19 February 2020

Attention: Lauren Evans
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Dear Lauren

Marulan South Limestone Mine Continued Operations State significant development application - Response to DPIE Water/NRAR and BCD request for further information

Boral Cement Limited (Boral) received a letter from the Department of Planning, Industry and Environment (DPIE) Water and the NSW Natural Resources Access Regulator (NRAR) on 18 December 2019 and from DPIE Biodiversity and Conservation Division (BCD) on 20 December 2019, requesting additional information on the Marulan South Limestone Mine Environmental Impact Statement (EIS).

The information requests are produced in **bold** and responses provided below the request in this letter.

DPIE Water/NRAR request for information

DPIE Water and NRAR's letter of 18 December 2019 requested certain information to be provided by Boral prior to project approval and other information to be provided post project approval i.e. that DPIE Energy Resource Assessments could consider in developing conditions of approval (refer to points 1-9 below).

A meeting was held with DPIE Water and NRAR on 30 January 2020 to discuss what additional hydrology assessment is required to address the 'prior to project approval' requirements in points 1-5. It was agreed that a summary of the potential changes in Marulan Creek hydrology provided in the Surface Water Assessment (Advisian 2019) along with additional hydrological assessment would be provided in a supplementary report to address the first and third dot points. It was agreed that no further assessment is required to address the other 'prior to project approval' requirements. A response to the second, fourth and fifth points are addressed after each point below.

It was agreed that the additional hydrological assessment would include:

- Average translucent flows – percentage time when inflow equals outflow of the dam;
- Average bypass flows – percentage time when flow bypasses the dam through the spillway;
- Cross sections upstream of the proposed dam showing levels for low, medium and flood flows; and
- Typical cross section downstream of the dam showing levels for low, medium and flood flows before and after construction of the dam.

Prior to project approval:

1. **The proponent must present an evaluation of flow modification through Barbers Creek in the event that the Marulan Creek Dam is constructed (while other dams in the Barbers Creek Management Zone are not modified) to replace the lost flow into Barbers Creek;**

   Refer to Appendix A.

2. **The proponent must present proposed measures to alter or remove dams from which Water Access Licence entitlements are obtained in order to provide mitigation to reductions in total flows and flow variability in Barbers Creek downstream of the Marulan Creek junction**

   A similar comment was included in DPIE Water/NRAR's revised submission on the EIS dated 15 August 2019. Boral included the following response in the RTS (Element, 27 September 2019):

   > Boral is currently negotiating the purchase/leasing of WALs with existing entitlement holders within the catchment. Boral is considering purchasing WALs additional to its requirements for the proposed dam to compensate for predicted reduced flow volumes along Marulan Creek downstream of the dam. This additional entitlement would be released as riparian flow when appropriate and may offset the potential impacts of the proposed dam on Marulan and Barbers Creeks to some extent. The certainty, quantity and timing of this purchase/lease is not known at present.
   >
   > Boral commits to not commencing construction of the proposed dam until sufficient WALs are secured.

   As discussed in the meeting with DPIE Water/NRAR on 30 January 2020 Boral are unable to:

   - demand that the current owners of WALs from which Boral purchase/lease part/all of their WAL entitlements, alter or remove dams on their properties from which their WAL entitlements are obtained; and
   - enforce after acquiring WAL entitlements that the previous owner of the entitlements, doesn't continue to take water that they have sold/leased entitlements to.

   As outlined in the RTS (Element, 27 September 2019):

   > Boral leases adjoining land to the north and west of active extraction areas to local farmers and graziers. Many of the dams located on Boral land, not associated with quarrying and mining operations are used by lessees for the purpose of stock watering. Any removal of these dams would adversely impact the viability of these ongoing and established agricultural uses.

3. **The proponent must present evaluation of water quality effects caused by altered flow relationships in Marulan Creek and Barbers Creek resulting from the construction of the proposed Marulan Creek Dam, and any proposed water quality mitigation measures to protect ecological values and maintain water quality values**

   Refer to Appendix A.

4. **The proponent must present an evaluation of options to remediate and rehabilitate degraded sections of Marulan Creek and other watercourses controlled by Boral Resources**

   A similar comment was included as a post approval recommendation in DPIE Water/NRAR's revised submission on the EIS dated 15 August 2019.

Boral included the following response in their RTS (Element, 27 September 2019):

> Boral agrees to include remediation and rehabilitation of channel degradation along streams in the project area in the rehabilitation management plan committed to in Table 29.2 of the EIS.

It was agreed in the meeting with DPIE Water/NRAR on 30 January 2020 that this comment does not need to be addressed prior to project approval and can be considered by DPIE Energy and Resource Assessments in preparing their conditions of approval.

5. **The proponent must present a list of options, with assessment of feasibility and effectiveness of those options, to mitigate modification to high flow events (potential changes in flow velocity, unit stream power, duration and sediment mobilisation and deposition characteristics) in Barbers Creek that occur as a result of construction of the proposed Marulan Creek Dam**

   It was agreed in the meeting with DPIE Water/NRAR on 30 January 2020 that this comment does not need to be addressed prior to project approval and can be considered by DPIE Energy and Resource Assessments in preparing their conditions of approval.

   DPIE Water/NRAR agreed that their intention was that this process of considering the feasibility and effectiveness of various options to mitigate modification to high flow events in Barbers Creek that occur as a result of the dam, should be undertaken during detailed design of the dam and the final options included in a Marulan Creek Dam operational management plan.

Post project approval:

6. **Works on waterfront land are to be carried out in accordance with the Guidelines for Controlled Activities (2012) https://www.industry.nsw.gov.au/water/licensingtrade/approvals/controlled-activities.**

   Boral has no further comment on this post approval condition.

7. **The project must obtain the required Water Access Licenses prior to commencement of works. Note that water take is to occur from the unregulated river category and not domestic and stock category. The proponent should provide evidence of purchase and transfer of WAL entitlements from within the Barbers Creek Management Zone of the Shoalhaven Water Source to account for retention and extraction of water from the proposed Marulan Creek Dam. In the event that water is not available to the mining operation, Boral Resources must adjust the scale of mining operations to match its water supply.**

   Boral has no further comment on this post approval condition other than changing 'Boral Resources' to 'Boral Cement Limited'.

8. **The proponent should develop and provide a detailed remediation program for Marulan Creek and other watercourses within its controls in consultation with DPIE Water.**

   Boral has already included the following response in their RTS (Element, 27 September 2019):

   > Boral agrees to include remediation and rehabilitation of channel degradation along streams in the project area in the rehabilitation management plan committed to in Table 29.2 of the EIS.

Therefore, it is suggested that DPIE Energy and Resource Assessments refer to the proposed 'plan' as a rehabilitation management plan.

9. **The proponent should develop a landscape rehabilitation plan in consultation with DPIE Water in relation to erosion risk, sediment generation and transport into Marulan Creek and downstream gorge.**

   Refer to Boral response to point 8 above.

DPIE BCD request for information

A response to DPIE BCD's request for clarification and further information has been prepared by the project ecologists, Niche Environment and Heritage and is included in Appendix B. Luke Baker of Niche has consulted with Allison Treweek of DPIE BCD in early February 2020 to seek clarity on the information requested and to discuss Niche's opinion that a revision of the Biodiversity Development Assessment Report (BDAR) is not necessary. Niche's response in Appendix B contains all the information that DPIE BCD ultimately required after consulting with them. This response has already been provided to Allison Treweek on 17 February 2020.

As we have consulted thoroughly with DPIE Water/NRAR and BCD on their additional information requests of December 2019, reached an agreement on the clarification and additional information they are seeking, and have provided all this information, it is assumed that this response will conclude the process of responding to additional comments by DPIE Water/NRAR and BCD on the EIS.

Please don't hesitate to contact me if you have any queries or require additional information.

Kind Regards

Neville Hattingh
Director

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APPENDIX A

RESPONSE TO DPIE WATER AND NRAR REQUEST FOR ADDITIONAL HYDROLOGICAL ASSESSMENT

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18 February 2020

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Dear Les

MARULAN SOUTH LIMESTONE MINE CONTINUED OPERATIONS

RESPONSE TO THE NSW DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT (DPIE) - WATER AND THE NATURAL RESOURCES ACCESS REGULATOR (NRAR) SUBMISSIONS - MARULAN CREEK DAM

1 Introduction

Boral Cement Limited (Boral) have submitted an Environmental Impact Statement (EIS) for the proposed Marulan South Limestone Mine Continued Operations Project (the Project). Public exhibition of the EIS ended on 1 May 2019, and Boral received a request to respond to submissions from the NSW Department of Planning, Industry and Environment (DPIE) - Water (dated 4 July 2019).

DPIE – Water and the Natural Resources Access Regulator (NRAR) subsequently met with Boral and Element Environmental on 29 July 2019 to discuss issues raised in its submission for the EIS exhibition. DPIE – Water and NRAR then provided a revised response to Boral on 14 August 2019. Boral provided additional information on 3 October 2019.

Further advice was provided by DPIE – Water and NRAR on 18 December 2019, with the following items to be resolved prior to Project Approval;

- The proponent must present an evaluation of flow modification through Barbers Creek in the event that the Marulan Creek Dam is constructed (while other dams in the Barbers Creek Management Zone are not modified) to replace the lost flow into Barbers Creek;
- The proponent must present proposed measures to alter or remove dams from which Water Access Licence entitlements are obtained in order to provide mitigation to reductions in total flows and flow variability in Barbers Creek downstream of the Marulan Creek junction;
- The proponent must present evaluation of water quality effects caused by altered flow relationships in Marulan Creek and Barbers Creek resulting from the construction of the proposed Marulan Creek Dam, and any proposed water quality mitigation measures to protect ecological values and maintain water quality values;

- The proponent must present an evaluation of options to remediate and rehabilitate degraded sections of Marulan Creek and other watercourses controlled by Boral Resources; and
- The proponent must present a list of options, with assessment of feasibility and effectiveness of those options, to mitigate modification to high flow events (potential changes in flow velocity, unit stream power, duration and sediment mobilisation and deposition characteristics) in Barbers Creek that occur as a result of construction of the proposed Marulan Creek Dam.

A meeting was held on 30 January 2020 to discuss the additional hydrology assessment that was required to meet the DPIE – Water and NRAR requirements. It was agreed that a summary of the potential changes in Marulan Creek hydrology provided in the Surface Water Assessment (SWA) along with additional hydrological assessment would be provided in a submission (this report) to address the first and third points above. The second, fourth and fifth points are addressed in a separate response by Element Environment (February 2020).

It was agreed in the meeting with DPIE – Water and NRAR that the additional hydrological assessment should include:

- Average translucent flows – percentage time when inflow equals outflow of the dam;
- Average bypass flows – percentage time when flow bypass the dam through the spillway;
- Cross sections upstream of the proposed dam showing levels for low, medium and flood flows; and
- Typical cross section downstream of the dam showing levels for low, medium and flood flows before and after construction of the dam.

2 Marulan Creek Dam

2.1 Concept

The proposed water supply systems for the Project includes the construction of a water storage dam on Marulan Creek. The dam would be located on land owned by Boral Resources (NSW) Pty Ltd north of Peppertree Quarry and would utilise existing infrastructure to transfer water to the mine. This dam would be licenced under the Water Management Act (2000) and was designed considering the requirements of the Greater Metropolitan Unregulated River Water Sources Water Sharing Plan (2011).

The dam concept involves a homogeneous earth fill embankment with batter slopes at 2.5H:1V, crest at 600 m AHD, full storage level at 597 m AHD, full storage capacity of 118 ML and a spillway on the left abutment. The width of the spillway has been designed for the estimated 1% AEP (1 in 100 year ARI) design event peak flow rate for the Marulan Creek Dam catchment (120 m^3/s) (PSM, 2016).

The Project water balance considers both the volumetric requirements associated with the Water Access Licence (WAL) and that riparian release from the dam would need to maintain a similar flow regime to protect water quality, ecological condition and maintain the geomorphic integrity of the downstream environment. This was considered in the Project water balance by assuming the dam would be subject to the release requirements of Tangarang Creek Dam at the adjacent Peppertree Quarry, which are detailed in Table 1.

Table 1: Marulan Creek Dam Riparian Release Rules

Upstream Inflow	Downstream Riparian Release
<1 ML/d	= Inflow
1 - 10 ML/d	1 ML/d
>10 ML/d	10% of inflow

The water balance model assumed a WAL of 173 unit shares (173 ML), would be transferred to the dam. This would occur through a combination of transfer of existing WALs held by Boral Cement Limited and the purchase of WALs held by others in the Barbers Creek Water Source in accordance with the requirements of the Greater Metropolitan Region Unregulated Area Water Sharing Plan. Sufficient entitlements exist in the Barbers Creek Water Source (1,176 unit shares) to allow acquisition of the required 173 unit shares.

2.2 Watercourse characteristics

The Marulan Creek dam site has a catchment of about 20 km^2 of primarily open grazing land. The proposed dam on Marulan Creek is located near the edge of the escarpment, where the creeks typically drain to steep rock-lined gorges. On the escarpment, the longitudinal gradients of the creeks are generally in the order of 0.5% to 1% with grass forming the majority of the vegetation cover in the bed of the creek (see Figure 1).

Figure 1: Marulan Creek Upstream of the Dam Site

Downstream of the proposed dam, Marulan Creek enters a steep sided gorge. The creek gradient increases to as much as 10% through the gorge, where it joins Barbers Creek and continues to the Shoalhaven River. This section of Marulan Creek is characterised by a rocky, boulder-strewn channel with rock pools. Throughout the gorge, natural vegetation extends from the stream banks to the top of the gorge. Geomorphology is consistent with spatial mapping of the catchment (NSW Office of

Water (2012), which characterises this section of Marulan Creek as Confined Valley Gorge (CVG), based on The River Styles Framework (Brierly, 2006). LiDAR data (NSW DFSI-Spatial Services, 2019) has been utilised to generate a digital elevation model of the catchment (as shown in Figure 3), the elevation profile of Marulan Creek is shown in Figure 4 from the confluence of Barbers Creek (0 m), with the location of the proposed dam shown approximately 1,700 m upstream.

Figure 2: Marulan Creek Downstream of the Dam Site

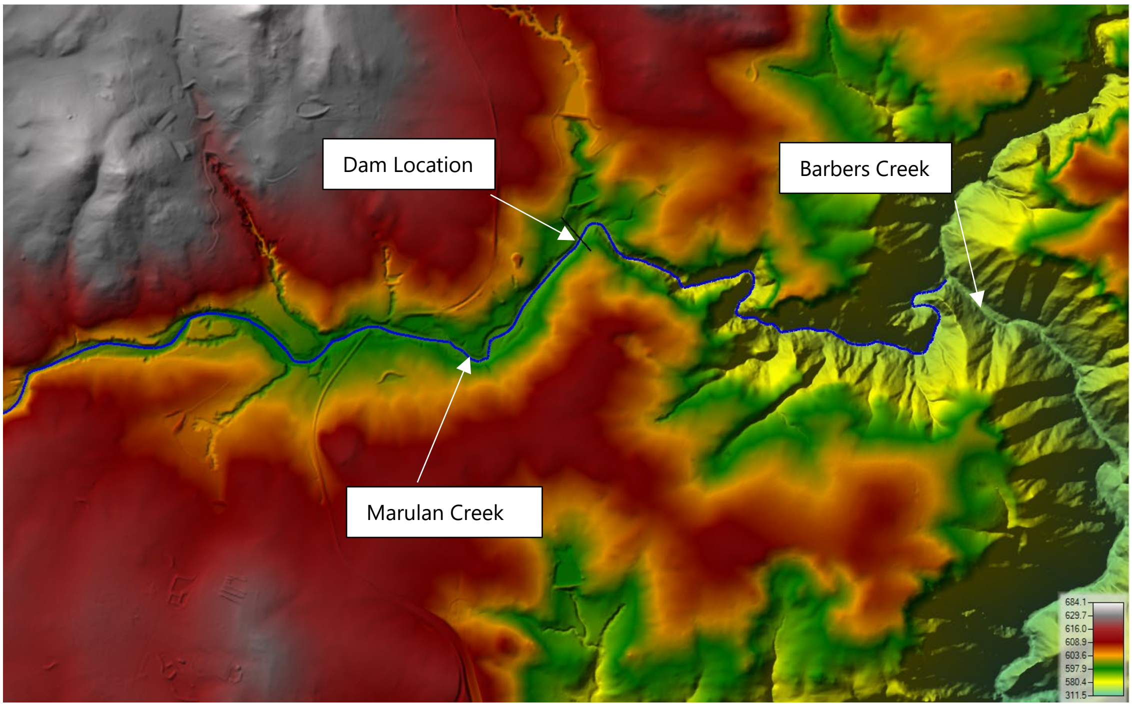

Figure 3: Marulan Creek DEM (source: NSW DFSI-Spatial Services, 2019)

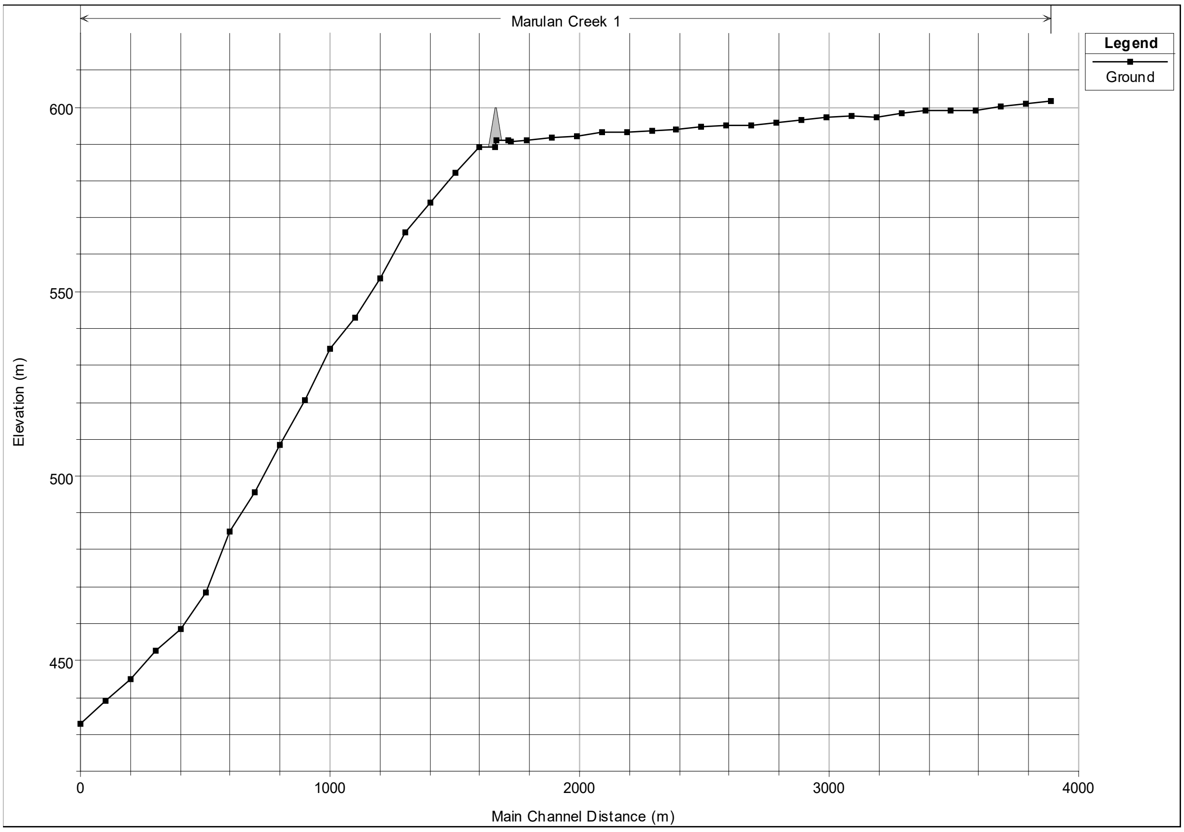

Figure 4: Marulan Creek longitudinal profile with location of the dam shown at approximately 1,700 m

Similarly, Barbers Creek downstream of the confluence with Marulan Creek is characterised by steep sided gorges. The gorge section of Barbers Creek extends from 1.5 km upstream of the confluence with Marulan Creek to the Shoalhaven River, a distance of 8 km in total. This section of Barbers Creek is characterised by a rocky, boulder-strewn channel with rock pools (see Figure 5). The channel gradient ranges from approximately 5% to 6%.

Figure 5: Barbers Creek at Water Quality Monitoring Point 'Barbers Creek Up'

Channel configuration in a gorge is ostensibly stable, with no potential for lateral adjustment. Vertical adjustment is restricted to local redistribution of coarse substrate. The geomorphic structure reflects infrequent high magnitude flood events (Brierley, 2006).

2.3 Hydrology Assessment

2.3.1 Catchment modelling

There are no stream gauges on Marulan Creek to allow direct analysis of the existing flow regimes. The nearest gauges other than the Shoalhaven River (which has very different flow characteristics) are located on Bungonia Creek and Kialla Creek. The catchment areas for these gauges are significantly larger (164 km^2 and 96 km^2 respectively) than Marulan Creek (about 20 km^2) and have relatively short periods of record (21 and 26 years respectively) as presented in Table 2.

In order to assess the long-term flow regime in Marulan Creek and the potential impact of the proposed Marulan Creek Dam, daily flow has been modelled using runoff parameters derived from the flow records listed in Table 2 together with the climate record (i.e. rainfall and pan evaporation). The Australian Water Balance Model (AWBM) has been adopted for modelling, with details of the model calibration process and generation of a daily flow sequence for input to the water balance model described in detail in Annexure D of the Surface Water Assessment (Appendix A).

Table 2: Stream Gauges Used for Estimating Flows in Marulan Creek

Gauging Station Name	Bungonia Creek at Bungonia	Kialla Creek at Pomeroy
Gauging Station Number	215014	212040
Catchment Area (km^2)	164	96
Start Record	1981	1979
Complete Years of Record	21	26
Location Relative to Project Area	12 km south	43 km north-west

2.3.2 Site Water Balance

Modelled flow has been included in the site water balance analysis and accounts for:

- Priority reuse of stormwater generated within the project;
- Riparian releases to maintain downstream flow; and
- Water availability – water can only be supplied if it is available in the dam.

A summary of the modelled extraction volume is provided in Table 3 with the modelled water storage shown in Figure 6. This indicates that the average supplementary water supply from Marulan Creek Dam over the life of the mine would be in the order of 98 ML/year with a range of 84 to 109 ML/year. The maximum demand would be 183 ML/year. Without Marulan Creek Dam, there would be significant shortfall in meeting the demands for all purposes which would severely restrict operation of the mine.

Table 3: Probability of required extraction volumes from Marulan Creek Dam

Year	Volume (ML/year)				
	Average	10th Percentile	Median	90th Percentile	Maximum
1	0	0	0	0	0
5	110	73	99	166	183
13	111	70	101	166	183
19	114	72	111	166	183
Life of mine	98	84	100	109	113

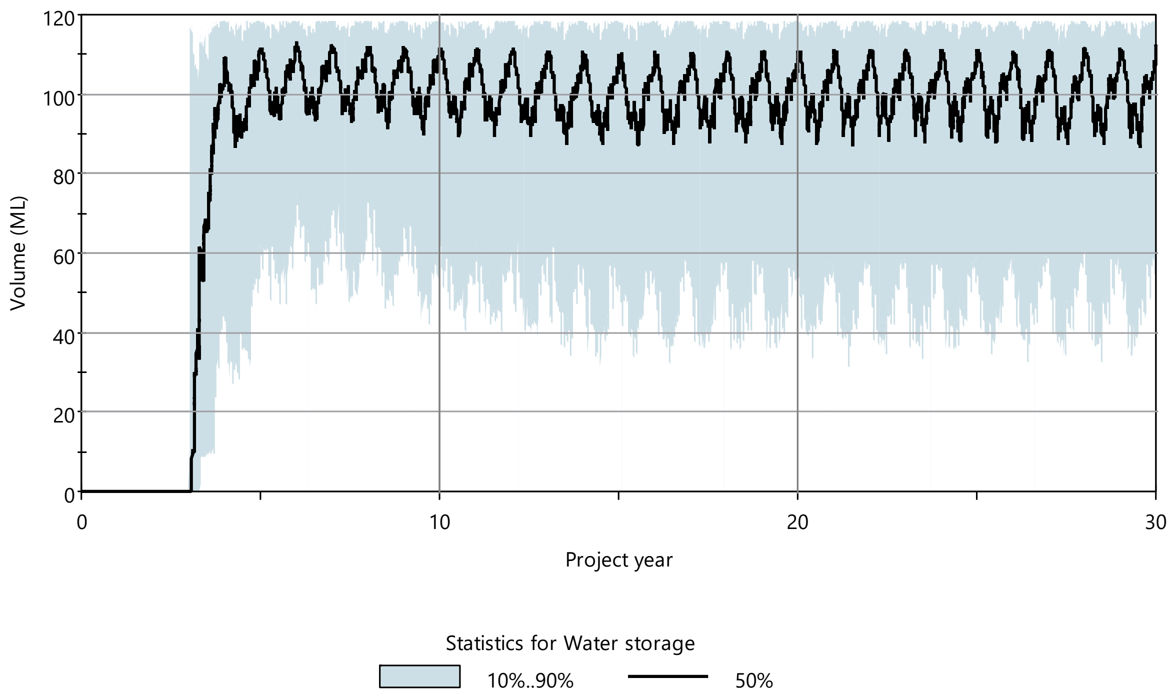

Figure 6: Marulan Creek Dam Storage

2.3.3 Baseline flow regime

Modelling indicates that flow in Marulan Creek is highly variable, with short duration flow events following runoff-producing rainfall (as shown in Figure 7). Long periods of low/no flow are predicted to occur between flow events. On average there are 10 flow events per year of greater than 1ML/day. However, there is variation year to year (10th percentile 7 events per year and 90th percentile 16 events per year) as shown in Figure 8.

The events are consistent through the year, with generally 3 events per quarter (range 0 – 5 events per quarter) as shown in Figure 8. Duration of events is about 3 days (with a range of 1-5 days). Figure 9.

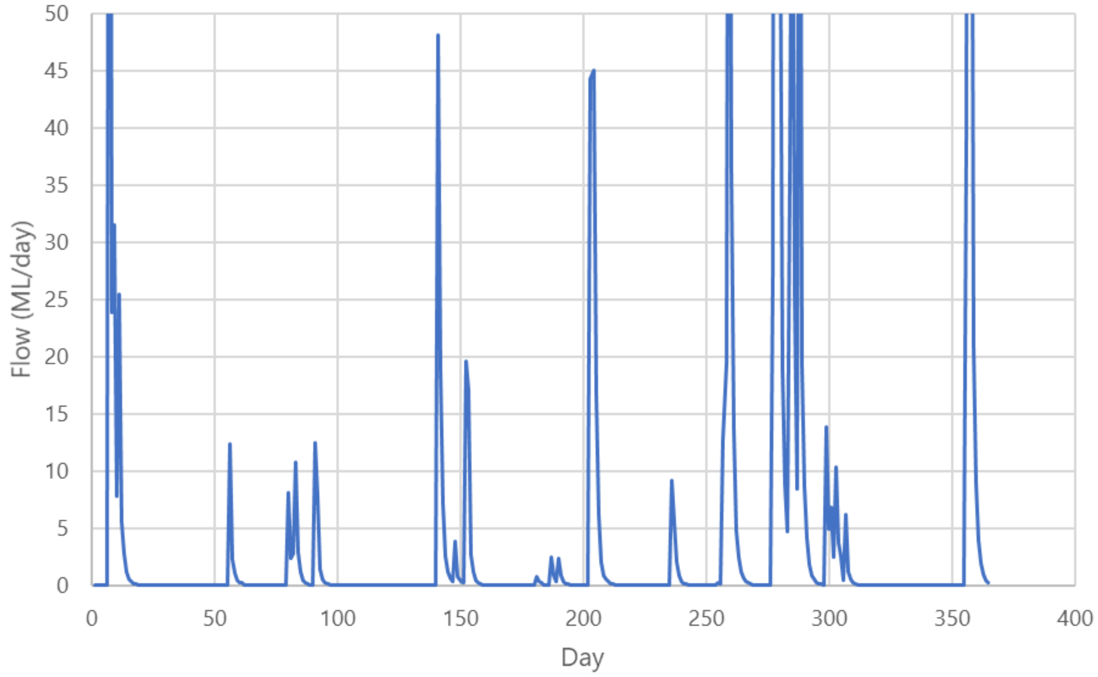

Figure 7: Modeled Marulan Creek Daily Flow (typical year)

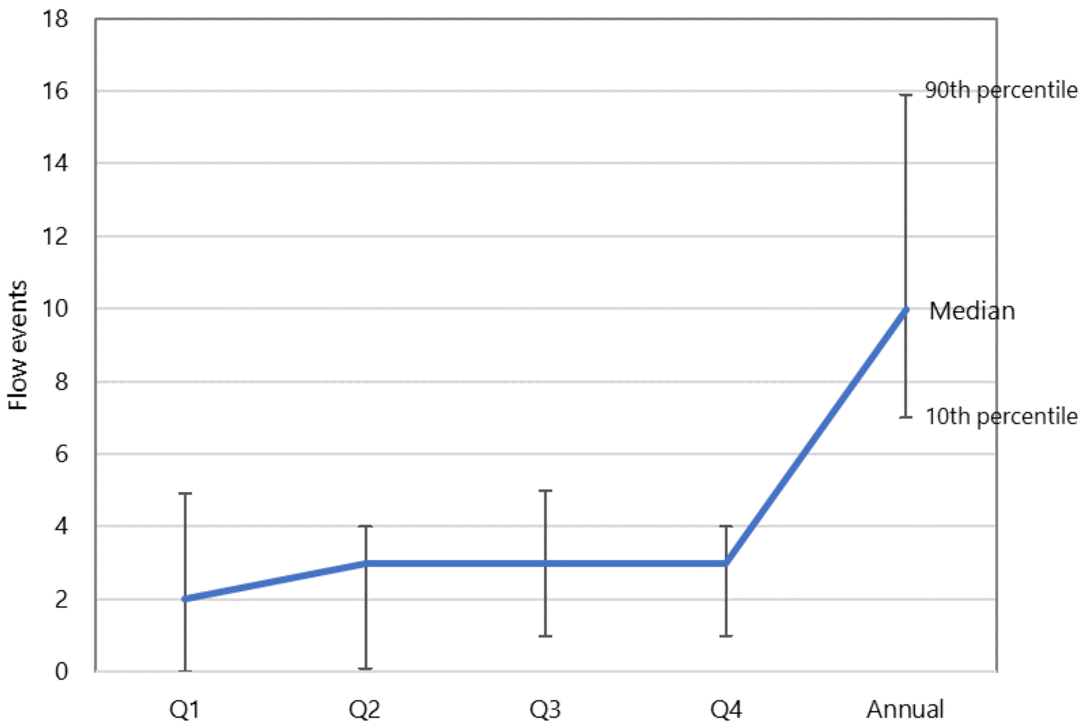

Figure 8 Marulan Creek Flow Events

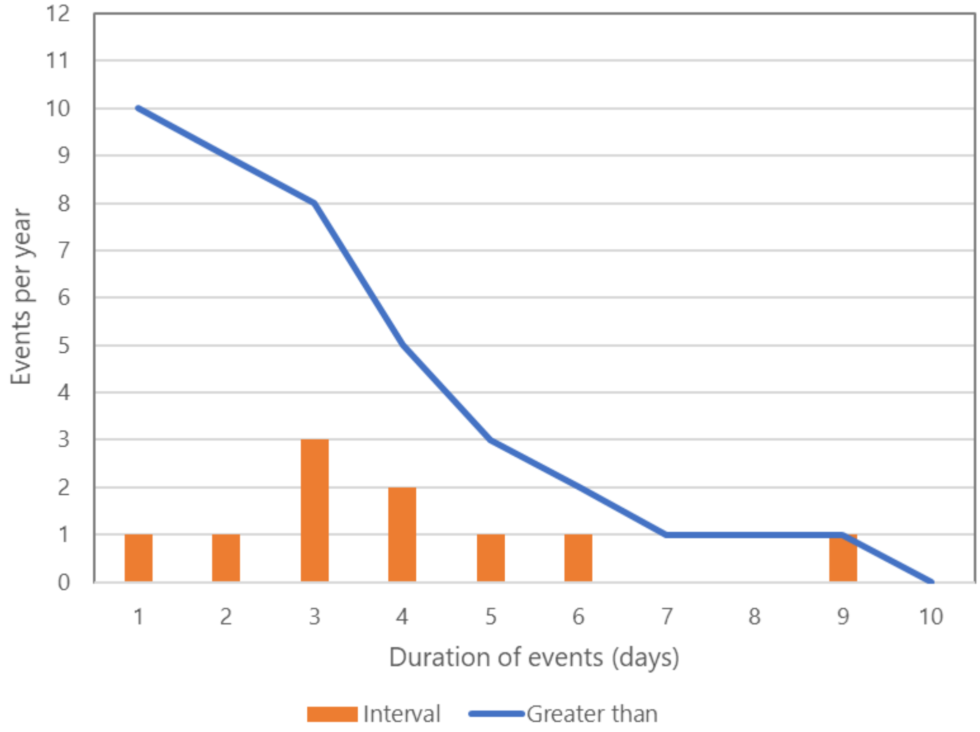

Figure 9: Duration of flow events

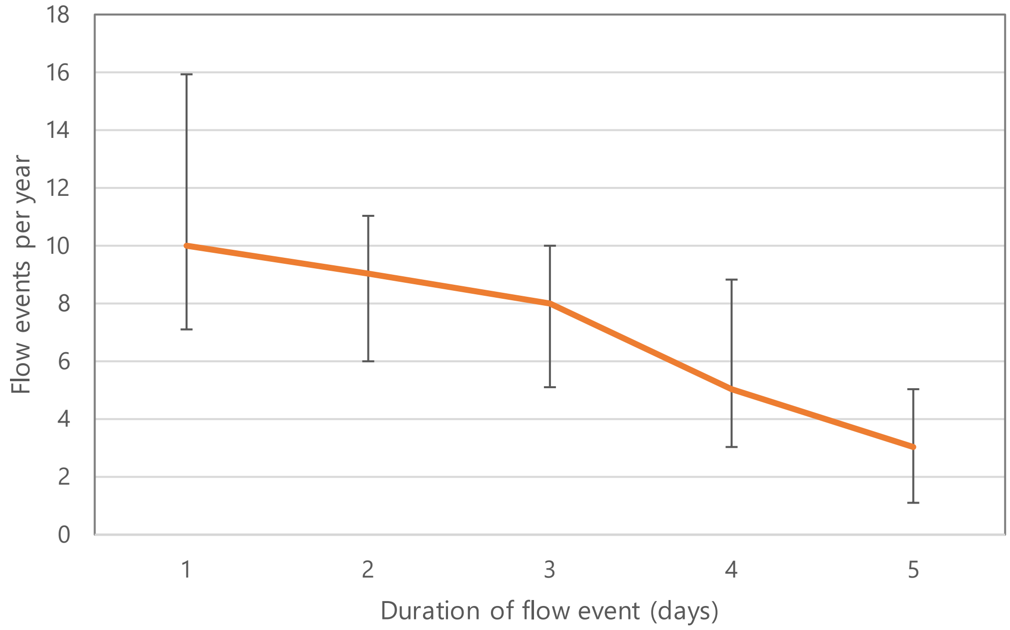

Figure 10: Mean duration of flow events

A steady state HEC-RAS model (USACE, 2019) was developed to determine the typical water depth in Marulan Creek. Water levels were determined for the 1 in 2 and 1 in 20 year ARI flood flows based on

PSM (2016) assessment of runoff upstream of the dam. The results of the model is shown in Figure 11, with greater flow depth on the plateau and lower flow depth in the gorge section through to the confluence with Barbers Creek.

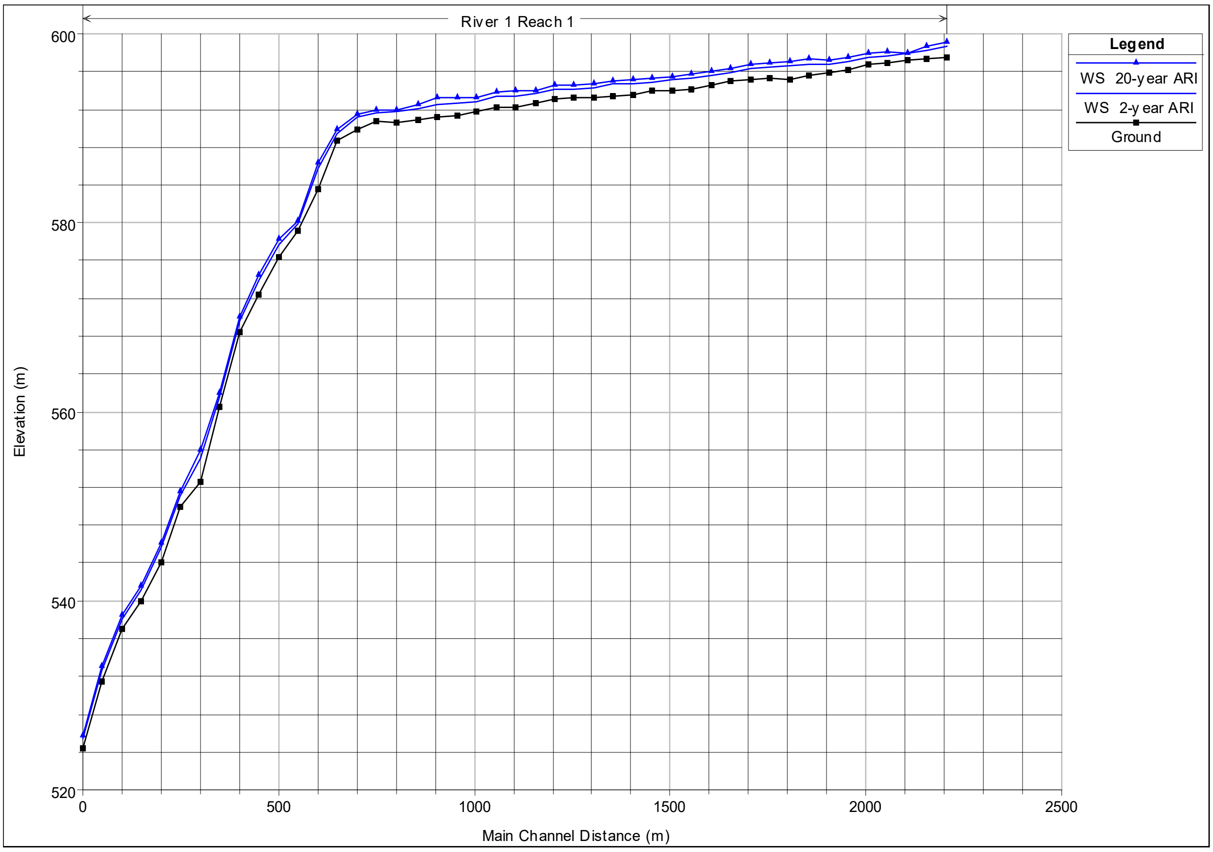

Figure 11: Peak Water profile of Marulan Ck

2.3.4 Flow regime with proposed dam

Flow duration curves produced by the water balance model for natural and regulated flow (as a result of the proposed dam) in Marulan Creek are shown on Figure 11. The modelled natural flow exhibits flow characteristics expected for an ephemeral creek such as Marulan Creek. The average annual flow downstream of the dam is expected to reduce from 1,023 ML/year under existing conditions to 829 ML/year during mine operation.

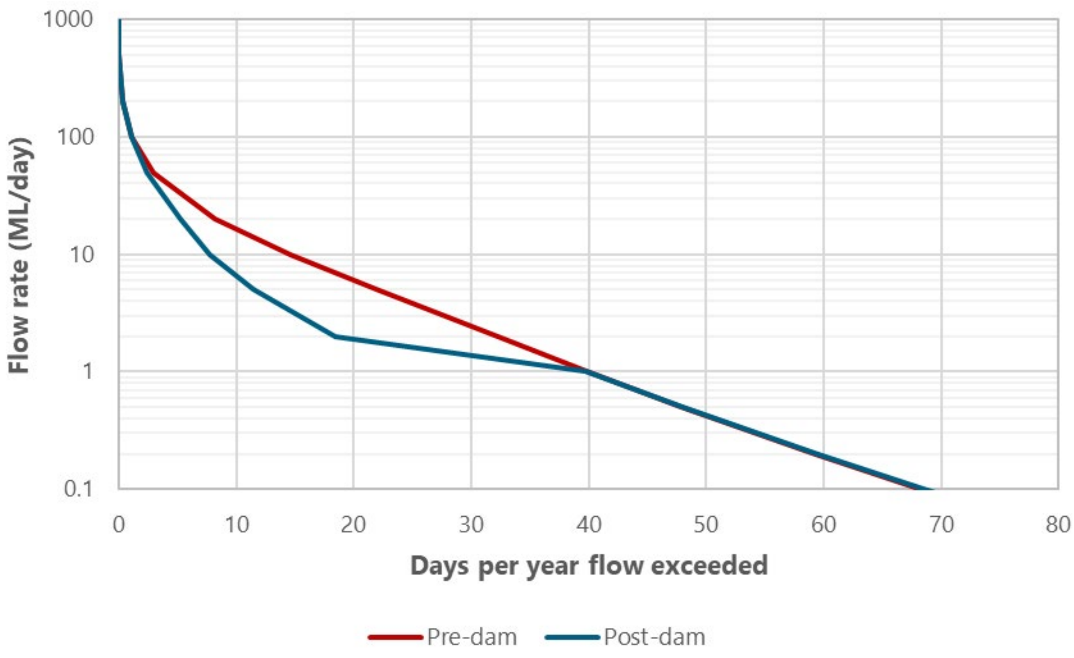

Figure 12: Marulan Creek Flow Duration Curves for a 30 Year Climate Period

Additional analysis of the impact of the dam on mid-range flows was undertaken as part of the previous response to submission (Advisian, 2019). The change in the mid-range flow frequency and duration is shown in Table 4. The analysis showed that the frequency and duration of flow events are maintained, noting that the average annual volume is reduced from 1,023 ML/year to 829 ML/year.

Table 4: Change in mid-range flow regime

	Marulan Creek upstream of dam			Marulan Creek downstream of dam		
	10th percentile	Median	90th percentile	10th percentile	Median	90th percentile
Flow events per year (>1ML/day)	7	10	16	7	10	16
Duration of flow events (> 1 ML/day)	1	3	6	1	3	6

Further analysis of the water balance model has been conducted by Advisian to determine the frequency that the dam provides:

- Translucent flows – where outflow from the dam is equal to inflow;
- Bypass flow – where the dam spillway is engaged, and flows pass through the dam; and

Analysis of the water balance model results shows that there is generally a large proportion of the year where either bypass or translucent flows are achieved.

Table 5: Modelled translucent and bypass flows

	Average days per year	% days where inflow > 0.1ML/day
Bypass	26 (7%)	36%
Translucency	324 (89%)	39%

2.3.5 Typical Marulan Creek Cross section

Upstream of the proposed dam, Marulan Creek has a typical cross section as shown in Figure 12. Flow velocity for the 1 in 2 year ARI event is 2.8 m/s and for the 1 in 20 year ARI event is 3.3 m/s. Downstream of the proposed dam, Marulan Creek has a typical cross section as shown in Figure 13. Flow velocity for the 2-year ARI event is 3.8 m/s and for the 20-year ARI event is 4.9 m/s, reflecting the increased channel gradient.

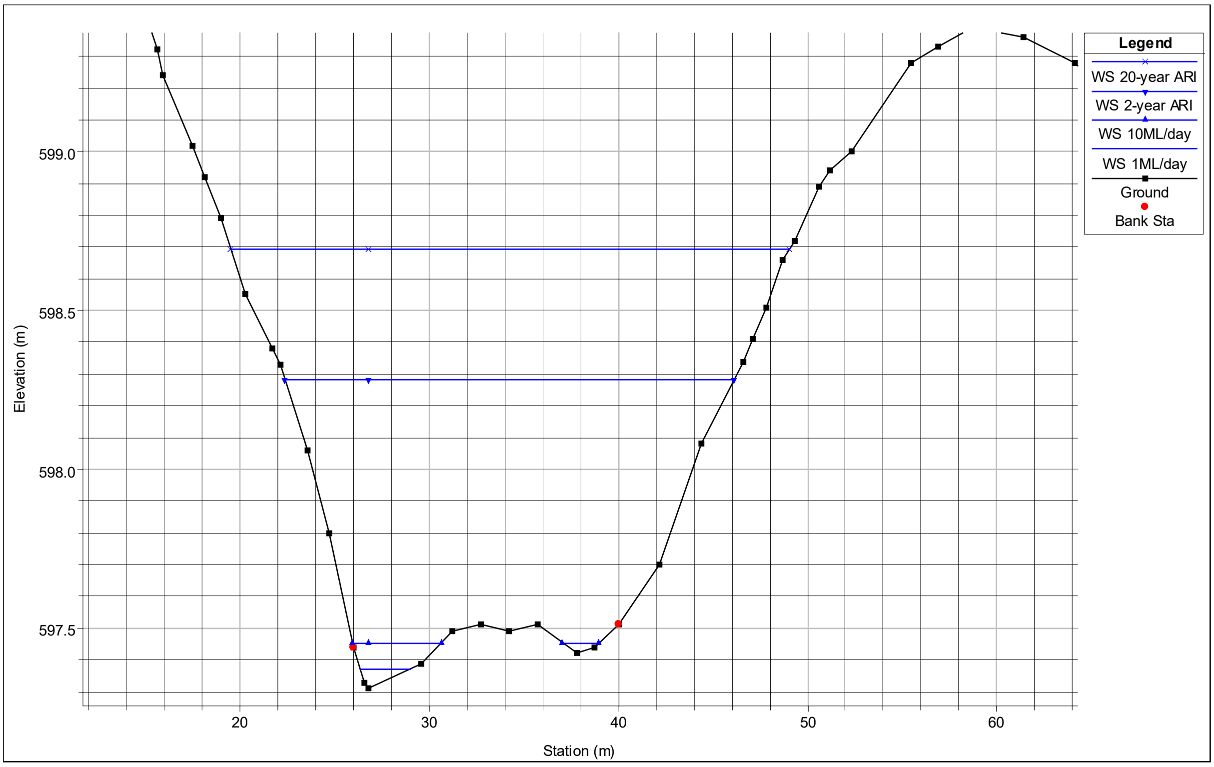

Figure 13: Marulan Creek Cross Section (at approximately 2160 m) with water levels

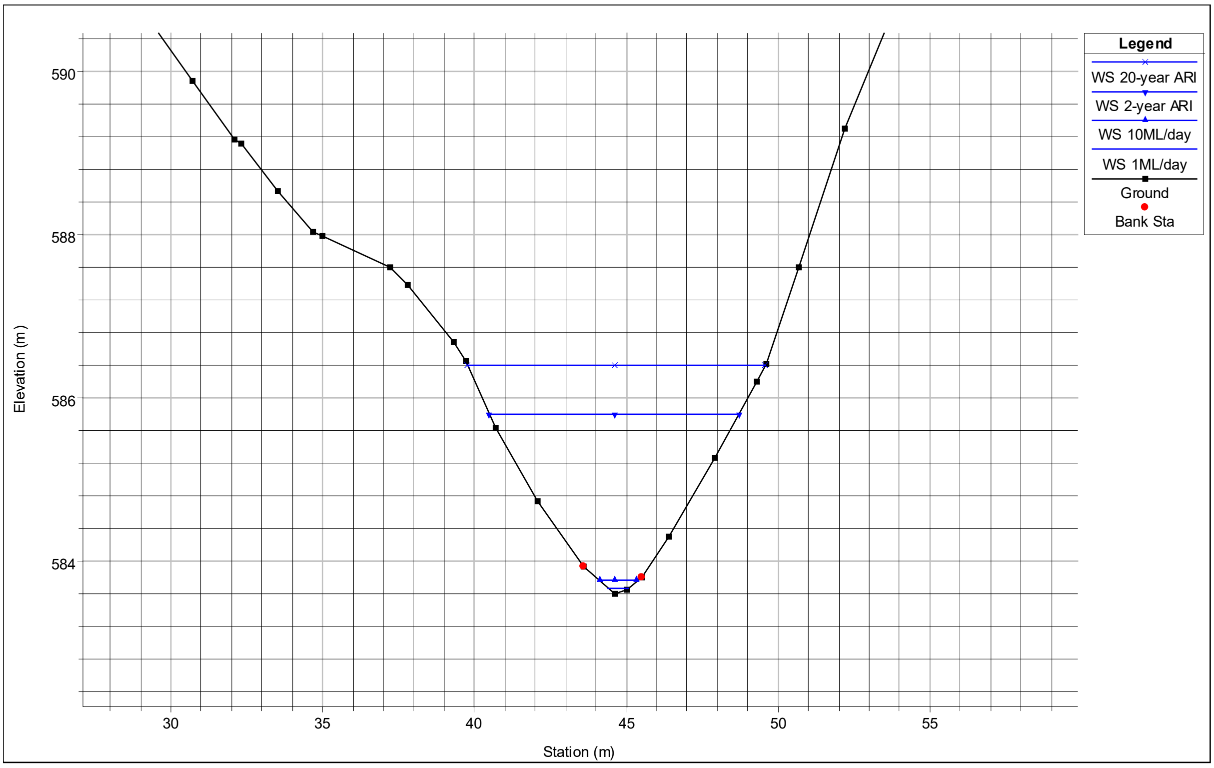

Figure 14: Marulan Creek Cross Section (approximately 600 m) with water levels

Based on the conceptual spillway arrangement provided in the PSM report, the dam only provides minor attenuation of the runoff hydrograph peak flow. The peak outflow from the dam for the 1 in 2 and 1 in 20 year ARI events is 37 m^3/s and 73 m^3/s respectively. Therefore, the typical flow downstream of the dam is similar to the baseline conditions in terms of water level and velocity (Figure 14).

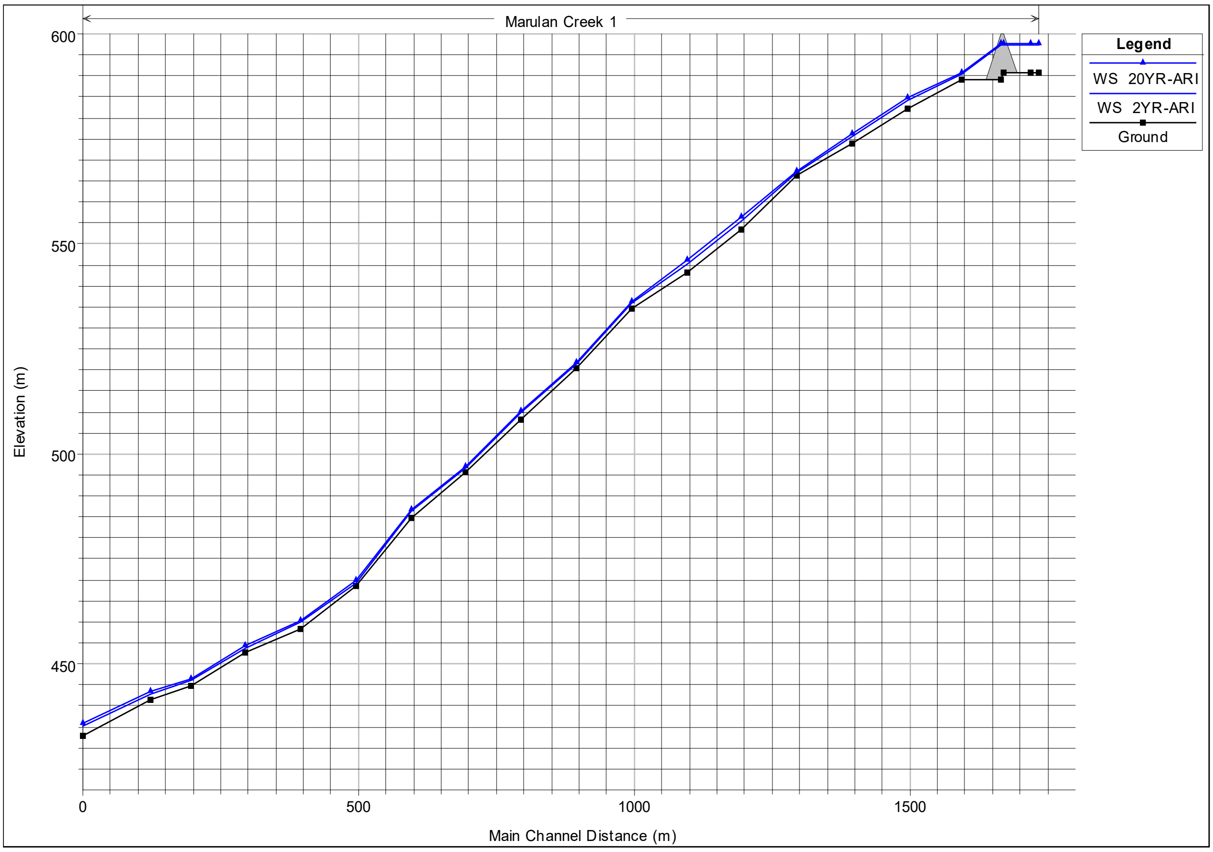

Figure 15: Marulan Creek profile with water level with dam

3 References

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Advisian
Worley Group

Appendix A

Marulan South Limestone Mine Continued Operations

Surface Water Assessment

Annexure D - Flow Regime in Marulan Creek

Advisian, 2019

Table of Contents

1 Introduction 1

2 AWBM Rainfall-Runoff Model 3

3 Streamflow and Climate Data 4

3.1 Streamflow Data 4

3.2 Rainfall Data 5

3.3 Evapotranspiration Data 6

3.4 AWBM Input Data 6

4 Model Calibration and Validation 7

4.1 Automatic Calibration 7

4.2 Validation (LOOCV Method) 8

4.3 Selection of Parameters 8

5 Project Area Daily Flow Regime Modelling 10

5.1 Marulan Creek AWBM Parameter Selection 10

5.2 Marulan Creek Flow Regime 13

6 References 15

Attachments

Attachment 1: Available Data Periods 16

Attachment 2: Modelling Results for Comparable Catchments 18

Attachment 3: Adopted Modelled and Published AWBM Parameters and Annual Rainfall and Runoff 21

List of Figures

Figure 1.1: Location of Marulan Creek Dam 2
Figure 2.1: Schematic of AWBM Structure 3
Figure 3.1: Map Showing Location of Streamflow and Rainfall Stations 5
Figure 5.1: Runoff Characteristics of Catchments near Marulan Creek 10
Figure 5.2: AWBM Average Capacity versus Calculated Runoff 11
Figure 5.3: Rainfall Calibration 12
Figure 5.4: Flow Duration Curves for Marulan Creek Dam Catchment 14

List of Tables

Table 3.1: Streamflow Gauging Stations and Periods of Available Record 4
Table 3.2: Summary of Relevant Bureau of Meteorology Rainfall Stations 5
Table 3.3: AWBM Input Data for Calibration Periods 6
Table 4.1: AWBM Results for Calibrated Catchments 9
Table 5.1: AWBM Parameters used to Generate Runoff/ Average Capacity Relationship 11
Table 5.2: AWBM Parameters Adopted for Marulan Creek 12
Table 5.3: Summary Statistics for Modelled Runoff from Representative Catchments 13

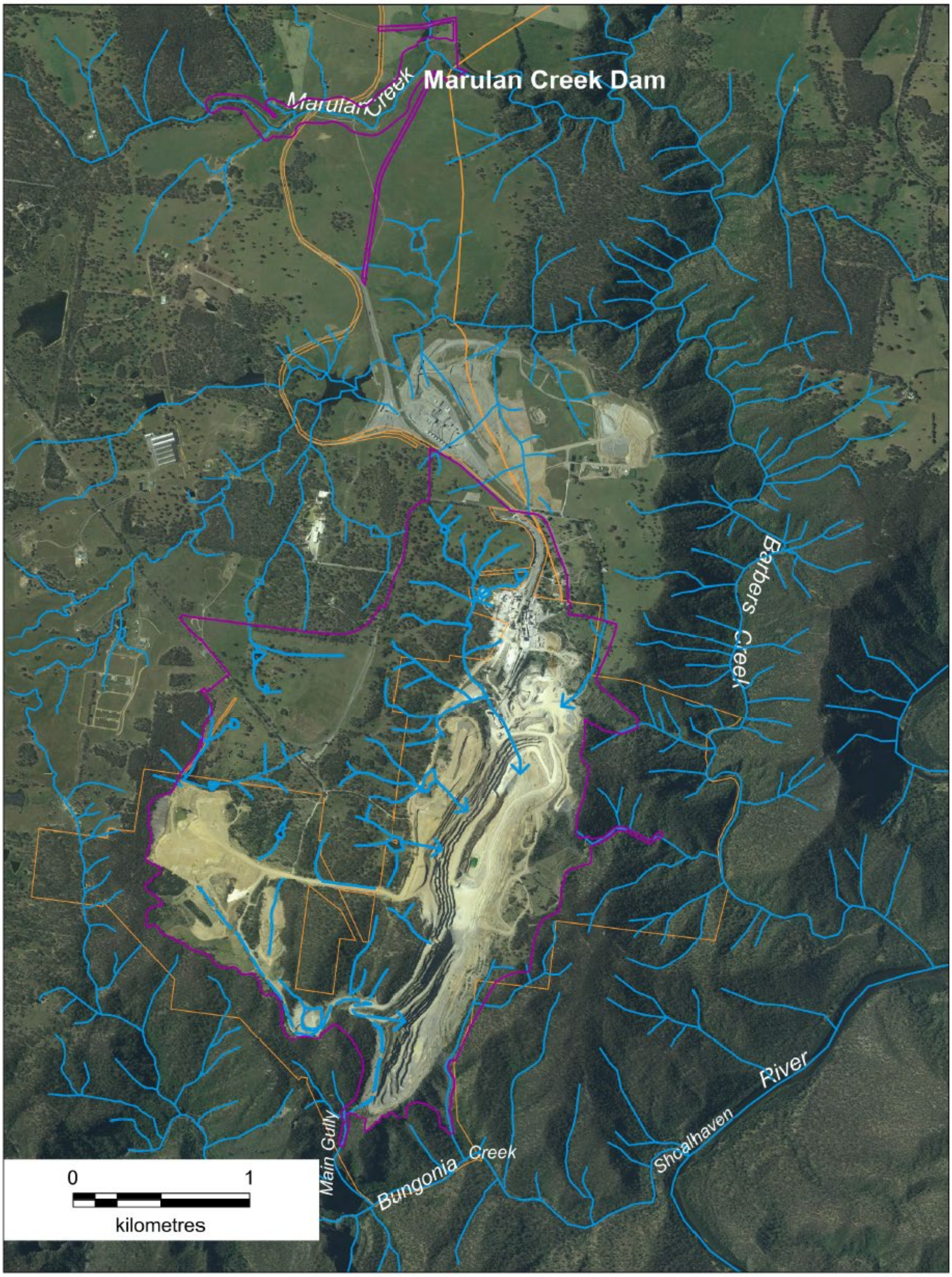
1 Introduction

The construction of a dam has been proposed on Marulan Creek, within the project boundary along the creek as shown on Figure 1.1, to provide water for Marulan South Limestone Mine. This dam would replace the water currently being supplied from Tallong Weir. This annexure details the methodology used to assess the flow regime of Marulan Creek. This information has been used in the water balance analysis (Annexure B) to assess the reliability of supplementary supply for the limestone mine and the impact that the dam would have on the downstream flow.

There are no stream gauges on Marulan Creek which would allow direct analysis of the existing flow regime and to assess the impact of the dam on the existing flow regime. Therefore, hydrologic modelling has been undertaken to characterise the flow regime for Marulan Creek in the vicinity of the proposed dam. The modelling is based on flow data for nearby creeks with comparable geology, land-use and climate to the Marulan Creek catchment.

The Australian Water Balance Model (AWBM) was selected to model the flow regime as it is a well-recognised, standard model developed specifically for assessment of runoff from Australian catchments.

Advisian
WorleyParsons Group



Key: Project boundary — CML 16 — Existing Drainage

Figure 1.1: Location of Marulan Creek Dam

2 AWBM Rainfall-Runoff Model

AWBM is a catchment water balance model developed for Australian conditions (Boughton, 1984; Boughton and Carroll; 1993, Boughton, 2010) based on the principle of conservation of mass. The model uses rainfall and potential evapotranspiration data together with a representation of the hydrologic processes to generate an estimate of daily runoff from a catchment. Once the surface storage capacity of the catchment has been replenished by rainfall, runoff is generated. This is divided into surface runoff and baseflow.

Figure 2.1 is a schematic diagram of the model structure which is based on many decades of observed catchment behaviour. The AWBM uses three different capacities of surface storage covering partial areas of the catchment. The water balance of each surface store is calculated independently of the others. The model calculates the moisture balance of each soil store at daily time steps. At each time step, rainfall is added to each surface store and effective evapotranspiration is subtracted from each store. If the value of moisture retained in any of the three stores exceeds its capacity, the excess moisture becomes runoff.

The three parameters A1, A2 and A3 represent three partial areas of surface storage capacity, i.e. the proportion of the catchment that is draining to the surfaces stores of set depth C1, C2 and C3, respectively. The baseflow index (BFI) dictates how much of the excess is diverted to the baseflow store via recharge, and the baseflow runoff parameter K_{base} describes the rate at which water retained in the baseflow store is released and contributes to runoff. The K_{surf} parameter dictates the rate of release of water from the surface runoff routing store.

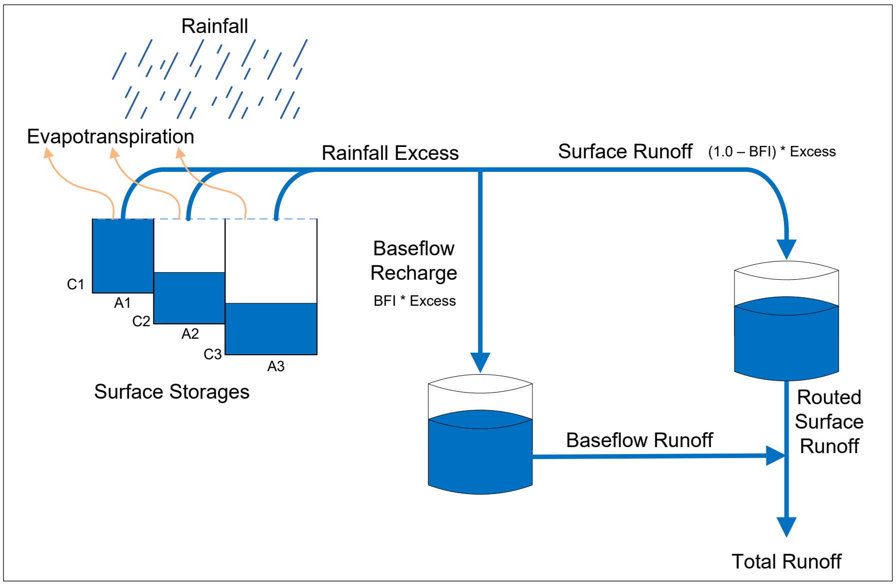


Figure 2.1: Schematic of AWBM Structure

Although the model represents A1, A2 and A3 as separate storages, Boughton (2010) reports that by analysis of a number of high quality data sets, it was found that the average value of surface storage capacity (Ave) was far more important for model calibration than the individual set of capacities and partial areas (where Ave = C1*A1 + C2*A2 + C3*A3). Boughton (2010) developed an average pattern that could be used to disaggregate Ave into three capacities (C1, C2 and C3 equal to 0.075*Ave, 0.762*Ave and 1.524*Ave) and three partial areas (A1 = 0.134, A2 = 0.433, A3 = 0.433).

3 Streamflow and Climate Data

This section describes the details of the streamflow, rainfall and potential evapotranspiration data used for the AWBM modelling of the Project area flow regime.

3.1 Streamflow Data

There is no continuous streamflow or peak flow data for Marulan Creek. It was therefore necessary to model nearby catchments to generate a set of representative AWBM parameters to reproduce the flow regime for Marulan Creek. The streamflow data was sourced from The NSW Office of Water website (NOW, 2014).

Table 3.1 lists the stations chosen to be used for AWBM modelling and the year each station opened and closed. For modelling purposes, only the years (July – June) with complete runoff records were used, as gaps in streamflow data cannot be reliably estimated using other sources. Refer to Attachment 1 for a bar chart illustrating period of available data.

Table 3.1: Streamflow Gauging Stations and Periods of Available Record

	Bungonia Creek at Bungonia	Kialla Creek at Pomeroy
Flow Station Number	215014	212040
Catchment Area (km^2)	164	96
Latitude	-34.8176	-34.6074
Longitude	149.9898	149.5442
Start Record	1981	1979
End Record	2014	2014
Years (July to June) with Complete Data Record (flow and rainfall)	21	26
Gauging Stn. Relative to Project Area	12 km south	43 km north-west

Figure 3.1 shows the location of the selected stream gauging stations.

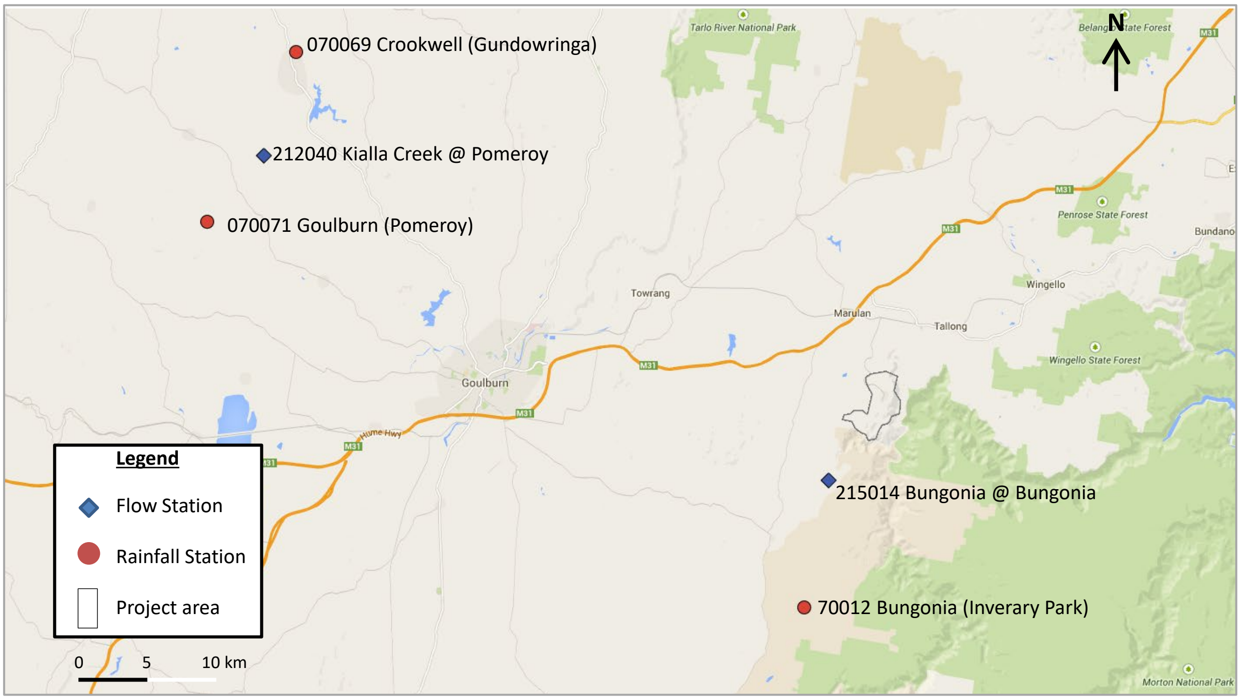


Figure 3.1: Map Showing Location of Streamflow and Rainfall Stations

3.2 Rainfall Data

The model calibration process is most robust in situations in which the rainfall record is derived from a location that is representative of the catchment. Rainfall data for use in AWBM modelling was sourced from Bureau of Meteorology (BoM) daily rainfall stations located in the same or nearby catchments to the flow stations listed in Table 3.1. The rainfall stations selected are listed in Table 3.2 and their locations shown in Figure 3.1.

Table 3.2: Summary of Relevant Bureau of Meteorology Rainfall Stations

Catchment	Rainfall Factor	Rainfall Stations	Latitude	Longitude	Record
Bungonia Creek	0.817	Bungonia (Inverary Park) (70012)	-34.9	149.97	1883-2014
Kialla Creek	1.171	Crookwell (Gundowringa) (70069)	-34.54	149.57	1945-2014
		Goulburn (Pomeroy) (70071)	-34.65	149.5	1901-2014

An average was taken of the daily rainfall values of stations within the vicinity of the particular flow gauge. Where there were gaps in the record supplied by the Bureau of Meteorology due to aggregated measurements over a number of days, the data was in-filled using the average over the number of days aggregated. See Attachment 1 for periods of available rainfall data.

The daily rainfall values were automatically scaled by the AWMB automatic model using the "auto scale" function, as recommended by Boughton (2012). The auto scale function strives to reduce the errors produced when estimating areal rainfall for input to the model. The values of these rainfall scaling factors are provided in Table 3.2.

3.3 Evapotranspiration Data

Areal potential evapotranspiration is the evapotranspiration that would occur if there was unlimited water supply from an area large enough that the effects of any upwind boundary transitions are negligible, and local variations are integrated to an areal average (Chiew et al., 2002).

As recommended by Boughton (2003), monthly areal potential evapotranspiration was input to the AWBM model. Areal potential evapotranspiration data was sourced from the digital version of the Climatic Atlas of Australia: Evapotranspiration (Version 1.0, Bureau of Meteorology, 2002). The monthly areal potential evapotranspiration values were used to calculate daily potential evapotranspiration values by dividing the monthly value by the number of days in each month.

3.4 AWBM Input Data

Table 3.3 lists the flow and climate data statistics adopted for the AWBM modelling.

The AWBM requires coincident daily streamflow and rainfall data. Based on the data availability summarised in Attachment 1, it can be seen that the availability of flow data was the limiting factor and dictated the calibration period.

Table 3.3: AWBM Input Data for Calibration Periods

Catchment Number	1	2
Flow Station	Bungonia Creek	Kialla Creek
Rainfall Stations	Bungonia (Inverary Park) (70012)	Crookwell (Gundowringa) (70069), Goulburn (Pomeroy) (70071)
Catchment Area (km^2)	164	96
Period (y)	21	26
Modelling Period (July to June)	1981 - 1982, 1984 - 1985, 1987 - 1991, 1994 - 1998, 1999 - 2004, 2006 - 2009, 2010 - 2013	1979 - 1981, 1984 - 1992, 1994 - 2000, 2001 - 2002, 2003 - 2009, 2010 - 2013
Ave Rainfall (mm/y)	644	394
Ave Potential Evap (mm/y)	1381	1405
Ave Flow (mm/y)	54	93
% Runoff (Observed Mean Runoff / Mean Rainfall)	8%	24%

4 Model Calibration and Validation

AWBM was utilised to generate a set of parameters describing the flow characteristics for the both Bungonia Creek at Bungonia and Kialla Creek at Pomeroy. The Leave-One-Out Cross Validation (LOOCV) procedure was used to guide the selection of the model parameters most representative of the actual flow regime. The modelling involved a three staged process, per Ladson (2008):

1. Automatic calibration
2. Validation (LOOCV procedure
3. Selection of parameters.

Further description of this process is provided below.

4.1 Automatic Calibration

The AWBM 2013 model selects a warm up period at the start of the data record and then runs the calibration for the remaining record. Default values are adopted for the baseflow and surface runoff parameters during the preliminary calibration of surface storage capacity. For the assessment period, the average surface storage capacity is then scaled up and down until the calculated runoff equals the actual runoff. Next, the BFI, K_{base} and K_{surf} parameters are first calibrated in that order, then a second time using a measure of difference between calculated and actual daily runoff hydrographs (Boughton, 2010).

Initially the model was set up and calibrated for the complete modelling period using the full data set, and a set of parameters generated ($Ave_{(all\ years)}$, $BFI_{(all\ years)}$, $K_{base(all\ years)}$, $K_{surf(all\ years)}$). This was achieved through the AWBM 2013 model's automatic calibration component, which generates parameters that describe the hydrological process when daily rainfall, monthly potential evapotranspiration and daily runoff are entered into the model. The output from the automatic calibration process is shown in the second column of Table 4.1.

The automatic calibration procedure uses a single parameter to represent a fixed pattern of surface storage capacities and partial areas represented by a single parameter (Ave). The model selects default values for A1, A2 and A3, 0.134, 0.433 and 0.433, respectively. Also, the values for C2, C2 and C3 are directly related (20*C1 = 2*C2 = C3), such that there is only one independent variable. Boughton (2010) reported that the average value of surface storage capacity was far more important to calibration than the individual set of capacities and partial areas. Accordingly, because the model parameters derived from were to be only used as a guide to parameters for the Project area, further disaggregation of A and C parameters was not attempted.

All daily values were entered directly into the model. The daily rainfall values were automatically scaled by the AWBM automatic model using the "auto scale" function, as recommended by Boughton (2012). The rainfall scaling factors for the two modelled catchments are outlined in Table 3.2.

The daily evapotranspiration values were scaled to 0.85 (to account for the reduction of actual evapotranspiration as the soil dries out). Applying a scale factor of 0.85 is an alternative to reducing the potential evaporation rate as the surface stores dry out (Boughton, 2010).

4.2 Validation (LOOCV Method)

The parameters were validated using the 'Leave one out cross validation' (LOOCV) procedure, a process which enables all available complete years of streamflow data to be utilised as described below.

The model was re-calibrated N times, where N represents the number of years of data. For i = 1 to N, the data for $year_{(i)}$ was omitted from the calculations. The model was then calibrated to the remaining points, with daily flow estimated and a set of model parameters derived ($Ave_{(i)}$, $BFI_{(i)}$, $K_{base(i)}$, $K_{surf(i)}$).

The LOOCV procedure produced N estimates of the model parameters. Of the N parameter sets, the minimum and maximum parameter values ($Ave_{(min)}$, $BFI_{(min)}$, $K_{base(min)}$, $K_{surf(min)}$ and $Ave_{(max)}$, $BFI_{(max)}$, $K_{base(max)}$, $K_{surf(max)}$) are listed in Table 4.1 to illustrate the range of results for each catchment. The N sets of parameters ($Ave_{(i)}$, $BFI_{(i)}$, $K_{base(i)}$, $K_{surf(i)}$ where i = 1 to N) provided an indication of the scatter in the parameter set.

AWBM has a spreadsheet version which was used to calculate the predicted runoff of the excluded year, $year_{(i)}$, using the parameter set generated when $year_{(i)}$ was omitted (i.e. $Ave_{(i)}$, $BFI_{(i)}$, $K_{base(i)}$, $K_{surf(i)}$). This method of model validation allows all data to be used.

As adopted by Boughton (2006), the Nash-Sutcliffe Coefficient of Efficiency (E) was used as a measure of model performance. Boughton (2006) notes that E is based on monthly runoff and is the most common measure for comparing modelled and recorded monthly runoff. It is a normalised statistic used to determine the relative magnitude of the residual variance compared to the measured data variance to indicate the predictive accuracy of the model (Nash & Sutcliffe, 1970, Moriasi et al., 2007). The value measures how closely the modelled results fit the 1:1 line, and is given by:

$$E = 1 - \frac{\sum_{t=1}^{T}(Q_o^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_o^t - \overline{Q_o})^2}$$

where: T = final time-step period

t = individual time-step period

Q_o = Observed data

Q_m = Modelled data

$\overline{Q_o}$ = Average of observed data

The efficiency value can range from –∞ to 1, where 1 indicates a perfect match of modelled data to observed data (Nash & Sutcliffe, 1970, Moriasi et al., 2007). The results for the test sample (LOOCV) with the highest Nash-Sutcliffe Coefficient of Efficiency, when modelled using the parameters generated using all the other years ($Ave_{(max\ E)}$, $BFI_{(max\ E)}$, $K_{base(max\ E)}$, $K_{surf(max\ E)}$) are listed in Table 4.1.

4.3 Selection of Parameters

A spreadsheet AWBM was set up for the complete data set (i.e. N years of data). The estimated daily runoff and corresponding Nash-Sutcliffe Coefficient of Efficiency values were calculated for the following parameter sets generated through the test sample assessment process:

- $Ave_{(all\ years)}$, $BFI_{(all\ years)}$, $K_{base(all\ years)}$, $K_{surf(all\ years)}$
- $Ave_{(min)}$, $BFI_{(min)}$, $K_{base(min)}$, $K_{surf(min)}$
- $Ave_{(max)}$, $BFI_{(max)}$, $K_{base(max)}$, $K_{surf(max)}$

The LOOCV highest E parameter set (i.e. $Ave_{(max E)}$, $BFI_{(max E)}$, $K_{base(max E)}$, $K_{surf(max E)}$), (refer Section 4.2), was also modelled using the manual version of AWBM and the complete data set

Table 4.1 contains the parameter sets and the statistical analysis which was used as a basis for selecting the parameters that adequately describe the flow characteristics at Marulan South. The Nash-Sutcliffe Coefficient of Efficiency, based on monthly totals, provides a measure of the model performance.

Attachment 2 contains the flow duration curves and cumulative runoff curves plots for the catchments modelled with the adopted parameters, as listed in Table 4.1. Attachment 2 also contains scatter plots of the calculated versus actual monthly runoff.

Table 4.1: AWBM Results for Calibrated Catchments

Input Parameters and Analysis	Full Record	Min	Max	Adopted parameters – LOOCV (highest E)
Catchment 1: Bungonia Creek at Bungonia				
Average Capacity (mm)	74.6	72.1	81.2	74.0
C1	5.6	5.4	6.1	5.6
C2	56.9	54.9	61.9	56.4
C3	113.8	109.9	123.8	112.8
BFI	0.200	0.200	0.260	0.210
K_{base}	0.875	0.875	0.885	0.885
K_{surf}	0.260	0.070	0.260	0.260
E (monthly data)	0.779	0.774	0.790	0.778
R^2 (monthly data)	0.795	0.797	0.793	0.794
Actual Runoff (mm)	54.0	54.0	54.0	54.0
Calculated Runoff (mm)	54.5	56.1	50.4	54.8
Catchment 2: Kialla Creek at Pomeroy				
Average Capacity (mm)	10.8	2.8	11.5	10.7
C1	0.8	0.2	0.9	0.8
C2	8.2	2.1	8.8	8.1
C3	16.5	4.2	17.5	16.2
BFI	0.150	0.150	0.300	0.150
K_{base}	0.979	0.969	0.980	0.979
K_{surf}	0.350	0.010	0.440	0.330
E (monthly data)	0.238	0.130	0.259	0.238
R^2 (monthly data)	0.240	0.239	0.262	0.240
Actual Runoff (mm)	93.3	93.3	93.3	93.3
Calculated Runoff (mm)	93.7	168.8	89.4	94.5

5 Project Area Daily Flow Regime Modelling

Model parameters for Marulan Creek were derived based on the modelling results provided in Section 4 (refer to Attachment 3 for adopted modelled parameters). The adopted parameters were applied to long term historical climate data to estimate the daily flow regime for Marulan Creek. The modelled runoff for the representative catchments provide a best estimate of the "existing" conditions and form "baseline" conditions for use in the assessment of dam impacts and the subsequent assessment of residual impacts on flow and water resources. The process used to model the runoff in Marulan Creek is described below.

5.1 Marulan Creek AWBM Parameter Selection

For the purposes of assessing the daily flow regime in the Project area tributaries, an AWBM catchment scenario model was set up. This model used parameters to represent the runoff characteristics of Marulan Creek. The adopted parameters are listed in Table 5.2.

The parameters selected for Bungonia Creek and Kialla Creek catchments, through the model calibration and validation process described in Section 4, formed the starting point to derive the parameter sets for the catchment scenario. The modelling results were considered in conjunction with benchmark model parameters for the region. The benchmark parameters are derived from an Advisian model of Wingecarribee River between the Berrima Weir flow gauge and the Greenstead flow gauge Weir ("Berrima Model"). See Attachment 3 for adopted modelled parameters and benchmark parameters. Two other factors were taken into account in selecting appropriate AWBM model parameters:

- the general relationship between average annual rainfall and annual runof
- the general relationship between average capacity and runoff.

Figure 5.1 shows the relationship between average annual rainfall and average annual runoff in the region, derived from the recorded data used for model calibration and benchmark parameters. Attachment 3 contains the rainfall and runoff data used in Figure 5.1.

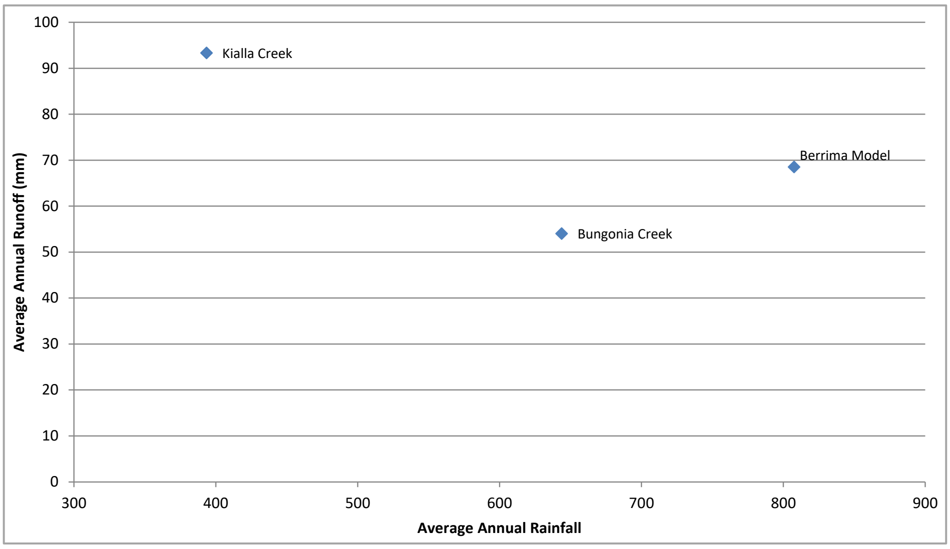


Figure 5.1: Runoff Characteristics of Catchments near Marulan Creek

An AWBM model was created for the Project area using the average BFI, K_{base} and K_{surf} parameters adopted for the Berrima Model and two catchments calibrated in Section 4 (listed in Table 5.1). The long term rainfall data for Marulan South (1813 – 2014) was used.

Table 5.1: AWBM Parameters used to Generate Runoff/ Average Capacity Relationship

	Ave	BFI	K_{base}	K_{surf}	E_f	R_f
Adopted Parameter	Varied	0.420	0.938	0.513	0.85	Varied

Successive runs of the model were made using different values of average capacity to generate the relationship between runoff and average capacity shown in Figure 5.2. Three curves were generated to reflect the rainfall scaling factors corresponding to the three calibrated catchments:

- Rf = 1.171, in line with Kialla Creek catchment
- Rf = 0.817, in line with Bungonia Creek catchment
- Rf = 1, in line with the Wingecarribee River catchment, between the Berrima Weir flow gauge and the Greenstead gauge (Advisian model).

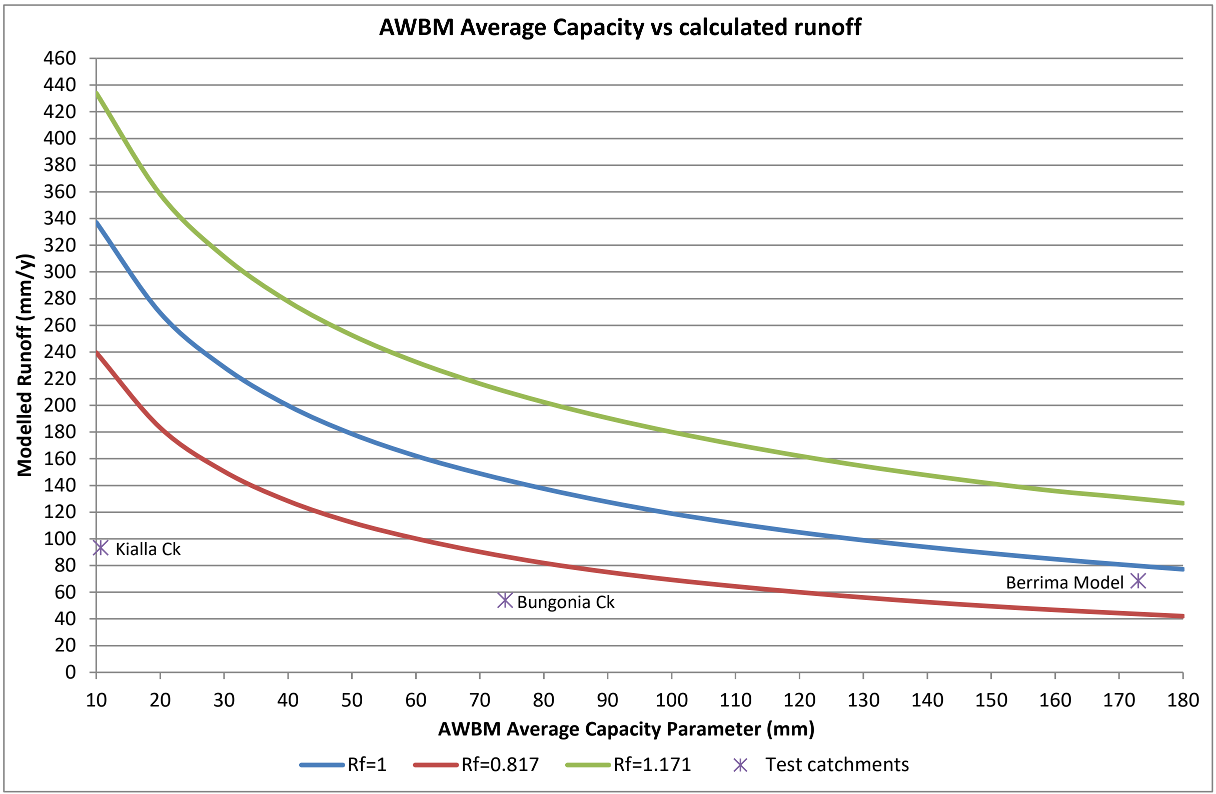


Figure 5.2: AWBM Average Capacity versus Calculated Runoff

The Rf = 1.171 curve indicates that at Marulan an average capacity of 10.7 mm gives a runoff of approximately 440 mm/year. This is inconsistent with the modelled runoff generated from the Kialla Creek calibration (an average capacity of 10.7 mm produces a runoff of approximately 93 mm/year). The Bungonia Creek modelled runoff and the Berrima Model more consistent with the respective runoff/ average capacity relationship.

Therefore, an average capacity parameter of 87 mm was selected for the Marulan Creek dam model. The Rf and BFI calculated for the Bungonia Creek calibration were also adopted. The K_{base} and K_{surf} values calculated during the Bungonia Creek calibration process were reduced to reflect that the Marulan Creek dam catchment is smaller than the Bungonia Creek catchment, and thus would have a smaller baseflow component.

Table 5.2 provides the AWBM parameters adopted for the Project area.

Table 5.2: AWBM Parameters Adopted for Marulan Creek

	Ave	BFI	K_{base}	K_{surf}
Adopted Parameter	87	0.21	0.2	0.1

The model was assessed to see if modelled high flow days accurately corresponded to recorded high rainfall events. A number of dates which had high recorded rainfall events between February 2012 and December 2014 have been provided by Peppertree Quarry. These dates, in addition to flow calculated using the parameters outlined in Table 5.2, are shown on Figure 5.3. It can be seen that high rainfall days correspond to days with a modelled high flow.

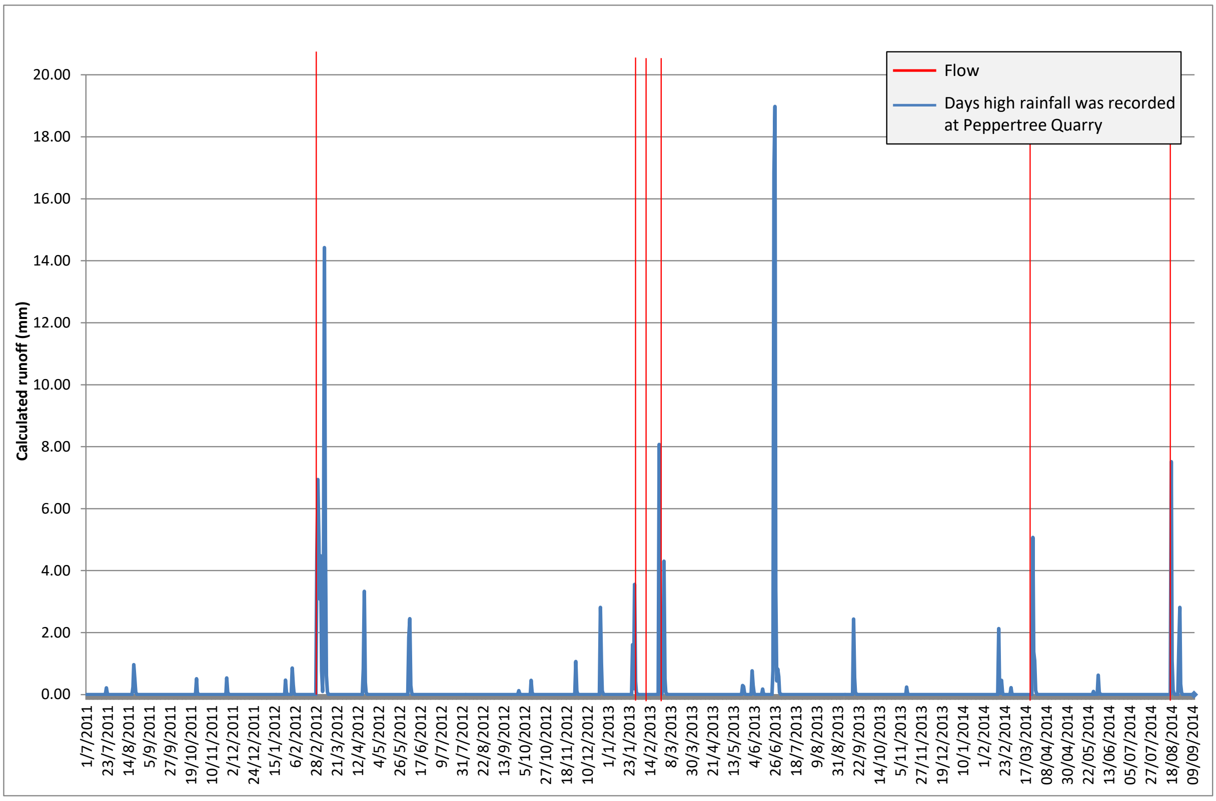


Figure 5.3: Rainfall Calibration

5.2 Marulan Creek Flow Regime

Daily flow models were created for the Marulan Creek dam catchment based on the adopted historical (amalgamated) climate record and the parameters listed in Table 5.2.

Table 5.3 provides a statistical summary of the modelled runoff for the representative catchments for the 131 years of climate data with the following climate statistics:

- average annual rainfall: 694 mm/year
- average annual areal potential evapotranspiration: 1,095 mm/year

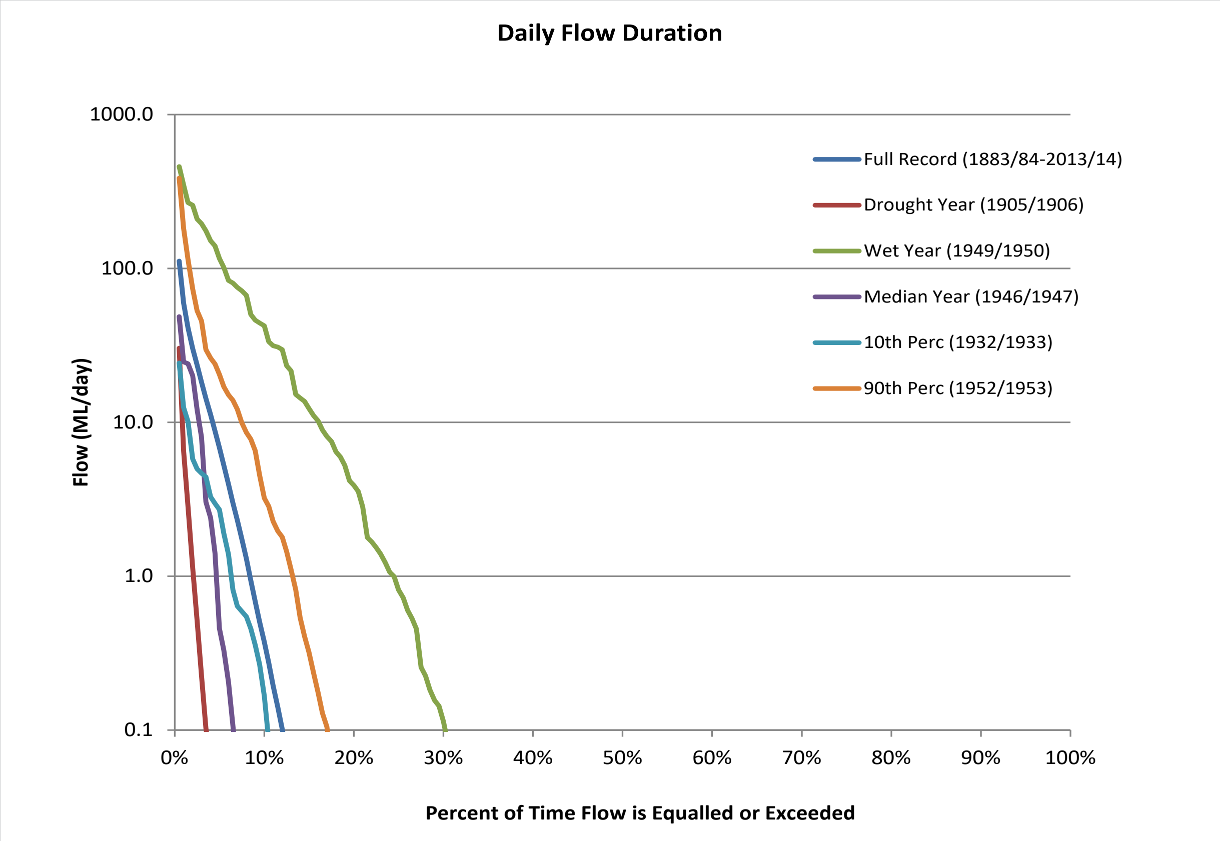
Daily and annual flow duration curves were created for the modelled runoff for each representative catchment to illustrate the flow patterns (see Figure 5.4). Each figure includes daily flow duration curves corresponding to the full climate record and for various years representing minimum, 10th percentile, median, 90th percentile and maximum modelled flow years. The annual runoff corresponding to each of these years is listed in Table 5.3.

Table 5.3: Summary Statistics for Modelled Runoff from Representative Catchments

Catchment Designation		
Area	(km^2)	19.2
Average Runoff	(mm/y)	53
Average Runoff	(ML/y)	1,023
Runoff as % of Rainfall		7.7
Minimum	(ML/y)	136
10th Percentile	(ML/y)	231
Median	(ML/y)	544
90th Percentile	(ML/y)	2,708
Maximum	(ML/y)	6,981

It can be seen that the daily flow duration curve for the complete record is a smoother line than the others. This is to be expected, as there are significantly more data points within the complete record, compared to flow duration over a single year, leading to less variation around the overall trend.

It should be noted that the modelled runoff from the Marulan Creek dam catchment is based on parameters derived from catchments with similar characteristics, not from the dam catchment itself. The flow characteristics presented in this report are, therefore, only illustrative of the volume and distribution of runoff that can be expected.



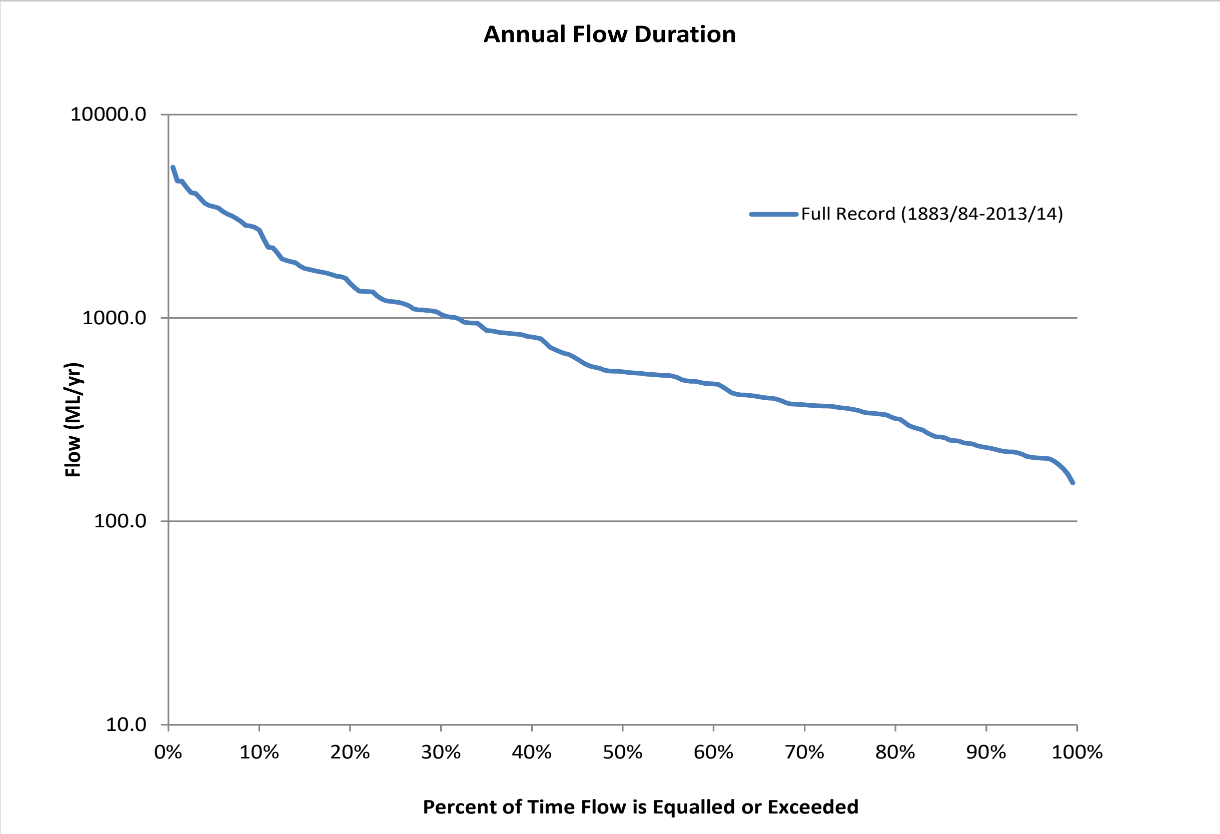


Figure 5.4: Flow Duration Curves for Marulan Creek Dam Catchment

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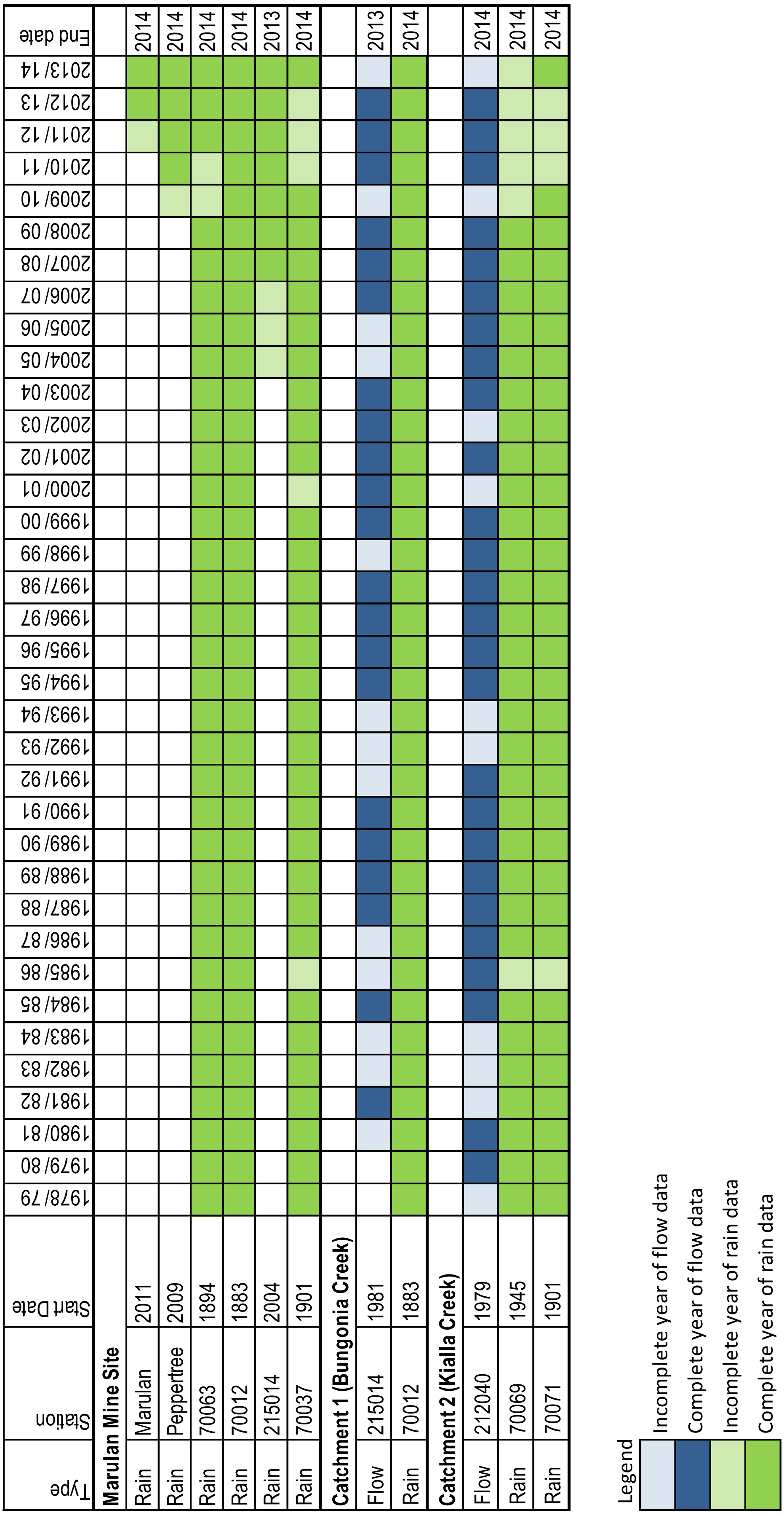
NSW Office of Water. Pinneena (Version 9.3, 2010) Database and User Manual

Attachment 1: Available Data Periods


Type
Station
Start Date
End date
1978/ 79
1979/ 80
1980/ 81
1981/ 82
1982/ 83
1983/ 84
1984/ 85
1985/ 86
1986/ 87
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1988/ 89
1989/ 90
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1991/ 92
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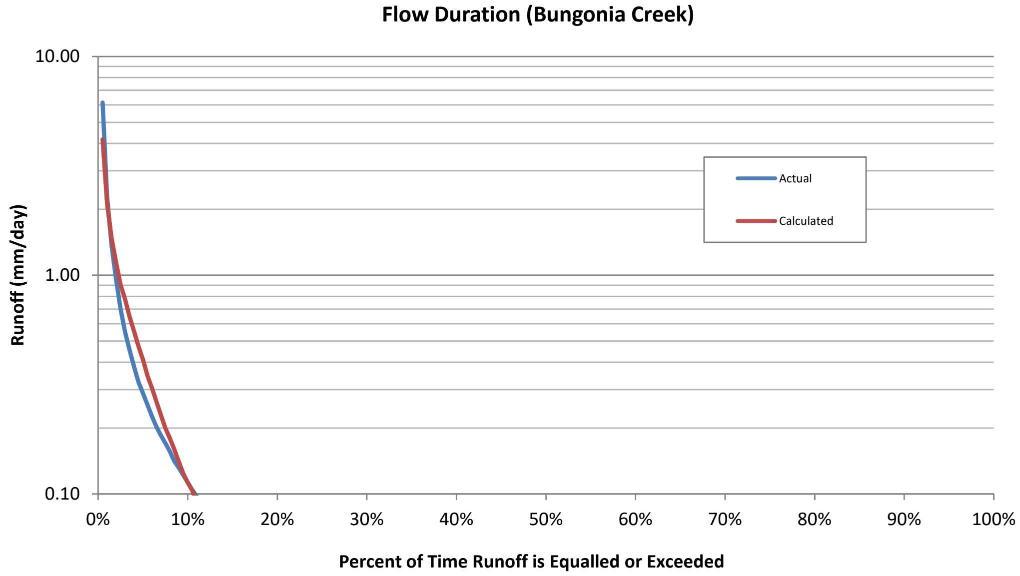
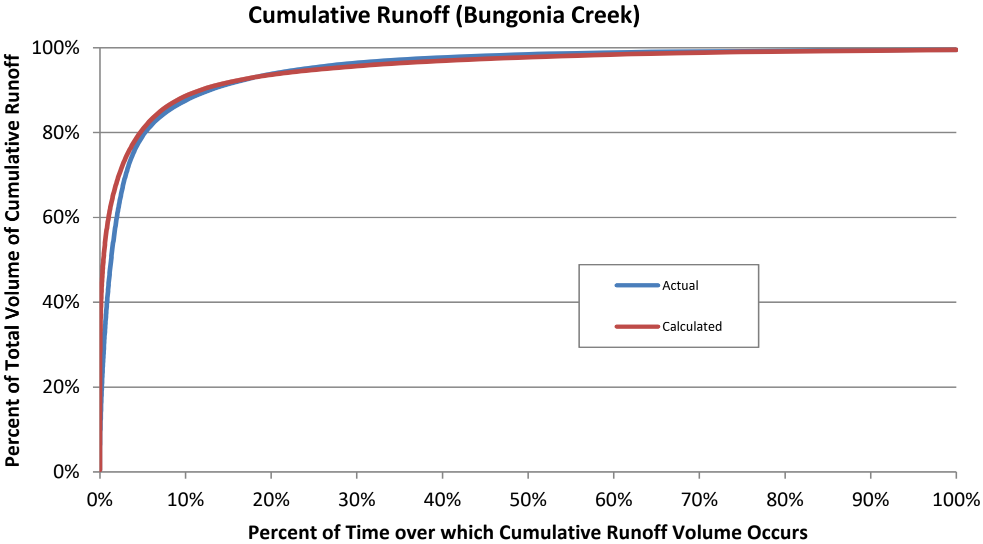
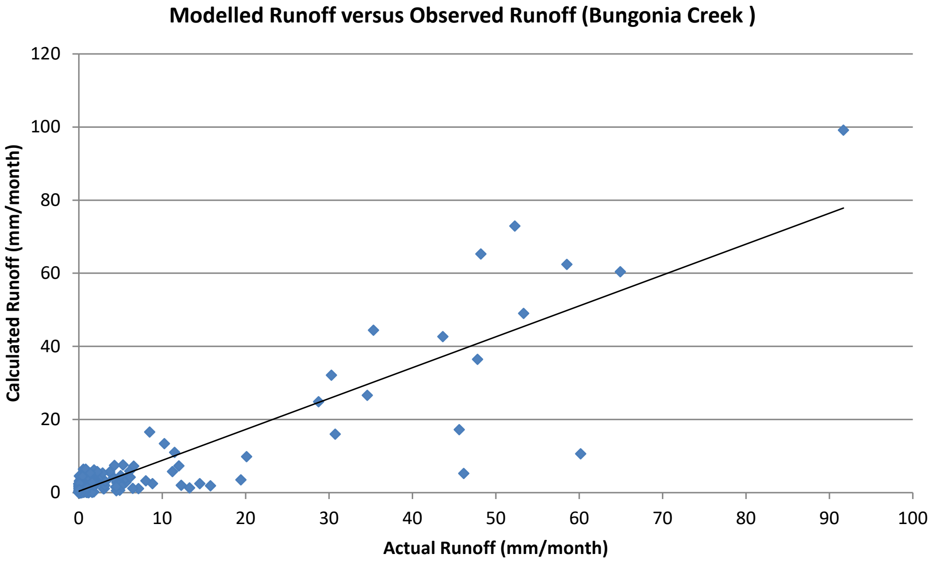
2007/ 08
2008/ 09
2009/ 10
2010/ 11
2011/ 12
2012/ 13
2013/ 14
Marulan Mine Site
Rain Marulan 2011 2014
Rain Peppertree 2009 2014
Rain 70063 1894 2014
Rain 70012 1883 2014
Rain 215014 2004 2013
Rain 70037 1901 2014
Catchment 1 (Bungonia Creek)
Flow 215014 1981 2013
Rain 70012 1883 2014
Catchment 2 (Kialla Creek)
Flow 212040 1979 2014
Rain 70069 1945 2014
Rain 70071 1901 2014
Legend
Incomplete year of flow data
Complete year of flow data
Incomplete year of rain data
Complete year of rain data

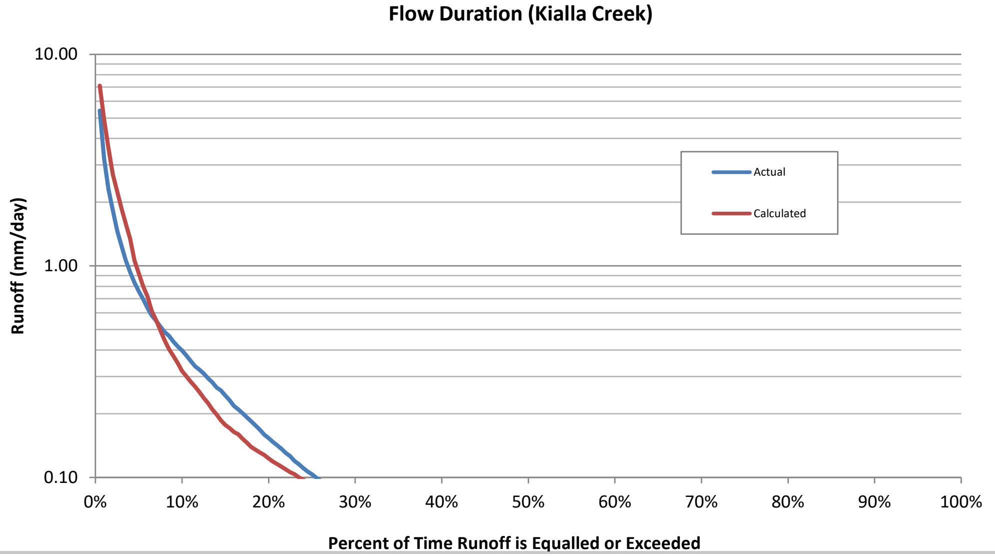
Attachment 2:
Modelling Results for Comparable Catchments

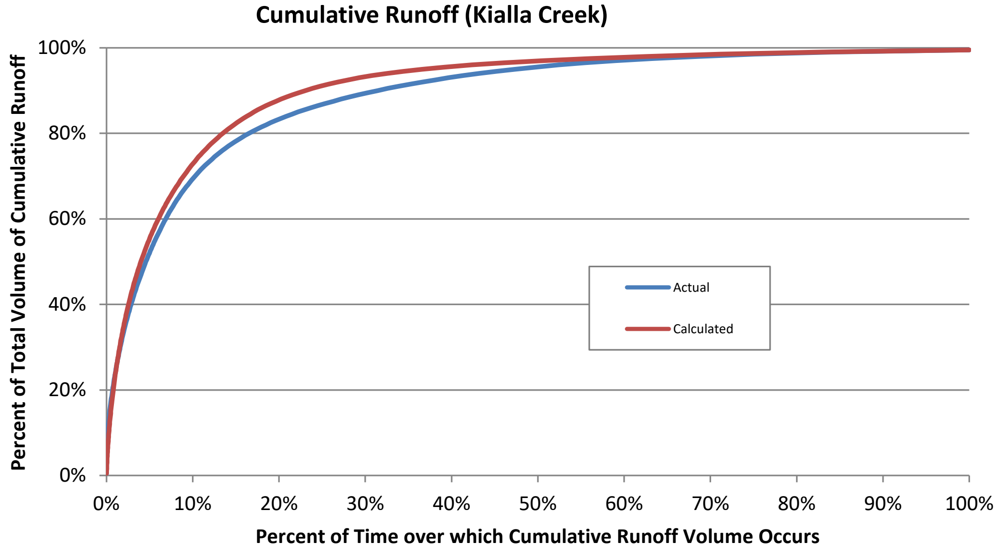


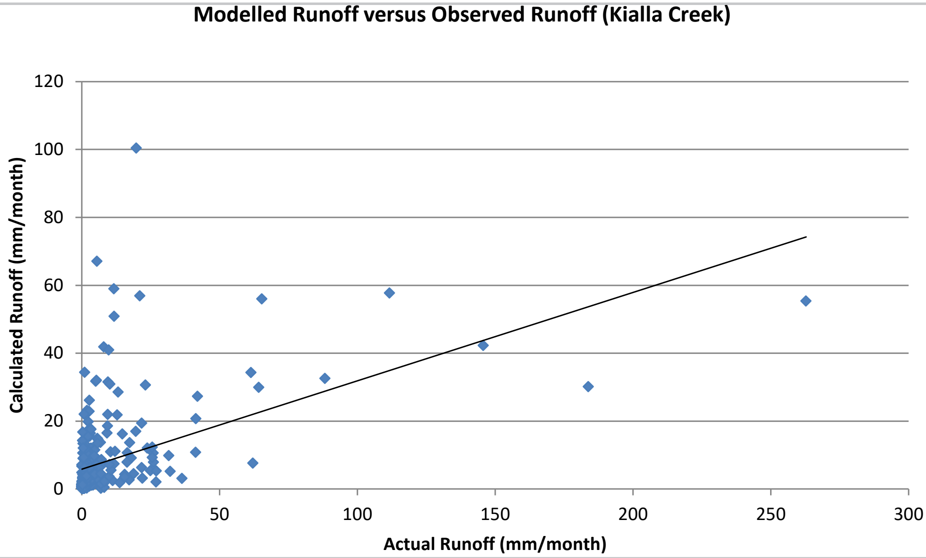




Modelling Results for Catchment 1 (Bungonia Creek 215014)







Modelling Results for Catchment 2 (Kialla Creek 212040)

Attachment 3: Adopted Modelled and Published AWBM Parameters and Annual Rainfall and Runoff

Creek	Kialla Creek	Bungonia Creek	Wingecarribee River (between Berrima and Greenstead)
Station No	212040	215014	Greenstead: 212009 Berrima: 212272
Area (km2)	96	164	360.22 ($A_{Greenstead} – A_{Berrima}$)
Cal Start	1979	1981	1990
Cal End	2013	2009	2012
Years	26	21	22
NB: Only years with complete data used between Period Start and Period End date			
C1	0.8	5.6	13.0
C2	8.1	56.4	131.8
C3	16.2	112.8	263.7
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
A3	0.433	0.433	0.433
BFI	0.15	0.21	0.900
K_{base}	0.979	0.885	0.950
K_{surf}	0.33	0.26	0.950
E (month)	0.238	0.778	0.821
Rsqr	0.240	0.794	0.822
Ave Cap (ref)	10.7	81.2	173.0
Rainfall (m/y)	394	644	808
Evap (mm/y)	1405	1381	1143
Runoff (mm/y)	93	54	69
Runoff %	24%	8%	8%
Rf	1.171	0.817	1.000

APPENDIX B

RESPONSE TO BCD REQUEST FOR CLARIFICATION AND FURTHER INFORMATION

17 February 2020

Allison Treweek
Senior Team Leader Planning
Biodiversity and Conservation Division
Department of Planning, Industry and Environment

Via email:
Allison Treweek Allison.Treweek@environment.nsw.gov.au

Dear Lauren and Allison,

Re: Marulan South Project, Biodiversity Development Assessment Report (BDAR) - Address of Comments from the Department of Planning Industry and Environment (DPIE) (REF: OC19/867602-2)

Niche Environment and Heritage Pty Ltd (Niche) have reviewed the comments provided by DPIE dated 20th of December 2019, in relation to the BDAR prepared for the Marulan South Project.

It is our understanding, that DPIE South East Biodiversity and Conservation Division require further clarification and confirmation, that the offset liability as presented in the BDAR for the Marulan South Project needs to be reduced, given the status of the Peppertree Modification 5 application.

As detailed in the DPIE letter, Niche have also been in contact with Lyndal Walters, and yourself, to discuss the comments and approach forward.

Niche can confirm that the 39.7 ha of native vegetation and habitat which was used to generate the offset liability for the Peppertree Modification 5, is contained within the area we have used to generate the offset liability for the Marulan South Project. To support this, we have attached a figure which shows the area of native vegetation/habitat used to generate the offset liability for both BDARs. As can be seen from the Figure, the area of impact to biodiversity for Peppertree Modification 5, occurs within the Marulan South Project footprint.

As such, given the progress of the Peppertree Modification 5 approval, the Marulan South offset liability as presented in the BDAR, needs to be reduced, by simply subtracting the offset liability for Peppertree Modification 5. The details of the credit reduction were provided in the Response to Submissions documentation (Boral Cement Limit 2019), which have been included in Table 1.

Table 1. Revised Offset liability for Marulan South Project

Offset liability	Marulan South Project BDAR	Peppertree Modification 5 BDAR	Revised Marulan South Project offset liability
PCT 1334 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands (SR670)	1,466	428	**1,038**
PCT 778 Coast Grey Box – stringybark dry woodland on slopes of the Shoalhaven Gorges -Southern Sydney Basin (SR534)	1,042	157	**885**
PCT 1150 - Silvertop Ash - Blue-leaved Stringybark shrubby open forest on ridges, north east South Eastern Highlands Bioregion (SR624)	260	0	**260**
PCT 731 - Broad-leaved Peppermint - Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion (SR524)	325	0	**325**
PCT 1334 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands (SR670) - Non-EEC water dependent	0	0	**0**
Solanum celatum	2	0	**2**
Koala	2,941	487	**2,454**
Large-eared Pied Bat	4,567	731	**3,836**

Given the amended change is not reducing Boral's overall biodiversity credit commitment for the combined total impact associated with the Marulan South Project and Peppertree Modification 5 Project, we request that an update of the Marulan South Project BDAR is not necessary.

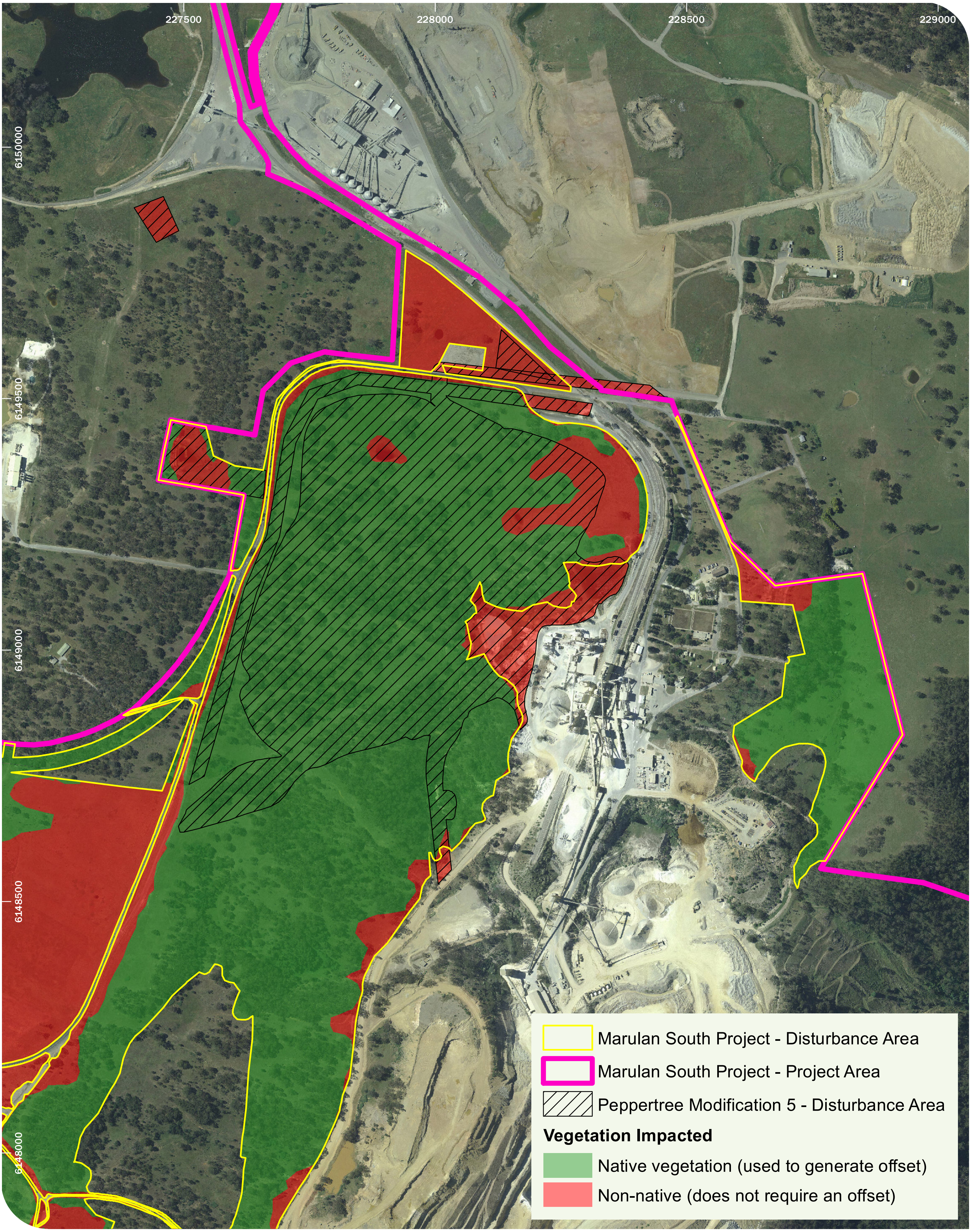
Should you require any further information, please do not hesitate to contact me.

Regards,

Luke Baker

Ecology Team Leader, Accredited Assessor

Niche Environment and Heritage



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niche Environment and Heritage

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GDA 1994 MGA Zone 56

Niche PM: Luke Baker
Niche Proj. #: 2155
Client: Boral Cement

Marulan South Project

Disturbance footprint of Peppertree Modification 5 in relation to the Marulan South Project

Figure 1