 0.60 | 6.85 | 25.33 |
| 91676 | DSS - Manufactured washed concrete sand | 5.04.09 | 0.88 | 8.96 | 0.36 | 0.49 | 6.79 | 1.75 | 108.20 | 264.30 | <0.1 | 3.44 | 2.60 | 60.40 | 32.30 |
| 91677 | DSS - Manufactured Coarse Washed Sand | 5.04.09 | 1.12 | 9.57 | 0.28 | 0.61 | 5.79 | 1.93 | 89.49 | 261.40 | <0.1 | 3.57 | 1.83 | 55.52 | 33.21 |

Notes:

| | |
|---|---|
| 1 | Criteria based on NEPM Guidelines on the Investigation for Soil and Groundwater, Column A 'Standard Residential land |
| 2 | Criteria based on NEPM Guidelines on the Investigation for Soil and Groundwater, Column D 'Residential land use with |
| 3 | Criteria based on NEPM Guidelines on the Investigation for Soil and Groundwater, Column E 'Parks, recreational open |
| 4 | Criteria based on NEPM Guidelines on the Investigation of Soil and Groundwater Ecological Investigation Levels (Interim Urban) |
| 5 | Criteria based on ANZECC B |
| 6 | Criteria based on the NSW Recovered Aggregate Exemption 2008 Table 2 Column 4 Absolute Maximum Conc. Applicable when the product is recycled. |
| | Shaded cells indicates sample exceeded criteria |
| LOR | Limit of Laboratory Reporting |
| -- | Sample not tested for this analyte |
| ND | Not detected. |

# APPENDIX C – ROCKLOW CREEK HYDRAULIC MODEL RESULTS




The 16 March 2017 Rocklow Creek runoff event was simulated using the TUFLOW two-dimensional hydraulic model. The model was forced at the upstream boundary using the recorded Rocklow Creek water levels.

# APPENDIX D – SEDIMENTATION DAM CALCULATIONS

**Dunmore Quarry: Sedimentation Dam Calculations**

**Calculation Assumptions**

Sedimentation dam volumes have been calculated in accordance with the methods provided in *Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries* (DECC, 2008). The following sizing methods have been adopted:

- The sedimentation dam sizing method for Type F and D soils has been adopted.
- Treatment volumes have been calculated based on the 95th Percentile 5 day rainfall event. This is in accordance with Condition of Approval number 31.
- A sediment storage volume equivalent to 50% of the treatment volume has been adopted.

Key assumptions are provided in the following table.

| Assumption | Adopted Value | Source |
|---|---|---|
| 95th Percentile Rainfall Depth | 101.1 mm | Table 6.3a Vol. 1 (Location Albion Park) |
| Soil Hydrologic Group | D – high runoff potential | Table F2 Vol. 1 |

**Calculated Dam Sizes**

| | Units | Dam Name | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Lower Dam | | | | | | |
| | | Haul Roads | Stockpiles and Vegetated Area | Total | Middle Dam | Upper Dam (existing) | Upper Dam (proposed) | Middle Dam (Cumulative Impact Assessment)[2] |
| **Catchment Area (ha)** | *(ha)* | 5.7 | 21.3 | 27 | 11.1 | 23.1 | 38.6 | 15.1 |
| **5 day Rainfall Depth** | *(mm)* | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 |
| **Soil Hydrologic Group** | | D | A | by calc | D | C | D | D |
| **Runoff Coefficient (Cv)[1]** | - | 0.79 | 0.37 | 0.46 | 0.79 | 0.7 | 0.7 | 0.79 |
| **Sedimentation Dam Volume** | *(ML)* | 4.6 | 8.0 | 12.5 | 9 | 16 | 27 | 12 |
| **Calculated Sediment Storage** | *(ML)* | 2.3 | 4.0 | 6.3 | 4 | 8 | 14 | 6 |
| **Total Dam Volume** | *(ML)* | 6.8 | 12.0 | 18.8 | 13 | 25 | 41 | 18 |

*Note 1: From Table F2 Vol. 1*

*Note 2: The Cumulative assessment calculations refer to the RailCorp Extraction Area extension scenario that is discussed in Section 7 of the Surface Water Assessment*

# APPENDIX E – WATER BALANCE RESULTS: RAILCORP EXTRACTION AREA EXPANSION SCENARIO

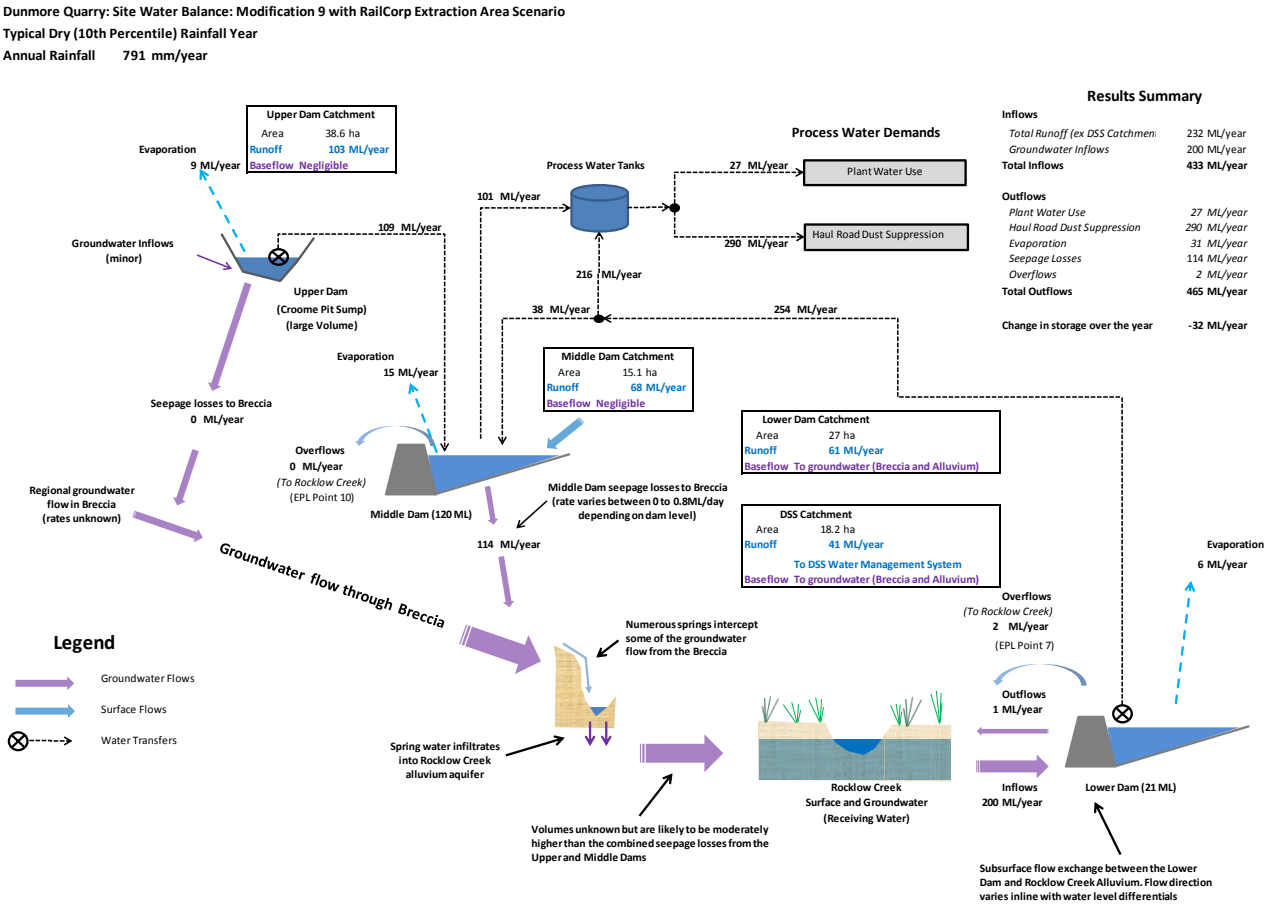



**Figure E1** – *RailCorp Extraction Area Extension Scenario: Water Balance Results: Dry Year*

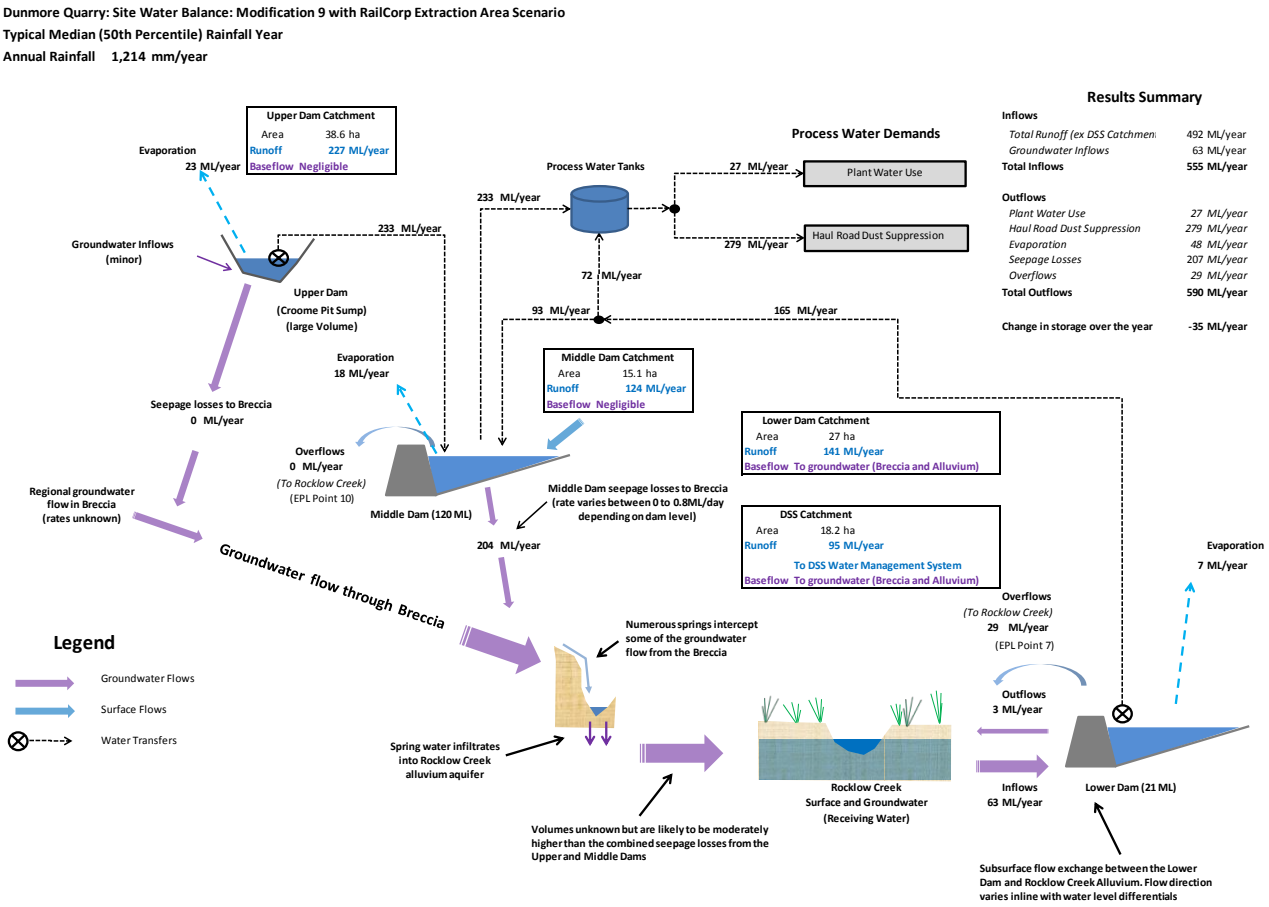



**Figure E2** – *RailCorp Extraction Area Extension Scenario: Water Balance Results: Median Year*

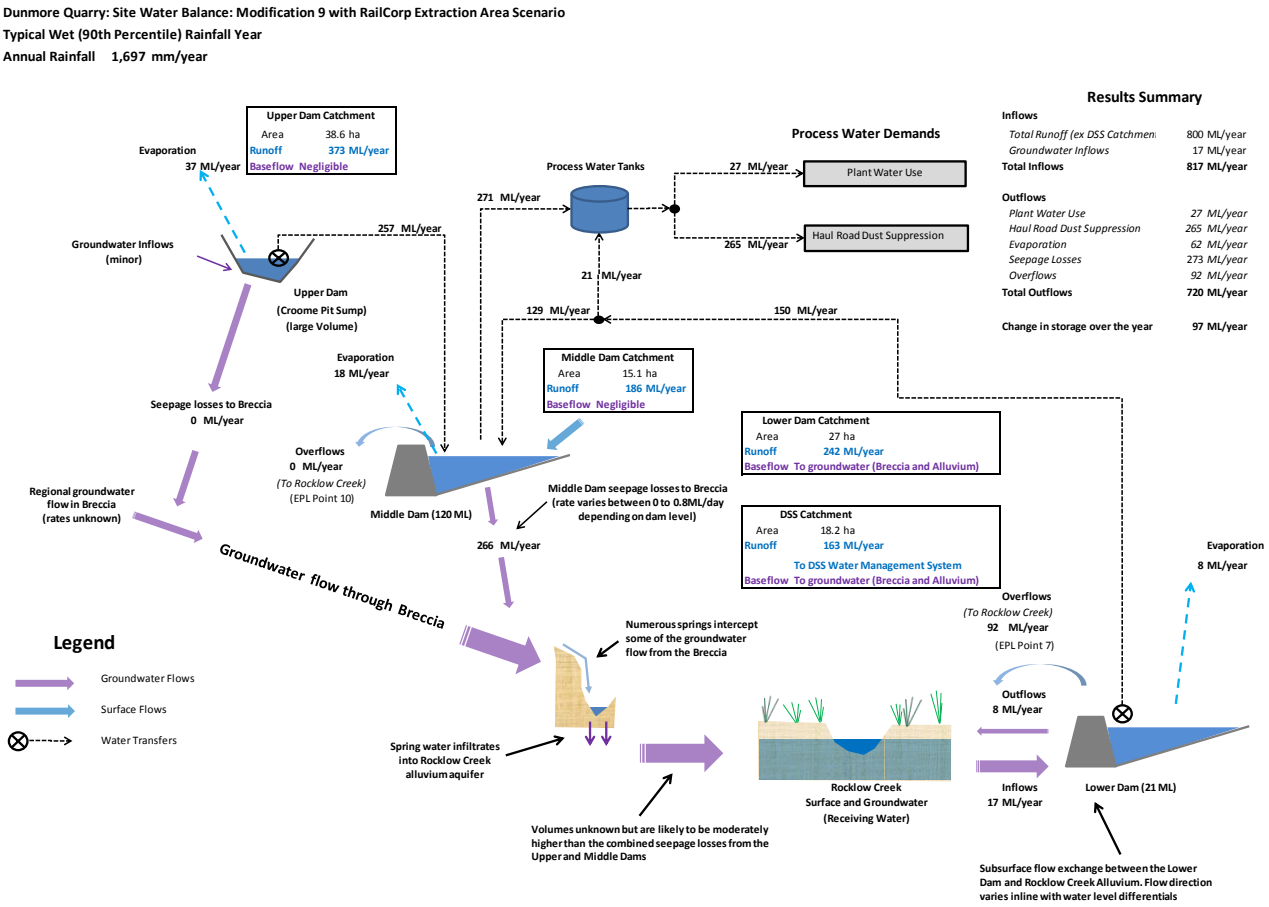



**Figure E3** – *RailCorp Extraction Area Extension Scenario: Water Balance Results: Wet Year*

# Appendix B

## Credit report for proposed modification

# BioBanking Credit Calculator

## Ecosystem credits

| | |
|---|---|
| Proposal ID : | 191/2017/4549MP |
| Proposal name : | Boral Zieria sp credit calculation |
| Assessor name : | Eugene Dodd |
| Assessor accreditation number : | 191 |
| Tool version : | v4.0 |
| Report created : | 04/08/2017 17:02 |

| Assessment circle name | Landscape score | Vegetation zone name | Vegetation type name | Condition | Red flag status | Management zone name | Management zone area | Current site value | Future site value | Loss in site value | Credit required for bio diversity | Credit required for TS | TS with highest credit requirement | Average species loss | Species TG Value | Final credit requirement for management zone |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.00 | SR520_Moderate/Good | Bracelet Honey-myrtle - Australian Indigo dry shrubland on volcanics, southern Sydney Basin Bioregion | Moderate/Good | Yes | 1 | 1.00 | 94.67 | 0.00 | 94.67 | 75 | 0 | | 0.00 | 0.00 | 75 |

# *BioBanking Credit Calculator*

## Species credits

| | |
|---|---|
| Proposal ID : | 191/2017/4549MP |
| Proposal name : | Boral Zieria sp credit calculation |
| Assessor name : | Eugene Dodd |
| Assessor accreditation number : | 191 |
| Tool version : | v4.0 |
| Report created : | 04/08/2017 17:02 |

| Scientific name | Common name | Species TG value | Identified population? | Can Id. popn. be offset? | Area / number of loss | Negligible loss | Red flag status | Number of credits |
|---|---|---|---|---|---|---|---|---|
| Zieria granulata | Illawarra Zieria | 1.40 | No | | 162.00 | 0.00 | Yes | 2,268 |

# Appendix C

## Credit report for simulated offset site

# *BioBanking Credit Calculator*

## Ecosystem credits

| | |
|---|---|
| Proposal ID : | 191/2017/4567B |
| Proposal name : | Boral Zieria sp credit offset |
| Assessor name : | Eugene Dodd |
| Assessor accreditation number : | 191 |
| Tool version : | v4.0 |
| Report created : | 04/08/2017 17:04 |

| Assessment circle name | Landscape score | TS subzone number | Vegetation zone name | Vegetation type name | Condition | Management zone name | Management zone area | Current site value | Future site value | Gain in site value | Total credit created for management zone |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21.00 | SR520_Moderate/Good_1 | SR520_Moderate/Good | Bracelet Honey-myrtle - Australian Indigo dry shrubland on volcanics, southern Sydney Basin Bioregion | Moderate/Good | 1 | 1.00 | 94.67 | 96.00 | 1.33 | 8 |

# BioBanking Credit Calculator

## Species credits

| | |
|---|---|
| Proposal ID : | 191/2017/4567B |
| Proposal name : | Boral Zieria sp credit offset |
| Assessor name : | Eugene Dodd |
| Assessor accreditation number : | 191 |
| Tool version : | v4.0 |
| Report created : | 04/08/2017 17:04 |

| Scientific name | Common name | Species TG value | Biobank on identified population? | Number found? | Units | Number of credits |
|---|---|---|---|---|---|---|
| Zieria granulata | Illawarra Zieria | 1.40 | No | 324.00 | indiv | 2,300 |

# Appendix D

## Aboriginal heritage management plan

# DUNMORE HARD ROCK QUARRY – MODIFICATION 9
# CROOME WEST EXTENSION
# (DA 470-11-2003 MOD 9)

## Aboriginal Heritage Management Plan

Prepared for
Boral Resources (NSW) Pty Limited

Shellharbour Local Government Area

DRAFT
June 2017

Ref. 1526

**KELLEHER NIGHTINGALE CONSULTING PTY LTD**
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## Document Information

| | |
|---|---|
| Project Name | Dunmore Hard Rock Quarry – Modification 9, Croome West Extension (DA 470-11-2003 MOD 9) Aboriginal Heritage Management Plan |
| Project Number | 1526 |
| Revision | 0.1 |
| Status | DRAFT |
| Client Name | Boral Resources (NSW) Pty Limited |
| Recipient | Kate Jackson, Senior Planning and Development Manager (NSW/ACT) |
| Issue Date | 9 June 2017 |
| Prepared by | Dr Matthew Kelleher; Alison Nightingale |
| Approved by | Dr Matthew Kelleher; Alison Nightingale |

## Contents



## Figures



## Tables

# 1 Introduction

Boral Resources (NSW) Pty Limited ('Boral') is seeking approval to expand the Croome Farm Pit, the westernmost of its existing extraction pits at the Dunmore Hard Rock Quarry on Tabbita Road, Dunmore in the Shellharbour Local Government Area. The pit expansion is required to enable the continuation of quarrying operations.

An Environmental Assessment (EA) was prepared by EMM Consulting Pty Ltd (February 2017) to accompany Boral's application to the Department of Planning and Environment (DP&E) to modify the existing Dunmore Quarry development consent (DA 470-11-2003). The modification for expansion of quarrying activities (Modification 9) is being sought under section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Kelleher Nightingale Consulting Pty Ltd (KNC) was engaged by Boral to undertake a detailed Aboriginal archaeological assessment and prepare an Aboriginal Cultural Heritage Assessment Report (CHAR) to inform the Modification 9 EA (KNC 2017). The CHAR was prepared in accordance with the DP&E EA requirements for the project and Office of Environment and Heritage (OEH) requirements and guidelines for Aboriginal community consultation and Aboriginal cultural heritage assessment. The assessment was included in the EA as:

- *Appendix F Aboriginal cultural heritage assessment – "Dunmore Hard Rock Quarry, Proposed Croome Farm West Pit Expansion, Dunmore NSW: Aboriginal Cultural Heritage Assessment Report" (KNC 2017)*

The CHAR identified the proposed quarry expansion would impact on Aboriginal heritage, requiring management and mitigation activities. The OEH submission on the Modification 9 EA requested an Aboriginal Heritage Management Plan (AHMP) be prepared, detailing the required Aboriginal heritage management and mitigation measures, including:

- Aboriginal community consultation;
- Archaeological salvage excavation;
- Long term management of excavated Aboriginal objects; and
- Unexpected finds procedure.

## 1.1 Purpose and Objectives

This AHMP has been prepared to:

- Facilitate consultation and engagement with the local Aboriginal community to appropriately manage the Aboriginal cultural heritage values associated with the project;
- Describe how Aboriginal heritage will be managed for the project;
- Ensure that impacts to Aboriginal heritage are appropriately mitigated through archaeological salvage excavation;
- Address long term management of salvaged Aboriginal objects; and
- Ensure appropriate controls and procedures are implanted in relation to any unexpected finds, including human remains.

## 1.2 Implementation of AHMP

Boral is committed to implementing Aboriginal heritage management and mitigation measures as outlined in the CHAR (KNC 2017) and this AHMP. The management strategies within the AHMP work in association with the CHAR and should be implemented in conjunction with the CHAR.

The management and mitigation measures will be implemented following issue of the Modification 9 development consent.

# 2 Background

## 2.1 Identified Aboriginal Sites

Three Aboriginal archaeological sites were identified in the proposed expansion area (KNC 2017). The sites were registered on the OEH Aboriginal Heritage Information Management System (AHIMS) in accordance with Section 89A of the *National Parks and Wildlife Act 1974*. The sites are listed in Table 1 and locations shown on Figure 1.

**Table 1. Registered Aboriginal sites – Dunmore Quarry Modification 9**

| AHIMS Site ID | Site Feature | Site Name | Easting | Northing | Datum |
|---|---|---|---|---|---|
| 52-5-0851 | Artefact | Croome West AFT 1 | 299035 | 6168718 | GDA |
| 52-5-0850 | Artefact | Croome West AFT 2 | 299050 | 6168911 | GDA |
| 52-5-0849 | Artefact | Croome West AFT 3 | 298880 | 6168925 | GDA |

**Croome West AFT 1 (AHIMS 52-5-0851)**
Site Croome West AFT 1 was located on the crest of a north west to south east running spurline in the south eastern portion of the study area and immediately south of a natural reservoir. Test excavation determined the site retained an intact low to moderate density archaeological deposit. 19 artefacts were recovered from seven test units excavated. Artefact density within the test excavation area, extrapolated to square metres, displayed a mean artefact density of 10.86/$m^2$. Artefact distribution was characterised by a low density deposit with a localised higher density in the middle of the tested area. The occurrence of localised higher density suggested limited horizontal movement within the deposit. The absence of cores and formalised tools within the assemblage indicated the site functioned as an area for maintenance and use of stone tools. The quality and aesthetic nature of the raw material indicated a selective activity area.

The site represented a commonly occurring site type in the region; however, the site type is uncommon in a ridgetop landform context. In addition, the range of raw materials and artefact types found at the site and context adjacent to the natural reservoir is unusual. The site demonstrated moderate scientific value and further investigation would contribute to our understanding of Aboriginal landscape use in a location where Aboriginal archaeological objects have not commonly been found. Based on the intactness, representativeness and research potential of the site, Croome West AFT 1 was determined to have moderate archaeological significance (high research values, moderate levels of soils disturbance and low conservation value).

**Croome West AFT 2 (AHIMS 52-5-0850)**
Site Croome West AFT 2 was located on the crest of a saddle immediately north of a natural reservoir. Test excavation determined the site retained an intact moderate density archaeological deposit. 57 artefacts were recovered from the ten test units excavated. Artefact density within the test excavation area was significantly higher than those of the other two test excavation areas and extrapolated to square metres, the test area displayed a mean artefact density of 22.8/$m^2$. Artefact distribution was characterised by a moderate density deposit with a localised higher density along the western edge of the tested area. The occurrence of localised higher density suggested limited horizontal movement within the deposit. The assemblage contained a small quantity of cores and formalised tools indicating that the creation of stone tools occurred at the site but was secondary to the maintenance and use of stone tools. The quality and aesthetic nature of the raw material indicated a selective activity area.

The site represented a commonly occurring site type in the region; however, the site type is uncommon in a ridgetop landform context. In addition, the range of raw materials and artefact types found at the site and context adjacent to the natural reservoir was unusual. The site demonstrated moderate scientific value and further investigation would contribute to our understanding of Aboriginal landscape use in a location where Aboriginal archaeological objects have not commonly been found. Further investigation may help to answer research questions related to Aboriginal occupation and exploitation of natural volcanic vents/reservoirs in the area, a rare physical landscape feature, as well utilisation of elevated areas such as hillcrests and ridgetops between the coast and sandstone escarpments to the west, transportation routes for movement of people or use of special areas or resources for specific or specialised activities. Based on the intactness, representativeness and research potential of the site, Croome West AFT 2 was determined to have moderate archaeological significance (high research values, moderate levels of soils disturbance and low conservation value).

**Croome West AFT 3 (AHIMS 52-5-0849)**
Site Croome West AFT 3 was located on the crest of hill in the western portion of the study area. Test excavation determined the site retained an intermittent low density archaeological deposit. Ten artefacts were recovered from the ten test units excavated. Artefact density within the test excavation area, extrapolated to square metres, displayed a mean artefact density of 4/$m^2$. Artefact distribution was characterised by an intermittent low density deposit. The overall unfocussed low density deposit and close proximity to structures suggested the deposit had been disturbed (house, outbuildings, agricultural activities and tree clearance). The absence of cores and formalised tools within the assemblage indicated the site functioned as an area for the maintenance and use of stone tools. The lower overall artefact density indicated the site area was a secondary/support activity location for limited maintenance.

The site represented a commonly occurring site type in the region; however, the site type is uncommon in a ridgetop landform context. The site demonstrated low scientific value due to the disturbed nature and low density of the archaeological deposit. It is unlikely that further investigation would contribute to our understanding of Aboriginal landscape use in the region. Based on the intactness, representativeness and research potential of the site, Croome West AFT 3 was determined to have low archaeological significance.

## 2.2 Impact of Proposal on Aboriginal Objects

The entirety of the Modification 9 pit expansion area would be impacted by quarrying and associated activities. The expansion of quarrying operations will remove the three identified Aboriginal archaeological sites (Table 2).

**Table 2. Modification 9 impact on Aboriginal sites**

| AHIMS Site ID | Site Name | Type of harm | Degree of harm | Consequence of harm | Significance of harm |
|---|---|---|---|---|---|
| 52-5-0851 | Croome West AFT 1 | Direct | Total | Total loss of value | Moderate |
| 52-5-0850 | Croome West AFT 2 | Direct | Total | Total loss of value | Moderate |
| 52-5-0849 | Croome West AFT 3 | Direct | Total | Total loss of value | Low |

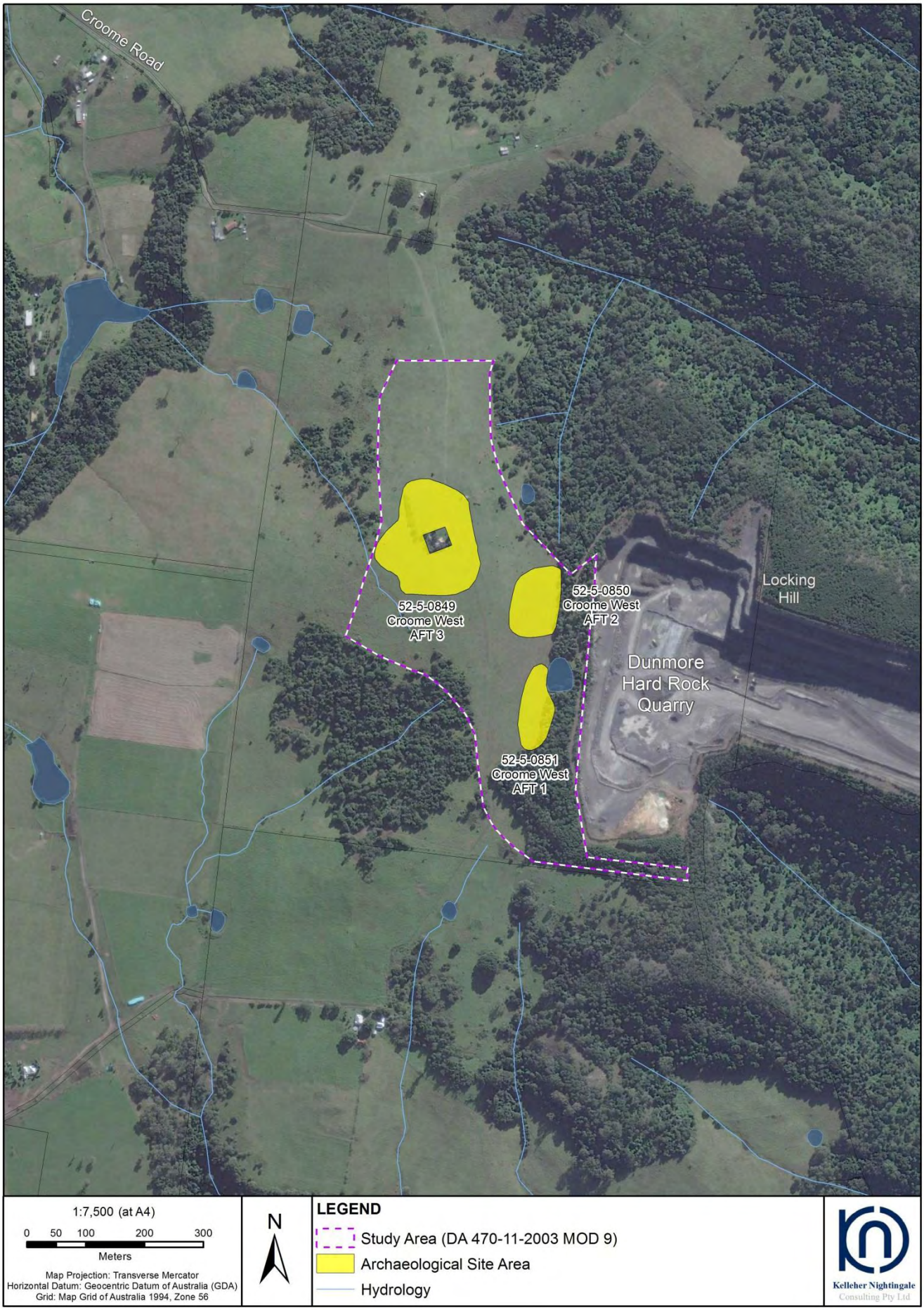


**Figure 1. Aboriginal archaeological sites**

# 3 Aboriginal Community Consultation

- **Registered Aboriginal Stakeholders will be consulted and provided with an opportunity to participate in the archaeological salvage excavation and contribute to the Aboriginal heritage assessment reporting.**

Boral is committed to effective consultation with the local Aboriginal community regarding their activities and Aboriginal cultural heritage values.

Twelve Aboriginal community groups or individuals registered their interest in the Modification 9 project. The Registered Aboriginal Stakeholders are listed in Table 3.

**Table 3. Registered Aboriginal Stakeholders – Dunmore Quarry Modification 9**

| Registered Aboriginal Stakeholder | Representative and/or Contact Person |
|---|---|
| Illawarra Local Aboriginal Land Council | Derek Hardman |
| Peter Falk Consultancy | Peter Falk |
| Minnamunnung | Aaron Broad |
| Gundungurra Tribal Technical Services | Christopher Payne |
| Woronora Plateau Gundungara Elders Council | Paul Cummins |
| Goobah | Basil Smith |
| Biamanga | Seli Storer |
| Cullendulla | Corey Smith |
| Gary Caines | Gary Caines |
| Gulaga | Wendy Smith |
| Murramarang | Roxanne Smith |
| Registered Aboriginal Stakeholder* | Details withheld |

* Details withheld in accordance with item 4.1.5 of the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010*

Registered Aboriginal Stakeholders for the Modification 9 project will continue to be consulted in relation to impacts on Aboriginal cultural heritage and the archaeological salvage excavations.

Registered Aboriginal Stakeholders will be provided with an opportunity to participate in the archaeological salvage program and contribute to the Aboriginal heritage assessment reporting.

Registered Aboriginal Stakeholders will be provided with a draft report for review and comment. Aboriginal stakeholder comments will be included in the final report.

Registered Aboriginal Stakeholders have been consulted on the storage location for recovered Aboriginal objects.

Consultation with Registered Aboriginal Stakeholders will follow OEH consultation requirements as applicable *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW 2010).

# 4 Archaeological Salvage Excavation

- **Archaeological salvage excavation will be undertaken according to the methodology attached as Appendix E to the CHAR (KNC 2017) to mitigate project impacts on Aboriginal heritage. The salvage program will be undertaken in consultation with Registered Aboriginal Stakeholders. Salvage excavation will occur following issue of Modification 9 approval and prior to commencement of actions in those areas.**

The following management and mitigation measures are required for identified Aboriginal heritage within the project area.

## 4.1 Mitigation through Archaeological Salvage Excavation

The archaeological sites in Table 4 are of moderate Aboriginal heritage significance and will be impacted by the project. These sites require archaeological salvage excavation to mitigate the impacts. Salvage excavation can only occur after project approval is obtained.

Salvage excavation must be completed prior to any activities which may harm Aboriginal objects at these site locations.

Salvage excavation activities would be undertaken in accordance with the methodology attached as Appendix E to the CHAR (KNC 2017).

**Table 4. Aboriginal sites requiring mitigation (salvage excavation)**

| Archaeological sites requiring mitigation | |
|---|---|
| Archaeological Sites (requiring salvage) | Croome West AFT 1 (AHIMS 52-5-0851)<br>Croome West AFT 2 (AHIMS 52-5-0850) |

## 4.2 No Archaeological Mitigation Required

No archaeological mitigation is required for the site in Table 5. The site may only be impacted after project approval is obtained.

**Table 5. Aboriginal sites with no further archaeological mitigation required**

| No further archaeological mitigation required | |
|---|---|
| Archaeological Sites (no archaeological mitigation) | Croome West AFT 3 (AHIMS 52-5-0849) |

## 4.3 Archaeological Salvage Excavation Report

An Archaeological Salvage Excavation Report will be prepared to document the findings of the archaeological salvage excavation program. The report will:

- include an executive summary
- describe the methods and results of the salvage excavation program
- describe any ongoing consultation with and involvement of Registered Aboriginal Stakeholders
- be completed with input and consultation with Registered Aboriginal Stakeholders
- detail the results of the analysis of recovered Aboriginal objects
- detail the long term management of Aboriginal objects
- include a statement of compliance with approval conditions and management and mitigation measures, and
- confirm that Aboriginal Site Impact Recording Forms have been completed and submitted to the OEH AHIMS Registrar.

# 5 Management of Salvaged Aboriginal Objects

- **Salvaged Aboriginal objects will be managed at a temporary storage location for analysis and reporting purposes and lodged for long term management with the Australian Museum.**

The short term management of excavated Aboriginal objects is as follows:

- Any Aboriginal objects that are removed from the land by actions authorised by the project approval, must be moved as soon as practicable to the temporary storage location (see below) for analysis, reporting and preparation for the long term management of the Aboriginal objects.
- The temporary storage location would be: Kelleher Nightingale Consulting Pty Ltd, Level 10, 25 Bligh Street, Sydney NSW 2000.
- Any Aboriginal objects stored at the temporary storage location must not be further harmed, except in accordance with the conditions of the approval.

The long term management of excavated Aboriginal objects is as follows:

- Once all analysis has been completed, recovered objects will be lodged with the Australian Museum in accordance with the *Australian Museum Archaeological Collection Deposition Policy* (January 2012, available online at: http://australianmuseum.net.au/document/Protocols-for-the-deposition-of-archaeological-materials).
- Requirement 26 "Stone artefact deposition and storage" in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (24 September 2010, available online at: http://www.environment.nsw.gov.au/resources/cultureheritage/10783FinalArchCoP.pdf) must be complied with.

# 6 Aboriginal Site Impact Recording Form

- **An Aboriginal Site Impact Recording Form will be completed following impacts to AHIMS sites authorised by the project approval.**

An Aboriginal Site Impact Recording Form (ASIRF) will be prepared and submitted to the AHIMS Registrar for each site, following impacts from actions authorised by the project approval. The Aboriginal Site Impact Recording Form is available online at: http://www.environment.nsw.gov.au/resources/cultureheritage/120558asirf.pdf

# 7 Heritage Training and Induction Process

- **Aboriginal heritage management procedures will be included in construction personnel training and induction process.**

Aboriginal heritage management procedures and responsibilities for compliance will form part of the project induction for construction personnel (employees, contractors, subcontractors and/or agents). This will include site identification (including construction heritage site map) to ensure all personnel are aware of Aboriginal heritage management responsibilities, issues affecting their activities and procedures for dealing with unexpected finds including human remains.

# 8 Unexpected Finds Procedure

- **Any unexpected Aboriginal heritage items (Aboriginal objects) will be managed appropriately.**

In the event that an unexpected find (Aboriginal object) is encountered the following procedure will apply:

1. Stop work and protect find area and report to environmental manager
2. Contact heritage advisor for identification
    a. No further action if the find is not an Aboriginal object
    b. If the find is an Aboriginal object proceed to next step
3. Undertake relevant regulatory requirements and contact with OEH/DP&E where required
4. Implement conservation or mitigation strategy
5. Obtain approval if required and comply with conditions
6. Recommence work

# 9 Suspected Human Remains

- **Note that Project Approvals do not include the destruction of human remains.**
- **Any potential human remains encountered will be protected and managed appropriately.**

All human remains in, on or under the land must not be harmed.

If suspected human remains are uncovered at any point, the following procedure will be implemented in accordance with *Skeletal Remains – Guidelines for the Management of Human Skeletal Remains under the Heritage Act 1977* (NSW Heritage Office 1998) and the *Aboriginal Cultural Heritage Standards and Guidelines Kit* (NPWS 1997):

1. as soon as remains are exposed, all work is to halt at that location immediately and the Project environmental manager is to be immediately notified to allow assessment and management;
    i. stop all activities
    ii. secure the site
    iii. not further harm the remains
2. contact police, the discovery of human remains triggers a process which assumes that they are associated with a crime. The NSW Police retain carriage of the process until such time as the remains are confirmed to be Aboriginal or historic;
3. DP&E, as the approval authority, will be notified when human remains are found;
4. once the police process is complete and if remains are not associated with a contemporary crime contact DP&E. DP&E will determine the process, in consultation with OEH and/or the Heritage Division as appropriate;
    i. if the remains are identified as Aboriginal, the site is to be secured and DP&E and all Aboriginal stakeholders are to be notified in writing. DP&E will act in consultation with OEH as appropriate. OEH will be notified in writing according to DP&E instructions; or
    ii. if the remains are identified as non-Aboriginal (historical) remains, the site is to be secured and the DP&E is to be contacted. DP&E will act in consultation with the Heritage Division as appropriate. The Heritage Division will be notified in writing according to DP&E instructions;
5. once the police process is complete and if the remains are identified as not being human work can recommence once the appropriate clearances have been given.

## References

DECCW, 2010. *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010: Part 6 National Parks and Wildlife Act 1974*. Department of Environment, Climate Change and Water NSW, Sydney.

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NSW National Parks and Wildlife Service (NPWS), 1997. *Aboriginal Cultural Heritage Standards and Guidelines Kit*. NSW National Parks and Wildlife Service, Hurstville.

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