RESPONSE TO SUBMISSIONS

Russell Vale Colliery Preliminary Works
Project Modification 4

FINAL

December 2018

RESPONSE TO SUBMISSIONS

Russell Vale Colliery Preliminary Works Project
Modification 4

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Wollongong Coal Limited

Project Director:	Barbara Crossley
Project Manager:	Marion O'Neil
Report No.	3976/R02
Date:	December 2018

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

Certified System
Quality
ISO 9001

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Disclaimer

This document has been prepared for the sole use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that for which it was supplied by Umwelt (Australia) Pty Ltd (Umwelt). No other party should rely on this document without the prior written consent of Umwelt.

Umwelt undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. Umwelt assumes no liability to a third party for any inaccuracies in or omissions to that information. Where this document indicates that information has been provided by third parties, Umwelt has made no independent verification of this information except as expressly stated.

©Umwelt (Australia) Pty Ltd

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	**Date**	**Name**	**Date**
V1	Bret Jenkins	18 December 2018	Barbara Crossley	19 December 2018
Final	Barbara Crossley	21 December 2018	Barbara Crossley	21 December 2018

Executive Summary

Wollongong Coal Limited (WCL) is seeking approval to amend the soil and water management commitments of the Project approval (MP 10_0046) in order to maintain the existing Bellambi Gully diversion pipe as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek. No other modifications are proposed.

The environmental assessment (EA) for the modification application (MP 10_0046 MOD 4) (Mod 4) was placed on public exhibition in March 2018. This report provides a response to the submissions made on the Mod 4.

During the public exhibition period a total of 41 submissions were made on the modification application. This included 8 government agency submissions and 33 submissions from community members and interest groups (i.e. 30 individual submissions from community members and 3 interest group submissions). All 33 of the submissions from community members and interest groups were in opposition to the proposed modification.

In response to the submissions on the Mod 4, WCL has commissioned revised flood studies and refined the proposed stormwater management strategy and made additional mitigation and management commitments based on updated flood modelling and further pipeline studies. The revised flood studies by Engeny (2018) and the revised flood water mitigation measures have been developed in accordance with the appropriate government guidelines and standards. The revised studies have also been peer reviewed. The key components of the revised stormwater management strategy are:

- **Separation of clean and dirty water systems:**
    - Construction of upstream levee to detain and divert upslope catchment runoff through the Bellambi Gully Diversion Pipeline.
    - Construct self-cleaning debris control structures at the inlets to both the 1800 mm and 600 mm pipes.
- **Control of flows through dirty water areas:**
    - Regrade eastern laydown area to form a dry detention basin. This basin will enable management of runoff within the laydown areas and minimise spills to Bellambi Lane.
    - Construct channel from laydown area to Stormwater Control Dam to manage and divert flows in excess of the capacity of Dam 1 and Dam 2 and the new dry detention basin in the laydown area to the Stormwater Control Dam.
- **Maintenance**
    - The above structures and existing controls will be included on regular maintenance schedules.

Modelling results showed that the changes to flow regimes within the site, associated with improved clean and dirty water separation, as well as construction of the dry detention basin and better conveyance of flows to the Stormwater Control Dam, will result in improvements in water quality leaving the site during flood events, in addition to reduced flood impacts to downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully.

Table of Contents

Figures

Tables

Appendices

1.0 Introduction

Wollongong Coal Limited (WCL) owns and operates the Russell Vale Colliery (the site) located in the foothills of the Illawarra Escarpment, within the Bellambi Gully catchment of the Southern Coalfields Region of New South Wales (NSW). The site is approximately 8 kilometres (km) north of Wollongong and 70 km south of Sydney (**Figure 1.1**).

WCL is seeking to amend the soil and water commitments, Appendix 3 of the Project Approval 10_0046, under Section 4.55(2) (previously Section 75W) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) by retaining the existing Bellambi Gully diversion pipe as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek as originally identified in the *Bellambi Gully Flood Study* (Cardno, 2015) and further refined by recent more detailed investigations by Engeny (2018a).

1.1 Overview of existing stormwater management system

The Bellambi Gully catchment area is approximately 427 hectares (ha). Runoff originating from the Illawarra Escarpment flows down the heavily vegetated steep slopes of the escarpment to the site at the foothills where it enters Bellambi Gully creek. The creek is about 4.3 km long and flows from the site towards the Pacific Ocean underneath the Princes Highway, various local roads and the Illawarra Rail line before reaching the coast at Bellambi Beach (**Figure 1.2**). Clean water runoff from the escarpment bypasses the site's pit top area including the coal stockpile area, through a series of pipes and channel infrastructure to allow clean water to continue to flow into Bellambi Gully creek, downstream of the site.

WCL currently holds an Environmental Protection License (EPL) (i.e. EPL 12040) that allows discharge of 2.5 million litres per day (ML/d) to Bellambi Gully under dry weather conditions via the licensed discharge point LDP2 (see Figure 1.2). During wet weather conditions (> 10mm/24hrs) water can be discharged under the license conditions in excess of 2.5 ML/day from LDP2 for the next 72 hours to maintain a safe water level within the Storm Water Control Dam (SWCD).

The stormwater system at the site currently consists of a dirty water system and clean water system (**Figure 1.2**):

- **Dirty water** – comprising runoff from any area disturbed by mining operations, runoff from areas where coal is stockpiled and handled and groundwater extracted from the underground workings.

- **Clean water** – comprising runoff from undisturbed and fully rehabilitated areas.

Further details of the relevant aspects of the current water management system are provided in **Section 5.0**.

1.2 History of Flood Control Designs for Bellambi Gully Creek

The existing Statement of Commitments (SoC) for the Preliminary Works Project (PWP) (MP 10_0046) requires WCL to complete the Bellambi Gully realignment works by December 2014. These works were originally committed to by the then owner of the mine, Gujarat NRE Coking Coal Ltd, in order to minimise the likelihood of a failure (such as the 1998 flood events) occurring in the future by reducing the risk of blockages in the stormwater system and by introduction of a dissipation pond reducing the energy of the clean stormwater flowing across the site.

The major flood event in 1998 involved Bellambi Gully Creek overtopping the constructed Bellambi Gully Diversion drain beneath the site's pit top facilities due to blockages, and consequently scouring a significant quantity of coal from the mine's Run-of-Mine (ROM) stockpile. This resulted in some overland flows down Bellambi Lane which affected a number of residences. The scouring of the stockpile area also caused some of the ROM coal material to enter the downstream sections of Bellambi Gully Creek.

The construction of the realignment works, presented in the Environmental Assessment (EA) for the PWP did not commence due to investigations identifying that the design required further detail investigation prior to confirming and completing final design. WCL then committed to preparing a detailed flood mitigation study to assess the flood risks and determine the most appropriate flood mitigation option for the surface infrastructure and stockpile areas at the pit-top site.

In June 2014, Cardno commenced the *Bellambi Gully Flood Study* to investigate alternative mitigation measures to reduce flooding impacts downstream of the site, particularly those associated with the impact of coal stockpile washouts on downstream properties as a result of flooding. The scope of this study was focused on ensuring that dirty water runoff from the stockpile area was controlled for the major storm and directed to Bellambi Gully creek in a manner which will prevent contaminated runoff from entering Bellambi Lane and pollution of Bellambi Gully. The study included a revision of the existing stormwater system to address inefficiencies and proposed measures and upgrades to reduce the likelihood of future failures. The proposed Cardno design was dependent on the adequate treatment of controlled runoff, before discharge into Bellambi Gully Creek. Cardno recommended a number of upgrades to the existing underground Bellambi Gully diversion pipe to minimise runoff entering the stockpile area. In addition, the proposed Cardno design recommended the raising of sections of the access road to the stockpile area to contain flows within the stockpile area.

However, the DPE and Wollongong City Council (WCC) considered the initial study insufficient to support the proposed alternative mitigation measures. Consequently, Cardno updated the 2014 report to include the following:

- a review of all past flood studies,
- a topographic survey and digital terrain model,
- identification of peak flows (5, 10 and 100 year Average Recurrence Interval (ARI)), and
- a flood model based on three scenarios and recommended mitigation measures.

Cardno modelled three blockage scenarios to assess flooding throughout the site (Cardno, 2015a). The models represented 100 year Average Recurrence Interval (ARI) events where the current stormwater pipes are completely blocked, 20% blocked and fully operational. Results indicated that flooding within the site is significant under all three scenarios. In all scenarios, while overland flows are mainly contained within the stockpile area, they also overtop the access road and continue as sheet flow towards and onto Bellambi Lane. In order to reduce clean runoff entering the stockpile area, while conveying all site runoff in a controlled way to Bellambi Gully (i.e. preventing flooding of Bellambi Lane), the following range of mitigation measures was recommended by Cardno (2015):

- upgrade the stockpile area access road and install a 6 m span culvert to convey the site runoff across the access road, into a proposed grass-lined swale before discharging into Bellambi Gully,
- implement a debris control structure (DCS) at the 1800 mm diameter pipe and M3 culvert opening to reduce probability of blockage within the system due to debris from the upstream catchment,
- formalise the swale in the vicinity of the existing 600 mm diameter pipe inlet,
- upgrade the existing 600 mm diameter pipe to an 825 mm diameter pipe,

- undertake regular maintenance works immediately upstream and downstream of the existing debris control structures within Bellambi Gully to minimise the potential for blockage of the system, and

- install culverts across the access road along the northern boundary of the site to direct flows from catchment M8 directly towards Bellambi Gully, in order to reduce clean water runoff conveyed into the stockpile area.

In addition, Cardno prepared a separate study, *Bellambi Gully Flooding Approach* (July 2015) which compared and analysed the two flood control designs (i.e. original proposed creek realignment as per the Beca (2010) design with the alternative design as presented by Cardno in 2015). This study concluded that although both designs would be effective at preventing impacts to local residences, the Cardno (2015) design would have the following additional advantages:

- more effective at preventing coal washouts to Bellambi Lane because the proposed raising of the access road will allow flows to be contained within the stockpile area for all storms up to a 1 in 100 year event,

- does not require any additional land disturbance, whereas the realignment of Bellambi Gully would occur in currently undisturbed areas, and

- more cost effective.

The 2015 Cardno design was assessed as part of the Part 3A Russell Vale Colliery revised Underground Expansion Project (UEP) project approval application. The DPE Addendum Report (November, 2015) prepared for the Planning Assessment Commission (PAC) included consideration of the Cardno design and outcomes of the 2015 Cardno report, and the DPE concluded that the revised stormwater management strategy was supported. WCC also supported the 2015 Cardno design. The PAC's Second Review Report, dated March 2016, made the following conclusion in relation to the revised stormwater management strategy, whilst still identifying that further information would be required in relation to other aspects of the UEP application:

> **Commission's Considerations and Findings**
>
> *The Commission is satisfied that the issue raised in the First Review Report has been adequately addressed and supports, if the project were to be approved, the inclusion of a condition of consent that requires the implementation of flood mitigation measures recommended in the Cardno 2015 Report within 12 months of the date of approval. It also supports the draft recommended condition requiring the installation of a swale alongside the stockpile access road, which should improve water management on the site, though it is noted that the discharge of dirty water from the site is regulated by the EPA under the site's Environment Protection Licence.*

As the UEP project application is still in progress, the proponent proceeded with the Section 75W Modification Application in order to seek and progress the relevant approvals to the revised stormwater management strategy.

1.3 Summary of Modification Process

The environmental assessment (EA) for the modification application (MP 10_0046 MOD 4) (Mod 4) was lodged with the Department of Planning and Environment (DPE) on 2 March 2018.

The EA was placed on public exhibition in March 2018 and a total of 41 submissions were made which included eight government agency submissions and 33 community and interest group submissions. Following review of the submissions, DPE requested further assessment of potential impacts and proposed mitigation measures for the proposed modification (refer to **Appendix A**). As part of the process of further investigation, the proposed stormwater management strategy has been further refined and assessed by Engeny (2018a) as discussed in further detail in **Sections 4.0** and **5.3**.

An overview of further investigations and studies undertaken post exhibition is provided in **Section 4.0** with a justification of why the stormwater management system has been further refined during this response process. An assessment of the potential environmental impacts of the revised stormwater management strategy and the proposed mitigation measures is provided in **Section 5.0**.

In correspondence dated 15 June 2018, DPE granted WCL an extension to complete the Bellambi Gully diversion works by 15 June 2019.

1.4 Structure of Report

This report has been prepared by Umwelt (Australia) Pty Limited (Umwelt) on behalf of WCL to address the key issues in the submissions received during the public exhibition period.

This RTS includes:

- Context and history of the existing flood management system and the Bellambi Gully diversion pipe with a summary of the modification process (**Sections 1.1, 1.2** and **1.3**);
- Overview of the exhibited application (**Section 2.0**);
- An analysis of the issues and themes raised by the government agencies, the community and interest groups (**Section 3.0**);
- A summary of actions undertaken after exhibition, including further government agency engagement and further environmental assessment (**Section 4.0**);
- Assessment of environmental impacts associated with the originally approved stormwater management strategy and the proposed updated stormwater management strategy (**Section 5.0**);
- A detailed response to government agency submissions, the community and interest group submissions (**Section 6.0**);
- Previously proposed and updated list of environmental management and control measures (**Section 7.0**);
- List of references (**Section 8.0**).

Image Source: Google Maps (2016)
Data Source: OEH (2016)

Legend
Russell Vale Colliery

FIGURE 1.1

Locality Plan

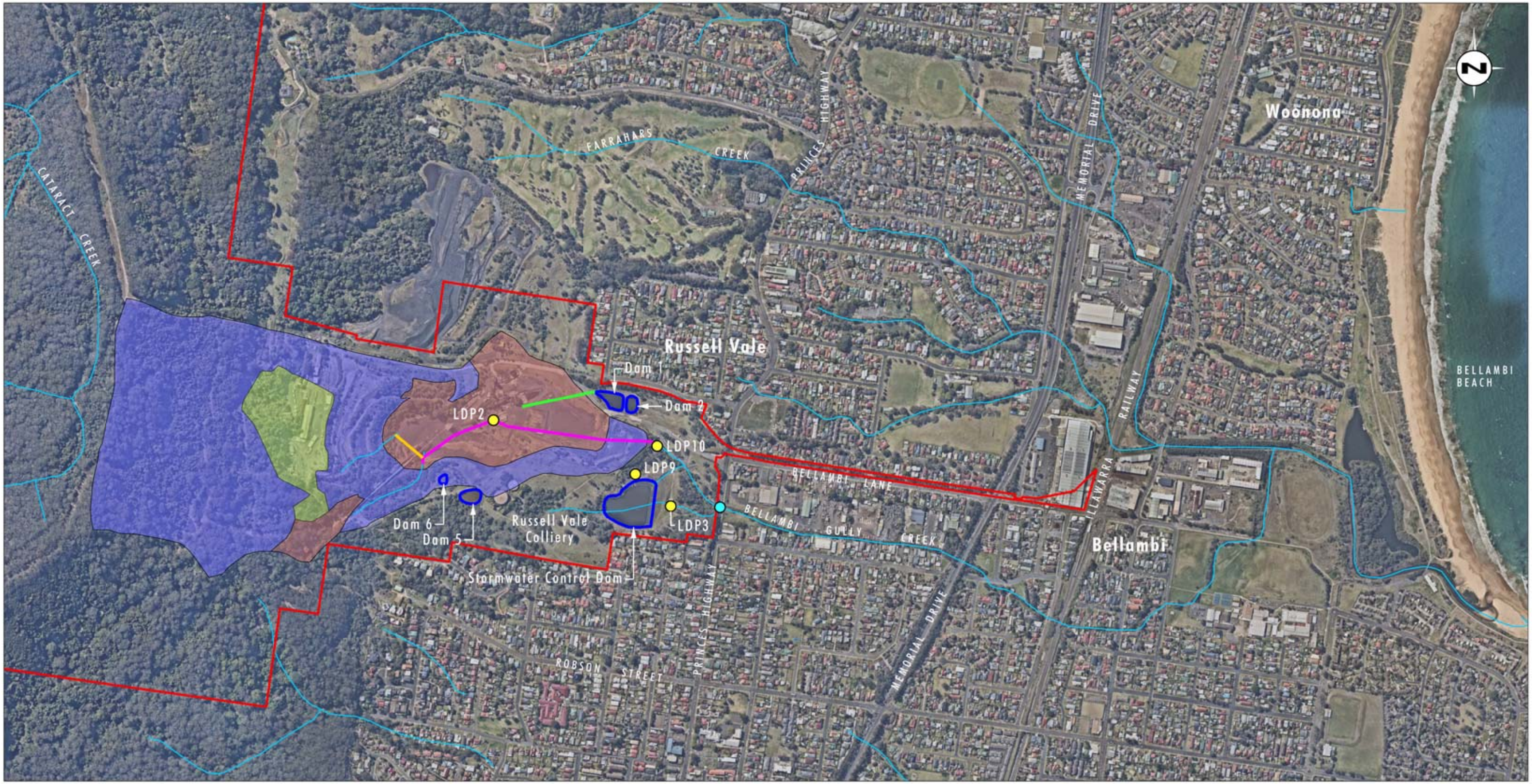


Image Source: Nearmap (Sep 2018)
Data Source: Engeny (2018),

Legend

- CCL745
- Drainage Line
- 1800mm Pipeline
- 600mm Pipeline
- Dirty Water Pipeline
- Princes Highway Culvert
- Licensed Discharge Point
- Clean Water Catchment
- Dirty Water Catchment
- Mine Water Catchment

FIGURE 1.2

Bellambi Gully and Existing Storm Water Management System on Site

File Name (A4): R02/3976_004.dgn
20181219 14.28

2.0 Overview of Exhibited Application

The proposed modification seeks approval to maintain the existing Bellambi Gully diversion pipe as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek.

No other modifications are proposed, WCL will continue to operate all other aspects of the existing operation in accordance with the Statement of Commitments (as modified) and the conditions of MP10_0046.

WCL proposes to modify Project Approval MP10_0046 to:

- amend the statement of commitments (Appendix 3 of Project Approval MP10_0046) to remove the following soil and water commitments:
  - The underground pipe section of Bellambi Gully Creek will be replaced with a suitably designed and engineered open bypass channel constructed on the southern side of the coal stockpile area. This will include:
    - A dissipation pond will be constructed at the end of the bypass channel to reduce the energy of flows back into Bellambi Gully Creek;
    - Upgrades to the existing channel including Reno mattresses and Gabion drop structures to reduce the velocity of water flowing down the gully; and
    - Regular maintenance to minimise souring during major flow events.
  - Construction of Bellambi Gully Creek will be undertaken in accordance with engineering plans prepared in general to meet the design parameters outlined in Coffey (2010).
- replace the above soil and water commitments with a requirement to:
  - Maintain the existing Bellambi Gully Diversion Pipeline as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek. Implement the recommended management and monitoring measures as detailed in **Section 7.0** of this RTS.

The proposed modification to the approved stormwater management strategy was assessed as part of the Part 3A UEP application and had been supported in the PAC's Second Review Report (March 2016), as well as by the DPE and WCC, but has not yet been approved due to issues raised in relation to other aspects of the UEP application.

3.0 Analysis of Submissions

A total of 41 submissions were received in relation to the modification application which was exhibited from 16 March 2018 to 30 March 2018.

This included 8 government agency submissions and 33 submissions from community members and interest groups (i.e. 30 individual submissions from community members and 3 interest group submissions). All 33 of the submissions from community members and interest groups were in opposition to the proposed modification.

DPE's submission letter noted that further assessment of potential impacts and the proposed mitigation measures is required for the consideration of Mod 4 (**Appendix A**). In addition, EPA and OEH raised a number of issues that triggered the need for further investigations and studies. An overview of additional investigations and studies undertaken post exhibition is provided in **Section 4.0** with an assessment of the potential environmental impacts and the proposed mitigation measures in **Section 5.0**.

3.1 Agency Submissions Analysis

The government agency submissions addressed in this Response to Submissions Report were from:

- Department of Planning and Environment (DPE)
- Environment Protection Authority (EPA)
- Office of Environment and Heritage (OEH)
- Office of Environment and Heritage - Heritage Division
- Department of Industry, Lands and Water Division
- Division of Resources and Geoscience (DRaG)
- Roads and Maritime Services (RMS)
- Department of Primary industries – Lands and Water (DPI Water)
- WaterNSW.

Apart from the EPA, no other government agencies identified that they are not in support of the proposed modification. The OEH noted that overall they have no major objection to the proposal; however recommendations for appropriate assessment and management of water related issues were made. These, and other government agency submissions, are discussed further in **Section 6.0.**

3.2 Community Submissions Analysis

3.2.1 Objecting Submissions from Individual Community Submissions

A total of 30 individual submissions were received from community members. All of the individual submissions objected to the proposed modification and raised similar issues relating to:

- Risks to downstream users (i.e. property and human health)
- Pollution of Bellambi Gully creek and downstream water resources
- Failure of the proponent to meet conditions
- History of non-compliance at the site
- Proponent is not fit to operate the site
- Failure of the Department to enforce compliance
- Dangerous planning precedents are set
- Community trust is eroded
- Department to carry out own investigations and specialist studies
- Application was not lodged in time.

Responses to the individual submissions are provided in the relevant sections within **Section 6.0** of this report.

3.2.2 Action Group Submission Analysis

Submissions were received from three interest groups, with all three submissions providing an objection to the proposed modification. Concerns related to:

- impact on downstream users (property and public health),
- pollution of Bellambi Gully creek,
- failure of the proponent to meet conditions
- the history of non-compliance at the site
- delay in the realignment of the Bellambi Gully Creek pipe, which inconsequently resulted in a number of flooding and pollution events.

The issues raised in objections are discussed in detail in **Section 6.0**.

4.0 Summary of actions following exhibition

4.1 Further Assessments and Investigations

During the exhibition period, the EPA and OEH submission letters raised issues relating to ongoing poor maintenance of stormwater infrastructure, ingress of turbid water into the Bellambi Gully Diversion pipe, the long term stability of the pipe, downstream impacts, utilisation of Council's recent blockage policy, floodplain risk management and water quality. To this end, Engeny was engaged by WCL to undertake additional investigations to adequately address and close out these issues. These investigations and studies involved:

- Review and assess the condition of the Bellambi Gully diversion pipe and define repairs and future maintenance required to prevent ingress of turbid water
- Review and assess structural capacity of the pipe to continue to serve its function of diverting clean water flows while supporting stockpile and vehicular loads
- Rigorous assessment of flood behaviour through additional flood modelling using a two dimensional hydrodynamic model incorporating detailed floodplain topographic data
- Confirm and refine option feasibility of the Cardno (2015) design.

As discussed in **Section 4.2.1,** a peer review of the additional Engeny flood assessment was also commissioned as requested by the DPE.

4.1.1 Bellambi Gully Flood Assessment (Engeny, 2018a)

The *Bellambi Gully Flood Assessment* (**Appendix C**) was undertaken by Engeny in 2018 to review and refine the Cardno (2015) stormwater management measures to manage flood risks at the site. This study used two dimensional hydraulic modelling that incorporated detailed digital terrain data and offered a significant advance in the accuracy of modelling results and options viability relative to the flood modelling used in the Beca (2010) and Cardno (2015) studies. The mitigation measures proposed by Cardno (2015) were included in the modelling scenarios undertaken for this study. A summary of the outcomes of the flood assessment and the revised recommended stormwater management and control measures (**Figure 5.1**) have been integrated into the design of the proposed modification works and are discussed in more detail in **Section 5.3**.

4.1.2 Bellambi Gully Diversion Pipeline Review (Engeny, 2018b)

A pipeline assessment report (*Bellambi Creek Diversion Pipeline Assessment*) was prepared by Engeny in December 2017 to investigate the current condition of the pipe network and determine the maintenance required to prevent ingress of turbid water. As detailed in **Section 1.3**, this report was submitted to the EPA in response to the Pollution Reduction Program (PRP) (PRP 8). Since then, WCL have undertaken a series of repair works on the pipeline to remediate all turbid water ingress points. WCL has provided photographs showing the typical works and also provided an updated analysis of the risk assessment based on the post-repair inspections (refer to **Appendix B**).

The *Bellambi Gully Diversion Pipeline Assessment* (Engeny, 2017) report had been superseded by the *Bellambi Gully Diversion Pipeline Review*, dated December 2018 (see **Appendix B**).

The 2018 Bellambi Gully Diversion Pipeline Review involved the following:

- Review of risk of turbid water ingress:
  - Detail the work carried out as part of the pipeline inspection program.
  - Identify further works required to minimise ingress of water.
  - Suggest timeframe for rectification based on a risk analysis for the defects.
  - Order of magnitude cost estimate for the repair works.
  - Outline monitoring that can be used to assess the effectiveness of the works.
  - Provide an updated risk assessment based on post-repair inspections.
- Review of pipeline loading and capacity review:
  - Undertake a loading analysis for the worst case loading scenario to equate this to the historic loads and infer what maximum loadings and operating methodology could be used in future in proximity to the pipeline.
  - Recommend stockpiling operating methodology in proximity to the pipeline to limit overloading.
  - Identify potential further works to determine the structural properties of the pipeline should greater accuracy for the assessment be required to reduce the risk of future damage to the pipeline

Turbid Water Ingress

Engeny (2018b) concluded that based on the updated risk ranking, all defects that were previously assessed as being *moderate* to *critical* have been addressed by WCL. The updated risk assessment has identified all deficits as having a *low* to *very low* pollution risk, which are unlikely to require remediation works in the next year. Consistent with the recommendations of the previous report, an ongoing monitoring program is recommended to regularly inspect the defects to determine the efficacy of the remediation works and any worsening of the low and very low ranked risk defects (see **Section 7.0**).

Pipeline loading and capacity analysis

The pipeline review (Engeny, 2018b) concluded that in order to reduce external loading of the pipeline to a level consistent with or lower than the previous loading, the proposed stockpile extents would need to be reduced. To aid in management of the height of the stockpile over the pipeline, it is suggested that WCL clearly delineate the maximum extents of the stockpile. It is also recommended that no heavy vehicle loads should be permitted in areas susceptible to heavy vehicle loads (i.e. CH 120 to 660) without further detail investigations into the structural condition of the pipe and depth of cover. A 5 m offset from the centreline from the pipe for heavy vehicles is proposed. Dedicated crossings of the pipeline will be considered and will consist of additional fill placed over the pipeline, or other structural solutions to spread the surface load through the soil profile to achieve an appropriate reduction in external loading of the pipeline.

Annual video surveillance/inspections of the pipeline will be implemented to determine any visual structural degradation. Additionally, inspection of the pipeline following major storm events (e.g. greater than 50 mm of rainfall in 24 hours) will be conducted.

Outcomes of this study and the recommended management measures have been incorporated into the consolidated set of mitigation and control measures as outlined in **Section 7.0**.

4.1.3 Surface water peer review (Umwelt, 2018)

In response to the request from DPE (refer **Section 4.2.1**), the additional flood study by Engeny (2018a) was subject to a technical surface water peer review that was commissioned in October 2018. The peer review was undertaken by Umwelt's Principal Water Engineer Mr Glenn Mounser.

The peer review included consideration of technical aspects of the following Engeny reports that address the longer term viability of the diversion pipeline:

- *Bellambi Creek Diversion Pipeline Assessment* (Engeny, 2017).
- *Bellambi Gully Diversion Pipeline Review* (Engeny, 2018b).

The key consideration of the peer review was to determine whether the mitigation measures proposed in the updated flood assessment (Engeny, 2018a) perform as well as (i.e. no worse than) the 2015 Cardno design. The secondary objective was to consider and comment on the pipeline assessment reports by Engeny that address the condition and longer term viability of the diversion pipeline to function as a key element of the site's flood mitigation measures.

4.2 Stakeholder Consultation

4.2.1 Department of Planning and Environment (DPE)

On 22 August 2018 a meeting was held with the DPE to discuss the approach and progress of the Mod 4 Response to Submissions (RTS) Report and the Underground Expansion Project (UEP) Revised Preferred Project and Response to Submissions (RPPRTS) Report.

The following key issues raised by the DPE were relevant to the Mod 4 application and required further assessment and investigations following the exhibition period:

- Establish a robust justification for additional flood assessments and further design refinements to the Cardno design (refer to **Sections 4.1.2 and 5.0)**.
- Commission a technical surface water peer review of the additional flood study (refer to **Sections 4.1.2** and **5.0**).

4.2.2 Other Government Agencies

During and post the public exhibition period for the Mod 4, WCL has undertaken ongoing consultation with government agencies in regard to the site's ongoing compliance programme for the' care and maintenance' regime at the site and in response to submissions to ensure appropriate actions are taken to investigate and close out issues. A summary of ongoing government consultation undertaken is provided in the table below.

Table 4.1 Summary of Ongoing Government Agency Consultation

Agency name	Date	Purpose
EPA	March 2018	Met with EPA and WCC to discuss variation of the EPL to satisfy further requirements from EPA.
	July 2018	Met with EPA and WCC's Floodplain Manager regarding the overall storm water management plan for the entire Bellambi Gully creek and to discuss the Mod 4 application and proposed revised water management system at the site.
Wollongong City Council (WCC)	March 2018	Met with EPA and WCC to discuss variation of the EPL to satisfy further requirements from EPA.
	July 2018	Met with EPA and WCC's flood plain manager regarding the overall storm water management plan for the entire Bellambi Gully creek and to discuss the Mod 4 application and proposed revised water management system at the site.

4.2.3 Community Consultative Committee (CCC) meetings

Russell Vale Colliery has an established Community Consultative Committee (RV CCC) that meets quarterly. At each meeting the CCC is briefed on all current and active approvals applications and provided with an overview of progress that has been made on each of the applications during the preceding months.

The following RV CCC meetings were held this year:

- 21 March 2018
- 18 June 2018
- 27 August 2018
- 26 November 2018.

5.0 Environmental Assessment

As noted earlier, the DPE raised the requirement for an assessment of potential impacts and the proposed mitigation measures. This section provides the assessment and comparison of the potential environmental impacts associated with the approved realignment works as per the Beca (2010) design and the proposed revised stormwater management strategy based on the Cardno (2015) strategy and updated by Engeny (2018a).

5.1 Approved Realignment Works (Beca, 2010)

Beca (2010) reviewed the existing stormwater system to identify inefficiencies in the system, and proposed measures and upgrades to reduce the likelihood of future failures. One of the key outcomes of the Beca (2010) study was the proposed replacement of the underground Bellambi Gully clean water pipe with a bypass channel system in order to divert stormwater runoff around the coal stockpile area, i.e. changing stormwater flow from an ‘in pipe’ system to an ‘open channel’ system. Additionally, implementation of a wet and dry sediment basin to provide better treatment of dirty water runoff was proposed for the site.

After comparison of water quality in Bellambi Gully and similar creeks in the area, Beca (2010) determined that discharge from the site was not expected to significantly impact the water quality or quantity in the Gully over the next 3 years under proposed production rates (up to 1 Mtpa). It was proposed that further water treatment and reuse on site be investigated, including the potential to separate process water and dirty stormwater. This was to also include further investigations for improving the management of solids from the water treatment plant on site.

Beca (2010) concluded that the proposed design would ensure that the creek downstream would be protected as it would receive clean water runoff via the diversion channel as well as treated dirty water runoff from the stockpile area.

The implementation of the Beca (2010) flood controls would require substantial construction works. This would involve the construction of the diversion drains, land grading, bunds and road crests within the steep batters as well as new access roads within the upstream catchments to ensure that all clean water flows be directed towards the proposed diversion channel. Reno mattresses and drop structures using gabion basket within catchments M1, M3, M5 and M6 would also need to be constructed.

Impacts associated with the approved realignment works are further considered, in relation to the now revised stormwater strategy, in **Section 5.4**.

5.2 Proposed Revised Stormwater Management Strategy (Cardno, 2015)

Cardno (2015) identified that blockages within and at the entrance to the Bellambi Gully diversion pipe were the primary cause of the overtopping and pollution event in 1998. Cardno (2015) determined that regular maintenance and upgrades to the existing stormwater systems would achieve the same stormwater management outcomes as would be achieved by the Beca (2010) proposed flood controls (detailed in **Section 5.1**).

The Cardno (2015) design involved retaining the existing Bellambi Gully diversion pipe as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek, with the addition of a series of mitigation measures in order to optimise the existing stormwater system.

A simplified 1D flood modelling approach was used in Cardno (2015), as follows:

- Full pipe capacities (no blockage assumed) estimated using Manning's Equation.
- Flows in excess of pipe capacity modelled as overland flows at the pipe inlets in a 1D HEC-RAS hydraulic model.
- Overland flow paths estimated for maximum size and location prior to modelling, using guidance in Beca (2010).
- Peak 100 year ARI inflows to culverts and overland flow paths based on the values in Beca (2010).

Cardno (2015) examined 3 blockage scenarios within the stormwater system, i.e. 100% blockage, 20% blockage and 0% blockage. For existing conditions under all 3 blockage scenarios, it was established that runoff from the pit top stockpile areas will overtop the stockpile area access road onto Bellambi Lane, causing impacts to downstream properties.

The mitigation measures proposed by Cardno (2015) included:

Table 5.1 Proposed Cardno (2015) stormwater management measures

Option	Proposed Cardno solution	Proposed Cardno design
1	**Raise stockpile area access road, install new culvert and formalise open channel**	The access road should be constructed with a low point (sag) to allow for overtopping of flows in excess of the culvert capacity. The culvert connects to the proposed grass-lined swale on the east side of the stockpile area access road before discharging into Bellambi Gully (6m span culvert).
2	**Debris control structures at the 1800 mm pipe inlet and the M3 Culvert**	Implementing Debris Control Structures (DCS) at the 1800 mm diameter pipe and M3 culvert. Rehabilitation and opening of the M3 culvert.
3A	**Formalisation of the 600 mm clean stormwater pipe**	Formalising swale of the existing 600 mm clean stormwater pipe to capture all clean water runoff.
3B	**Upgrade 600 mm clean stormwater pipe**	Upgrade to an 825 mm diameter pipe between the pipe inlet and the 1800 mm pipe (to convey flows up to the 100 year ARI storm).
4	**Maintenance to existing structures**	Maintenance of debris control structures.
5	**Upgrade through roads**	Install culverts across the access road along the northern boundary of the site to direct flows from the catchment M8 directly towards Bellambi Gully.

For the proposed mitigation measures, 25% blockage was applied to the proposed 6 m wide box culvert, while 100% blockage was applied to all other culverts, in accordance with WCC's blockage policy applicable at the time (WCC, 2009). The flood modelling results in Cardno (2015) demonstrated that the proposed road upgrade, 6m culvert and swale are adequate to convey the 100 year ARI flows.

As part of the UEP, WCL proposed to construct a 6 ML capacity dry sedimentation basin to treat runoff from the pit-top prior to discharging into Bellambi Gully from the licenced discharge point.

WCL also committed to continue implementation of maintenance work within the upper reaches of Bellambi Gully, as originally detailed within the Preliminary Works EA including stabilising areas as required with appropriately designed structures or supporting material where required and removing obstructions from drainage channels in order to minimise downstream blockages. Maintenance of the debris structures recommended by Cardno (2015) has also been undertaken.

5.3 Proposed Updated Stormwater Management Strategy (Engeny, 2018a)

As discussed in **Section 4.1.1**, additional flood modelling and investigations were undertaken by Engeny (2018a) after the EA has been exhibited to confirm and refine the Cardno (2015) proposed revised stormwater management strategy. A full copy of the Bellambi Gully Flood Assessment is included in **Appendix C**.

5.3.1 Modelling and Assessment Approach by Engeny (2018a)

The potential impacts of flooding and proposed management measures as per the 2015 Cardno design were assessed by Engeny (2018a) using a hydrologic model and a hydraulic model to represent the catchment areas and creek system. The assessment approach for the modelling, Australia Rainfall and Runoff (AR&R) 1987 (IEAust, 1987), was selected to be consistent with the methodology used to assess the 2015 Cardno proposed flood mitigation measures and flood modelling in the downstream and surrounding catchment areas undertaken by WCC.

The upslope catchment areas were modelled using the hydrology model of XP-STORM, with some routing of flows to the boundary of the hydraulic model. The main area of the site was modelled in TUFLOW. The boundaries of the various models and interactions are described in Section 5 and shown on Figure 1.1 of the Bellambi Gully Flood Assessment (**Appendix C**). The capacity of the upstream drainage systems was based on the analysis undertaken by Beca (2010) and confirmation during site inspections. The failure of drainage system during events greater than the 100 year ARI storm event results in additional catchment areas flowing to Bellambi Lane during these events.

The downstream boundary of the study area was immediately upstream of the Memorial Drive Culverts to allow both modelling of potential impacts on flooding at and downstream of the Princes Highway.

The study investigated both the existing flood behaviour as well as the proposed solution to assist in flood/stormwater management at the site. The study also considered the range of options proposed by Cardno (2015), with detailed modelling used to consider the potential outcomes if the Cardno (2015) solution was implemented.

A range of storm events were modelled, including the 5 year, 10 year and 100 year Average Recurrence Interval (ARI) storm events as well as the Probable Maximum Precipitation (PMP). In addition, the 200 year and 500 year ARI storm events were modelled to simulate the potential impacts of climate change.

5.3.2 Review of Cardno (2015) Modelling and Assessment Approach

The 2015 Cardno study was undertaken using catchment delineations and peak flows determined by Beca (2010) and a one-dimensional HEC-RAS model. The HEC-RAS model covered the area of the stockpile area but did not extend to the access road or consider the interactions between the access road (i.e. Bellambi Lane and Broker Street to the north).

Cardno (2015) considered three flood scenarios to assess flooding risk to the site, these included the current stormwater pipes being completely blocked, 20% blocked and fully operational during the 100 year ARI event. A series of flood mitigation measures were proposed by Cardno (2015) and were designed to reduce clean runoff entering the stockpile area, while conveying all site runoff in a controlled way to Bellambi Gully. It was however determined that the majority of these options were not modelled and the final report by Cardno contains limited quantification of the modelling outcomes (Engeny, 2018a).

5.3.2.1 Overview of Modelling Results

The modelling results from Engeny (2018a) showed that the Cardno (2015) proposed measures (refer to **Table 5.1**) will have the following outcomes:

- No change to flood behaviour upstream of the pipeline as a result there is no change of flood levels at the inlet to the Bellambi Gully Diversion pipe.
- No change to flood levels in Broker Street.
- Slight decrease in existing 100 year ARI flood levels along Bellambi Lane and downstream of the Princes Highway adjacent to Bellambi Lane – between 0.01 and 0.02m. However, this is offset by an increase to existing 100 year ARI flood levels (approximately 0.02m) downstream of the Princes Highway culverts on Bellambi Gully.
- Modelling of the 600 mm clean water pipe (Option 1 + 3A) predicts that the pipe operates at capacity in the 100 year ARI event and, as such, the introduction of the swale has little effect on downstream flooding.
- Modelling of Option 1 + 3A + 3B indicates increased peak flows through the 1800 mm Bellambi Gully Diversion Pipeline. Combined with the swale, the result is an increase in peak flows over the Princes Highway.
- Option 5 reduces peak flows through the properties on Broker Street by approximately 1 m3/s, however, these flows are redirected to the Princes Highway with similar increases to peak flows and associated flood levels over the Princes Highway and at the properties downstream of the Princes Highway.
- Modelling of the above scenarios indicates that there is minimal change to the performance of the dry detention basin in each option. Modelling indicates that the concept design for the dry detention basin described in Cardno (2015) does not meaningfully affect flows either within or downstream of the site. This is largely due the design of the inlet structure and the elevated bund walls resulting in a portion of flows bypassing the basin inlet.

Further modelling was undertaken to identify mitigation measures that would minimise Bellambi Lane flooding while not worsening flooding at the Princes Highway culvert downstream of the surface facilities.

The modelling further demonstrated that refinements to the Cardno (2015) proposed mitigation strategy, by incorporating detention storage related to the construction a new upstream levee (**Figure 5.1**), will have significant benefits over the 2015 Cardno solution.

umwelt

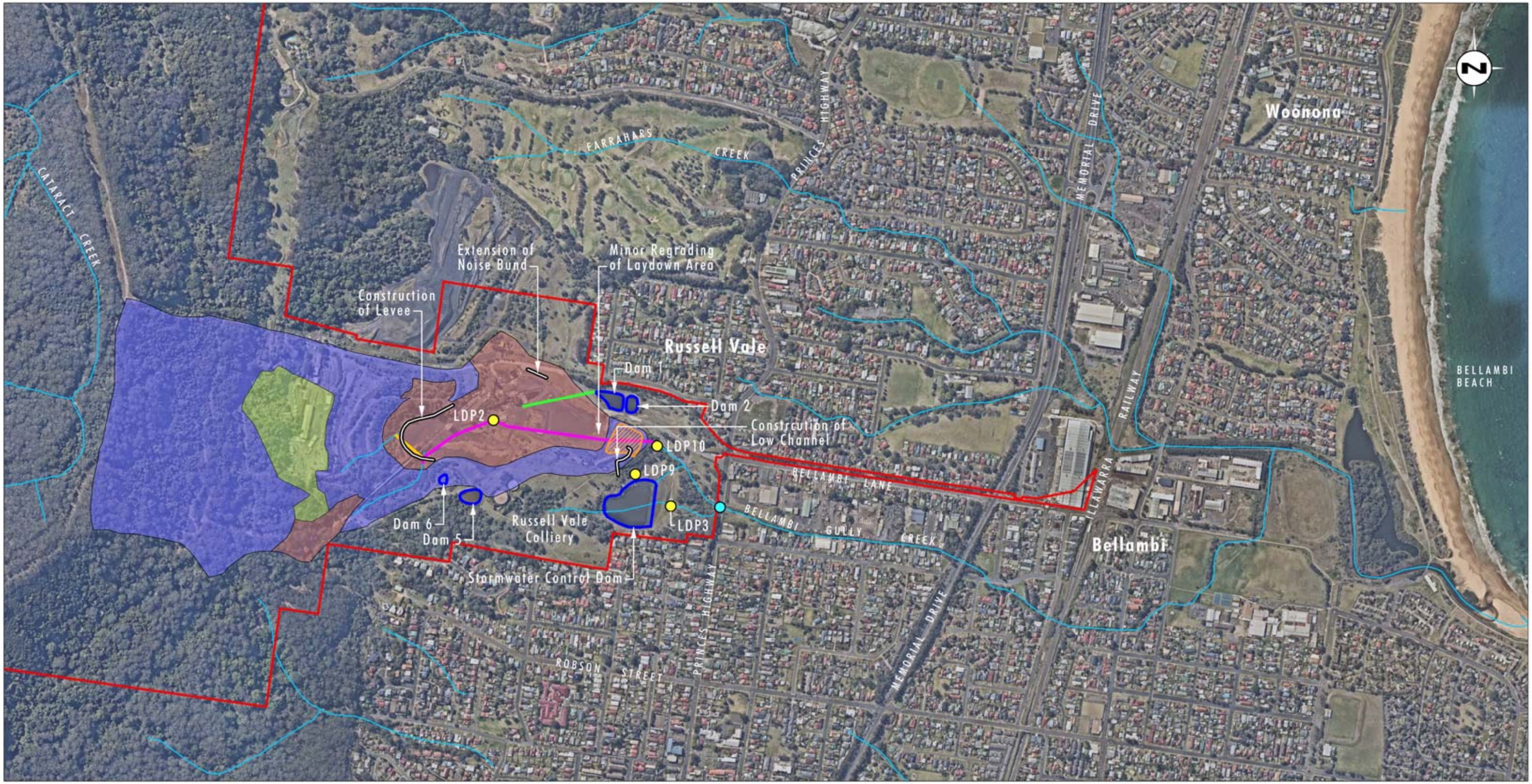


Image Source: Nearmap (Sep 2018)
Data Source: Engeny (2018)

0 0.25 0.5 0.75km
1:15 000

Legend

- CCL745
- Drainage Line
- 1800mm Pipeline
- 600mm Pipeline
- Dirty Water Pipeline
- Princes Highway Culvert
- Licensed Discharge Point (LDP)
- Clean Water Catchment
- Dirty Water Catchment
- Mine Water Catchment
- Proposed Dry Detention Basin

FIGURE 5.1

Updated Proposed Stormwater Management Measures

File Name (A4): R02/3976_005.dgn
20181219 14.26

Site observations confirmed that existing debris control structures (e.g. trash racks) can fully block with rocks and boulders within a short period from the nearby steep (high energy) upstream catchment (Cardno, 2015). As with the Cardno preferred solution, the debris control structures are included in the Engeny proposed mitigation measures. To optimise performance of all mitigation measures, regular/programmed inspection and clearing of debris control structures is proposed. This will be imperative to avoid a similar situation to August 1998.

Further, modelling results showed that the following mitigation options outlined in Cardno (2015) can be precluded from the proposed mitigation strategy:

- Upgrades to the 600 mm clean water diversion pipe: formalise entry swale and increase pipe to 825 mm.

  Reason for non-inclusion: The results of the flood modelling showed there is no need for this pipe to be upgraded.

- Upgrade drainage on the through road (Bellambi Lane extended), including installation of culverts at 3 site access points, to intercept runoff from the local catchment and direct the flow easterly towards Bellambi Gully.

  Reason for non-inclusion: The modelling results indicate there is no need for this upgrade as flows typically do not enter the dirty water system but continue easterly along Bellambi Lane towards Bellambi Gully and the Princes Highway.

Impacts associated with the updated water management strategy (described in **Section 5.3.3**) are further assessed in **Table 5.2**.

5.3.2.2 Design of the Dry Detention Basin

The dry detention basin referenced in Cardno (2015) was originally proposed in BECA (2010). The BECA dry detention basin formed part of a suite of recommendations, including a clean water diversion, along the southern boundary of the laydown area. The purpose of the dry detention basin was to capture all dirty water runoff that flowed through the stockpile area up to and including the 10 year ARI storm event. The dry detention basin was bounded by the clean water diversion to the south and the existing noise bund to the north.

The TUFLOW modelling (Engeny 2018a) indicated that the changes to the layout, including removal of the clean water diversion drain, results in dirty water flows bypassing the dry detention basin and spilling towards Bellambi Lane. As such the full storage capacity of the dry detention basin is not used in the 10 year ARI storm event.

The Cardno (2015) dry detention basin design has been refined by Engeny (2018a) to consider changes to surface levels and flow paths as well as locating the dry detention basin in the laydown area.

The current proposed location for the dry detention basin is the easternmost area of the laydown area with regrading of access routes to the west to redirect flows into the dry detention basin (see **Figure 5.1**). The current design includes an overflow channel to the SWCD. The volume of the basin in the laydown area is constrained by the depth to the Bellambi Gully Diversion Pipeline and the relocation of the noise bund (as part of the proposed UEP application). Initial investigations indicate that the maximum detention volume used during storm events is ~2.1 ML.

5.3.3 Engeny (2018a) Proposed Mitigation and Management Measures

The updated stormwater management strategy proposed by Engeny (2018a) is a refinement of the Cardno (2015) design and is based on the outcomes of more detailed and up to date flood modelling. This strategy is illustrated on **Figure 5.1** and includes:

- Construction of a levee upstream of the stockpile area to minimise clean water runoff entering the stockpile and laydown areas from upslope drainage systems and divert these flows to the 1800 mm and 600 mm diameter pipes. This could be achieved by raising the access road or by the construction of a free standing levee in the area between the access road and the existing stockpile area. The levee would need to range between 1 m to 3.5 m above the existing landform to the north and west of the stockpile and 5 m above the existing landform to the south of the stockpile.

- Extending the noise bund east of the coal loader to the access road.

- Minor regrading of the laydown area to convey flows to the east and limit spilling to Bellambi Lane. The laydown area east of the current truck wash will be utilised as a dry detention basin with a low flow channel (point 4 below) conveying overflows to the SWCD. The effective capacity of the dry detention basin is 2.1 ML.

- Construction of a flow channel from the laydown area to the SWCD to act as an outlet from the dry detention basin. The proposed channel would be trapezoidal in shape, follow the existing access track in this area with a base width of 4 m and grading from 39.0 mAHD to 38.0 mAHD before flowing into the SWCD. Batter slopes have been modelled at 1:1.5 (v:h) which is typical of the batter slopes of the existing noise/visual bunding.

Engeny (2018a) concluded that the above updated stormwater management strategy will have improved flood management outcomes compared to the 2015 Cardno solution. To optimise performance of all mitigation measures, regular/programmed inspection and clearing of debris control structures is proposed. This will be imperative to avoid a similar situation to August 1998.

5.4 Comparison of the approved realignment works and proposed updated stormwater management strategy

This section provides a comparative assessment of the potential environmental impacts associated with two proposed stormwater control designs as described in **Sections 5.1** and **5.3** above.

Table 5.2 Comparative assessment of the approved and proposed updated stormwater systems

Environmental impact	Approved diversion works as per the Beca (2010) design	Proposed updated stormwater management strategy as per Engeny (2018a)
Construction impacts		
Soils Landscapes and Landform	Construction of the open diversion channel will involve excavation of a new channel approximately 1.2 m deep, 2.5 m wide and 0.75 m long through an undisturbed area and will require the removal of Dam 6 (**Figure 1.2**) and regrading of surrounding areas.	This design will involve upgrading and maintaining of existing structures and optimising the existing stormwater management system on the site. Minor land clearance and disturbance may be required to replace or upgrade existing structures; however this would all be restricted to already disturbed areas. It is not expected that land clearance and/or disturbance within existing undisturbed areas will be required for the implementation of the updated design.
Fauna and Flora	The vegetation to be impacted by the	No additional vegetation disturbance would

Environmental impact	Approved diversion works as per the Beca (2010) design	Proposed updated stormwater management strategy as per Engeny (2018a)
	construction of the open diversion channel is mostly disturbed grassland. However, the proposed works has the potential to impact a small area of Moist Box Foothills Redgum Forest. This vegetation within the site is however highly modified through weed invasion and erosion of the creek banks. The removal of Dam 6 would potentially impact the Green and Golden Bell Frog and foraging habitat for the Large-footed Myotis. Surveys for the Green and Golden Frog were undertaken at Dam 6 in May and September 2010. Although no Green and Golden Bell Frogs were recorded during these surveys, the previous recorded sites were in close proximity therefore there is a likelihood of occurrence of the Green and Golden Bell Frogs at the Russell Vale Colliery.	be required for the implementation of this proposed design. There would be no disturbance or impacts to Dam 6 with the implementation of this proposed design.
Noise Impacts	The potentially most exposed receivers will be residences located in Russell Vale along Broker Street and West Street (nearest point approximately 170 m away); and in Corrimal along Midgley Street, Wilford Street, Lyndon Street and Taylor Place (nearest point approximately 180 m away). Construction activities such as vegetation removal and excavation works as well as the use of heavy vehicles will have noise impacts to the nearby residential receivers. Measures to reduce and manage noise during the construction works will be implemented.	Any potential noise impacts to be experienced by the nearby residences during the construction are expected to be in daytime hours and the impact to be short term and low.
Air Quality Impacts	Depending on the wind strength and direction, there is the potential for nuisance dust as a result of land clearance and excavation works. The nature of the air quality impacts would be short-term, minor and temporary with the implementation of dust suppression measures and progressive rehabilitation of disturbed areas.	No change in air quality at the site is expected.

Environmental impact	Approved diversion works as per the Beca (2010) design	Proposed updated stormwater management strategy as per Engeny (2018a)
Operational impacts		
Separation of clean water and dirty water runoff systems	The clean water system will be separated from dirty water stockpile runoff via the diversion swale. Dirty water would be managed and discharged into Bellambi Gully creek via LDP3.	Clean water will be conveyed beneath and around the stockpile area via the diversion drains and proposed swales. The detention of overland flows behind the upstream levee (**Section 5.3.3**) will result in a reduction of peak flows through the stockpile area with no clean water runoff from the upslope catchment areas flowing through the stockpile area. Modelling showed that flows through the stockpile area will be from local runoff only.
Groundwater ingress	No groundwater ingress will be experienced with the implementation of this design.	Repair works on the Bellambi Gully diversion pipe have been assessed as having a low to very low risk for ingress of groundwater. It is unlikely that further remediation works will be required within the next 12 months. An ongoing monitoring program is proposed to regularly inspect the pipeline for defects to determine the efficacy of the remediation works and any worsening of the low and very low ranked risk defects (see **Section 7.0**). Additionally, inspections of the pipeline after major storm events (e.g. greater than 50 mm of rainfall in 24 hours) will also be undertaken to determine whether there has been any damage to the pipeline as a result of the storm event. As part of the UEP for future operations, management measures would be implemented to ensure that heavy vehicle movements over the pipe are restricted and managed in such a way to prevent further structural degradation of the pipe. A program of pipeline replacement is also proposed.
Efficient treatment of stormwater runoff	Both wet and dry sediment basins are proposed for flows up to the 10 year ARI. Implementation of the wet and dry sediment basin will provide for improved treatment of dirty water runoff from the site.	The proposed flood mitigation measures (Engeny 2018a) include various methods to improve water quality leaving the site during flood events. These are: the upstream levee; debris control structures at the major pipe inlets; a dry detention basin; and conveyance of site flows, where possible, through the SWCD. The result of lower peak flows through the stockpile area will reduce associated erosion potential and sediment transport. Additional containment / retention of flows within the water management system during flood events will allow for additional sediment capture. It is envisaged that this will occur in both the dry detention basin, Dams 1 and 2, and the SWCD.
Reduce flood	This design will result in a reduction of	Flood impacts on downstream properties will

Environmental impact	Approved diversion works as per the Beca (2010) design	Proposed updated stormwater management strategy as per Engeny (2018a)
impacts on downstream residential properties	flood impacts on downstream properties for flood events up to the 10 year ARI. Flows originating from the upper catchments (steep escarpment slopes) would be diverted around the stockpile area, reducing the amount of flows within the stockpile area. It is predicted that flood impacts in the residential areas downstream of the site will decrease due to the diversion of flows through the proposed diversion channel.	be reduced during the 100 year ARI event. There will be a reduction in peak flood levels and flood extents as a result of the increased detention of overland flows in the eastern laydown area and the detention of water behind the upstream berm. Negligible impacts to downstream properties in the 5 year ARI event are predicted. Modelling confirmed there will be no impact on flood levels to the properties to the south of the SWCD.
Reduce coal washout onto Bellambi Lane and downstream residential area	Flows up to 10 year ARI would be treated via the proposed wet and dry sediment basins, which would reduce/eliminate the amount of coal washout towards Bellambi Lane as well as the residential areas downstream of the site.	The proposed flood management strategy (Engeny, 2018a) will reduce peak flows through the stockpile area during the 100 year event, even with 100% pipe blockage, primarily by the separation of clean water (i.e. additional conveyance to the pipeline by using the levee. The construction of debris control structures would significantly reduce the risk of 100% blockage. The modelled peak flow rates for the 20% blockage scenario with the 100 year ARI event predicted reduced flow rates by over 60%. Lower peak flows through the stockpile area will reduce associated erosion potential and sediment transport. Engeny (2018a) indicated that in all modelled flood events the volume of water flowing to Bellambi Lane from the stockpile and laydown areas will be reduced, resulting in an increase of runoff volumes flowing through the site water management controls (i.e. Dams 1 and 2 and the SWCD). The modelled reduction in peak flows and water levels down Bellambi Lane and across the Princes Highway will reduce hazard during flood events and improve access to properties in the area including the Russell Vale Colliery site during the 100 year ARI event.

6.0 Response to Submissions

6.1 Agency Submissions

The issues raised in the agency submissions are identified in the following sections in text boxes, with a response provided following each text box.

6.1.1 Department of Planning and Environment (DPE)

6.1.1.1 Impact of the proposed modification

No assessment of potential environmental impacts of the proposed works was included in the Cover Letter, Bellambi Gully Flood Study or the Bellambi Creek Diversion Pipeline Assessment. Please provide an assessment of potential impact and proposed mitigation measures if Modification 4 were to be approved.

The proposed works have been assessed in the previous environmental assessment that supported the Response to Planning Assessment Commission (PAC) Review Report, Part 1 (Hansen Bailey, 2015). Furthermore, the DPE Addendum Report prepared for the PAC included consideration of the 2015 Cardno Report and supported the revised Cardno design. WCC also supported the revised Cardno design. While the PAC has identified that further information is required in relation to other aspects of the UEP application, in its Second Review Report dated March 2016, the PAC made the following findings in relation to the Bellambi Creek Flood Management (Section 4.7):

> ***Commission's Considerations and Findings***
>
> *The Commission is satisfied that the issue raised in the First Review Report has been adequately addressed and supports, if the project were to be approved, the inclusion of a condition of consent that requires the implementation of flood mitigation measures recommended in the Cardno 2015 Report within 12 months of the date of approval. It also supports the draft recommended condition requiring the installation of a swale alongside the stockpile access road, which should improve water management on the site, though it is noted that the discharge of dirty water from the site is regulated by the EPA under the site's Environment Protection Licence.*

Given the fact that the Cardno (2015) design has been further refined based on update flood modelling post the exhibition period, an assessment of environmental impacts of the proposed updated revised flood management strategy (Engeny 2018a) in comparison to the currently approved design is provided in **Section 5.0**. Refer to **Table 5.2** for a comparison of environmental impacts associated with both flood control strategies.

6.1.2 Environmental Protection Authority (EPA)

6.1.2.1 Flooding

The EPA requests that DPE consider the following information and seek additional information from WCL in a number of areas, as you determine this modification:

- **Wollongong LGA suffered significant flooding in August 1998. During this event, the inlet to the Bellambi Gully diversion at Russell Vale Colliery was blocked by debris washed from upstream catchments, causing flood waters to flow through the Russell Vale Colliery stockpile area, washing a significant volume of ROM coal downstream into properties along Bellambi Lane.**
- **The Cardno flood study modelled three scenarios to asses flooding risk to the site being: pipeline completely blocked; pipeline 20% blocked; and pipeline fully operational during a 100 year ARI event. The modelling indicates significant site flooding at Russell Vale colliery in all three scenarios.**
- **The proposed alternate flood mitigation measures to management flood risk on site are designed to reduce clean runoff entering the stockpile area, while conveying site runoff in a controlled way to Bellambi Creek. Mitigation measures include debris control structures, new swales, appropriate maintenance, and installation of new culverts.**

The August 1998 flooding event was one of the major historical East Coast Lows (ECL) when rainfall totals over a four day period (6 to 9 August) were more than 300 mm at many locations in the Metropolitan and Illawarra districts (BOM, 2007).

This event is over represented in local living memory because of how traumatic it was. The event was so extreme there was one fatality locally and three in the Sydney metropolitan region the week before from a persistent ECL. The entire Wollongong area was flooded and access in and out of the area was cut off, not just the WCL mine. WCL mine was one of many suffering damage due to this extreme ECL weather event.

The extreme rainfall resulted in major erosion and landslips along the Illawarra Escarpment above the Russell Vale Colliery. This affected the headwaters of Bellambi Gully Creek that carried stormwater and debris for a period of time until it silted up and consequently over topped the bank at the M3 culvert located adjacent the pit top area concrete apron. The stormwater and associated debris then travelled down to the ROM stockpile at the time, which subsequently was made unstable and fluidised to the point of a large amount of material being washed down Bellambi Lane.

Since this time a regular inspection and maintenance program has been in place to ensure that blockages are removed from the site drainage system. Currently there is no ROM stock pile and the approval to recover the Russell Vale Emplacement Area (RVEA) material would further de-risk the site of stored material.

In addition, WCL have recently commissioned Engeny to review and update the onsite Stormwater Management Plan to further improve the capacity and management of the stormwater management system.

The updated proposed flood management strategy (**Section 5.3**) by Engeny (2018a) would reduce flooding risks in such a manner that there would be negligible impacts on downstream properties and Bellambi Gully. Engeny (2018a) concluded that the updated proposed flood management measures detailed in **Section 5.3.3** and illustrated on **Figure 5.1** reduce hazard during flood events and improve access to properties in the area including the Russell Vale Colliery site during the 100 year ARI event. Flow regimes within the site, associated with better clean and dirty water separation, as well as construction of the dry detention basin and better conveyance of flows to the Stormwater Control Dam, would result in improvements in water quality leaving the site during flood events (Engeny, 2018a).

WCL produces an Annual Environmental Monitoring Report and Annual Returns to the EPA. WCL is committed to continuous improvement of environmental performance and reporting.

6.1.2.2 Maintenance

- **In recent years, the EPA has investigated many environmental incidents at Russell Vale Colliery. A summary of EPA regulation is provided in Attachment 1. The root cause of many of these incidents has been poor maintenance and management by WCL of their stormwater and pollution control devices.**

WCL have implemented a system of regular maintenance and monitoring of all storm water systems to improve water management at the site. Furthermore, WCL performs post rain event inspections for greater than 10 mm rain events on all sites.

Refer to **Section 7.0** for further description of the proposed ongoing monitoring programme that will be implemented to determine any visual structural degradation of the stormwater pipe and to inspect the pipe following major storm events (e.g. greater than 50 mm of rainfall in 24 hours).

6.1.2.3 PRP 8 - Stormwater Turbidity Reduction Program

- **On 13 March 2017, EPA issued WCL a S58 Notice adding '*Pollution Reduction Program 8 (PRP 8) Stormwater Turbidity Reduction Program*' to Environmental Protection Licence 12040 – Wollongong Coal Limited Russell Vale Colliery. The catalyst for this PRP was a number of environmental incidents at Russell Vale Colliery.**
- **The aim of PRP 8 was to reduce the level and occurrence of grey/brown coloured water that is discharged from the premises during and after high volume rainfall events. PRP 8 required WCL arrange for inspections of Bellambi Gully Diversion Pipeline to determine condition of the pipe network and the maintenance required to prevent ingress of turbid water into Bellambi Creek Diversion Pipeline. PRP 8 also required the development of a monitoring program. PRP 8 was not intended to assess or determine the longer-term stability of the Bellambi Creek Diversion pipeline or its suitability for use as a component of the Cardno Flood Study works.**
- **WCL provided two reports to EPA on 29 December 2017 to satisfy PRP 8. The reports were: 'Russell Vale Emplacement Area Pipeline Assessment – Engeny Water Management December 2017 (N1800_001)' and 'Bellambi Creek Diversion Pipeline Assessment – Engeny Water Management December 2017 (N1800_001)'. Note Attachment 2.**
- **Engeny recommend remediation works and timeframes for repair for the full list of defects in the Bellambi Creek Diversion Pipeline. The EPA proposes to progress this program of works under EPL 12040.**

On 13 March 2017, the Environment Protection Authority (EPA) added Pollution Reduction Program 8 (PRP 8) to EPL 12040 as discharge of turbid stormwater from the site had been observed during and after high volume rainfall events. It was determined that the discharge of turbid groundwater occurred due to groundwater ingress from fractures and degraded connections into the Bellambi Gully clean stormwater diversion pipe. In brief, PRP 8 required inspection of the Bellambi Gully diversion pipe to determine the condition of the pipe network and the maintenance required to prevent ingress of turbid water. A remote closed circuit television (CCTV) inspection of the Bellambi Gully diversion pipe identified a number of areas where there is the potential for ingress of turbid water.

Engeny Water Management (Engeny) was engaged to investigate the condition of the pipeline and to determine the maintenance required to prevent ingress of turbid water. To this end, Engeny recommended a program of maintenance and repair works to reduce the turbid water ingress (**Appendix B**). This program was developed using a risk based analysis.

WCL has subsequently undertaken a series of repair works to address all defects having a *moderate* to *critical* pollution risk. All turbid water ingress points have been remediated. The 2017 Bellambi Gully Diversion Pipeline Assessment report has been updated to take account of the repair works and to update the risk assessment based on post-repair inspections (see **Appendix B**). The updated risk assessment identified that the remaining defects have a *low* to *very low* pollution risk and are unlikely to require remediation works in the next year. Consistent with the recommendations of the previous report, an ongoing monitoring program is to be implemented to regularly inspect the defects to determine the efficacy of the remediation works and any worsening of the *low* and *very low* ranked risk defects.

WCL completed the PRP 8 studies in October 2018 and are presently in the planning stage to implement pre-treatment of dirty water using flocculent block at the inlet to Dam 1 to aid settling of solids prior to overflowing into Dam 2.

WCL are also presently planning to transfer water collected in the LDP3 sump to the Highway Dam as the lower discharge will allow the pump to discharge at a higher flow rate. As outlined above, water from the Highway Dam is transferred back to the SWCD. The Highway Dam Pump has a much higher capacity than the LDP3 sump submersible pump.

6.1.2.4 Long term stability of the Bellambi Gully Diversion pipeline

- **The Engeny report has identified defects in the Bellambi Creek Diversion Pipeline; however it does not make any assessment of longer-term stability or durability of the Bellambi Creek Diversion Pipeline.**
- **DPE should seek confirmation the Bellambi Creek Diversion Pipeline is adequate to meet the performance requirements in the 2015 Cardno report, both under the current Care and Maintenance regime and under active cola mining if this were to recommence.**
- **The Umwelt letter specifically states the Engeny report does not conclude that the pipeline is 'inadequate' to meet the performance requirements in the 2015 Cardno Report, not does it state the pipeline is 'adequate' to meet the performance requirements in the 2015 Cardno Report.**
- **In response to previous incidents, WCL have reported to EPA that damage to the Bellambi Gully Diversion Pipeline is likely due to the weight of coal stockpiles placed over the pipeline, and the use of heavy earth moving equipment used to build and reclaim the coal stockpiles. The Engeny report also identifies deformations in the Bellambi Creek Diversion Pipeline that may have been caused by vertical loadings. Any future use of the area above the Bellambi Creek Diversion Pipeline for coal stockpiling could further compromise Bellambi Creek Pipeline integrity based on the Engeny 2017 report.**

As described in **Section 4.1.2**, the *Bellambi Gully Diversion Pipeline Review* (Engeny, 2018b) was commissioned to report on the existing condition of the pipeline and provide an analysis of structural loading. This report is subsequent to the Engeny 2017 pipeline review report referred to by the EPA and provides responses to the issues raised by the EPA.

During 2018 WCL have undertaken a series of repair works to address all defects having a *moderate* to *critical* pollution risk. All turbid water ingress points have been remediated. The 2017 Bellambi Gully Diversion Pipeline Assessment report has been updated to take account of the repair works and to update the risk assessment based on post-repair inspections (see **Appendix B**). The updated risk assessment identified that the remaining defects have a *low* to *very low* pollution risk and are unlikely to require remediation works in the next year. Consistent with the recommendations of the previous report, an ongoing monitoring program is to be implemented to regularly inspect the defects to determine the efficacy of the remediation works and any worsening of the *low* and *very low* ranked risk defects. Based on the supplied WCL risk assessment, the remediation works undertaken to the pipeline are believed to have been successful.

The report concluded that in order to reduce external loading of the pipeline to a level consistent with or lower than the previous loading, the proposed stockpile footprint would need to be reduced. To aid in management of the height of the stockpile over the pipeline, it is recommended that WCL clearly delineate the maximum extents of the stockpile. It is also recommended that no heavy vehicle loads should be permitted in areas susceptible to heavy vehicle loads (i.e. CH 120 to 660) without further detail investigations into the structural condition of the pipe and depth of cover. A 5 m offset from the centreline from the pipe for heavy vehicles is proposed. Dedicated crossings of the pipeline will be considered and will consist of additional fill placed over the pipeline, or other structural solutions to spread the surface load through the soil profile.

Annual video surveillance/inspections of the pipeline will be implemented to determine any visual structural degradation. Additionally, inspection of the pipeline following major storm events (greater than 50 mm of rainfall in 24 hours) will be conducted.

6.1.2.5 Existing mining operation

- **The future of Russell Vale Colliery is uncertain. If mining operations were to cease, a Mining Operations Plan (MOP) Closure would be prepared, describing rehabilitation works to support Mine lease surrender and security deposit return. The NSW Resources Regulator opinion on the acceptability of an underground pipeline compared to a surface diversion channel to achieve future site rehabilitation standards are important considerations in the determination of MOD 4 and EPA requests NSW Resources Regulator opinion be obtained prior to DPE determining MOD 4.**

Russell Vale is valuable asset which is currently planning expansion and has a schedule towards achieving approval to recommence production.

WCL currently has an application in with the DPE to expand the mining operations at the Russell Vale Colliery; referred to as the Underground Expansion Project (UEP). This application is ongoing and anticipated to be further progressed in early 2019.

The Mining Operations Plan (MOP) will be reviewed and updated as part of the UEP. NSW Resources regulator has commented and is expecting a Section 124 application to recommence operation with a minimal subsidence mining methodology in the Russell Vale Colliery.

The need for removal of the pipeline, along with all other site buildings, structures and infrastructure will be considered as part of the detailed mine closure planning process for the site upon completion of mining activities at the Russell Vale Colliery. This assessment will have regard for the post-mining land uses to be approved for the site following closure.

6.1.3 Office of Environment and Heritage (OEH)

6.1.3.1 Flooding

Overall we raise no major objection to the proposal, however do make recommendations for appropriate assessment and management of water related impacts.

FLOOD RISK MANAGEMENT AND WATER QUALITY ADVICE

As the site is subject to flooding, we suggest that DPE be satisfied that the following matters have been adequately addressed with relation to floodplain risk management:

- **The impact of flooding and stream erosion from the proposed works (up to and including the PMF)**
- **The impact of the proposed works on flood behaviour including any management measures to mitigate adverse flood impacts**

As described in **Section 5.3**, the Engeny (2018a) modelling results showed that the updated proposed flood management measures would reduce flooding for downstream properties and down Bellambi Gully. In addition, the modelling indicated that the updated proposed flood management measures would reduce hazard during flood events and improve access to properties in the area including the Russell Vale Colliery site during the 100 year ARI event. The modelling also indicated that the changes to flow regimes within the site, associated with better clean and dirty water separation, as well as construction of the dry detention basin and better conveyance of flows to the Stormwater Control Dam, should result in improvements in water quality leaving the site during flood events.

6.1.3.2 Impacts on downstream properties

- **Downstream impacts (flood risk and water quality) from the mobilization of maters and sediments due to run-off from the sit**
- **The impact of flooding on the safety of people/users for the full range of floods including issues linked with isolation and accessibility for emergency service**

The Engeny (2018a) modelling results showed that the changes to flow regimes within the site, associated with better clean and dirty water separation, as well as construction of the dry detention basin and better conveyance of flows to the SWCD, will result in improvements in water quality leaving the site during flood events, in addition to reduced flood impacts to downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully (refer to **Section 5.3**). An assessment of impacts to downstream properties is provided in **Table 5.2.**

6.1.3.3 Climate Change

- **The implications of climate change (particularly increased rainfall intensity) on flooding**

The potential impacts of climate change on flood behaviour have been assessed by Engeny (2018a) in the *Bellambi Gully Flood Assessment* by modelling the 200 year and 500 year ARI events as substitutions for climate change. The modelling results showed that in general the flood behaviour remains unchanged between the 200 year and 500 year ARI events. Flood extents are typically similar for the two events with minor differences (refer to Figure 6.1 of **Appendix C**).

6.1.3.4 Relevant Planning policies

- **The development control plans and policies of Wollongong City Council in relation the management of flood risks**
- **Utilisation of best available flood information held by Wollongong City Council for the area including but not limited to council's Collins Creek Floodplain Risk Management Study and Plan (2014) and the Review of Collins Creek Flood Study (ongoing)**
- **Blockage conditions applied were in accordance with council's DCP (2009), which has since been superseded with a revised blockage policy**
- **Relevant local flood related development controls and best available flood information held by council be incorporated into the assessment**

Best available flood information held by WCC

Engeny (2018a) reported that there is an existing flood study for the catchment area held by Council, which is the *Combined Catchments of Whartons, Collins and Farrahars Creeks, Bellambi Gully and Bellambi Lake Flood Study*, 2010, Lyall & Associates Consulting Water Engineers. This is Council's approved flood study (Engeny 2018a). Engeny further noted that data from this study was used and referenced in the flood assessment. Engeny met with Council to discuss the study who confirmed that this was the latest flood modelling data relevant for the catchment area.

WCC's updated blockage policy

The blockage assumptions utilised in Engeny (2018a) are consistent with the Cardno (2015) study which was accepted by WCC as appropriate (refer to DPE Addendum Report, 2015). It is noted that the WCC Blockage Policy is outlined in the Wollongong Development Control Plan (DCP) dated 2009 (i.e. prior to the Cardno 2015 study).

During 2016 a review of the WCC blockage policy proposed a series of changes to the blockage factors to be used for future flood assessments. Subsequently an implementation plan for the use of changed blockage factors for flood assessments was submitted for approval at an Ordinary Meeting of WCC on 30 May 2016. WCC accepted the implementation plan, which included an action to amend the Wollongong DCP 2009, Wollongong LEP 2009, Wollongong LEP 1990 and Wollongong LEP No.38 (1984) as required, to make these documents consistent with the revised blockage policy.

To date the DCP (2009) has not been revised to include the revised blockage policy.

Engeny (2018a) advised that discussions were held with the relevant floodplain manager officer at WCC in July 2018 and it was understood that no changes have been made to WCC flood blockage policy relevant to this study since the Cardno (2015) study.

Engeny (2018a) assessed blockage scenarios in accordance with the methodology put forward in the Bellambi Gully Flood Study (Cardno, 2015) as was accepted by both OEH and WCC at the time. This approach was considered reasonable for Mod 4 as these blockage scenarios are considered appropriate for the site (i.e. this policy adopts design level blockage of 100% (more conservative) than the revised draft blockage policy for box culvert and pipe openings less than 6m).

6.1.3.5 Hydraulic modelling

From the information available to us, it is unclear whether these issues have been addressed in their entirety. We also note that there were significant flood and water quality impacts from the site in the August 1998 event. Specifically, the following are noted for consideration:

- **Hydraulic modelling is limited to the downstream extent of the site**
- **Flow routing leading to this point is not clear (noting extensive surface works/potential diversions upstream). Inter-catchment flow diversions into other catchments has the potential to adversely impact downstream communities and as such catchment diversions created by the mine need to be identified and managed**
- **The report notes that detailed survey has not been undertaken for the site, and that designs are preliminary on this basis**
- **The assessment was completed over 3 years ago, with the potential for site conditions to have since changed in a way which impacts flooding outcomes**

The hydraulic modelling inputs have been updated and re-run by Engeny (2018a) in the *Bellambi Gully Flood Assessment* taking account of the above considerations. Refer to Section 5 of the 2018 Engeny report (**Appendix C**) for the modelling methodology and approach.

- **The report notes that a 6m clear span box culvert is proposed, however the 'Proposed Flood Mitigation' plan indicates this to be (2x) 1200W x 1200H box culverts**

Cardno (2015) proposed an upgrade of road drainage along Bellambi Lane, including the installation of a 6 m span culvert to convey site runoff across the access road. The updated modelling prediction from the 2018 Engeny flood assessment indicated that these measures are not required, as the flows down Bellambi Lane do not typically flow into the dirty water systems and the inclusion of the 6 m box culvert would increase flood impacts at the Princes Highway.

The updated flood management measures proposed by Engeny (2018a) therefore does not include the 6 m box culvert, as discussed in **Section 5.3**.

6.1.3.6 Surface Water

The report confirms that the scope is limited to assessment of flood mitigation measures only, and that water quality measures proposed in the Beca 2009 report should be further investigated to confirm suitability. With consideration of the above, it is recommended that:

- **Detailed survey be undertaken, and modelling updated to reflect current site conditions**

In the updated flood assessment prepared by Engeny (2018a) a NSW Government LiDAR survey of the site dated April 2013, pipeline survey (as used by Cardno) and 2017 site supplied survey information was used in the analysis, as well as recent aerial photographs.

- **Flow paths upstream of the hydraulic modelling extent be confirmed through simulation of a direct rainfall model for the catchment**

The upper catchment areas, steep slopes and dense vegetation were modelled in a hydrology model prepared by Engeny (2018a) (see Figure 1.1 of **Appendix C**).

Engeny further noted that the breakup of the catchments within the hydrology modelled was informed by LiDAR data, site inspections and the Beca (2010) assessment.

The hydrology model was used to provide inflows into the hydraulic model. A two dimensional hydraulic model was used, which extended to consider areas where multiple flow paths could occur.

- **Off-site flood impacts including those associated with any flow diversions be assessed and strategies to off-set these impacts be identified and incorporated into any future approval**

As described in **Sections 5.3 and 5.4**, the Engeny (2018a) modelling results indicated that the updated proposed flood management measures (**Figure 5.1**) will produce no adverse impacts off-site (refer to **Section 5.3** and **Table 5.2**).

- **Mitigation measures be reviewed with consideration of updated survey, modelling and blockage assumptions**

The Engeny (2018a) flood modelling was based on updated survey data as referenced in earlier sections of this report. The blockage assumptions utilised are consistent with the Cardno (2015) study which was accepted by WCC as appropriate (refer to DPE Addendum Report, 2015). Engeny resolved that no changes have been made to WCC's flood blockage policies since the Cardno (2015) study as discussed with Jason Cooper at WCC in July 2018.

- **The report scope to be extended to include consideration of the water quality measures proposed in the Beca 2009 report. There is a clear strategy to manage downstream flood and water quality impacts from the site.**

The Engeny (2018a) modelling indicated that clean water and dirty water separation and management will be improved with the proposed flood measures. The reduction of flows of upslope clean water through the dirty water management system and provision of additional settling areas and flow management controls will assist in reducing dirty water discharges from the site and improvement to downstream water quality during flood events.

Given the nature of the site and associated potential to discharge highly polluted surface runoff into downstream receiving waters, it is recommended that previous water quality approaches such as that provided in the Beca 2009 report be thoroughly reviewed in the conjunction with the flood assessment. Further advice should be sought from the EPA with regard to the management of point source impacts on water quality and its management. It is recommended that proposed water quality measures be reviewed in conjunction with flood and stormwater and with consideration to current and future site conditions. It may also be prudent for DPE to consult with Wollongong City Council regarding flood and stormwater related issues.

Comment is noted. Responses relating to issues raised in this comment have been provided in earlier responses to OEH comments in **Section 6.1.3**.

6.1.4 OEH – Heritage Division

6.1.4.1 Heritage

It is considered that no changes relate to any heritage conditions and the management of heritage will be undertaken in an appropriate manner during the projects lifetime. Accordingly, the Heritage Division has no further comments in relation to this project at this time.

It is noted that the OEH – Heritage Division has no comments regarding this application.

6.1.5 Department of Industry, Lands and Water Division

6.1.5.1 Crown Land

A Land status investigation on Russell Vale Colliery - Modification 4 (MP 10_0046 MOD 4) shows that there is no Crown land. Therefore, Department of Industry - Lands has no comment at this stage.

It is noted that the Department of Industry – Lands has no comment regarding this application.

6.1.6 Division Resources and Geoscience (DRaG)

6.1.6.1 Rehabilitation

The Division, in conjunction with the Resources Regulator, advise the consent authority that the environmental assessment requirements for rehabilitation and resources have been adequately addressed in the Environmental Assessment (EA) for Project, dated 23 February 2018.

This comment is noted.

The Division has determined that sustainable rehabilitation outcomes can be achieved as a result of the Project and that any identified risks or opportunities can be effectively regulated through the conditions of mining authorities issued under the *Mining Act 1992*.

This comment is noted.

The Resources Regulator requests that consent authority notify the proponent of the following general terms of approval associated with the granting of a mining lease pursuant to the Mining Act 1992:

- **Any disturbance resulting from the activities carried out under the mining lease will need to be rehabilitated to the satisfaction of the Minister.**
- **The lease holder must apply to the Minister for approval to amend the current Care and Maintenance Mining Operations Plan (MOP) to reflect the “alternate mitigation measures identified through Bellambi Gully Flood Study undertaken by Cardno, 2015 and the works schedule identified in the Bellambi Creek Diversion Pipeline Assessment undertaken by Engeny, 2017”.**

- **The lease holder should amend or update the 2015 Rehabilitation Management Plan to address the "short, medium and long term" rehabilitation of the Bellambi Gully Diversion Pipeline and Bellambi Gully Floodplain Management at the Mine site.**

The Mine Operating Plan (MOP) / Rehabilitation Management Plan (RMP) details the site rehabilitation requirements and obligations and will be updated to reflect any approved changes and works associated with the proposed stormwater management measures. It is also noted that the modification would not result in additional disturbance.

- **The lease holder will be required to provide and maintain a security deposit to secure funding for the fulfilment of obligations of all and any kind under the mining lease, including obligations of any kind under the mining lease that may arise in the future.**

WCL currently has a security deposit held by the DPE. On 18 September 2018 the DPE notified WCL that the Assessed Deposit for the fulfilment of rehabilitation obligations under CCL 745, ML1575 and MPL271 in relation to Russell Vale Colliery has been determined at **$7,662,000**.

- **Both the Division and Resources Regulator request a review of the draft development consent conditions prior to finalisation and any granting of development consent.**

This comment is noted.

6.1.7 RMS

6.1.7.1 Traffic and Transport

RMS has completed an assessment of the development, based on the information provided and does not believe the proposed modification will have a significant impact on the State Road Network. On this basis, RMS does not object to the development application subject to any technical implications regarding subsidence being referred to the Wollongong Coal RMS Longwall Mining Technical Committee.

This comment is noted.

6.1.8 Department of Primary Industries – Lands and Water

6.1.8.1 Annual audits

The proponent should be required to undertake and report on annual audits of the condition and maintenance of water conveyance infrastructure associated with the site and to undertake event based (ie heavy rainfall/high flow) monitoring and assessment of the movement of clean and dirty water to identify any inadequacies requiring further attention and demonstrate that the maintenance and upgrade works are achieving required outcomes.

WCL has an environmental compliance system in place and is currently performing post rain event inspections for greater than 10mm rain events on all sites. As a subsequent part of the Stormwater review, sediment and erosion control plans have been updated and in accordance with the Managing urban stormwater: soils and construction - Volume 1, 4th Edition (the Blue Book) (Landcom, 2004). The separation of clean and dirty water is a core principal of the Blue Book.

Annual video surveillance inspections of the pipeline would be implemented to determine any visual structural degradation. Additionally, inspection of the pipeline following major storm events (greater than 50 mm of rainfall in 24 hours) would be conducted.

6.1.8.2 Water

Works within waterfront land should be undertaken in accordance with the Guidelines for Controlled Activities on Waterfront Land (2012).

Noted.

Works should be designed and constructed so as not to increase flow velocities impacting the highway crossing culvert or increase backwater impinging on the mine disturbance area.

As noted earlier, Engeny (2018a) concluded that the proposed updated water management strategy will have negligible impacts on downstream properties and the Bellambi Gully creek. The modelling predicted that the updated proposed management measures will reduce hazard during flood events and improve access to properties in the area including the Russell Vale Colliery site during the 100 year ARI event.

6.1.9 WaterNSW

6.1.9.1 Water

WaterNSW has reviewed the Environmental Assessment and does not have any specific comments on the modification proposal as the proposed works are located outside the Sydney drinking water catchment. Nevertheless, WaterNSW has an interest in the Russell Vale Colliery and the broader operations of Wollongong Coal Limited as its mining operations are located beneath the declared Sydney catchment area and as such it would be appreciated if further modifications or assessments be referred to WaterNSW.

It is noted that WaterNSW does not have comments relating to this application and wish to remain informed with regard to further applications relating to Russell Vale Colliery.

6.2 Community and Other Stakeholder Submissions

As outlined in **Section 3.0**, a total of 30 individual community submissions and three interest group submissions were received relating to the proposed EA. A response to the issues raised in these submissions is included in the following sections grouped by theme.

A number of the community and interest group submissions received were similar or had consistent themes. Where this is the case, the theme of the concern has been provided in bold in the text boxes below with some examples of specific quotes from the submissions provided in normal type to assist the reader. Specific issues, that is, where an issue was raised only once have also been addressed.

As described in **Section 4.1**, revised flood modelling and revised storm water system designs have been undertaken since submission of the EA, by Engeny (2018a) to address storm water and flooding issues and water quality issues. The additional Engeny work has also been peer reviewed. Further details of responses to these specific issues are provided in the following sub-sections.

6.2.1 Pollution of Bellambi Gully Creek

Issues relating to surface water were raised in all 30 individual community submissions and all three interest group submissions.

6.2.1.1 Community

'*I live close to the mine, and have seen firsthand the impacts of the coal mine polluting Bellambi Creek*.'

'*The proposal will not prevent the coal pollution of Bellambi Creek. Bellambi Creek has been polluted numerous times since WCL has been operating Russell Vale Colliery. Every one of those pollution events could have been avoided if Bellambi Creek was realigned. However, WCL's documents say that under their proposed option Bellambi Creek will still not be protected from further pollution events. The creek will continue to flow through a deteriorating concrete culvert that runs directly under the colliery stockpile and working area, risking ongoing contamination of the creek*.'

'*Bellambi Creek has been polluted so many times by WCL since they have been operating Russel Vale Colliery*.'

'*Pollution from the mine has continued unabated for far too long. The proposal will not prevent the coal pollution of Bellambi Creek*.'

'*The proposed Option does not protect Bellambi Creek from pollution. This is made clear by Wollongong Coal's consultant documentation. The best Option to save the creek from pollution is to realign the creek as per the Preliminary Works Project condition. The Wollongong Coal option does not take into consideration the latest version of the Underground Expansion Projects drastically reduced colliery footprint. The creek could be realigned in a more favourable location. One that could almost follow the original line. This would facilitate a better outcome when the mine is closed down and rehabilitated*.'

'*Bellambi Creek has a diverse riparian zone which hosts a variety of native flora and fauna, including water dragons and native turtles. Furthermore, Bellambi Creek leads to the wetlands and ocean at Bellambi beach. The proposed modification is not a better solution for Bellambi Creek; it is just a cheaper solution. The creek will continue to flow through an aged and deteriorated concrete culvert under the colliery stockpile and working area, risking ongoing contamination of the creek. The impecunious status of the proponent should not compromise the ecosystems downstream of the colliery*.'

'*While Bellambi Creek runs directly under the mine's coal stockpile & working area the surrounding properties are at risk. There are shocking pictures showing graphic evidence of pollution during heavy rain events in Bellambi Ck since 2011 these pollution events would have been avoided if WCL had abided by its license conditions & completed the Creek realignment*.'

'*While most of the environmental impact opinions regarding the application address significant issues, including flooding impacts, there are limited 'big-picture' views. That is, specific issues have been isolated from the total landscape or topography between the Wollongong Coal Ltd. mine and the Bellambi Creek outflow at Bellambi Beach, a distance of about 3kms.(the two markers). The main issue regarding this application is how Bellambi Creek looks now between these two markers from above (see attached Google Earth map). Whilst any improvements to limiting coal pollution wash from the mine site are welcome, flood mitigation must occur along the full length between the two markers. Downstream flood mitigation is equally as important as upstream (mine) flood mitigation. This is only indirectly assessed in the environmental and other reports*.'

6.2.1.2 Action groups

Wilderness Society Illawarra

'*The proposal will not prevent the coal pollution of Bellambi Creek - Bellambi Creek has been polluted numerous times since WCL has been operating Russell Vale Colliery. Every one of those pollution events could have been avoided if Bellambi Creek was realigned. However, WCL's documents say that under their proposed option Bellambi Creek will still not be protected from further pollution events. The creek will continue to flow through a deteriorating concrete culvert that runs directly under the colliery stockpile and working area, risking ongoing contamination of the creek*.'

Lock the Gate Alliance

'*As the Department would be well aware, Russell Vale colliery has been causing pollution in Bellambi Creek for years*.'

'*The diversion of the creek was a crucial condition of the Preliminary Works approval. Surface water contamination of the creek was a key issue raised by the public when the Preliminary Works approval was assessed*.'

'*Indeed, the mine caused another pollution incident in Bellambi Creek in November 2016 - just a month after the order was issued by the Department of Planning*.'

6.2.1.3 Response

Flooding impacts and potential coal washout to downstream properties and into Bellambi Gully have been investigated by Engeny (2018a) (**Appendix C**). Engeny (2018a) concluded that the proposed updated water management strategy shown in **Figure 5.1** (refer to **Section 7.0**) will result in improved flooding impacts to downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully and will result in improvements to water quality as a result of flooding (**Appendix C**). The outcomes of the revised study are summarised in **Section 5.3**.

6.2.2 Impact on downstream users

Issues relating to impacts on downstream users were raised in 17 individual community submissions and all three interest group submissions.

6.2.2.1 Community

Flooding risks to downstream users putting properties and lives in dangers

'*WCL's failure to carry out the works has placed residents downstream in danger - In 1998 a storm event occurred that blocked the opening to the Bellambi Creek culvert at the Russell Vale mine. The resulting overtopping caused flooding of properties downstream and carried large quantities of coal off site. The realignment of Bellambi Creak was meant to protect residents from a similar accident. Through failing to carry out the flood mitigation works, WCL and the Department have placed lives and property in danger*.'

'*They should have completed the re-alignment of Bellambi Creek in 2012 (6 years ago). This realignment was to protect properties from flooding and inundation of water borne coal.*'

'*DoPE must surely be aware of the danger that this places residents in who live downstream. Can any of you imagine what it must be like living with this ticking time bomb?*'

'*I feel very deeply about this for many reasons but one of the main reasons is that a friend of mine died in the 1998 flooding in Bellambi. WCL has done nothing to protect residents from a similar accident*.'

'*This realignment condition was placed on the 2011 approval to protect downstream properties from flooding and inundation with water borne coal. It was also intended to address the ongoing pollution of Bellambi Creek by the Colliery.*'

'*Protect the downstream community from flooding*.'

'*The continued operation of this mine & the ongoing existence & placement of the coal stockpile, places untenable risks on the surrounding communities, coastline & marine environment. It is imperative for community wellbeing & environmental protection that the conditions of this mining license are enforced & I request the Dept of Planning & Environment to reject this proposal*.'

6.2.2.2 Action groups

Wilderness Society Illawarra

'WCL's failure to carry out the works has placed residents downstream in danger - In 1998 a storm event occurred that blocked the opening to the Bellambi Creek culvert at the Russell Vale mine. The resulting overtopping caused flooding of properties downstream and carried large quantities of coal off site. The realignment of Bellambi Creek was meant to protect residents from a similar accident. Through failing to carry out the flood mitigation works, WCL and the Department have placed lives and property in danger.'

Lock the Gate Alliance

'The NSW Government has failed to uphold the law and protect the public interest in allowing this situation to continue despite numerous incidents.'

Georges River Environmental Alliance

'A flood event of 1998 demonstrated the need for creek re-alignment on the basis of human safety. Approval of the non-alignment is not acceptable as it puts human and property assets at risk. An approval would make the approval agent both responsible for such unacceptable risks and negligent.'

6.2.2.3 Response

The purpose of Mod 4 is to achieve improved flood impact outcomes. Revised flood studies by Engeny (2018a) and the development of revised flood water mitigation measures have been developed by independent specialists in accordance with the appropriate government guidelines and standards. The revised studies have also been peer reviewed. The revised flood water mitigation measures will result in improved flooding impacts to downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully and will result in improvements to water quality as a result of flooding (**Appendix C**). The outcomes of the revised study are summarised in **Section 5.3**.

6.2.3 Non-compliance

Concerns about previous and current non-compliance at the site were raised in 26 individual community submissions and all three interest group submissions.

6.2.3.1 Community

History of non-compliance

'*I note the long history that Wollongong Coal has in not meeting its obligations to planning authorities, and not paying moneys owed to both the NSW Government or Wollongong Council.'*

'*The realignment, to protect nearby properties from flooding and inundation with water borne coal, was a condition of the colliery's 2011 approval. It is now more than 5 years overdue. The proponent mined and sold the coal under the approval, but failed to meet the conditions of this coal extraction*.'

'*Why was this allowed to happen? Under WCL's original 2011-approved project, they were required by DoPE to undertake the Bellambi Creek realignment based on BECA 2010 designs in 2012. How is it that when WCL decided that they were not going to do this, that they were still allowed to continue to mine? And furthermore, how is it that WCL was even able to continue to gain subsequent modification approvals by DoPE? I note that the NSW DoPI 2011 Project Approval Statement of Commitments required that: All erosion, sediment control and runoff diversion measures will be established before any excavation begins. These will be left in place throughout the works execution and beyond works completion until all surfaces have been full restored and stabilised, and the required timing of this commitment was that it be done During construction. Where does this allow for what has actually happened?*'

'The realignment of Bellambi Creek is now nearly 6 years overdue and should have been completed in a timely manner.'

Failure to enforce compliance

'*Department of Planning and Environment (DoPE) failed to monitor and enforce WCL's meeting of its conditions of operation, making a farce of the planning and approval process Moving the goal posts now, by changing the condition more than 5 years after it was due to be met, makes a farce of the Department's approval process. It sets a risky precedent and erodes community trust in the Department's governance of extractive industries.*'

'*I am calling on the Department to reject this proposal and become more serious about monitoring and enforcing compliance with mining development approvals*.'

'*This company, after all this time, wants to change the agreement to suit themselves rather than make sure that the surrounding community is kept safe. This certainly makes DoPE look like it either does not care about the agreement or has no power to enforce it - how can the community have confidence in such a department?'*

'*Changing the requirement now because it has not been complied with is unacceptable. It does not inspire confidence in the Department of Planning's ability to monitor and enforce compliance. The Department must recognise the community's concerns about the risks of mining, particularly so close to a residential area. Companies cannot be allowed to flout their obligations on the basis of their financial situation.'*

6.2.3.2 Action groups

Wilderness Society Illawarra

'The proponent mined and sold the coal under the approval, but failed to meet the conditions of this coal extraction.'

'Department of Planning and Environment (DoPE) failed to monitor and enforce WCL's meeting of its conditions of operation - Moving the goal posts now, by changing the condition more than 5 years after it was due to be met, makes a farce of the Department's approval process. It sets a risky precedent and erodes community trust in the Department's governance of extractive industries.'

'The Wilderness Society Illawarra calls on the Department to reject this proposal and become more serious about monitoring and enforcing compliance with mining development approvals.'

Lock the Gate Alliance

'We object to this modification in the strongest terms and would take this opportunity to express our profound disappointment that instead of taking appropriate action against Wollongong Coal for failing to meet this condition of consent since it was granted in 2011, the Department of Planning has now accepted and exhibited for public comment a modification to remove the condition instead.'

'The EPA fined the company in July 2016 for discharging coal fines in to Bellambi Gully in December 2015. Around 70 tonnes of coal fines entered Bellambi Creek, washing material from the coal stockpile into an unsealed access portal into a Bellambi Creek diversion pipe - which the company had failed to replace as per the conditions of its consent.'

'In October 2016, the Department of Planning fined Wollongong Coal for failing to undertake the Bellambi Creek diversion, and issued an order that the underground pipe section of Bellambi Gully Creek be replaced in accordance with the Environmental Assessment and Statement of Commitments in the Preliminary Works Project approval by no later than 18 months from the date of the order - 16 June this year. That action has clearly not been taken by the proponent, which admits in its assessment material that it began discussion with the Department about this modification within two months of the order being issued. The assessment material says, "A meeting was held with DPE on 5 December 2016 with a further teleconference held on 7 March 2017 to discuss the proposed modification and the approval pathway".'

'Why did the Department not uphold the order it had issued that the work be done? Why did it instead begin discussions with the company for a modification to the consent to relieve the company of the condition? This amounts to a scandalous disregard for the environment and the public.'

Georges River Environmental Alliance

'There has been a failure of this proponent to meet past conditions of consent, as Bellami Ck was to be re-aligned in 2012 and this has not occurred. As a consequence further pollution to the creek has occurred and will continue to occur in the future should this be approved and that is not acceptable.'

6.2.3.3 Response

As discussed in previous sections, the realignment of the Bellambi Gully diversion pipe was never implemented due to the fact that the information presented in the Environmental Assessment (EA) for the PWP required further detail investigation prior to confirming and completing final design. Subsequently, WCL had also committed to preparing a detailed flood mitigation study to assess the flood risks and determine the most appropriate flood mitigation option for the surface infrastructure and stockpile areas at the pit-top site.

Further flood assessments were undertaken by Cardno in 2015 and Engeny in 2018, aimed to investigate alternative mitigation measures that would reduce flooding impacts downstream of the site, particularly those associated with the impact of coal stockpile washouts on downstream properties as a result of flooding.

Engeny (2018a) concluded that the proposed updated water management strategy (in **Section 5.3**) would reduce flooding risks for downstream properties and the Bellambi Gully. The modelling predicted that the updated proposed management measures will reduce hazard during flood events and improve access to properties in the area including the Russell Vale Colliery site during the 100 year ARI event. Modelling results showed that the changes to flow regimes within the site, associated with better clean and dirty water separation, as well as construction of the dry detention basin and better conveyance of flows to the SWCD, should result in improvements in water quality leaving the site during flood events.

In light of the above, it is concluded that the proposed updated stormwater management strategy (Engeny 2018a) would have the following additional advantages:

- It is more effective at preventing coal washouts to Bellambi Lane and will allow flows to be contained within the stockpile area for all storms up to a 1 in 100 year event;
- This design will not require any additional land disturbance or vegetation clearance of existing undisturbed areas, whereas the realignment of Bellambi Gully would occur in currently undisturbed areas; and
- It is more cost effective.

6.2.4 Proponent not fit

Concerns regarding the ability of the proponent to operate the site were raised in 16 individual community submissions and all three interest group submissions.

6.2.4.1 Community

Financial capacity of the Proponent

'Insufficient capital should not be the basis of a mining company changing a condition of approval - WCL has cited shortage of capital as the principal reason for the proposed change.'

'This is not a better plan for Bellambi Creek; it is just a cheaper plan. Approval of this plan condones the playing of the Major Projects planning system by financially compromised proponents at the expense of communities and the environment.'

'In the event of the mine's financial collapse (which seems imminent to me) or of a mining disaster, Wollongong City Council and therefore residents may be liable for most expensive remediation. In the event that they finally paid the money owing, which I think is highly unlikely, it would most likely not be enough to cover the costs to rehabilitate this heavily contaminated site.'

'WCL have put forward this modification because it would be cheaper for them. If they are unable to afford the original agreement then it is obvious that they would not be in any situation to pay and repair the damage that could be done if such flooding occurs again.'

'In recent times the Russell Vale mine has been burdened with proponents that are financially compromised, making mining operations at this sensitive site problematic. This constricted mine site is surrounded by dense residential suburbs on three sides, located on an environmentally sensitive escarpment and mines under the vital Sydney Water Catchment area.

This financially stressed company is struggling to pay its rents and levies to the NSW Government and Russell Vale Emplacement Area bond to Wollongong City Council. Both the Government Resources Regulator and Wollongong City Council are pursuing Wollongong Coal in court. Wollongong Coal has taken the coal under the Preliminary Works Project and its Modifications but now they cannot meet their financial obligation to realign Bellambi Creek.

The community has been told repeatedly that there is a financial upside to approvals for WCL. The $8m realignment was a condition and commitment imposed on WCL for the extraction and sale of coal under the Preliminary Works Project and is owed to the people of NSW. If the money is not used now for the realignment of the creek now, then it should go into trust for the rehabilitation of the creek when the mine is closed.

Wollongong Coal is struggling financially and is only operating because they are propped up by their parent company in India, Jindal Steel and Power.'

WCL were found guilty by the NSW Local Court in 2017 for the late payment of rental fees and administrative levies (Administrative Fees) due under the Mining Act 1992. In June 2018 the Secretary of the Department of Planning and Environment accepted an enforceable undertaking proffered by WCL and its subsidiary Wongawilli Coal Pty Ltd by which WCL has undertaken a full review of its systems that led to the late payment of these Administrative Fees. WCL has also committed to the prepayment of Administrative Fees through to 2022 at least 12 months in advance of them falling due. Under the terms of the enforceable undertaking, a bank guarantee has also been provided to secure the undertakings. A number of the financial commitments in the undertaking have fallen due since the undertaking was agreed and all relevant commitments (including the prepayment of Administrative Fees due in 2019) have been satisfied.

Proponent is not considered fit to operate the site

'WCL has been under investigation by the Resources Regulator (previously DRE) since 2015 over whether it is a fit and proper entity to hold a mining license.'

'The excuse that the proponent cannot find the capital to do the work is more of a reason for non-approval as it demonstrates they are not fit and proper.'

6.2.4.2 Action groups

Wilderness Society Illawarra

'Insufficient capital should not be the basis of a mining company changing a condition of approval - WCL has cited shortage of capital as the principal reason for the proposed change. WCL has been under investigation by the Resources Regulator since 2015 over whether it is a fit and proper entity to hold a mining license. Not only has WCL failed to meet the Bellambi Creek flood mitigation works condition of approval by the due date in 2012, the company has a history of non-compliance with approval conditions. This is not a better plan for Bellambi Creek; it is just a cheaper plan. Approval of this plan condones the playing of the Major Projects planning system by financially compromised proponents at the expense of communities and the environment. The Wilderness Society Illawarra calls on the Department to reject this proposal and become more serious about monitoring and enforcing compliance with mining development approvals.'

Lock the Gate Alliance

'In our view, the owner of Russell Vale mine has demonstrated that it is financially incapable of operating the facility in a manner that ensures the safety of the environment and its own the workforce. This constricted mine site is surrounded by dense residential suburbs on three sides, located on an environmentally sensitive escarpment and mines under the vital Sydney Water Catchment area. The company is currently being investigated by the Resources Regulator as to whether it is fit and proper to hold a mining title in New South Wales. It is currently the subject of legal action by the Resources Regulator and Wollongong City Council. The Department of Planning must refuse this modification application and immediately ensure that the Bellambi Creek diversion is completed.'

'This terrible state of affairs highlights the folly of granting mining approvals or allowing the purchase and transfer of mining titles to companies that are not fit and proper to operate in New South Wales. The local community is gravely concerned about the fate of Bellambi Creek given the financial situation of the proponent and the limited $9 million rehabilitation bond held by the Government.'

Georges River Environmental Alliance

'The excuse that the proponent cannot find the capital to do the work, is more of a reason for non-approval as it demonstrates they are not fit and proper.'

6.2.4.3 Response

WCL is well supported by its ultimate majority shareholder, Jindal Steel & Power Ltd., a steel and energy company based in India. With turnover of approx. US$ 3.3 billion, JSPL is a part of about US$18 billion diversified Jindal Group conglomerate. JSPL is a leading player in steel, power, mining, oil and gas and infrastructure in India. Jindal Group remains supportive of WCL and its operations on ongoing basis.

It is acknowledged that previously the management of stormwater issues on the site has required improvement. WCL have completed substantial work during 2018 to improve their compliance programme. As described in earlier sections of this report, additional investigations were undertaken after exhibition to address concerns raised by a number of government agencies and the community. WCL have also implemented a system of regular maintenance and monitoring of all storm water systems to improve water management at the site. Furthermore, WCL performs post rain event inspections for greater than 10mm rain events on all sites.

As described in **Section 6.1.2.3**, WCL completed the PRP 8 studies in October 2018 and are presently in the planning stage to implement pre-treatment of dirty water using flocculent block at the inlet to Dam 1 to aid settling of solids prior to overflowing into Dam 2.

The proposed updated stormwater management system (Engeny 2018a) would reduce flooding risks to downstream residential properties, the Princess Highway, Bellambi Lane and the Bellambi Gully creek and include various methods to improve water quality leaving the site during flood events. Further, the result of lower peak flows through the stockpile area will reduce associated erosion potential and sediment transport. Additional containment/retention of flows within the water management system during flood events will allow for additional sediment capture.

Refer to **Section 7.0** for further description of the proposed ongoing monitoring programme that will be implemented to determine any visual structural degradation of the stormwater pipe and to inspect the pipe following major storm events (greater than 50 mm of rainfall in 24 hours).

6.2.5 Application Process

Concern regarding the relevance of approval path was raised in two individual community submissions.

6.2.5.1 Community

'The application is out of time and cannot therefore be considered. This is because of Schedule 2 of the Environmental Planning and Assessment (Savings, Transitional and Other Provisions) Regulation 2017. Schedule 2 is the former Schedule 6A to the Act. (The umwelt correspondence dated 23 February 2018 incorrectly refers to Schedule 6A as part of the approval path-see 2.0 at page 2 of that correspondence).

Schedule 2 relevantly provides as follows: 'SCHEDULE 2 – TRANSFERRED TRANSITIONAL ARRANGEMENTS ON REPEAL OF PART 3A--FORMER SCHEDULE 6A TO THE ACT 1 DEFINITIONS AND APPLICATION 3BA WINDING-UP OF TRANSITIONAL PART 3A MODIFICATION PROVISIONS ON CUT-OFF DATE OF 1 MARCH 2018 AND OTHER PROVISIONS RELATING TO MODIFICATIONS …..

The modification application cut-off date is the 1 March 2018. That is, the application must be lodged 'before' the cut-off date. This application was lodged on the 2 March 2018. My interpretation of the date is consistent with other EA Exhibitions on the Department's website.

6.2.5.2 Response

The modification application Mod 4 has been transitioned by the DPE to Part 4 and is currently being considered under Section 4.55(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

6.2.6 Department to commission own studies

One community submission raised the question regarding the Department commissioning independent studies.

6.2.6.1 Community

'Is it possible for DoPE to instigate its own investigations, into the most effective way to manage Bellambi Gully runoff, pollution management and flood mitigation and then contract an independent investigations and the costs of all resulting works should be covered by WCL who should no longer have any say in how these matters are handled. WCL has had ample opportunity to behave as a responsible corporate citizen and has failed to do so. Why should anyone trust WCL to do the right thing now?'

6.2.6.2 Response

Revised flood studies and revised flood water mitigation measures have been developed by specialists in accordance with the appropriate government guidelines and standards. The revised studies have also been peer reviewed. Flooding impacts downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully have been investigated by Engeny (2018a) including water quality issues (**Appendix C**). The outcomes of this study are summarised in **Section 5.3**.

6.2.7 Dangerous planning precedent

Issues regarding setting a dangerous planning precedent were raised in two community submission.

6.2.7.1 Community

> *'Department of Planning and Environment are prepared to assist Wollongong Coal in `pencil whipping' away an approval condition. If they are prepared to accommodate Wollongong Coal in this situation for purely financial reasons where will it end?'*
>
> *'Undermines the authority of the DoPE. Allowing the change would also undermine the authority of the DoPE, as companies could presume that they can override DoPE decisions simply by holding off on doing what they've been required to do.'*
>
> *'Undermines the DoPE process. Moving the goal posts now, by changing the condition many years after it was due to be met, makes a mockery of the Department's approval process.'*

6.2.7.2 Response

The purpose of Mod 4 is to achieve improved flood impact outcomes. Revised flood studies by Engeny (2018a) and the development of revised flood water mitigation measures have been developed by specialists in accordance with the appropriate government guidelines and standards. The revised studies have also been peer reviewed. The revised flood water mitigation measures will result in improved flooding impacts to downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully and will result in improvements to water quality as a result of flooding (**Appendix C**). The outcomes of the revised study are summarised in **Section 5.3**.

6.2.8 Eroding community trust

Issues regarding community trust were raised in two community submission.

6.2.8.1 Community

> *'Erodes public trust in processes. For all the reasons outlined above, allowing the change would erode public trust in the processes currently in place. Moreover, if something goes wrong as a result of a modification to the condition there is likely to be significant public backlash.'*
>
> *'How can a situation like this occur? The Department of Planning and Environment has a procedural system for mining approvals, are required to comply with. How can the community believe and trust in the system again. How can we believe and trust in Department of Planning and Environment and Wollongong Coal again.'*
>
> *'Another Part 3A Modification: In 2011, the NSW Government repealed Part 3A of the Environmental Planning and Assessment Act and yet Department of Planning and Environment are still accepting modifications under this Part 3A and extending the life of approvals.'*

6.2.8.2 Response

The purpose of Mod 4 is to achieve improved flood impact outcomes. Revised flood studies by Engeny (2018a) and the development of revised flood water mitigation measures have been developed by specialists in accordance with the appropriate government guidelines and standards. The revised studies have also been peer reviewed. The revised flood water mitigation measures will result in improved flooding impacts to downstream properties, the Princes Highway, Bellambi Lane and Bellambi Gully and will result in improvements to water quality as a result of flooding (**Appendix C**). The outcomes of the revised study are summarised in **Section 5.3**.

7.0 Management, Monitoring, and Contingency Measures

The following monitoring, management and contingency measures are integral to the proposal of retaining the Bellambi Gully diversion pipe as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek.

These measures will be incorporated in the Surface Facilities Water Management Plan for Russell Vale Colliery. This will include trigger action response plans (TARPs) for each aspect of the monitoring, management and contingency measures outlined below.

7.1 Revised Stormwater Management Measures

The following updated stormwater management measures proposed by Engeny (2018) will be implemented:

- **Separation of clean and dirty water systems:**
  - Construction of upstream levee to detain and divert upslope catchment runoff through the Bellambi Gully Diversion Pipeline.
  - Construct self-cleaning debris control structures at the inlets to both the 1800 mm and 600 mm pipes.
- **Control of flows through dirty water areas:**
  - Regrade eastern laydown area to form a dry detention basin. This basin will enable management of runoff within the laydown areas and minimise spills to Bellambi Lane. The basin would have an effective capacity in the order of 2.1 ML. The detailed design of the dry detention basin should consider the refinements made to the design of the Cardno dry detention basin (refer to **Section 5.3.2.2**).
  - Construct channel from laydown area to SWCD to manage and divert flows in excess of the capacity of Dam 1 and Dam 2 and the new dry detention basin in the laydown area to the SWCD.
- **Maintenance**
  - The above structures and existing controls will be included on regular maintenance schedules.

7.2 Management Measures

7.2.1 Stockpile heights

The proposed stockpile extents (as part of the UEP) will be managed to ensure a maximum stockpile height of 7 m above the Bellambi Gully Diversion Pipeline. Therefore, the maximum stockpile height will not exceed the historical surveyed stockpile height.

To aid in management of the height of the stockpile over the pipeline, WCL will clearly delineate the maximum extents of the stockpile as part of the UEP.

7.2.2 Heavy vehicle routes

In areas where the depth of cover is less than 2.5 to 3.0 m above the pipe obvert (i.e. Ch 120 to 660) no heavy vehicle loads will be permitted in these areas (i.e. Ch 120 to 660) without further detail investigations into the structural condition of the pipe and depth of cover and any necessary additional structural mitigation measures required prior to heavy vehicle crossing these sections of road. As part of the UEP a truck haulage route is proposed to cross the Bellambi Gully Diversion Pipeline. If this route is operational prior to pipeline replacement works occurring, a series of load bearing/distributing crossings will be designed and constructed to minimise increased loading to the Bellambi Gully Diversion Pipeline. The proposed crossings will be designed and constructed prior to the truck haulage route being utilised for Ch 120 to 660.

Offset areas of 5 m from the centreline of the pipe either side with dedicated crossings for heavy vehicles are proposed. The concept designs for crossings will be finalised as part of the UEP.

7.2.3 Progressive replacement of pipeline

WCL will implement a program of works to replace the downstream reaches (i.e. Ch 120 to 660) of the Bellambi Gully Diversion Pipeline.

The replacement program will consist of the following stages:

- Detailed design of pipeline sections (0 to 6 months), including:
    - pipe class, trenching and bedding requirements;
    - soil and water management during construction; and
    - staging plans.
- Pipeline replacement construction program (6 to 18 months) to be conducted in segments timed to occur in forecast dry weather periods.

7.3 Ongoing Monitoring Program

A monitoring program of the Bellambi Gully Diversion Pipeline will be implemented at the Russell Vale Colliery site. The purpose of the ongoing monitoring program is to ascertain the efficiency of remediation works undertaken to date and to identify any worsening of non-remediated defects.

A yearly CCTV inspection program will be implemented to determine any visual structural degradation or potential leakage points.

In addition, photographic inspections will be undertaken following remediation works to the pipeline and after major storm events (e.g. greater than 50 mm of rainfall in 24 hours).

The post remediation photographic inspection will include:

- Inspection of the remediation works on defective areas identified as having a risk category of Moderate – Critical. The inspection should ascertain that the remediation has been successful and that there are no indications of further groundwater ingress from the defect.
- Inspection of defects assessed as having a Very Low to Low risk category. The inspection should note if any worsening of the defect is observed to allow for reassessment of the defect's risk category.
- Identification and inspection of any additional defects found along the pipeline length.

The post major storm event photographic inspection will include:

- Inspection of the remediation works and identification of any degradation.
- Identification and inspection of any additional defects found along the pipeline length.

The photographic monitoring records will be prepared to allow correlation and comparison to the yearly CCTV inspection records.

Any changes to either effectiveness of remediation works or identification of worsening of defects or new defects identified in the yearly CCTV, post remediation or post major storm event inspections will reviewed based on their risk and repaired/remediated if required. The risk assessment will consider both turbid water ingress and structural failure components.

Repair/remediation works and/or monitoring will be undertaken on defect/remediation that is identified during the inspections as follows:

- High risk will be repaired within 1 month.
- Medium risk within 3 months.
- Low risk identified for future monitoring.

WCL will review the yearly CCTV inspections as well as photographic inspection records and document in the Annual Review the following:

- Summary of inspections undertaken.
- Identification of incidents or failures of all previous remediation works and necessary/adopted corrective actions.
- Any worsening of defective areas that have not been remediated, relative to previous pipeline inspections.

7.4 Contingency Measures

In case of unforeseen failure or imminent repairs being required prior to the replacement program being complete, WCL will hold suitable sections of pipeline and equipment ready on-site (or within 1 hour delivery time) to enable emergency repairs to be carried out when wet weather is forecast.

8.0 References

BECA, 2010. *Gujarat NRE Stormwater Hydrology Review*, edited for Part 3A submission. Prepared for Gujarat NRE.

BECA, 2010. *Water Management Report No.1 Colliery, Russell Vale*. Prepared for Gujarat NRE.

Bureau of Meteorology (BOM), 2007. *About East Coast Lows*. Accessed on 13 June 2018 at http://www.bom.gov.au/nsw/sevwx/facts/ecl.shtml.

Cardno, 2015a. *Bellambi Gully Flood Study* – Report Reference NA82014089, Version 06. Prepared for Wollongong Coal Limited.

Cardno, 2015b. *Russell Vale Colliery – Bellambi Gully Flooding Approach*.

Engeny Water Management (Engeny), 2017. *Bellambi Creek Diversion Pipeline Assessment*– Report Reference N1800_001*.* Prepared for Wollongong Coal Limited.

Engeny Water Management, 2018a. *Bellambi Gully Flood Assessment, Russell Vale Colliery* – Report Reference N1800_006. Prepared for Wollongong Coal Limited.

Engeny Water Management, 2018b. *Bellambi Gully Diversion Pipeline Review – Report Reference N1800_004.* Prepared for Wollongong Coal Limited.

Hansen Bailey, 2015. *Russell Vale Colliery Response to Planning Assessment Commission Review Report Part 1*. Prepared for Wollongong Coal Limited.

Landcom, 2004. *Managing urban stormwater: soils and construction* - Volume 1, 4th Edition. ISBN 0-9752030-3-7.

NSW Department of Planning and Environment (DPE), 2015. *Addendum Report: Major Project Assessment Russell Vale Colliery Underground Expansion Project (MP 09_0013)*.

NSW Department of Planning and Environment (DPE) Resources and Energy, 2018. *Wollongong and Wongawilli Coal enforceable undertaking accepted*. Accessed on 4 July 2018 at https://www.resourcesandenergy.nsw.gov.au/about-us/news/2018/wollongong-and-wongawilli-coal-enforceable-undertaking-accepted.

NSW Department of Planning and Environment (DPE), 2018. Russell Vale Colliery (MP 10_0046 MOD 4) Modification 4, p.2.

NSW Department of Planning and Environment (DPE) Resources and Geoscience, 2018. *Enforceable undertakings*. Accessed on 4 July 2018 at https://www.resourcesandgeoscience.nsw.gov.au/regulation/compliance-and-enforcement/enforceable/enforceable-undertakings

NSW Planning Assessment Commission (PAC), 2016. *Russell Vale Colliery Underground Expansion Project Second Review Report*.

APPENDIX A

DPE Correspondence

NSW GOVERNMENT | Planning & Environment

Planning Services
Resource Assessments & Compliance
Contact: Jack Murphy
Phone: 8217 2016
Email: jack.murphy@planning.nsw.gov.au

Mr Eladio Perez
Environment and Approvals Manager
Wollongong Coal Ltd
PO Box 281
FAIRY MEADOW NSW 2519

Dear Mr Perez

Russell Vale Colliery (MP 10_0046 MOD 4)
Modification 4

The public exhibition of the Environmental Assessment (EA) for Modification 4 concluded on Friday 30 March 2018.

The Secretary requests that you prepare and submit a report detailing your responses to the issues raised in submissions, at your earliest convenience. The submissions can be viewed on the Department's website www.majorprojects.planning.nsw.gov.au.

In addition, the Department has identified several areas where further assessment or additional information is required (see **Attachment A**).

Please note that the Department expects further submissions in relation to the proposal. The Department will make these submissions available to you as soon as possible.

If you wish to discuss this matter, please contact Jack Murphy on 8217 2016.

Yours sincerely,

Howard C Reed

Howard Reed 3.4.18
Director
Resource Assessments

Attachment A

1. Impact of the proposed modification

The Department notes that no assessment of potential environmental impacts of the proposed works were included in the Cover Letter, Bellambi Gully Flood Study or the Bellambi Creek Diversion Pipeline Assessment. Please provide an assessment of potential impacts and proposed mitigation measures if Modification 4 were to be approved.

APPENDIX B

Bellambi Gully Diversion Pipeline Assessment Reports (Engeny, 2018)

WOLLONGONG COAL LTD

Russell Vale Colliery

Bellambi Gully Diversion Pipeline Review




December 2018

N1800_004

www.engeny.com.au
P: 02 4926 1225
Suite 5, Level 1, 19 Bolton Street Newcastle 2300 | PO Box 787 Newcastle 2300

DISCLAIMER

This report has been prepared on behalf of and for the exclusive use of WOLLONGONG COAL LTD and is subject to and issued in accordance with WOLLONGONG COAL LTD instruction to Engeny Water Management (Engeny). The content of this report was based on previous information and studies supplied by WOLLONGONG COAL LTD.

Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party. Copying this report without the permission of WOLLONGONG COAL LTD or Engeny is not permitted.

N1800_004 BELLAMBI PIPE LOADING					
N:\Projects\N1800 Wollongong Coal\N1800_004 RV Bellambi Pipe Loading\07 Deliv\Docs\Report\Revs\REP-003-BellambiPipe\N1800_004-REP-003-1-Bellambi Pipeline.docx					
REV	**DESCRIPTION**	**AUTHOR**	**REVIEWER**	**APPROVED BY**	**DATE**
Rev 0	Client Issue	Tim Evans	Susan Shield	Susan Shield	14 December 2018
Rev 1	Client Issue	Tim Evans	Susan Shield	Susan Shield	20 December 2018
Signatures					

CONTENTS

Appendices

List of Tables

List of Figures

1. INTRODUCTION

1.1 Background

Wollongong Coal Limited (WCL) operates the Russell Vale Colliery (formerly the NRE No.1 Colliery) in the Southern Coalfields of New South Wales (NSW). The Russell Vale Colliery operates under Project Approval (10_0046) granted by the Planning Assessment Commission (PAC) on 13 October 2011. Three Modifications have been made to the Project Approval: MOD1 December 2012; MOD2 November 2014; and MOD3 October 2014.

The Russell Vale Colliery (the Site) is located on the lower slopes and foothills of the Illawarra escarpment, in the catchment areas of Bellambi Gully and Hicks Creek. Hicks Creek is a tributary of Bellambi Gully. Bellambi Gully flows into the Pacific Ocean approximately 3 km east of the site.

The Bellambi Gully Pipeline is a clean water diversion pipe that conveys upslope runoff from the Bellambi Gully catchment area under the coal stockpile at the Russell Vale Colliery pit top to the creek line downstream.

WCL was issued with a Pollution Reduction Program (PRP) (PRP 8) on their Environment Protection Licence (EPL) (EPL 12040) for the Russell Vale Colliery site. The PRP stemmed from the observance of turbid stormwater, with a grey/brown colour, that is discharged from the premises during and after high volume rainfall events.

PRP 8 – Stormwater Turbidity Reduction Program – Part 1 – Stormwater Pipelines identified that discharge of turbid groundwater has occurred due to groundwater ingress from fractures and degraded connections in to the Bellambi Gully clean stormwater diversion pipe.

The PRP stipulates that the licensee (WCL), must arrange for inspections of the Bellambi Gully Diversion Pipe to determine the condition of the pipe network and the maintenance required to prevent ingress of turbid water. A remote closed-circuit television (CCTV) inspection of the pipeline was conducted by Interflow on 13/20 June 2017.

Subsequent to the PRP the Department of Planning and Environment (DPE) raised concerns regarding the structural capacity of the pipeline.

1.2 Scope of Work

Engeny was engaged to undertaken two study components, as follows:

- Review of Risk of Turbid Water Ingress:
  - Collate and review background information.
  - Prepare a report detailing:
    - The work carried out as part of the pipeline inspection program.
    - Identification of works required to minimise ingress of water.
    - A suggested timeframe for rectification based on a risk analysis for the defects.
    - Order of magnitude cost estimate for the repair works.
    - Outline monitoring that can be used to assess the effectiveness of the works.
  - Provide an updated report considering the remediation/repair works that had been undertaken on the pipeline.

- Pipe loading and capacity review:
  - Collate and review background information. Including; historic and current survey, pipeline alignment and invert levels, plant used on site and Interflow CCTV inspection of the Bellambi Pipeline.
  - Undertake a loading analysis to determine historic maximum loadings exhibited on the pipeline.
  - Undertake a loading analysis for the worst case loading scenario to equate this to the historic loads and infer what maximum loadings and operating methodology could be used in future in proximity to the pipeline.
  - Prepare a report detailing:
    - The pipe loading analysis undertaken.
    - Recommendations for stockpiling operating methodology in proximity to the pipeline to limit overloading.
    - Identification of potential further works to determine the structural properties of the pipeline should greater accuracy for the assessment be required to reduce the risk of future damage to the pipeline.

1.3 Information Sources

The following information was used for the purpose of this review:

- Interflow pipeline inspection report and inspection plan:
  - 20170613 - DN1800.pdf.
  - Bellambi Gully Diversion Inspection from MHB to MHA.pdf.
  - Bellambi Gully Diversion Inspection from MHB to MHC.pdf.

- EPL 12040.

- LiDAR data dated April 2014 obtained from NSW spatial services.

- Contour data for the site dated March 2017.
- Inspection notes provided by WCL dated 19/10/17 (refer to Appendix A).
- Bellambi Gully Flood Study Report, January 2015, Cardno.
- Bellambi pipeline clean water system shape file/GIS data.
- Potential stockpile height.pdf received from WCL 13 August 2018 – depicting a maximum stockpile height of 22 m.

2. BELLAMBI GULLY PIPELINE HISTORY AND CONTEXT

The Bellambi Gully Diversion pipeline is an 1800 mm diameter concrete pipe of approximately 608 metres long. Some sections of the pipe have a concrete base constructed in them, other sections are lined with corrugated pipe.

This pipe was installed during a major reorganisation of colliery undertaken between October 1960 – 17th January 1962. Consequently, the pipeline is between 56 to 58 years old.

The first 100 m of the pipeline was initially installed to prevent coal from washing into the creek from the stockpile. In 1977 an additional 200 m was installed due to the stockpile area being extended. In the mid 1980's the pipeline was further extended to the current alignment.

By 1987 deterioration of the pipeline was noted. Consequently, in the late 1980's the pipeline was repaired and reinforced in sections by lining the pipeline with corrugated steel. A grout layer was injected behind the corrugated steel approximately 50-70 mm thick to provide additional structural strength.

2.1 Pipeline Inspection and Previous Work

Interflow conducted a remote CCTV inspection of the Bellambi Gully Diversion Pipeline on 16 and 20 June 2017. In total of 62 defects were recorded.

In December 2017, Engeny provided a report *"Bellambi Gully Diversion Pipeline Assessment"* to categorise the defects as recorded by interflow using a risk-based assessment with respect to water ingress into the diversion. Based on the risk analysis of the defects, the report suggested actions and timeframes to rectify the defects as well as to introduce a monitoring and maintenance program. It is noted that the above works were focussed on reducing pollution and turbid groundwater ingress to the clean water diversion as opposed to a structural loading assessment.

2.2 Vehicles and Machinery used at the Russell Vale Colliery Pit Top

Details of the machines and plant proposed to be used on site (as advised by WCL), their respective operating weights and bearing pressures are listed below in Table 2.1.

The initial assessment considered use of a D11 Dozer (Engeny, 2017). The subsequent loading review was revised to consider a D8 Dozer as the largest bulldozer to be used on the stockpile (refer to Table 2.1).

Table 2.1 Russell Vale Vehicle Loadings

Vehicle	Configuration	Operating Weight (kg)	Ground Contact Area (m^2)	Surface Pressure (kPa)
D11 Dozer (previously proposed – no longer likely)	Tracked	104,236	6.30	162.3
D8 Dozer (proposed)	Tracked	37,003	3.60	101.0
988B Wheel Loader	Wheeled	43,365	1.77	240.3
972H Wheel Loader	Wheeled	25,395	1.07	232.1
345B Excavator	Tracked	43,000	4.84	87.2

Sourced from www.ritchiespecs.com

In the initial assessment (Engeny, 2017), despite the lower bearing pressure than the 988B wheel loader, the worst case loading was found to be the D11 dozer tracking over the pipeline parallel to the direction of the pipe. This is due to the fact that a tracked vehicle exhibits a strip loading over a length of the pipeline as opposed to a point load in the case of a wheeled vehicle. The strip loading only dissipates downwards in two dimensions through the soil profile as opposed to four with the point load.

However, in the updated assessment, when comparing the tracked D8 dozer and the 988B wheel loader, this effect is cancelled out by the surface pressure of the 988B. Both vehicles were analysed for all depths throughout the assessment, but the wheel loader was found to exhibit the worst-case loading scenario on the pipeline. The expected loadings on the pipeline are discussed further in Section 4.2.

3. TURBID WATER INGRESS ASSESSMENT

3.1 Overview

PRP 8 on EPL 12040 stipulates that the licensee (WCL), must arrange for inspections of the Bellambi Gully Diversion Pipe to determine the condition of the pipe network and the maintenance required to prevent ingress of turbid water. A remote closed-circuit television (CCTV) inspection of the pipeline was conducted by Interflow on 13/20 June 2017.

Engeny prepared a report in December 2017 which reviewed the pipeline inspection work and suggested a program of maintenance/repair/inspection works to reduce the turbid water ingress. The program was developed using a risk-based analysis.

WCL has subsequently undertaken a series of repair works on the pipeline. WCL has provided photographs showing the typical works and also provided an updated analysis of the risk assessment based on the post-repair inspections (refer to Appendix A).

This turbid water ingress assessment provides an update to the December 2017 report and considers the WCL repair works and updated risk assessment.

3.2 Risk Assessment

A risk matrix was developed for the December 2017 assessment to categorise the pipe defects according to their pollution risk. Each identified pipe defect was assessed according to the probability that it would allow turbid groundwater inflows into the clean water system, as well as the estimated consequence/severity of the pollution scenario.

A risk profile for each defect was applied using the risk matrix. The risk profile, ranging from Very Low to Critical, was then used to inform the timeframes for the required rectification and pipe maintenance.

The risk matrix developed for the pipeline assessment is presented in Table 3.1. The descriptions of the pollution consequence and likelihood categories are presented in Table 3.2 and Table 3.3 respectively. While the suggested actions and associated timeframes for each risk category are presented in Table 3.4.

Table 3.1 Risk Matrix

		Almost certain	Likely	Moderate Likelihood	Unlikely	Rare
CONSEQUENCES	5	Critical	Critical	High	High	Moderate
	4	Critical	High	High	Moderate	Low
	3	High	High	Moderate	Low	Low
	2	High	Moderate	Low	Low	Very Low
	1	Moderate	Low	Low	Very Low	Very Low

Table 3.2 Pollution Consequence Category Description

Consequence category	Description
5	Extreme damage to pipe, total failure. Large volume of turbid water discharged off site.
4	Major damage to pipe, large volume of turbid water discharged off site.
3	Moderate damage to pipe, small to medium volume of turbid water discharged off site. Or obstruction with potential to back up pipe in large storm events to cause a small to medium volume of turbid water discharged off site.
2	Minor impact to pipe. Minor volumes of turbid water inflow into pipe.
1	Minor degradation to pipe, negligible impact on conveyance or containment. No inflow of turbid water.

Table 3.3 Pollution Likelihood Category Description

Likelihood	Description
Almost certain	Pollution is currently likely to be occurring, or will likely happen within a month.
Likely	Pollution is likely to happen within 6-12 months.
Moderate Likelihood	Pollution is likely within approximately 1-5 years without amelioration.
Unlikely	Pollution potential without amelioration within 5+ years.

Likelihood	Description
Rare	Pollution potential negligible.

Table 3.4 Suggested Actions and Timeframes by Risk Category

Risk Category	Timeframe and required actions.
Critical	Urgent remediation works required. Works to be implemented to reduce the risk exposure to an acceptable level (i.e. low or very low).
High	Remediation works required within 1 to 6 months. Works to be implemented to reduce the risk exposure to an acceptable level (i.e. low or very low).
Moderate	Monitor ongoing risk of pollution and deterioration of the pipe. Remediation works required within 6-12 months.
Low	Annual monitoring required. Remediation works likely to be required within 1 - 5 years.
Very Low	Annual monitoring required.

3.3 Risk Based Analysis of Defects

The following section outlines the defects that have been identified along the pipeline in the original detailed inspection by Interflow and the updated risk assessment of turbid water ingress, undertaken by WCL, based on the recent repair works. The full list of defects, repair works undertaken and the updated risk analysis, is presented in Appendix B.

Based on the updated risk ranking, all defects that were previously assessed as being *moderate* to *critical* have been addressed by WCL. The updated risk assessment has identified all defects as having a *low* to *very low* pollution risk, which are unlikely to require remediation works in the next year. Consistent with the recommendations of the previous report, an ongoing monitoring program is to be implemented to regularly inspect the defects to determine the efficacy of the remediation works and any worsening of the low and very low ranked risk defects. Refer to Section 3.2 for details.

3.3.1 Location Manhole B to Manhole A

The Bellambi Gully Diversion Pipeline extends approximately 167 m from Manhole B to Manhole A. The pipeline consists of 1800 mm diameter reinforced concrete pipe or corrugated metal pipe. A summary of the observations by chainage and their assessed risk profile is presented below in Figure 3.1.

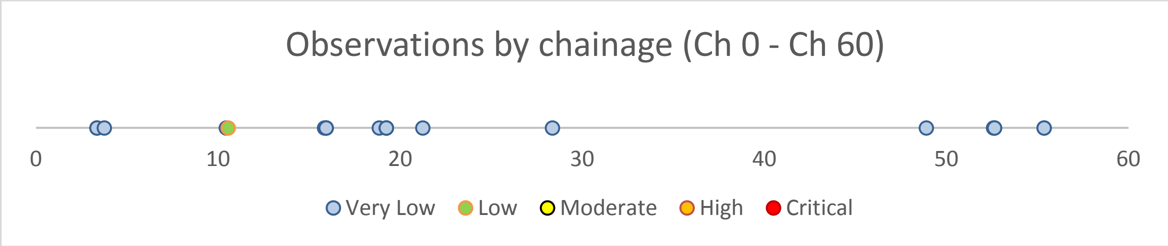


Figure 3.1 Identified Defects MH B to MH A

A total of 29 defects or observations were made on the Bellambi pipeline between Manhole B to Manhole A. Most of the defects occur between chainages 3 – 56 m, with an isolated observation of a wooden obstruction at Chainage 166.70 m. The risk ranking for the defects range from Very Low to Low.

The previous assessment identified structural damage to the pipeline at seven locations between chainages 3 – 16 m. This was indicated by exposed reinforcement and cracking. This suggests that the serviceability limit state for the pipeline has locally been exceeded, likely from an external surface loading. Of the seven structural defects, six were identified as having moderate risk or above. WCL indicated, based on visual assessment, that the majority of these defects are cosmetic only and do not pose a risk of structural pipe failure. Where repairs were undertaken, these involved removal of scale within the pipe and repair of joints using grout and clay.

Several external connections had previously been identified between chainage 16 – 22 m which were considered to pose a risk of directing turbid water directly in to the pipeline. All external connection defects have been remediated by WCL. Repairs involved removal of intruding connections and sealing penetrations with grout and clay. The risk of ingress from these defects is now considered very low.

Based on the supplied WCL risk assessment, the remediation works undertaken to the pipeline are believed to have been successful. All the defects from manhole A to B are now assessed as presenting a low and very low pollution risk to Bellambi Gully. Annual monitoring is required to continue to confirm the efficacy of the repairs. No further repair works are currently required to take place.

3.3.2 Location Manhole B to Manhole C

The Bellambi Gully Diversion Pipeline extends approximately 441 m from Manhole B to Manhole C. The pipeline consists of 1800 mm diameter reinforced concrete or corrugated iron. A summary of the observations by chainage and assessed risk profile by WCL is presented below in Figure 3.2 and Figure 3.3

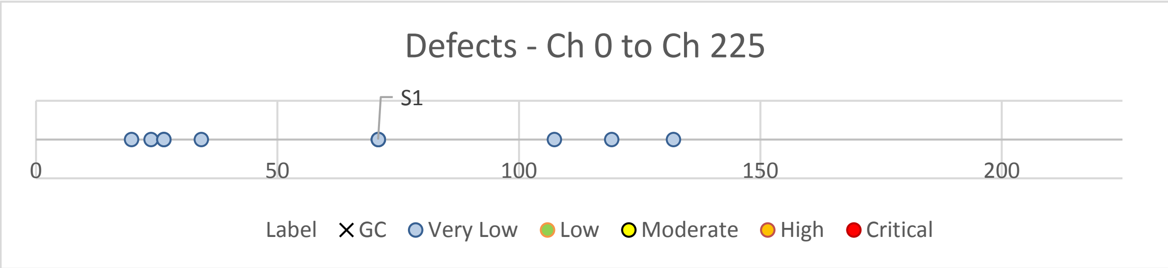


Figure 3.2 Identified Defects MH B to MHC, Part 1

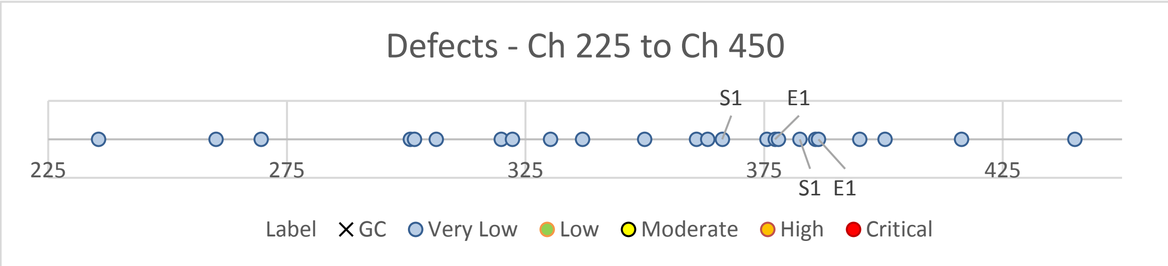


Figure 3.3 Identified Defects MH B to MHC, Part 2

A total of 47 defects or observations were made on the Bellambi Gully Diversion Pipeline between Manhole B to Manhole C. Previously, 21 of these defects were identified as having moderate risk or above. WCL has further assessed these defects and conducted repairs were necessary. The works undertaken included joint repairs using grout and clay. Following the recent repair works, all defects have been reassessed by WCL as presenting a very low risk of turbid water ingress. No further remediation works are currently required.

An unknown pit was identified at Chainage 306.27 m. Confirmation as to whether the pit is still required is needed to determine the potential for groundwater ingress at the pit. If the pit is not required, suggested remediation works include construction of a reinforced concrete plug, dowelled into RCP / Manhole.

4. PIPELINE LOADING ASSESSMENT

4.1 Overview

An initial pipe loading review for the Bellambi Gully Diversion Pipeline was undertaken by Engeny in May 2018 to assist WCL in managing potential risks associated with the structural integrity of the pipeline. The assessment was subsequently updated in September 2018 to account for changes in operating methodology for the proposed stockpile and plant to be used on site.

Limited data was available for both the original and revised assessment, as no construction drawings for the pipeline were available. Consequently, the loading assessment was based on:

- Historic stockpile heights, determined from LiDAR survey of the site dated April 2013 compared to 2017 survey information.
- Proposed stockpile height and shape as advised by WCL.
- Assumed live loads for the plant proposed to be used on site by WCL.

4.2 Loading Analysis

The historical loading applied to the Bellambi Gully Diversion Pipeline was estimated using the difference between the current and 2014 topographic survey information as well as the pipeline invert levels as described in the 2015 Cardno Bellambi Gully Flood Study report.

The proposed stockpile was modelled in 12d to match the *Proposed stockpile height.pdf* provided by WCL. The stockpile extents were modified to pull the batter away from the inlet to the Bellambi pipeline. Two revisions of the stockpile were modelled; RevA concentrated on avoiding impact to the Bellambi Gully inlet while maintaining the WCL extents, while RevB sought to avoid impact to the inlet as well as reduce the overall fill height above the pipeline to the historical stockpile height. Plan views of the modelled stockpiles above the pipeline are shown below in Figure 4.1 and Figure 4.2.

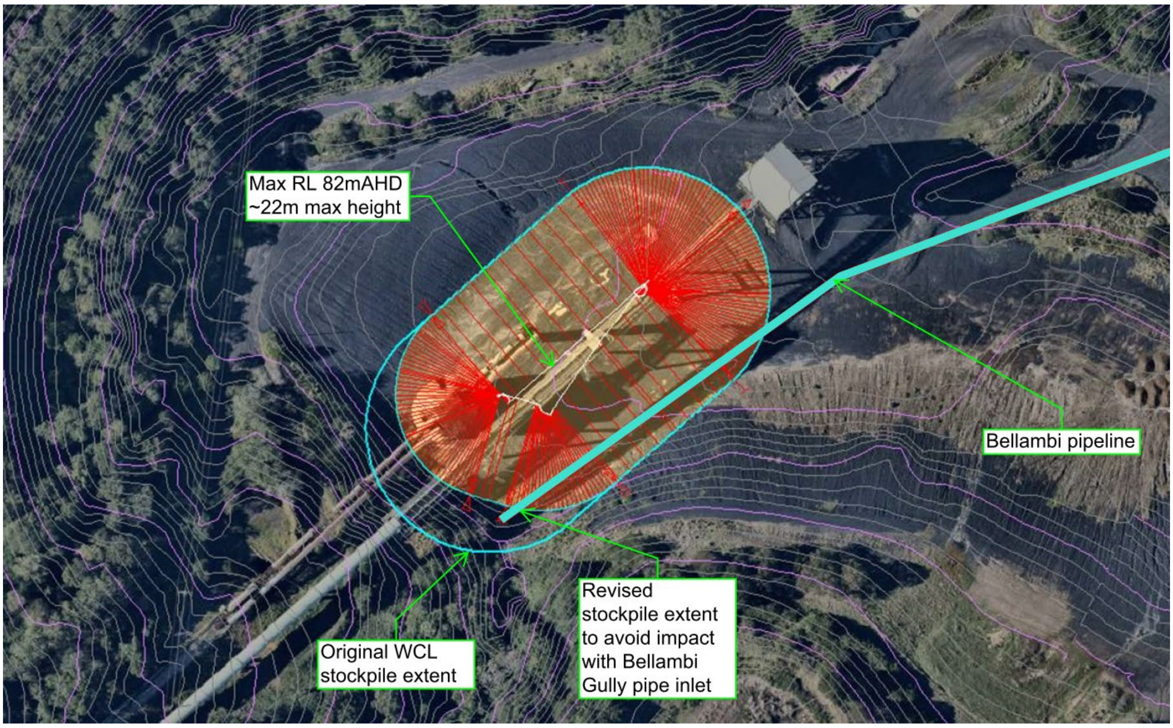


Figure 4.1 Proposed Russell Vale ROM stockpile RevA – WCL Extents Maintained

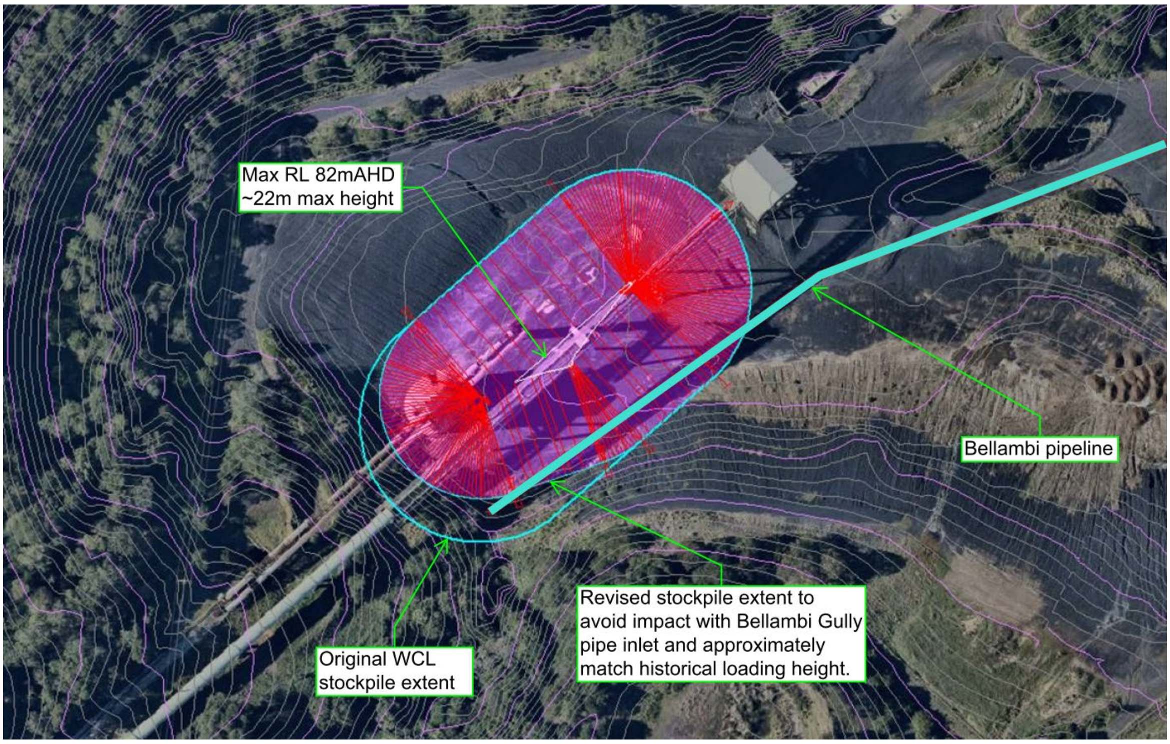


Figure 4.2 Proposed Russell Vale ROM Stockpile RevB – WCL Extents Modified to Reduce Fill Height over Pipeline

A long section for the diversion, as used in this assessment, is presented in Figure 4.3.

The analysis indicates that the cover to the obvert of the pipe ranges from a minimum of 0.3 m (chainage 220) to historically 10.4 m (chainage 60). The proposed cover for the RevA stockpile is 12.2 m (chainage 25) or alternatively for RevB 10.0m (chainage 40). To investigate the range of potential loads, pipe loading scenarios were calculated at 1 m increments for this depth range using pipe loading Software PipeClass, developed by the Concrete Pipe Association of Australia. The scenarios considered both the dead load of the trench backfill and coal stockpile above the pipe as well as the live load of on-site machinery, in accordance with the provisions of Section 10.2 of AS/NZS 3725:2007.

No as-built information for the pipeline was available at the time of the assessment. Further to this, the structural capacity of buried concrete pipelines is highly sensitive to the trenching and backfilling conditions used in construction. As such, a sensitivity analysis was undertaken for various loading scenarios for both favourable and unfavourable pipe trench and backfill conditions. The results of the analysis are presented below in Table 4.1 and Table 4.2.

The favourable conditions assumed that the pipe was laid with vertical trench walls close to the pipe with ‘H2’ bedding support, whereas the unfavourable conditioned assumed a sloping trench of 2(H):1(V) side slopes from the bottom of the pipe trench coupled with ‘U’ type backfill and compaction. The worst-case vehicle load was exhibited by a Caterpillar 988B wheel loader.

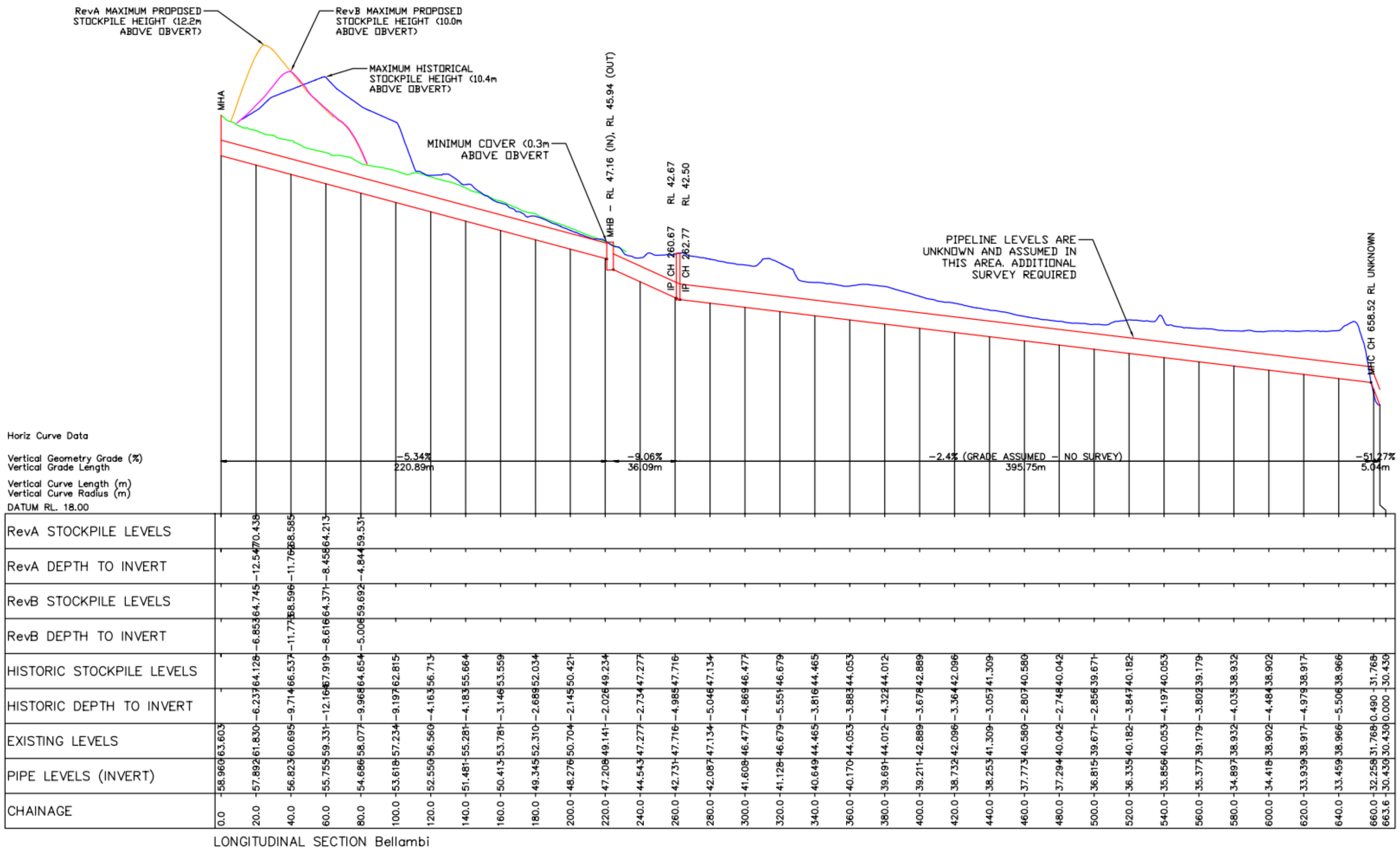


Figure 4.3 Longitudinal Section - Bellambi Gully Diversion Pipeline

Table 4.1 Favourable Conditions: Vertical Trench Walls, 'H2' Bedding Support

Cover (m)	Earth Load (kN/m)	Vehicle load – 988B (kN/m)	Total Load (kN/m)	Proof Load (kN/m)	Pipe Class required	Reserve Capacity
0.3	5.0	39.0	44.0	62.0	2	29.0%
1	17.9	22.9	40.8	62.0	2	34.2%
2	37.7	12.0	49.7	62.0	2	19.8%
3	52.9	7.9	60.8	62.0	2	1.9%
4	66.1	5.9	72.0	93.0	3	22.6%
5	77.6	4.7	82.3	93.0	3	11.5%
6	87.5	3.7	91.2	93.0	3	1.9%
7	96.1	3.1	99.2	124.0	4	20.0%
8	103.6	2.5	106.1	124.0	4	14.4%
9	110.1	2.1	112.2	124.0	4	9.5%
10	115.7	1.9	117.6	124.0	4	5.2%
10.4	117.7	1.7	119.4	124.0	4	3.7%
11	120.6	1.6	122.2	124.0	4	1.5%
12	124.8	1.4	126.2	186.0	6	32.2%
12.2	125.6	1.4	127.0	186.0	6	31.7%

Note: The required pipe class refers to the class or strength of a new reinforced concrete pipe in accordance with AS4058-2007 if the pipe was installed to the assumed favourable trenching conditions. The reserve capacity is the residual structural capacity of a new pipeline under the given loading scenario.

Table 4.2 Unfavourable Conditions: Sloping 2:1 Trench Walls, 'U' Bedding Support

Cover (m)	Earth Load (kN/m)	Vehicle load – 988B (kN/m)	Total Load (kN/m)	Proof Load (kN/m)	Pipe Class required	Reserve Capacity
0.3	10.0	58.5	68.5	93.0	3	26.3%
1	35.8	34.3	70.1	93.0	3	24.6%
2	79.1	18.0	97.1	124.0	4	21.7%
3	131.3	11.9	143.2	186.0	6	23.0%
4	194.5	8.9	203.4	248.0	8	18.0%
5	251.3	7.0	258.3	310.0	10	16.7%
6	303.5	5.6	309.1	310.0	10	0.3%
7	355.5	4.6	360.1	310.0	10+	-16.2%
8	407.4	3.8	411.2	310.0	10+	-32.6%
9	459.6	3.2	462.8	310.0	10+	-49.3%
10	511.0	2.8	513.8	310.0	10+	-65.7%
10.4	532.3	2.6	534.9	310	10+	-72.5%
11	562.7	2.4	565.1	310.0	10+	-82.3%
12	607.7	2.1	609.8	310.0	10+	-96.7%
12.2	613.8	2.1	615.9	310.0	10+	-98.7%

The loading analysis indicates that the dead and live loads acting on the pipe are highly sensitive to the trenching and backfilling methodology used in the construction of the pipeline. For the higher stockpile levels, the difference between the favourable and unfavourable construction scenarios results in a 490% increase of the ultimate pipe load.

The analysis indicates that in general, when cover depths are greater than ~1 m, the total load (i.e. dead load and live load) acting on the pipe increases as stockpile/overburden depth increases and that the weight of the stockpiled material does not offset the reduction in live load as the vehicle forces are distributed down through the increasingly deep soil profile. It can also be seen that if the pipe support conditions reflect the unfavourable assumptions, that the dead load from the stockpiled coal is considerably larger than the vehicle loading on the pipeline.

However, as the support conditions, concrete strength and construction methodology for the pipe are unknown, it is impossible to make a conclusive assessment on the structural capacity of the pipeline. Instead it is considered more useful to assess the existing condition of the pipeline, based on CCTV inspection photos, and compare the pipeline condition to current and historic cover levels at each section.

Based on the CCTV inspection report and images (Interflow, 2017) there is significant evidence of structural degradation in many areas, especially in those areas with lower depths of cover. The apparent structural damage to the pipe is generally in the form of exposed reinforcement, longitudinal cracks in the pipe, holes or previous repairs to the top of the pipeline, squashed or irregular cross section and bulging/bellies in the line of the corrugated steel pipe liner.

In general, the pipe located under the coal stockpile appears to be in good structural condition (based on the visual Interflow inspection report and photographs, 2017), despite the historical stockpile height and associated dead load. It should be noted that it is unknown if any live loads were applied to the pipeline concurrent with the maximum dead load. A representative photo of the pipeline under the stockpile area are shown in Figure 4.4.

Photo: SW001 (US Part 2)_MH A_MH B_20062017_133200_A.jpg
129.42m, New material, Concrete Pipe , General Comments returns to original pipe material

Figure 4.4 CCTV Inspection Photos for ~Chainage 60 (Interflow, June 2017)

Apparent structural damage exists to the pipeline in the low cover areas surrounding Manhole B and under the laydown area. CCTV photos of some of these damaged locations are shown in Figure 4.5 and Figure 4.6.

Photo: SW001 (US Part 1)_MH A_MH B_20062017_123939_A.jpg
3.34m, Steel reinforcement is visible with little or no corrosion evident , from 11 to 1 o'clock

Photo: SW001 (US Part 1)_MH A_MH B_20062017_124126_A.jpg
3.34m, Suspected Surface Damage , Obstruction: 5-20%, General Comments Hole in pipe obvert has been repaired using a steel sheet, from 10 to 2 o'clock

Photo: SW001 (US Part 1)_MH A_MH B_20062017_124203_A.jpg
3.75m, Steel reinforcement is visible with little or no corrosion evident , from 11 to 1 o'clock

Photo: SW001 (US Part 1)_MH A_MH B_20062017_124258_A.jpg
10.44m, Reinforcement is exposed and corroded , General Comments possible repair of pipe hole, from 11 to 1 o'clock

Figure 4.5 CCTV Inspection Photos for ~Chainage 200 to 220 (Interflow, June 2017)

Photo: SW001 (Section 3B)_MH B_MH C_20062017_120205_A.jpg
11.92m, Defective repair , other defects: Bulging of corregated iron in invert

Photo: SW001 (Section 3B)_MH B_MH C_20062017_120355_A.jpg
21.35m, Defective repair , other defects: Bulging of corregated iron, General Comments on left hand side of pipe wall

Figure 4.6 CCTV Inspection Photos for ~Chainage 485 to 495 (Interflow, June 2017)

It is noted that during recent pipeline inspections, undertaken by WCL, that the bulges in the corrugated steel are solid throughout. It is believed that the bulging is primarily caused by over pressurisation of the grout injection, undertaken in the late 1980's, rather than overloading of the pipeline.

It is not possible to accurately determine the current structural capacity of the pipeline due to the unknowns in construction as well as the unknowns associated with the impacts of the apparent structural damage. However, it is likely that in these low cover areas, the ultimate bearing capacity of the pipe has been adversely affected.

4.3 Conclusions and Recommendations

Under the stockpile area, based on visual inspection, the Bellambi Gully Diversion Pipeline appears to range in structural condition. Whilst the maximum historic stockpile height of 10.4 m is known, it is impossible to know if any live loads were concurrently applied.

As the support conditions, concrete strength and construction methodology for the pipe are unknown, it is not possible to make a conclusive assessment on the structural capacity of the pipeline. A review has been made considering the existing condition of the pipeline, based on CCTV inspection photos, and a comparison of historic loads to potential future loads on the pipeline.

WCL has indicated that a D8 dozer or 988B wheel loader may be used in the stockpile area (i.e. CH 0 to 120). Considering the historical loading of the pipe due to the dead load height of 10.4 m, an equivalent total loading combined with a D8/988B is a dead load height of 10 m. This is equivalent to an estimated stockpile height 7 m based on a depth of cover from the base of the stockpile to the pipe obvert of 2 m. This indicates that a maximum stockpile height of 7 m should not be exceeded above the pipeline. With the current plan of a 22 m high stockpile, the estimated stockpile height is 12.2 m over the pipeline (refer to stockpile model revision A). It is noted that a future stockpile of 22 m high is not likely, given that future production is only 1 Mtpa as opposed to 3 Mtpa in the past.

The proposed stockpile extents should be revised to reduce loading of the pipeline to a level consistent with or lower than the previous historical loading. The *revision B* model for the stockpile, described in Section 4.2, attempts to achieve this scenario. To aid in management of the height of the stockpile over the pipeline, it is suggested that WCL clearly delineate the maximum extents of the stockpile.

In areas where the depth of cover is less than 2.5 m to 3.0 m above the pipe obvert (i.e. Ch 120 to 660), the pipeline is much more susceptible to heavy vehicle live loads. It is considered that no heavy vehicle loads should be permitted in these areas (i.e. CH 120 to 660) without further detail investigations into the structural condition of the pipe and depth of cover (refer to Figure 4.1). A suggested offset for heavy vehicles from the pipeline is 5 m from the centreline of the pipe. The parking of vehicles on the laydown area and the route taken to the transfer station/stockpile should consider this offset. Dedicated crossings of the pipeline could also be considered. These may consist of additional fill placed over the pipeline, or other structural solutions to spread the surface load through the soil profile.

4.4 Future Investigations

Further investigations to determine the strength and ability for the pipeline to withstand future loading could include:

- Determination of the compression strength (f'c) of the concrete by taking a concrete core sample and undertaking compression testing or measurement using a Schmidt Rebound Hammer.
- XRAY survey of the pipeline to determine the steel reinforcement spacing.
- Liaison with concrete manufacturers using the above information to determine the likely strength of the pipe based on what was available at the time of the installation. Or using the compressive strength and reinforcement details to build undertake a finite element analysis of the pipeline to determine is ultimate strength/bearing capacity.
- Geotechnical investigation using a drill rig to determine the trenching and backfilling conditions used in the construction of the Bellambi pipeline diversions.
- Survey of the invert levels of the pipeline from Ch 260 to 660.
- Finite element analysis of the pipeline using the information from the above suggested investigations.

5. MONITORING, MANAGEMENT AND CONTINGENCY MEASURES

The pipeline monitoring, management and contingency measures will, upon approval of Modification 4, be incorporated into the Surface Facilities Water Management Plan for Russell Vale Colliery. This will include trigger action response plans (TARPs) for each aspect of the monitoring, management and contingency measures outlined below.

5.1 Monitoring Program

A monitoring program of the Bellambi Gully Diversion Pipeline will be implemented at the Russell Vale Colliery site. The purpose of the ongoing monitoring program is to ascertain the efficacy of remediation works undertaken to date and to identify any worsening of non-remediated defects.

A yearly CCTV inspection program will be implemented to determine any visual structural degradation or potential leakage points.

In addition, photographic inspections will be undertaken following remediation works to the pipeline and after major storm events (e.g. greater than 50 mm of rainfall in 24 hours).

The post remediation photographic inspection will include:

- Inspection of the remediation works on defective areas identified as having a risk category of Moderate – Critical. The inspection should ascertain that the remediation has been successful and that there are no indications of further groundwater ingress from the defect.
- Inspection of defects assessed as having a Very Low to Low risk category. The inspection should note if any worsening of the defect is observed to allow for reassessment of the defect's risk category.
- Identification and inspection of any additional defects found along the pipeline length.

The post major storm event photographic inspection will include:

- Inspection of the remediation works and identification of any degradation.
- Identification and inspection of any additional defects found along the pipeline length.

The photographic monitoring records will be prepared to allow correlation and comparison to the yearly CCTV inspection records.

Any changes to either effectiveness of remediation works or identification of worsening of defects or new defects identified in the yearly CCTV, post remediation or post major storm event inspections will be reviewed based on their risk and repaired/remediated if required. The risk assessment will consider both turbid water ingress and structural failure components.

Repair/remediation works and/or monitoring will be undertaken on defect/remediation that are identified during the inspections as follows:

- High risk will be repaired within 1 month.
- Medium risk within 3 months.
- Low risk identified for future monitoring.

WCL will review the yearly CCTV inspections as well as photographic inspection records and document in the Annual Review the following:

- Summary of inspections undertaken.
- Identification of incidents or failures of all previous remediation works and necessary/adopted corrective actions.
- Any worsening of defective areas that have not been remediated, relative to previous pipeline inspections.

5.2 Management

5.2.1 Stockpile Heights

The proposed stockpile will be managed to ensure a maximum stockpile height of 7 m above the Bellambi Gully Diversion Pipeline. That is, the maximum stockpile height will not exceed the historical surveyed stockpile height.

To aid in management of the height of the stockpile over the pipeline, WCL will clearly delineate the maximum extents of the stockpile.

5.2.2 Heavy Vehicle Routes

In areas where the depth of cover is less than 2.5 m to 3.0 m above the pipe obvert (i.e. Ch 120 to 660) no heavy vehicle loads will be permitted in these areas (i.e. CH 120 to 660) without further detail investigations into the structural condition of the pipe and depth of cover (refer to Figure 4.1). Heavy vehicles routes will be offset a minimum of 5 m from the centreline of the pipe.

The parking of vehicles on the laydown area and the route taken to the transfer station/stockpile should consider this offset. Dedicated crossings of the pipeline could also be considered. These may consist of additional fill placed over the pipeline, or other structural solutions to spread the surface load through the soil profile.

As part of the Underground Extension Project (UEP) a truck haulage route is proposed that crosses the Bellambi Gully Diversion Pipeline. If this route is operational prior to pipeline replacement works occurring (see above), a series of load bearing/distributing crossings will be designed and constructed to minimise increased loading to the Bellambi Gully

Diversion Pipeline. The proposed crossings will be designed and constructed prior to the truck haulage route being utilised.

5.2.3 Pipeline Replacement

WCL proposes that after approval of Modification 4 a program of works to replace the downstream reaches (i.e. Ch 120 to 660) of the Bellambi Gully Diversion Pipeline will occur. The pipeline replacement will occur in short lengths during periods of dry weather forecasts.

The replacement program consists of the following stages:

- Detailed design of pipeline sections (0 to 6 months), including:
  - pipe class, trenching and bedding requirements;
  - soil and water management during construction; and
  - staging plans.
- Pipeline replacement construction program (6 to 18 months).

5.3 Contingency Measures

In case of unforeseen failure or imminent repairs being required prior to the replacement program being complete, WCL proposes to hold suitable sections of pipeline and equipment ready on-site (or within 1 hour delivery time) to enable emergency repairs to be carried out when wet weather is forecast.

6. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c. Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

   (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d. Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e. This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report.

f. If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g. This report does not provide legal advice.

APPENDIX A

Site Observations and Photographs

Wollongong Coal Ltd

ACN 111 244 896
ABN 28 111 244 896

Head Office
7 Princes Highway, cnr Bellambi Lane
CORRIMAL NSW 2518

PO Box 281
FAIRY MEADOW NSW 2519

Phone +61 2 4223 6800
Fax +61 2 4283 7449
www.wollongongcoal.com.au

Bellambi Creek Pipeline Inspection - 19/10/17

LDP2

Repaired Joints

Repair and Patch of Joints

40m
patched 300mm x 300mm
hole with agg line →

63m
patched up hole 600mm x 500mm
old pipe line →

86m
1300mm pipe going off on
an angle

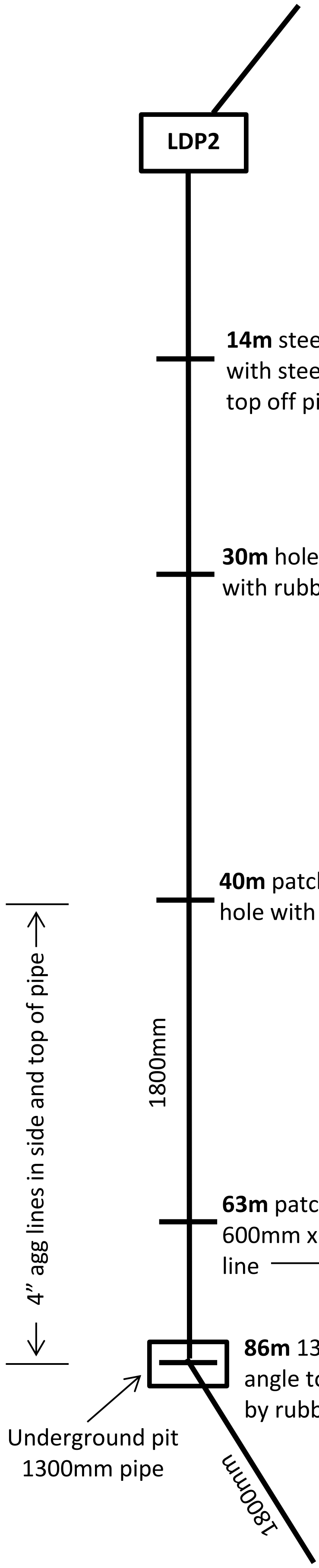
4" agg lines in side and top of pipe

1800mm

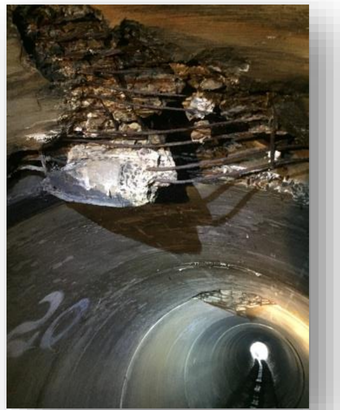
Underground pit
1300mm pipe

1800mm

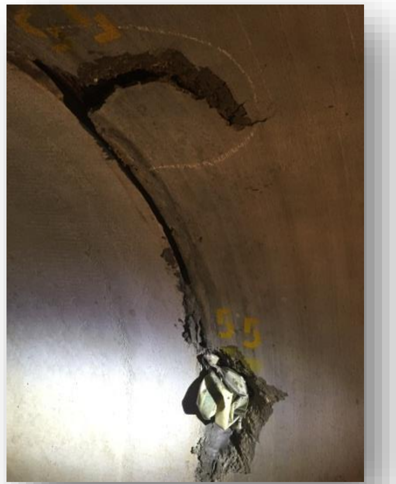
Bellambi Creek Pipeline Inspection
19/10/17



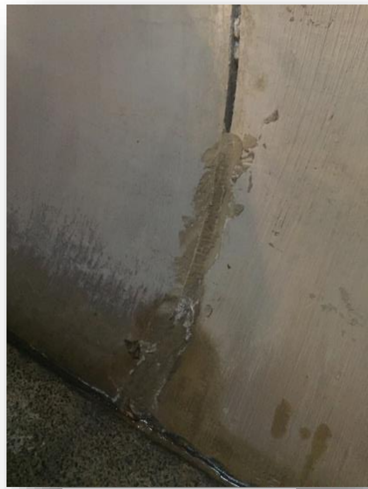
14m steel plate and hole with steel showing on top off pipe



30m hole in top of pipe with rubber belt



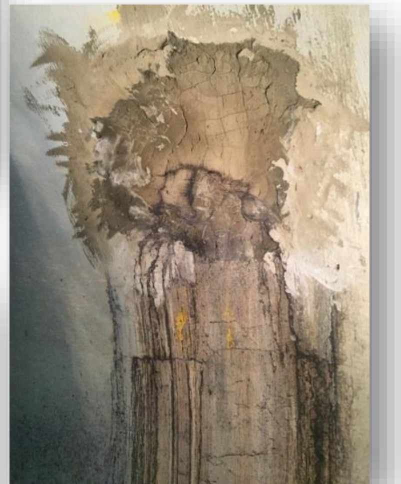
Joint between pipes

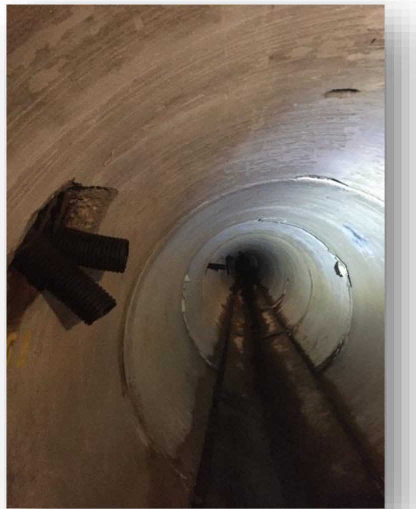


Repaired Joints

Repair and Patch of Joints

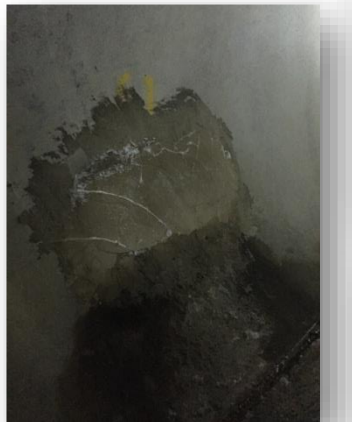
40m patched 300mm x 300mm hole with agg line





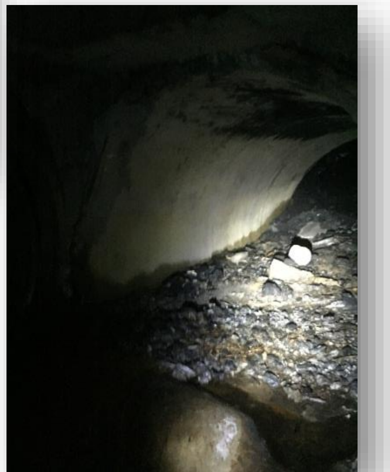
After 40m to 63m agg pipes

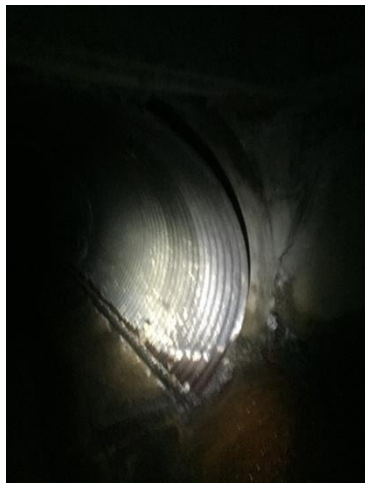
63m patched up hole 600mm x 500mm old pipe line



86m 1300mm pipe going off on an angle to about 3-4 metres blocked by rubble

Underground pit 1300mm pipe





86m start of corrugation repairs

Inspected by:
Paul Wheeler

APPENDIX B

Detailed Pipeline Observations, Risk Profile and Proposed Remediation

Bellambi Gully Pipeline MHB to MHA

Total Chainage	Listed Chainage	Code	Observation	Consequence Rating (Engeny 2017)	Likelihood (Engeny 2017)	Risk Category (Engeny 2017)	Current Consequence Rating (WCL 2018)	Current Likelihood (WCL 2018)	Current Risk Category (WCL 2018)	Recommended remediation (Engeny 2017)	Remediation undertaken (WCL 2018)
3.34		SRV	Steel reinforcement is visible with little or no corrosion evident, from 11 to 1 o'clock	4	Moderate Likelihood	High	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
3.34		SYY	Suspected Surface Damage, Obstruction: 5-20%, General Comments Hole in pipe obvert has been repaired using a steel sheet, from 10 to 2 o'clock	4	Likely	High	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
3.75		SRV	Steel reinforcement is visible with little or no corrosion evident, from 11 to 1 o'clock	3	Rare	Low	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
10.44		SRC	Reinforcement is exposed and corroded, General Comments possible repair of pipe hole, from 11 to 1 o'clock	4	Moderate Likelihood	High	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
10.55		DEE	Encrustation/Scale is attached to the wall above the waterline, Obstruction: <5%, General Comments Possibly caused by infiltration, at 10 o'clock	1	Almost certain	Moderate	1	Moderate Likelihood	Low	Clean pipe.	Pipe cleaned and scale removed. No Infiltration observed. Risk of Ingress - Low
15.83		SRV	Steel reinforcement is visible with little or no corrosion evident, at 12 o'clock	4	Moderate Likelihood	High	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
15.92		SH	Hole in wall, at joint, General Comments with reinforcement exposed, at 12 o'clock	4	Moderate Likelihood	High	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Joint repaired with clay behind grout. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - N/A
15.92		CI	Intruding connection, magnitude of intrusion: 5-20%, General Comments protruding into line with reinforcement exposed, at 10 o'clock	3	Likely	High	2	Rare	Very Low	Investigate source of connection, only clean water sources to be directed to pipeline. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
15.92		CI	Intruding connection, magnitude of intrusion: 5-20%, General Comments Protruding into line, at 10 o'clock	3	Likely	High	2	Rare	Very Low	Investigate source of connection, only clean water sources to be directed to pipeline. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
18.85		CI	Intruding connection, magnitude of intrusion: 5-20%, General Comments Protruding into line, at 10 o'clock	3	Likely	High	2	Rare	Very Low	Investigate source of connection, only clean water sources to be directed to pipeline. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
19.23		CI	Intruding connection, magnitude of intrusion: 5-20%, General Comments Protruding into line with reinforcement exposed, at 11 o'clock	3	Likely	High	2	Rare	Very Low	Investigate source of connection, only clean water sources to be directed to pipeline. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
19.23		CI	Intruding connection, magnitude of intrusion: 5-20%, General Comments Protruding into line with reinforcement exposed, at 12 o'clock	3	Likely	High	2	Rare	Very Low	Investigate source of connection, only clean water sources to be directed to pipeline. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
19.23		CI	Intruding connection, magnitude of intrusion: 5-20%, General Comments Protruding into line with reinforcement exposed, at 12 o'clock	3	Likely	High	2	Rare	Very Low	Investigate source of connection, only clean water sources to be directed to pipeline. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
20.90		GC	General Comments Unknown Pit found	0	N/A	Comment	0	N/A	Comment	Confirm if pit is still required. If not, construct reinforced concrete plug, dowelled in to RCP / Manhole.	N/A Not required No ingress observed
21.24		CXD	Defective Connection - The connecting pipe is damaged, magnitude of obstruction 51-75%, General Comments Collapsed 600mm junction, at 3 o'clock	3	Likely	High	2	Rare	Very Low	Construct reinforced concrete plug, dowelled in to connecting RCP.	Repaired; Connections removed and penetrations sealed with clay behind grout. Risk of ingress - very low. No visible ingress. Likelihood - rear
21.36		MC	New material, Corrugated Iron	0	N/A	Comment	0	N/A	Comment		
23.92		GC	General Comments Multiple attachments on pipe wall to hold corrugated iron in place; rusting present throughout	0	N/A	Comment	0	N/A	Comment		

Total Chainage	Listed Chainage	Code	Observation	Consequence Rating (Engeny 2017)	Likelihood (Engeny 2017)	Risk Category (Engeny 2017)	Current Consequence Rating (WCL 2018)	Current Likelihood (WCL 2018)	Current Risk Category (WCL 2018)	Recommended remediation (Engeny 2017)	Remediation undertaken (WCL 2018)
28.35		IYY	Suspected Infiltration, General Comments through corrugated iron, at 2 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Cement pressure grout annulus behind CMP / replace band connection, or seal band / CMP gap with expanding sealant.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
34.41		GC	General Comments Section completed	0	N/A	Comment	0	N/A	Comment		
46.91	12.50	GC	General Comments Starts at 12.5m	0	N/A	Comment	0	N/A	Comment		
48.89	14.48	DEE	Encrustation/Scale is attached to the wall above the waterline, Obstruction: <5%, General Comments possibly due to infiltration, from 2 to 6 o'clock	1	Likely	Low	1	Unlikely	Very Low	Cement pressure grout annulus behind CMP / replace band connection, or seal band / CMP gap with expanding sealant.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
52.58	18.17	DI	Dropped invert, depth of drop 10mm, General Comments drop in invert of pipe- uneven surface	1	Unlikely	Very Low	1	Unlikely	Very Low	Is this due to displacement of a pipe joint or erosion of the concrete floor or something else? Requires further inspection to determine appropriate repair.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
52.64	18.23	DEW	Other Deposits on the wall, Jointing Material, Obstruction:<5%, General Comments rusting/staining of joining mechanism, from 12 to 4 o'clock	1	Likely	Low	1	Unlikely	Very Low	Cement pressure grout annulus behind CMP / replace band connection, or seal band / CMP gap with expanding sealant.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
52.64	18.23	DEE	Encrustation/Scale is attached to the wall above the waterline, Obstruction: <5%, General Comments rusting/staining/possible infiltration of joining mechanism, from 7 to 12 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Cement pressure grout annulus behind CMP / replace band connection, or seal band / CMP gap with expanding sealant.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
55.35	20.94	IR	Infiltration, running, General Comments spurting out pipe wall, from 7 to 8 o'clock	2	Almost certain	High	1	Unlikely	Very Low	Cement pressure grout annulus behind CMP / replace band connection, or seal band / CMP gap with expanding sealant.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
55.35	20.94	DEE	Encrustation/Scale is attached to the wall above the waterline, Obstruction: <5%, General Comments due to infiltration, from 6 to 12 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Cement pressure grout annulus behind CMP / replace band connection, or seal band / CMP gap with expanding sealant.	Repaired, gaps sealed and grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
163.48	129.07	MC	New material, Concrete Pipe, General Comments returns to original pipe material	0	N/A	Comment	0	N/A	Comment		
166.70	132.29	CNGO	Connection, good workmanship, connection appears to be open, diameter approx. 600mm, at 3 o'clock, General Comments Large wooden object wedged at pipe entrance	1	Rare	Very Low	1	Rare	Very Low	Remove blockage	Object removed and pipe is clear. No damage.
166.72	132.31	GC	General Comments Unknown pit found	0	N/A	Comment	0	N/A	Comment	Confirm if pit is still required. If not, construct reinforced concrete plug, dowelled in to RCP / Manhole.	Not required - very low risk

Bellambi Gully Pipeline MHB to MHC

Total Chainage	Listed Chainage	Code	Observation	Consequence Rating (Engeny 2017)	Likelihood (Engeny 2017)	Risk category (Engeny 2017)	Current Consequence rating (WCL 2018)	Current Likelihood (WCL 2018)	Current Risk category (WCL 2018)	Recommended remediation (Engeny 2017)	Remediation undertaken (WCL 2018)
0.00	0.00	STMS	Start node, maintenance shaft, Node name: MH B	0	N/A	Comment	0	N/A	Comment		
19.74	19.74	CNPC	Connection, poor workmanship, connection appears to be open, diameter approx. 225mm, General Comments suspect a possible displacement	1	Likely	Low	1	Unlikely	Very Low	Penetration appears to have been capped. Potential for seepage around annulus. Either epoxy pressure grout annulus between RCP and penetration or remove penetration, and reinstate RCP wall by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
23.77	23.77	SWS	Wall Staining is present on the surface of the conduit, at joint, General Comments Possible infiltration is present, at 4 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
26.45	26.45	IR	Infiltration, running, at joint, General Comments Wall staining also present, at 4 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
26.45	26.45	DEE	Encrustation/Scale is attached to the wall above the waterline, at joint, Obstruction: <5%, General Comments from infiltration, at 4 o'clock	1	Unlikely	Very Low	1	Unlikely	Very Low	Clean pipewall during repair of pipe joint seal	Pipe cleaned and scale removed. No Infiltration observed.
34.20	34.20	SRV	Steel reinforcement is visible with little or no corrosion evident, at 12 o'clock	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Non cracking noted. Likely local concrete spalling. Repair by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
38.06	38.06	GC	General Comments Unknown Pit found	0	N/A	Comment	0	N/A	Comment	Confirm if pit is still required. If not, construct reinforced concrete plug, dowelled in to RCP / Manhole.	N/A
70.84	70.84	MC	New material, Corrugated Iron, General Comments Reduces diameter of pipe	2	Rare	Very Low	2	Rare	Very Low	Confirm if the annulus between the CMP and RCP has been cement pressure grouted. If not, cement pressure grout the annulus.	N/A
70.84	70.84	RXM	Defective repair, major or irregular gaps or both in the pipe wall, General Comments Packer is hanging loose	1	Unlikely	Very Low	1	Unlikely	Very Low	Cement pressure grout annulus.	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
70.84	70.84	DM	Deformation, mixed orientation, change in diameter 5-10%,length of deformation 500mm, General Comments Corrugated iron causing deformed pipe shape, from 12 to 1	1	Unlikely	Very Low	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
107.30	107.30	RXB	Defective repair, bellies in the line, General Comments dropping of corrugated iron	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Possible multiple causes. Where safe to do so, cut out bulge and install bolted strengthening plate/ring. Cement pressure grout outside CMP to fill any voids.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. Dispensation- use as is and monitor.
119.21	119.21	DEW	Other Deposits on the wall, Rusting, Obstruction: <5%, at 1 o'clock	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Where safe to do so, install bolted strengthening plate/ring. Cement pressure grout outside CMP to fill any voids.	Pipe cleaned and scale removed. No Infiltration observed. Very Low risk
125.47	6.26	MC	New material, Corrugated Iron	0	N/A	Comment	0	N/A	Comment		
131.98	12.77	RXB	Defective repair, bellies in the line, General Comments Drooping of corrugated iron	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Where safe to do so, install bolted strengthening plate/ring. Cement pressure grout outside CMP to fill any voids.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No drumbiness or void detected. Dispensation- use as is and monitor.
139.07	19.86	GC	General Comments Multiple joining mechanisms on pipe wall to hold corrugated iron in place; rusting present	0	N/A	Comment	0	N/A	Comment	Consider re-lining pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
235.50	116.29	RXZ	Defective repair, other defects: Bulging of pipe wall @ 3 o'clock	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Possible multiple causes. Where safe to do so, cut out bulge and install bolted strengthening plate/ring. Cement pressure grout outside CMP to fill any voids.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No Ingress observed. Dispensation- use as is and monitor.
249.24	130.03	GC	General Comments Full length of cable reached	0	N/A	Comment	0	N/A	Comment		
258.80	9.56	MC	New material, Corrugated Iron	0	N/A	Comment	0	N/A	Comment		
260.16	11.92	RXZ	Defective repair, other defects: Bulging of corrugated iron in invert	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Possible multiple causes. Where safe to do so, cut out bulge and install bolted strengthening plate/ring. Cement pressure grout outside CMP to fill any voids.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
269.59	21.35	RXZ	Defective repair, other defects: Bulging of corrugated iron, General Comments on left hand side of pipe wall	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Possible multiple causes. Where safe to do so, cut out bulge and install bolted strengthening plate/ring. Cement pressure grout outside CMP to fill any voids.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
292.91	44.67	MC	New material, Reinforced Concrete Pipe, General Comments Returns to original pipe material	0	N/A	Comment	0	N/A	Comment		

Bellambi Gully Pipeline MHB to MHC

Total Chainage	Listed Chainage	Code	Observation	Consequence Rating (Engeny 2017)	Likelihood (Engeny 2017)	Risk category (Engeny 2017)	Current Consequence rating (WCL 2018)	Current Likelihood (WCL 2018)	Current Risk category (WCL 2018)	Recommended remediation (Engeny 2017)	Remediation undertaken (WCL 2018)
300.84	52.60	GC	General Comments Large repair	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Non cracking noted. Likely local concrete spalling. Repair by scrabbling/cleaning the concrete surface, applying a bonding agent (e.g. Epirez 133) and repair with non-shrink cement mortar repair.	Very Low risk, cosmetic only - No ingress observed. Dispensation - use as is and monitor
301.69	53.45	DI	Dropped invert, depth of drop 8mm, General Comments slight dip in invert	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Is this due to displacement of a pipe joint or erosion of the concrete floor or something else? Requires further inspection to determine appropriate repair.	Very Low risk, cosmetic only - No ingress observed. Dispensation - use as is and monitor
306.27	58.03	GC	General Comments Unknown Pit found	0	N/A	Comment	0	N/A	Comment	Confirm if pit is still required. If not, construct reinforced concrete plug, dowelled in to RCP / Manhole.	
306.27	58.03	CLW	Longitudinal wall crack, width 2mm, General Comments on unknown pit wall, at 11 o'clock	2	Unlikely	Low	1	Unlikely	Very Low	Epoxy pressure grout crack.	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
319.89	71.65	IYY	Suspected Infiltration, General Comments at pipe joint, from 4 to 6 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
322.26	74.02	IYY	Suspected Infiltration, at joint, General Comments from pipe joint, from 4 to 6 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
330.24	82.00	IYY	Suspected Infiltration, at joint, General Comments at joint, from 4 to 6 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
336.96	88.72	IYY	Suspected Infiltration, at joint, from 2 to 6 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
349.96	101.72	DV	Vertical deformation, change in diameter 5-10%, length of deformation 200mm, General Comments pipe has been squashed, at 10 o'clock	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
360.78	112.54	IYY	Suspected Infiltration, at joint, from 6 to 9 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
363.18	114.94	IYY	Suspected Infiltration, at joint, from 6 to 9 o'clock	1	Almost certain	Moderate	1	Unlikely	Very Low	Likely a deteriorated pipe joint seal. Either epoxy pressure grout joint (more permanent) or install internal expanding seal to joint (e.g. Trellborg).	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
366.22	117.98	CLW	Longitudinal wall crack, width 2mm, General Comments runs through to pipe sections, at 12 o'clock, Start	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Epoxy pressure grout crack.	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
375.56	127.22	DV	Vertical deformation, change in diameter 5-10%, length of deformation 300mm, at 12 o'clock	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
377.28	128.94	CLW	Longitudinal wall crack, width 2mm, General Comments runs through to pipe sections, at 12 o'clock, End	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Epoxy pressure grout crack.	Repaired and Grouted. Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
378.01	129.67	DV	Vertical deformation, change in diameter 5-10%, length of deformation 200mm, at 12 o'clock	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
378.01	129.67	GC	General Comments Full length of cable has been reached again	0	N/A	Comment	0	N/A	Comment		
378.01	66.58	GC	General Comments Unknown starting meterage	0	N/A	Comment	0	N/A	Comment		
382.47	71.04	CLW	Longitudinal wall crack, width 2mm, at 12 o'clock, Start	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Epoxy pressure grout crack.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
385.77	74.34	DV	Vertical deformation, change in diameter 5-10%, length of deformation 200mm, at 11 o'clock	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely

Bellambi Gully Pipeline MHB to MHC

Total Chainage	Listed Chainage	Code	Observation	Consequence Rating (Engeny 2017)	Likelihood (Engeny 2017)	Risk category (Engeny 2017)	Current Consequence rating (WCL 2018)	Current Likelihood (WCL 2018)	Current Risk category (WCL 2018)	Recommended remediation (Engeny 2017)	Remediation undertaken (WCL 2018)
386.39	74.96	CLW	Longitudinal wall crack, width 2mm, at 12 o'clock, End	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Epoxy pressure grout crack.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
395.04	83.61	CLS	Longitudinal surface crack, width 2mm , at 12 o'clock	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Epoxy pressure grout crack.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
400.28	88.95	DI	Dropped invert, depth of drop 10mm, General Comments dip in pipe invert	2	Moderate Likelihood	Low	1	Unlikely	Very Low	Is this due to displacement of a pipe joint or erosion of the concrete floor or something else? Requires further inspection to determine appropriate repair.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
416.35	105.02	DV	Vertical deformation, change in diameter 5-10%, length of deformation 500mm, at 12 o'clock	3	Moderate Likelihood	Moderate	1	Unlikely	Very Low	Re-line pipe (i.e. installing CMP / Polypipe pipe and cement pressure grouting the annulus or installing an insitu reinforced concrete pipe (e.g. Tunneline system). Note the pipe invert appears to have a concrete floor. This may need to be demolished prior to relining.	Thought to be caused by overpressure during the original grout pumping process behind iron sheets. Structural - Very Low risk and cosmetic damage only. No ingress observed. Dispensation- use as is and monitor.
440.10	128.77	GC	General Comments Unknown Pit found	0	N/A	Comment	1	Unlikely	Very Low	Confirm if pit is still required. If not, construct reinforced concrete plug, dowelled in to RCP / Manhole.	Risk of ingress - Very Low. No visible ingress. Likelihood - Unlikely
440.78	128.82	LR	The conduit curves to the right, length of curved section 500mm	0	N/A	Comment	0	N/A	Comment		
441.46	129.50	FHO	Finish node, outfall or culvert headwall, Node name: MH C	0	N/A	Comment	0	N/A	Comment		

APPENDIX C

Bellambi Gully Flood Assessment (Engeny, 2018)

WOLLONGONG COAL

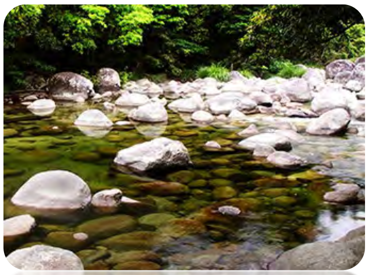
ENGENY
WATER MANAGEMENT

WOLLONGONG COAL LTD

Bellambi Gully Flood Assessment

Russell Vale Colliery



December 2018

N1800_006

www.engeny.com.au
P: 02 4926 1225
Suite 5, Level 1, 19 Bolton Street Newcastle 2300 | PO Box 787 Newcastle 2300

DISCLAIMER

This report has been prepared on behalf of and for the exclusive use of WOLLONGONG COAL LTD and is subject to and issued in accordance with WOLLONGONG COAL LTD instruction to Engeny Water Management (Engeny). The content of this report was based on previous information and studies supplied by WOLLONGONG COAL LTD.

Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party. Copying this report without the permission of WOLLONGONG COAL LTD or Engeny is not permitted.

N1800_006 Bellambi Gully Flood Assessment					
N:\Projects\N1800 Wollongong Coal\N1800_006 WCL Bellambi Gully Flood\07 Deliv\Docs\Report\N1800_006 Bellambi Gully Flooding_rev3					
REV	**DESCRIPTION**	**AUTHOR**	**REVIEWER**	**APPROVED BY**	**DATE**
Rev 0	Client Issue	Susan Shield	Aaron Hallgath	Susan Shield	15 August 2018
Rev 1	Client Issue	Michael Best	Susan Shield	Susan Shield	16 November 2018
Rev 2	Client Issue	Michael Best	Susan Shield	Susan Shield	17 December 2018
Rev 3	Client Issue	Michael Best	Susan Shield	Susan Shield	20 December 2018
Signatures		M Best	SShield	SShield	

CONTENTS

Appendices

List of Tables

List of Figures

1. INTRODUCTION

1.1 Background

Wollongong Coal Limited (WCL) operates the Russell Vale Colliery (formerly the NRE No.1 Colliery) in the Southern Coalfield of New South Wales (NSW). The Russell Vale Colliery operates under Project Approval (MP 10_0046) granted by the Planning Assessment Commission (PAC) on 13 October 2011. Three Modifications have been made to the Project Approval: MOD1 December 2012; MOD2 November 2014; and MOD3 October 2014.

The Russell Vale Colliery (the Site) is located on the lower slopes and foothills of the Illawarra escarpment, in the catchment areas of Bellambi Gully and Hicks Creek. Hicks Creek is a tributary of Bellambi Gully. Bellambi Gully flows into the Pacific Ocean approximately 3 km east of the site.

Under the current Part 3A Project Approval applying to the site (MP10_0046- Russell Vale Colliery Preliminary Works Approval), WCL was required to implement diversion works on Bellambi Gully to manage pollution risks associated with flooding of the creek. Further investigations were undertaken by WCL to optimise the design of the stormwater controls. As such these diversion works were never implemented.

The Underground Expansion Project (UEP) application under Part 3A of the EP&A Act was lodged in August 2009. The 2014 revised UEP project approval application included mine plan changes as well as a revised water management strategy.

The Bellambi Gully Flood Study was prepared by Cardno (2015) to support the augmentation and maintenance of the existing water management system to manage flows down Bellambi Gully as part of the Underground Expansion Project (UEP). Although the UEP project application is still in progress, the Department of Planning and Environment (DPE) and Wollongong Council supported the proposed design (as per DPE Addendum Report: Major Project Assessment Russell Vale Colliery Underground Expansion Project, November 2015; and PAC Second Review Report, March 2016).

In 2018, a Section 75W Modification to Project Approval MP10_0046 for the Russell Vale Colliery Preliminary Works Project was submitted to DPE to gain approval to retain the existing Bellambi Gully Diversion Pipeline as the method to divert upslope runoff from the Bellambi Gully catchment through the site to the downstream creek. The submission from the Office of Environment and Heritage (OEH), dated 29 March 2018, provided a series of recommendations for appropriate assessment of water related impacts in regards to both floodplain risk management and water quality advice (refer to Section 8).

1.2 Scope of Work

This study, using two dimensional modelling techniques, has been undertaken by Engeny Water Management (Engeny) to determine the required water management measures to manage flood flows at the site in the catchment area of Bellambi Gully and provide a response to the floodplain risk management and water quality advice comments provided by OEH.

The current study uses modern, data rich, two dimensional modelling techniques to mimic existing flood behaviour at the site in a level of detail not undertaken in the previous modelling exercises 4 years ago.

1.3 Modelling and Assessment Approach

The potential impacts of flooding and proposed management measures were assessed using a hydrologic model and a hydraulic model to represent the catchment areas and creek system. The assessment approach for the modelling, Australia Rainfall and Runoff (AR&R) 1987 (IEAust, 1987), was selected to be consistent with the methodology used to assess the previously proposed flood mitigation measures (Cardno 2015) and flood modelling in the downstream and surrounding catchment areas undertaken by Council.

The upslope catchment areas were modelled using the hydrology model of XP-STORM, with some routing of flows to the boundary of the hydraulic model. The main area of the site was modelled in the TUFLOW two dimensional hydraulic model. The boundaries of the various models and interactions are described in Section 4 and 5 and shown on Figure 1.1. The capacity of the upstream drainage systems was based on the analysis undertaken by BECA (2009) and confirmation during site inspections. BECA (2009) indicated that the failure of drainage system during events greater than the 100 year ARI storm event results in additional catchment areas flowing to Bellambi Lane during these events.

The downstream boundary of the study area is located immediately upstream of the Memorial Drive Culverts (refer to Figure 1.1) to allow both modelling of potential impacts on flooding at and downstream of the Princes Highway.

The study investigates both the existing flood behaviour as well as the proposed solution to assist in flood/stormwater management at the site. The study also considers the range of options proposed by Cardno (2015), with detailed modelling used to consider the potential outcomes if the Cardno (2015) solution was implemented.

A range of storm events were modelled, including the 5 year, 10 year and 100 year Average Recurrence Interval (ARI) storm events as well as the Probable Maximum Precipitation (PMP). In addition, the 200 year and 500 year ARI storm events were modelled to simulate the potential impacts of climate change.

Level 2, Suite 5, 19 olton St, Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

Figure 1.1 - Model Context

Job Number: N1800_006
Revision: 2
Drawn: Michael Best
Checked: SS
Date: 17/12/2018

2. OVERVIEW OF CARDNO STUDY

As summarised by Umwelt (Australia) Pty Limited (Umwelt) in the Section 75W Modification to Project Approval letter dated 23 February 2018, Cardno (2015) considered three flood scenarios to assess flooding risk to the site, these included the current stormwater pipes being completely blocked, 20% blocked and fully operational during the 100 year ARI event. The modelling results (Cardno, 2015) indicate that flooding within the site is significant during all three scenarios however overland flows are mainly contained within the stockpile area. In order to manage flood risk on site, a series of flood mitigation measures were proposed to reduce clean runoff entering the stockpile area, while conveying all site runoff in a controlled way to Bellambi Gully (refer to Section 2.1). However, the majority of these options were not modelled and the final report by Cardno (2015) contains limited quantification of the modelling outcomes.

2.1 Proposed Water Management Measures

The mitigation measures proposed by Cardno (2015) are shown in Appendix A and included:

- Upgrade existing stockpile area access road including installation of 6 m span culvert to convey site runoff across the access road and into a proposed grass-lined swale before discharging into Bellambi Gully.
- Installation of an additional debris control structure at the 1800 mm diameter pipe and 600 mm diameter pipe opening to reduce probability of blockage within the system due to debris from upstream catchment.
- Formalise the swale in the vicinity of the existing 600 mm clean water inlet. This would provide increased temporary storage for stormwater which helps to manage peak flows from the upstream catchment and to ensure all the clean water runoff is captured before entering the stockpile area.
- Upgrading the existing 600 mm diameter clean water pipe to an 825 mm diameter pipe which would be able to convey flows up to the 100 year ARI storm.
- Appropriate maintenance to be carried out immediately upstream and downstream of the existing debris control structures within the Bellambi Gully to minimise the potential for blockage of the system.
- Culverts may be installed across the access road along the northern boundary of the site to direct flows directly towards Bellambi Gully, in order to reduce clean water runoff conveyed into the stockpile area.

Flood modelling included applying a 25% blockage to the proposed 6m culvert and a 100% blockage applied to all culverts upstream. The modelling results demonstrated that the proposed road upgrade, 6m culvert and swale are adequate to convey the 100 year ARI flows.

As part of the UEP, WCL proposed to construct a 6 ML capacity dry sedimentation basin to treat runoff from the pit-top prior to discharging into Bellambi Gully from the licenced discharge point.

In addition, as per Umwelt (2018), the DPE Addendum Report, November 2015, for the UEP states that "the Department is satisfied that the proposed flood mitigation works (i.e. Cardno, 2015) would reduce clean runoff entering the stockpile area, while conveying all site runoff in a controlled way to Bellambi Gully. Wollongong Council has also confirmed that it is satisfied with the proposed flood mitigation measures".

WCL also committed, as per Umwelt (2018), to continue to carry out maintenance work within the upper reaches of Bellambi Gully, as originally detailed within the Preliminary Works EA including stabilising areas as required with appropriately designed structures or supporting material where required and removing obstructions from drainage channels in order to minimise downstream blockages. Maintenance of the debris structures recommended by the Cardno 2015 Report has also been undertaken.

2.2 Cardno Approach

The Cardno Study (2015) was undertaken using catchment delineations and peak flows determined by BECA (2009) and a one-dimensional HEC-RAS model. The HEC-RAS model covered the area of the stockpile area but did not extend to the access road or consider the interactions between the access road (i.e. Bellambi Lane and Broker Street to the north).

Cardno initially modelled three flood scenarios to determine the existing flood behaviour of the stockpile areas. The three scenarios mimicked 100% blockage, 20% blockage and fully functioning (i.e. 0% blockage). The modelling results (Cardno 2015) indicated that the flooding within the site was significant although mainly remaining contained within the stockpile area. The modelling also indicated that runoff from the stockpile area overtops the access road near the settling ponds and continues as sheet flow down Bellambi Lane in all of the modelled scenarios.

Cardno (2015) also concluded that the existing stormwater system was adequate for managing flows on site (except for the capacity of the 600 mm clean water pipe), on the basis that the structures were regularly maintained.

Cardno (2015) proposed a series of flood mitigation measures (refer to Section 2.1), however only the proposed culvert and grass lined swale (mitigation Option 1) was modelled. None of the other proposed flood mitigation measures were modelled.

2.3 Cardno Outcomes

The modelling of Option 1 by Cardno (2015) concluded that the proposed culvert and grass lined swale would be effective in eliminating flooding on Bellambi Lane.

No quantitative modelling results were presented in the Cardno report for Option 1 nor for any of the other proposed flood mitigation measures.

3. COUNCIL FLOOD STUDIES

In addition to the Cardno Flood Study (2015) there have been flood studies undertaken in the region and catchment by Council.

The *Combined Catchments of Whartons, Collins and Farrahars Creeks, Bellambi Gully and Bellambi Lake Flood Study* was prepared by Lyall & Associates Consulting Water Engineers in 2010. The Council Flood Study defines the flood behaviour for floods ranging between the 5 year and 500 year Average Recurrence Interval (ARI) and for the Probable Maximum Flood (PMF). The mapped flood levels for the 100 year ARI storm event are included in Appendix B.

The Council Flood Study (Lyall, 2010) documents the modelled flood levels in the reaches of Bellambi Gully between the Princes Highway and Memorial Drive as well as documenting flow rates at the Princes Highway. This data has been used to verify the modelling results from this study (refer to Section 4).

4. HYDROLOGY

Design event hydrology was developed using the XP-STORM modelling package. The Laurenson rainfall runoff routing approach was adopted for the design hydrology.

The following sections detail the development of the XP-STORM model and design rainfall estimates.

4.1 Catchment Delineation and Model Schematisation

Catchment delineation was undertaken manually using geospatial (GIS) software. The following data was used to delineate hydrologic catchments:

- A 1m DEM generated from NSW LPI LiDAR data (2015).
- Site survey data provided by WCL in the form of 1m contour data.
- Stormwater drainage drawings.
- Site observations gathered during site inspections undertaken on 14 February 2018 and 4 April 2018.

The adopted sub-catchment delineation for the study area is shown in Figure 4.1. Impervious and pervious fractions have been identified for each sub-catchment, based on aerial imagery and site inspections. Impervious areas include buildings, roads and hardstand areas. Stockpile and laydown areas consist of coal and gravel materials as well as some grassed areas. Site inspections have identified significant infiltration across stockpile areas which have therefore been classified as pervious. Catchment parameters are summarised in Table 4.1.

Table 4.1 Catchment Summary

Catchment	Area (ha)	Slope (%)	Impervious Fraction (%)
1	9.59	0.34	0
2	9.98	0.36	0
3	5.66	0.20	5
4	2.25	0.14	5
5	3.58	0.15	40
6	1.46	0.18	25
7	8.90	0.15	45
8	2.01	0.10	5

Catchment	Area (ha)	Slope (%)	Impervious Fraction (%)
9	5.93	0.05	5
10	5.89	0.08	5
11	7.79	0.05	15
11a	1.75	0.05	90
12	4.37	0.08	5
13	6.35	0.05	20
14	6.75	0.04	20
15	0.84	0.02	0
16	1.54	0.03	5
17	26.24	0.01	50
18	8.51	0.32	0

Level 2, Suite 5, 19 olton St, Newcastle NSW 2300

www.engeny.com.au

P: 02 4926 1225

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

Figure 4.1 - Hydrologic Model Overview

Job Number: N1800_006
Revision: 2
Drawn: Michael Best
Checked: SS
Date: 17/12/2018

4.2 Runoff Routing

Where runoff hydrographs were required to be routed between sub-catchments, the XP-STORM hydraulic package was utilised. Typical channel cross section shape and slope were sourced from the 1 m NSW LPI LiDAR DEM, and flow was routed using the 'natural channel' link type.

4.3 Model Parameters

4.3.1 Design Losses

The initial and continuing loss rates are based on the Council Flood Study (Lyall, 2010) and are consistent with values recommended by Australian Rainfall & Runoff (AR&R) (IEAust, 1987). Table 4.2 summarises the adopted design loss values.

Table 4.2 Design Losses

Loss Parameter	Design Storms between 20% and 0.2% AEP		PMF	
	Pervious Areas	Impervious Areas	Pervious Areas	Impervious Areas
Initial Loss (mm)	10	2	0	0
Continuing Loss (mm/hr)	2.5	0	2.5	0

4.3.2 Sub-Catchment PERN Value

The Laurenson rainfall runoff routing approach uses a PERN value based on the catchment roughness to modify sub-catchment runoff behaviour. Manning's 'n' roughness values are converted to PERN by the XP-STORM software.

The adopted Manning's 'n' values are summarised in Table 4.3. These values are based on the values adopted in the Council Flood Study (Lyall, 2010) and observations gathered during site inspections.

Table 4.3 Manning's 'n' Values

Element	Manning's 'n'
Pervious Catchment Areas	0.10
Impervious Catchment Areas	0.02

4.4 Design Storm Events

The following sources of design rainfall depths were adopted for this study:

- Point design rainfall depths for events up to 100 year ARI consistent with the principles set out in Chapter 2 of AR&R (IEAust, 1987) were sourced from the Bureau of Meteorology (BoM) website (www.bom.gov.au).
- Point design rainfall depths for the 0.5% and 0.2% AEP events were sourced from Wollongong City Council published data (BMT WBM, 2015).
- PMP rainfall estimates were sourced from the Dambreak and Consequence Category Assessment for the Russell Vale Colliery – Stormwater Control Dam (Hatch, 2014).

Given the relatively small size of the Bellambi Gully catchment being considered, no Areal Reduction Factors (ARFs) were applied to the point rainfall depths.

For ARI events up to and including the 500 year ARI event, Average Variability Method (AVM) temporal patterns consistent with AR&R 87 (IEAust, 1987) were adopted. For the PMP rainfall, the temporal pattern from the Generalised Short Duration Method (GSDM) documentation (BoM, 2003) was adopted.

Storm durations ranging from 30 minutes to 24 hours were simulated in the XP-STORM model to determine critical durations for the study area. The critical duration was determined to be the 2 hour storm for all AEP events up to the PMP. The critical duration for the PMP storm event was found to be 15 min. The adopted design rainfall for each critical storm event are listed in Table 4.4.

Table 4.4 Design Rainfall Intensities

Average Recurrence Interval (ARI)	Average Rainfall Intensity (mm/hr)	Critical Duration (h)
5 year	43.0	2
10 year	50.2	2
100 year	81.5	2
200 year	90.6	2
500 year	104.0	2
PMP	680.0	0.25

4.5 Design Hydrology Results

The modelled hydrographs for each of the inflow locations into the hydraulic model for the 5 year, 10 year and 100 year ARI events are presented in Figure 4.2 to Figure 4.4.

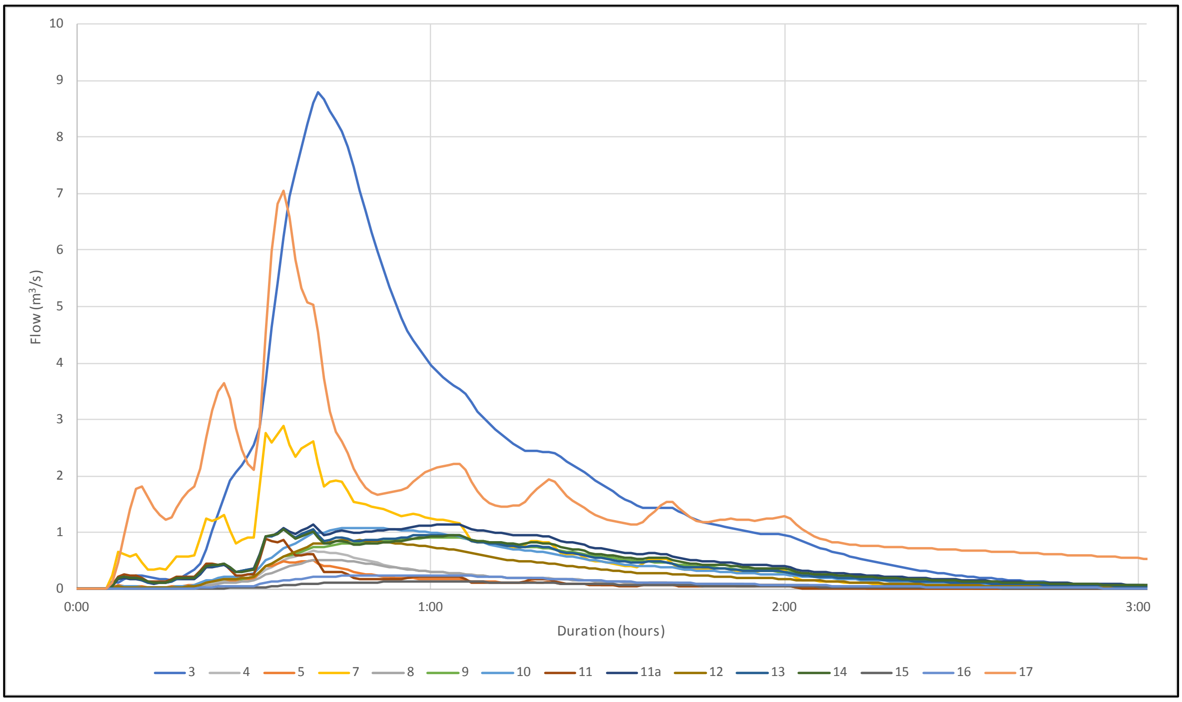


Figure 4.2 5 Year ARI Modelled Inflows

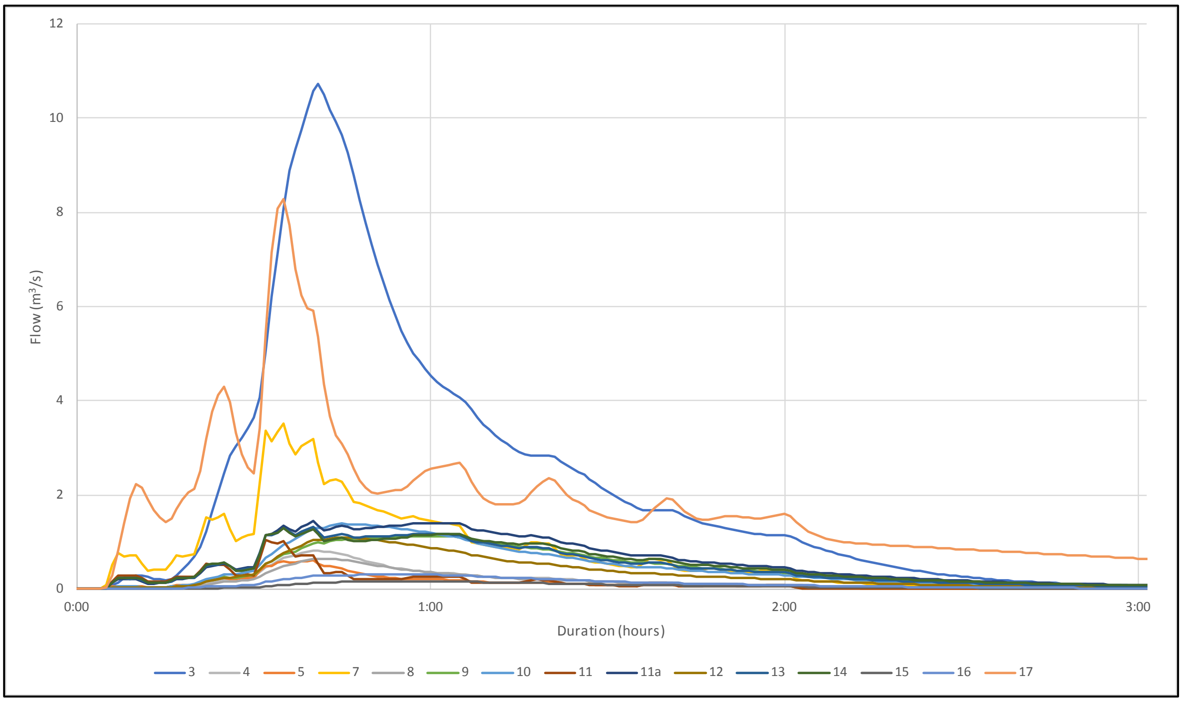


Figure 4.3 10 Year ARI Modelled Inflows

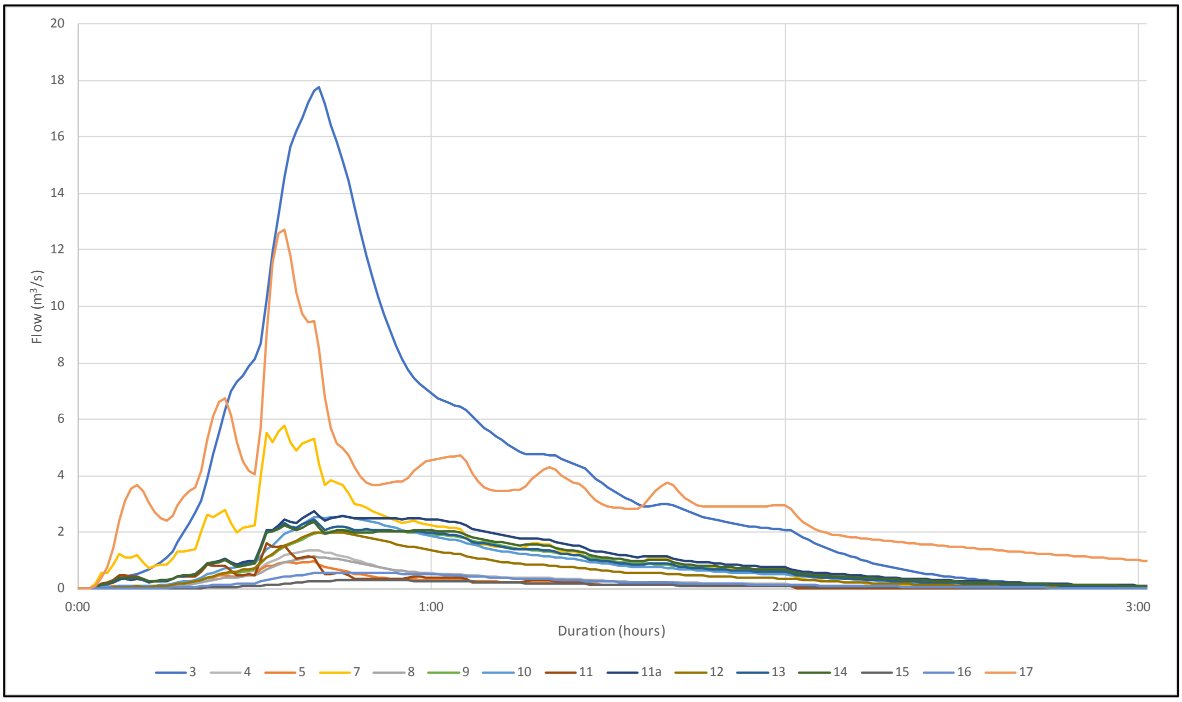


Figure 4.4 100 Year ARI Modelled Inflows

4.6 Design Flow Validation

The peak design flows adopted in this study have been validated to the previously documented design hydrology for the Site. The sources of previous peak design flow estimates that have been used for validation include:

- Peak design flow estimates documented in the 2009 hydrologic investigation undertaken by BECA (BECA, 2009). These flows have been used to validate peak design flows from the upslope catchment areas of U1 & U2 (BECA, 2009) (labelled catchments 1 & 2 for this study) (refer to Appendix A).
- Peak flows documented in the WCL Bellambi Gully Flood Study (Cardno, 2015) were adopted directly from the BECA (2009) report and peak design flows for catchments 1 & 2 in this study have therefore been validated to this study.
- Peak design flow estimates documented in the 2010 Council Flood Study (Lyall, 2010). These flows have been used to validate peak design flood flows at the downstream Site boundary (Princes Highway). Routed flows from the developed TUFLOW model have been used for comparison at this location.

The results of the peak flow comparisons are presented in Table 4.5 and Table 4.6 for the data published in the previous studies. As can be seen, the peak flow estimates adopted in the current study are consistent with previous design flow estimates made for the catchment (refer to Table 4.5).

Flows in the downstream area at the Princes Highway culverts from the TUFLOW model (refer to Section 5) are consistently below the reported flows from the 2010 Council Flood Study (refer to Table 4.6). This is likely due to attenuation through the site and behind the Princes Highway.

Table 4.5 Design Flow Validation Results (U1 & U2 in Appendix A)

Study	5 year ARI	10 year ARI	100 year ARI
BECA (2009)/Cardno (2015)	5.33	6.71	12.05
Current Study	6.16	7.48	12.31

Table 4.6 Design Flow Validation Results– Lyall (2010) (at the Princes Highway)

Study	5 year ARI	10 year ARI	100 year ARI	200 year ARI	500 year ARI	PMF Event
Lyall (2010)	16.3	19.8	33.9	38.8	45.6	86.0
Current Study	10.3	11.9	24.1	28.7	33.6	70.6

5. HYDRAULIC MODELLING

5.1 Approach

Hydraulic modelling was undertaken using the TUFLOW software package. A dynamically-linked 1D/2D model was developed over the Site and downstream reaches of Bellambi Gully. The TUFLOW modelling software is used extensively throughout Australia for similar flood studies.

The following sections provide a summary of key hydraulic modelling input parameters (i.e. drainage assets, 2-D grid size, model extent and surface roughness).

5.2 Model Setup

5.2.1 Topography and Model Extent

The TUFLOW model utilises the 1 m DEM based on NSW LPI LiDAR data captured between 2013 and 2015 and historical survey data provided by WCL. As much of the upper catchment is covered in dense vegetation, resulting in some inconsistencies in the LiDAR and survey data, Engeny has had to make some assumptions on flow paths and drains based on the data provided by site. For the purposes of this study the accuracy of the topography has been deemed to be sufficient.

The hydraulic model extends from upstream of the waterway crossing beneath the coal conveyor to Memorial Drive, approximately 650 m downstream of the Site boundary.

Figure 5.1 provides an overview of the hydraulic model domain.

Level 2, Suite 5, 19 olton St, Newcastle NSW 2300

www.engeny.com.au

P: 02 4926 1225

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

180 0 180 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

Figure 5.1 - Hydraulic Model Overview

Job Number: N1800_006
Revision: 2
Drawn: Michael Best
Checked: SS
Date: 17/12/2018

5.2.2 Grid Size and Timestep

Following an analysis of typical sections of the waterway area within the hydraulic model extent, a 2 m grid cell size was considered appropriate for providing sufficient definition of the waterway in the model. A model time step of 0. 5 seconds was found to provide a stable model configuration for all events.

5.2.3 Model Boundary Conditions

Rainfall runoff flows within the model domain have been applied as ‘flow over area’ boundaries. This type of boundary applies inflows initially in the lowest elevation cell within the catchment and then to all wet cells subsequently.

A fixed level downstream boundary, located immediately upstream of Memorial Drive, was applied to the model. Values for the boundary were sourced from the Council Flood Study (Lyall, 2010).

A sensitivity analysis was conducted on the level at the downstream boundary. A reduction in the fixed level was found to have no significant impact on model results.

5.2.4 Hydraulic Roughness

The hydraulic roughness (Manning’s ‘n’) applied in the TUFLOW model was based on the existing land use conditions obtained from Nearmap aerial photography dated 19-1-2018. Land use types and associated Manning’s ‘n’ values are displayed in Table 5.1.

Table 5.1 Manning’s Roughness

Material	Manning’s n
Low density residential	0.200
High density residential	0.350
Car park/road	0.030
Paddock with high density trees	0.090
Stockpile area	0.040
Moderately vegetated channel	0.045

5.2.5 Channel Representation

Channels within the 2D domain have been accurately captured from the LiDAR data. Based on grid resolution adopted, relative to the channel dimensions, it is considered that this approach is adequate to reasonably represent channel conveyance.

5.2.6 Hydraulic Structures

Culvert data (dimensions and invert levels) for the TUFLOW model were sourced from site survey and the Bellambi Gully Flood Study (Cardno, 2015).

The key Bellambi Gully clean water diversion hydraulic structures and dimensions are identified in Figure 5.1 and discussed in Table 5.2 below.

Table 5.2 Key Clean Water Diversion Structures

Structure	Description
Primary Bellambi Gully Diversion Pipeline (1800 mm diameter)	Collects upstream runoff from and conveys it under the site, discharging into Bellambi Gully, approximately 250 m upstream of the Princes Highway culvert.
Secondary Bellambi Gully Diversion Pipeline (600 mm diameter)	Collects runoff from catchments 6 and 8 and feeds into the 1800 pipe under the site.
Princes Highway Culvert (2.4 m x 1.5 m Box Culvert)	Conveys Bellambi Gully under the Princes Highway.
Primary dirty water pipeline (1000 mm diameter)	Conveys dirty water from sumps to the north of the stockpile area to Dam 1.

Dirty water on site is directed through channels and pipes to Dam 1, Dam 2 and the Stormwater Control Dam. Overflows from Dam 2 are conveyed through a 1050 mm diameter pipe to the Stormwater Control Dam.

5.2.7 Blockage

The blockage assumptions utilised in this study are consistent with the Cardno (2015) study which was accepted by Wollongong Council as appropriate (refer to DPE Addendum Report, 2015). It should be noted that the Wollongong Council Blockage Policy is outlined in the Wollongong Development Control Plan (DCP) dated 2009 (i.e. prior to the Cardno 2015 study).

During 2016 Council undertook a review of the blockage policy. The review proposed a series of changes to the blockage factors to be used for flood assessments. Subsequently an implementation plan for the use of changed blockage factors for flood assessments was submitted for approval at an Ordinary Meeting of Council on 30 May 2016. Council accepted the implementation plan, which included an action to amend the Wollongong DCP 2009, Wollongong LEP 2009, Wollongong LEP 1990 and Wollongong LEP No.38 (1984) as required, to make these documents consistent with the revised blockage policy.

To date, there have been no updates to the DCP which documents the required blockage analysis for developments in the Council area.

This study assesses blockage scenarios in accordance with the methodology put forward in the Bellambi Gully Flood Study (Cardno, 2015) as was accepted by both OEH and Council (refer to Section 1).

This approach, that is, using the Council blockage policy that is currently in place and that was in place in 2015, is considered to be a conservative approach for the study. That is, as the revised blockage policy has reduced blockage scenarios compared to the current blockage policy and the study area is located in the upper reaches of the catchment area the adoption of the 2015 blockage scenarios provides a conservative estimate of the likely impacts associated with MOD4.

The Council blockage policy in place in 2015 allows for consideration of 100% 'design' blockage for pipes and culverts with an opening less than 6 m and 25% 'bottom up' blockage for openings of 6 m or greater. In this study modelling results for existing conditions and proposed scenarios include consideration of 0% blockage, 20% blockage and 100% blockage. Modelling of these blockage scenarios allow comparison of stormwater system performance to be made for a range of blockage conditions including those within the Council blockage policy in place in 2015.

6. EXISTING FLOODING BEHAVIOUR

Flood maps showing the outputs from the flood model are included in Appendix C. The flooding behaviour and flows are described below.

Modelling indicates that clean water flows occur through the stockpile area when the capacity of the 1800 mm pipe is reached or when channels/drains conveying the flows to the inlet of these pipes reach their capacity. In larger events the flows through the site will then break out of the laydown area and split, with a portion flowing down Bellambi Lane, flowing over the Princes Highway and re-joining the channel downstream of the Princes Highway. The remaining flow re-enters the channel upstream of the Princes Highway. When the outlet pipe capacity of Dams 1 and 2 to the Stormwater Control Dam is exceeded both Dams 1 and 2 will fill and overflow to Bellambi Lane and the Princes Highway. These flows are increased during larger storm events by flows from the laydown area flowing into Dams 1 and 2 and Bellambi Lane.

The model also indicates flows down Broker Street and Bellambi Lane from the upslope local catchment and Bellambi Lane. The modelled inundation areas for the 100 year ARI event are consistent with those mapped in the Council Flood Study.

Model results indicate that the Princes Highway overtops in all modelled events. The overland flow along Bellambi Lane is largely responsible for this in smaller events while flows arriving at the culvert via Bellambi Gully also contribute to the overtopping in the 100 year ARI and larger events (refer to Appendix C).

The modelling indicates that the peak flows through the Bellambi Gully Diversion 1800 mm pipe are 15.6 m^3/s and 1.5 m^3/s through the 600 mm pipe during the 100 year ARI event.

A cross check was done for the 1800 mm pipe capacity using HY-8, a hydraulic modelling software package, produced by the US Federal Highway Administration in conjunction with Aquaveo Solutions. Modelling of the 1800 mm diameter pipe in HY-8 indicates that the modelled results from TUFLOW are approaching the peak capacity of the pipe, estimated at 16.6 m^3/s, considering the modelled upstream water levels.

Table 6.1 shows the peak modelled flowrates through the 1800 mm pipe, 600 mm pipe, Princes Highway culvert and over the Princes Highway.

Table 6.1 Modelled Peak Flows

Event	1800 mm Pipe Peak Flow (m^3/s)	600 mm Pipe peak Flow M^3/s	Princes Highway Culvert (m^3/s)	Princes Highway Overflow (m^3/s)
5 year ARI	9.5	1.0	9.9	0.4

Event	1800 mm Pipe Peak Flow (m^3/s)	600 mm Pipe peak Flow M^3/s	Princes Highway Culvert (m^3/s)	Princes Highway Overflow (m^3/s)
10 year ARI	11.8	1.3	11.4	0.6
100 year ARI	15.6	1.5	14.1	10.0
PMF	17.3	1.6	15.5	55.2

6.1 Climate Change and Extreme Event Analysis

The potential impacts of climate change on flood behaviour have been assessed by modelling the 200 year and 500 year ARI events as proxies for climate change. In general, the flood behaviour remains unchanged between the 200 year and 500 year ARI events. Flood extents typically similar for the two events with minor differences (refer to Figure 6.1).

Level 2, Suite 5, 19 olton St, Newcastle NSW 2300

www.engeny.com.au

P: 02 4926 1225

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

60 0 60 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

Figure 6.1 - 200 year and 500 year Modelled Flood Extents

Job Number: N1800_006
Revision: 2
Drawn: Michael Best
Checked: SS
Date: 20/12/2018

6.2 Blockage Analysis

A blockage analysis was undertaken for the 100 year ARI event. Two separate scenarios, consistent with Cardno (2015), were modelled:

1. 20% blockage applied to all 1D elements (i.e. pipes and culverts).
2. 100% blockage applied to all 1D elements (i.e. pipes and culverts).

Table 6.2 summarises the modelled increase of the overland flow through the stockpile / laydown areas and the spill from the site in scenarios with pipe blockage.

Table 6.2 Modelled Peak Flows - Blockage Analysis

Event	1800 mm Pipe Peak Flow (m^3/s)	Flow Through Stockpile Areas (m^3/s)	Bellambi Lane Overflow (m^3/s)	Princes Highway Culvert (m^3/s)	Princes Highway Overflow (m^3/s)
100 Year - Unblocked	15.6	6.1	9.4	14.1	10.0
100 Year - 20% blockage	12.6	9.2	11.4	11.4	13.1
100 Year 100% Blockage	-	22.8	20.1	-	24.5

The blockage analysis indicates that when the upstream pipes and culverts are 20% blocked, there is an increase in clean water flowing through the stockpile and laydown areas and re-joining Bellambi Gully upstream of the Princes Highway culverts.

The full blockage scenario causes a significant increase in flows through the stockpile and laydown areas and subsequent spill into Bellambi Gully. The increase in this volume, along with the blockage applied at the Princes Highway culvert causes 24.5 m^3/s to overflow the Princes Highway. The majority of this overflow will spill into downstream properties before re-entering the channel downstream. Flood depths downstream of the Princes Highway are increased by approximately 0.2 m for 100% blocked conditions compared with unblocked conditions.

7. REVIEW OF CARDNO PROPOSALS

7.1 Cardno Scenarios

The 2015 Cardno Study proposed a series of options to provide water management upgrades at the Russell Vale Colliery surface facilities. Of the proposed water management options there are five distinct options that have the potential to result in changes to flood behaviour and flows. These options are outlined below in Table 7.1.

Table 7.1 Proposed Cardno Solutions

Option	Proposed Cardno Solution	Proposed Cardno Design
1	Raise stockpile area access road, install new culvert and formalise open channel	The access road should be constructed with a low point (sag) to allow for overtopping of flows in excess of the culvert capacity. The culvert connects to the proposed grass-lined swale on the east side of the stockpile area access road before discharging into Bellambi Gully (6m span culvert).
2	Debris control structures at the 1800 mm pipe inlet and the M3 Culvert	Implementing Debris Control Structures (DCS) at the 1800 mm diameter pipe and M3 culvert. Rehabilitation and opening of the M3 culvert (refer to Appendix A).
3A	Formalisation of the 600 mm clean stormwater pipe	Formalising swale of the existing 600 mm clean stormwater pipe to capture all clean water runoff
3B	Upgrade 600 mm clean stormwater pipe	Upgrade to an 825 mm diameter pipe between the pipe inlet and the 1800 mm pipe (to convey flows up to the 100 year ARI storm)
4	Maintenance to existing structures	Maintenance of debris control structures
5	Upgrade through roads	Install culverts across the access road along the northern boundary of the site to direct flows from the catchment M8 directly towards Bellambi Gully (refer to Appendix A).

The Cardno Study (2015) presented modelled results of Option 1, while options 2 through to 5 were recommended to improve system performance but no modelled results were presented. To allow a comparison to the existing study, these options were assessed using the current TUFLOW model for their performance with regards to separation of clean and dirty water as well as downstream flooding impacts. The preferred option was then compared to existing conditions and the proposed suite of mitigation measures described in Section 8.1.

The following combinations of options from Cardno (2015) were modelled to determine the preferred option with consideration of clean and dirty water separation as well as downstream flooding impacts:

- Option 1.
- Option 1 + Option 3A.
- Option 1 + Option 3A and 3B.
- Option 1 + Option 5.

It was considered that Options 2 and 4 are implicitly modelled by considering appropriate blockage scenarios. The potential impacts of blockage are assessed and commented on, for the preferred Cardno option, in Section 9.2.

For each of the above options a dry detention basin, as per Cardno (2015) was included to assist in stormwater management) (refer to Section 7.3).

7.2 Cardno Scenarios Results

The performance of each option was considered for each of the following criteria:

- Peak flows down Broker Street;
- Peak flows down Bellambi Lane;
- Peak flows over the Princes Highway; and
- Peak flows through the stockpile and laydown areas.

The outcomes from the modelling is presented below.

Table 7.2 Peak Flow Comparison (m^3/s) – 100 Year ARI

Location	Existing	Option 1	Option 1 + 3A	Option 1 + 3A + 3B	Option 1 + 5
Broker Street	1.9	1.9	1.9	1.9	0.9
Bellambi Lane[1]	9.4	5.0	5.0	5.0	1.7
Princes Highway Overflows	10.0	10.8	10.9	11.8	11.1
Stockpile and laydown area	6.1	6.1	6.1	6.0	4.6

1. *Flow reported for roadway only (i.e. excludes flow in swale)*

In the comparative review and selection of the preferred option, it was considered that options that worsen flood impacts on public roads or private properties although providing benefits at other locations would not be considered as favourable.

In summary:

- All modelled options show an increase in peak flow over the Princes Highway.
- Option 1 modelling shows a small increase in overtopping of the Princes Highway, which is reflected in a decrease in flows down Bellambi Lane.
- Modelling of the 600 mm clean water pipe (Option 1 + 3A) indicates that the pipe operates at capacity in the 100 year ARI event and, as such, the introduction of the swale in Option 3A has little effect on downstream flooding.
- Modelling of Option 1 + 3A + 3B indicates increased peak flows through the 1800 mm Bellambi Gully Diversion Pipeline. Combined with the swale, the result is an increase in peak flows over the Princes Highway.
- Option 5 reduces peak flows through the properties on Broker street by approximately 1 m^3/s, however, these flows are redirected to the Princes Highway with similar increases to peak flows and associated flood levels over the Princes Highway and at the properties downstream of the Princes Highway.
- Modelling of the above scenarios indicates that there is minimal change to the performance of the dry detention basin in each option. Modelling indicates that the concept design for the dry detention basin described in Cardno (2015) does not meaningfully affect flows either within or downstream of the site. This is largely due the design of the inlet structure and the elevated bund walls resulting in a portion of flows bypassing the basin inlet.

Due to the modelled increases in peak flow at the Princes Highway for options that include 3A, 3B and 5, it is considered that Option 1 would provide the most benefit to downstream flooding, water quality and the retention of dirty water on site. Options 3A, 3B and 5 all serve to accelerate the peak runoff from the clean and dirty water catchments, thus causing an increase in the peak flow overtopping the Princes Highway. As discussed above, it was considered that increasing impacts at the Princes Highway would likely be unacceptable. As such Option 1 has been selected as the preferred Cardno option. Further investigations into refinements to the design of the dry detention basin are discussed in Section 7.3.

7.3 Design of Dry Detention Basin

The dry detention basin referenced in Cardno (2015) was originally proposed in the BECA (2009) report. The BECA dry detention basin formed part of a suite of recommendations, including a clean water diversion, along the southern boundary of the laydown area. The purpose of the dry detention basin was to capture all dirty water runoff that flowed through the stockpile area up to and including the 10 year ARI storm event. The dry detention basin was bounded by the clean water diversion to the south and the existing noise bund to the north.

Subsequent designs of the dry detention basin have relocated the dry detention basin to the south of the noise/visual bunds immediately to the south of Bellambi Lane (Cardno, 2015). The TUFLOW modelling (refer to Section 7.2) indicates that the changes to layout, including removal of the clean water diversion drain, results in dirty water flows bypassing the dry detention basin in this location and spilling towards Bellambi Lane. As such the full storage capacity of the dry detention basin is not used in the 10 year ARI storm event.

It should be noted that the dry detention basin proposed by WCL (refer to Section 8) is located in the easternmost area of the laydown area with regrading of access routes to the west to redirect flows into the dry detention basin.

The Cardno (2015) dry detention basin design has been refined to consider changes to surface levels and flow paths as well as locating the dry detention basin in the laydown area (Option 1A). The dry detention basin includes an overflow channel to the Stormwater Control Dam. The volume of the proposed dry detention basin in the laydown area is also constrained by the depth to the Bellambi Gully Diversion Pipeline and the relocation of the noise bund (as discussed in Option 1 above). Initial investigations indicate that the maximum detention volume used during storm events is ~2.1 ML.

Table 7.3 Peak Flow Comparison (m^3/s) – 100 Year ARI – Existing to Refined Cardno Preferred Option

Location	Existing	Option 1	Option 1A
Broker Street	1.9	1.9	1.9
Bellambi Lane[1]	9.4	5.0	4.2
Princes Highway Overflows	10.0	10.8	7.4
Stockpile and laydown area	6.1	6.1	6.1

1. *Flow reported for roadway only (i.e. excludes flow in swale)*

The modelled results for the refined dry detention basin combined with the Option 1 channel indicates a reduction in peak flow rates overflowing the Princes Highway and flows down Bellambi Lane (refer to Table 7.3). Option 1A (i.e. Option 1 with the refined dry detention basin design) has been used for the comparison to the proposed solution (refer to Section 8.3).

It can be seen in the flood afflux map for the 100 year ARI event (refer to Appendix C), there is a small reduction in modelled flood levels (0.01 - 0.05 m) at the Princes Hwy for Option 1A, whereas the modelling results for the original Cardno Option 1 showed a small increase in overtopping depths at the Princes Highway.

8. PROPOSED FLOOD MANAGEMENT AND MITIGATION MEASURES

8.1 Proposed Management Measures

A series of flood management measures have been designed with the intent to separate the clean and dirty water flows, as well as minimising dirty water from the stockpile and laydown areas from flowing down Bellambi Lane and either re-entering Bellambi Gully or overtopping the Princes Highway. The flood management measures have been designed to cater for clean water separation during the 100 year ARI event with consideration of 20% blockage of the Bellambi Gully Diversion Pipeline (as per Cardno, 2015).

The Council blockage policy in place in 2015 allows for consideration of 100% 'design' blockage for pipes and culverts with an opening less than 6 m and 25% 'bottom up' blockage for openings of 6 m or greater. In this study modelling results for existing conditions and proposed scenarios include consideration of 0% blockage, 20% blockage and 100% blockage. Modelling of these blockage scenarios allow comparison of stormwater system performance to be made for a range of blockage conditions including those within the Council blockage policy in place in 2015.

The proposed measures included in this assessment are shown on Figure 8.1 and include:

1. Construction of a levee upstream of the stockpile area to minimise clean water runoff entering the stockpile and laydown areas from upslope drainage systems and divert these flows to the 1800 mm and 600 mm diameter pipes. This could be achieved by raising the access road or by the construction of a free standing levee in the area between the access road and the existing stockpile area. The levee would need to range between 1 m to 3.5 m above the existing landform to the north and west of the stockpile and 5 m above the existing landform to the south of the stockpile.

2. Extending the noise bund east of the coal loader to the access road (as per the Noise Management Plan).

3. Minor regrading of the laydown area to convey flows to the east and limit spilling to Bellambi Lane. The laydown area east of the current truck wash will be utilised as a dry detention basin with a low flow channel (point 4 below) conveying overflows to the Stormwater Control Dam. The effective capacity of this dry detention basin is 2.1 ML.

4. Construction of a flow channel from the laydown area to the Stormwater Control Dam to act as an outlet from the dry detention basin. The proposed channel would be trapezoidal in shape, follow the existing access track in this area with a base width of 4 m and grading from 39.0 mAHD to 38.0 mAHD before flowing into the Stormwater Control Dam. Batter slopes have been modelled at 1:1.5 (v:h) which is typical of the batter slopes of the existing noise/visual bunding.

100 0 100 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Level 2, Suite 5, 19 olton St, Newcastle NSW 2300

www.engeny.com.au

P: 02 4926 1225

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

Bellambi Gully Flood Assessment

Figure 8.1 – Proposed Flood Management/Mitigation Measures

Job Number: N1800_006
Revision: 2
Drawn: Michael Best
Checked: SS
Date: 17/12/2018

8.2 Modelling Results

Modelling indicates that the construction of the upstream levee will increase the volume of ponding at the inlet into the Bellambi Gully Diversion Pipeline. In larger events this results in an increase in flows through both the 1800 mm and 600 mm pipes and attenuation behind the levee, preventing overland flow across the stockpile and laydown areas for events up to and including the 100 year ARI event. During smaller flood events the modelling indicates that the effect of the upstream berm is minimal as the majority of existing upstream flows during these flood events are conveyed through the Bellambi Gully Diversion Pipe (i.e. overland flow paths occur from local runoff only).

The regrading of the laydown area results in an increase in maximum ponding, with maximum ponded depths reaching approximately 1.3 m during the 100 year ARI event prior to flowing through the flow channel to the Stormwater Control Dam.

Appendix C shows the results for the flood depths and velocities with the proposed flood management measures conditions for the modelled events.

The results of the blockage analysis are discussed in Section 8.2.5.

8.2.1 Upstream Flood Levels at Bellambi Gully Diversion Pipe Inlets

The upstream levee allows for increased ponding at the inlet to the 1800 mm pipeline (south of the stockpile) and adjacent to the inlet to the 600 mm pipeline (north and east of the stockpile). Modelled peak water levels in these areas indicate maximum ponding depths of 2.15 m and 1.5 m respectively during the 100 year ARI event.

The detention of overland flows behind the upstream levee results in a reduction in peak 100 year ARI flows through the stockpile areas from 6.1 m3/s to 3.5 m3/s, with no clean water runoff from the upslope catchment areas flowing through the stockpile area (refer to Figure 8.2). Flows through the stockpile are from local runoff only.

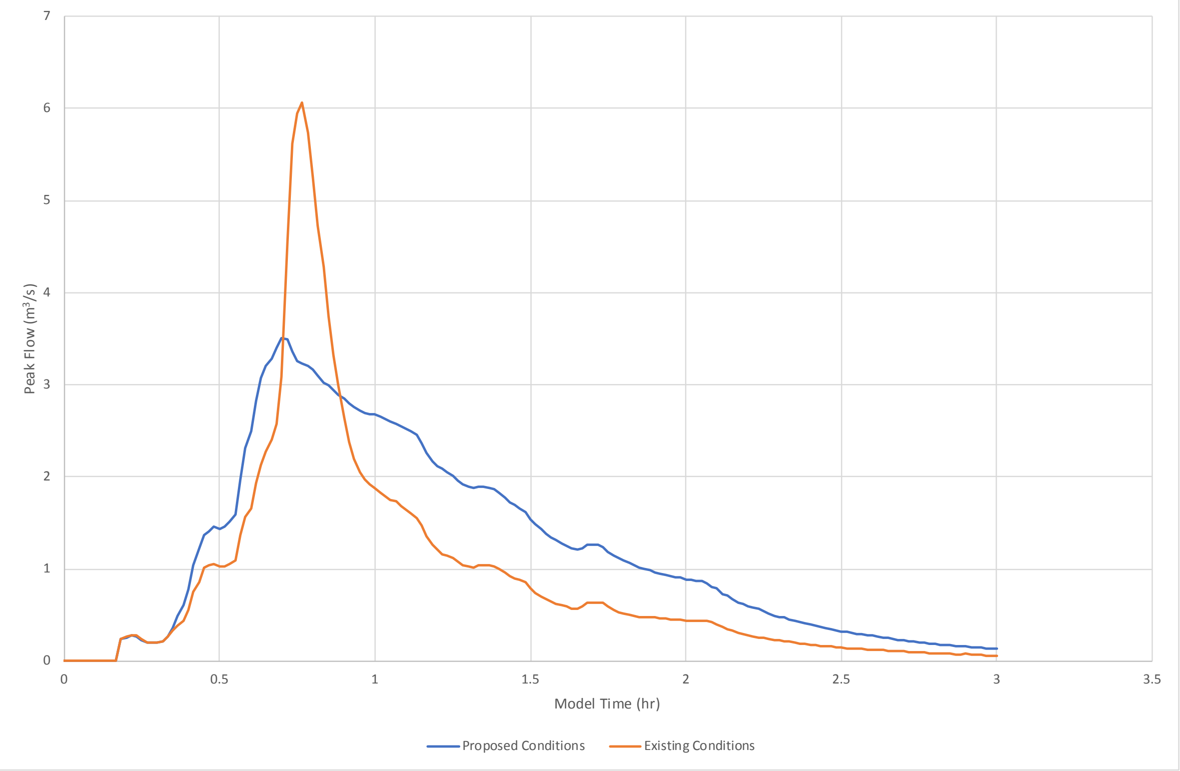


Figure 8.2 Stockpile Areas – Modelled Peak Flows - 100 Year ARI Event

8.2.2 Peak Flows through Bellambi Gully Diversion Pipe

The modelled increase in water level behind the levee results in an increase of approximately 2.5 m3/s in flowrate and 1.0 m/s for velocity during the 100 year ARI event through the Bellambi Gully Diversion Pipeline. Figure 8.3 shows the hydrograph through the 1800 mm pipeline for the 100 year ARI event. The peak modelled velocity through the 1800 mm pipeline increases from 6.1 m/s to 7.1 m/s during the 100 year ARI event. An analysis of Bellambi Gully downstream of the diversion pipe indicates that there is a negligible change to velocities in the 5 year and 10 year ARI events. The 100 year ARI event sees minor increase in velocities immediately downstream of the diversion pipe. These velocities range between 1 m/s and 2.6 m/s, the proposed conditions see a maximum increase of less than 0.15 m/s during the lower velocity periods (i.e. the maximum velocity remains at 2.6 m/s).

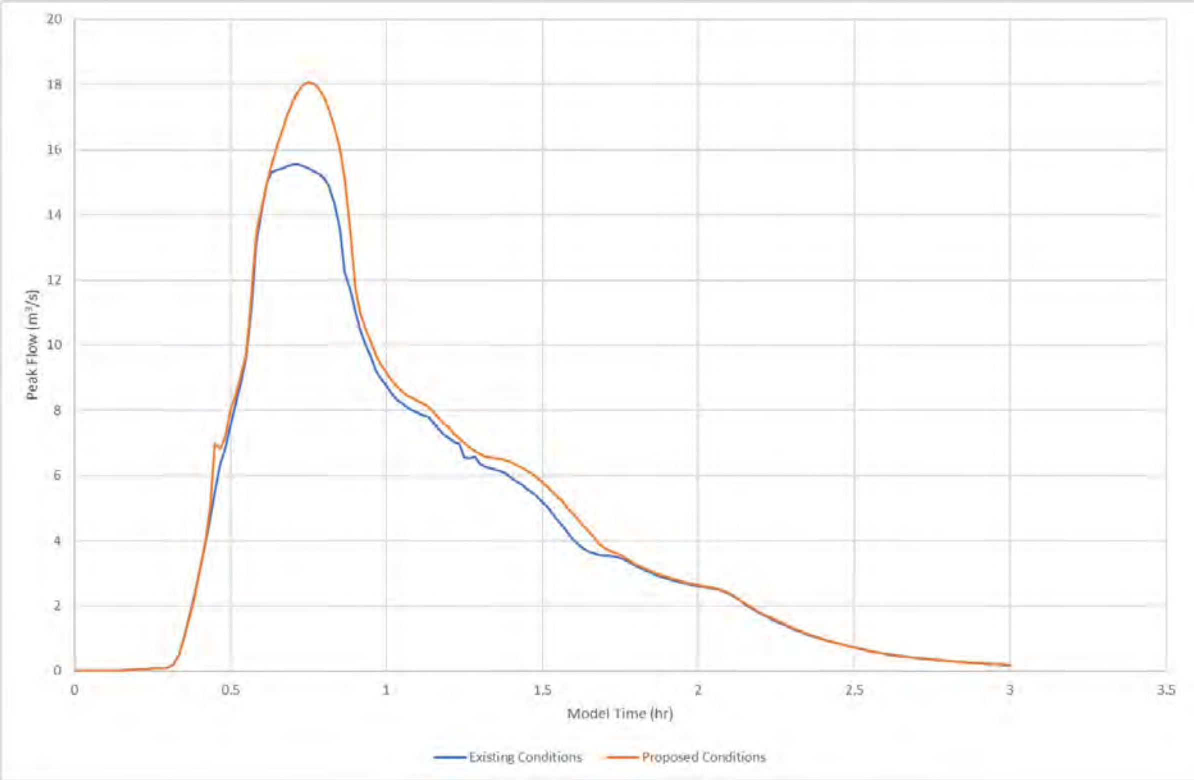


Figure 8.3 Bellambi Gully Diversion Pipe – Modelled Peak Flows 100 year ARI Event

The increased detention and retainment of flows through the stockpile and laydown areas results in a modelled decrease of flows over the Princes Highway by 3.6 m3/s in the 100 year ARI event from 10.0 m3/s to 6.4 m3/s. The modelling also indicates reductions of flows over the Princes Highway during the 5 year and 10 year ARI events.

The detention of water behind the upstream levee results in a modelled increase in peak flows through the Bellambi Gully Diversion Pipeline. Conversely the flows through the stockpile and laydown area from local runoff are reduced with detention in the laydown area and the reduction of flows down Bellambi Lane. The overall effect is a modelled slight decrease in peak flood levels upstream of the Princes Highway and a reduction in overflows at the Princes Highway (refer to Table 8.1).

The modelled peak flows for the existing conditions and with the flood measures are summarised in Table 8.1.

Table 8.1 Peak Flow Comparison

	1800 mm Pipe Peak Flow (m^3/s)		Princes Highway Culvert (m^3/s)		Princes Highway Overflow (m^3/s)	
Event	Existing	Proposed	Existing	Proposed	Existing	Proposed
5 year ARI	9.5	9.7	9.9	10.0	0.4	0.1
10 year ARI	11.8	12.0	11.4	11.3	0.6	0.3
100 year ARI	15.6	18.1	14.1	13.9	10.0	6.4

Due to increased detention capacity, the flood management measures see a reduction in peak flowrates at the Princes Highway (i.e. flows through the culverts and overtopping of the highway) from 24.1 m3/s to 20.3 m3/s.

8.2.3 Flood Levels at the Princes Highway

Modelled peak flood levels at the Princes Highway are reduced by up to 40 mm during the 10 year and 100 year ARI events and 20 mm during the 5 year ARI event.

In all events the volume of water flowing to Bellambi Lane from the stockpile and laydown areas is reduced, resulting in an increase of runoff volumes flowing through the site water management controls (i.e. Dams 1 and 2 and the Stormwater Control Dam).

The modelled reduction in peak flows and water levels down Bellambi Lane and across the Princes Highway will see an improvement in access to the site during flooding events.

8.2.4 Impacts on Downstream Properties

As seen in the results presented in Appendix C there is a modelled minor decrease in flood levels – typically around 40 mm in the 100 year ARI event and between 10 mm and 20 mm in the 10 year ARI event - downstream of the Princes Highway. This reduction in peak flood levels and associated extents is due to the increased detention of overland flows in the eastern laydown area and the detention of water behind the upstream berm.

Modelling indicates that there are negligible impacts to downstream properties in the 5 year ARI event.

Modelling also indicates that the peak flood levels in the Stormwater Control Dam are 32.2 mAHD for the existing scenario and 32.3 mAHD with the proposed flood management measures. The embankment of the Stormwater Control Dam is at 33.5 mAHD. The dam was modelled with an initial water level of 30.7 mAHD which is based on typical operating levels. As such a freeboard remains in the Stormwater Control Dam of 1.2 m.

The closest private properties to the Stormwater Control Dam are located to the south on Midgley Street. The lowest point of these properties is located at approximately 3 metres higher than the modelled 100 year ARI event peak flood level in the Stormwater Control Dam. As such there will be no impact on flood levels on the properties to the south of the Stormwater Control Dam.

There is no change to overland flow from runoff and street drainage through the low point of the properties on Broker Lane with the proposed flood management measures.

8.2.5 Blockage Analysis

Applying a blockage factor to pipes sees more water detained behind the upstream levee and in the eastern laydown area. Flood levels upstream of the levee increase from 70.0 mAHD to 70.6 mAHD in the north and east, and from 68.2 mAHD to 70.0 mAHD in the south with 20% pipe blockage. In the 100% blocked scenario, this increases to 71.3 mAHD in the north and east and 71.2 mAHD in the south. The levee is overtopped at both locations in the 100% blocked scenario.

Table 8.2 shows the comparison of flows for existing and proposed conditions for each modelled blockage scenario.

Table 8.2 Blockage Analysis of Proposed Conditions

Event	Flow Through Stockpile Areas (m^3/s)		Bellambi Lane Overflow (m^3/s)		Princes Highway Overflow (m^3/s)	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
100 Year - Unblocked	6.1	3.5	9.4	4.0	10.0	6.4
100 Year - 20% Blockage	9.2	3.5	11.4	4.2	13.1	9.5
100 Year 100% Blockage	22.8	22.2	20.1	11.8	24.5	16.9

Increased storage detention at the upstream levee and in the eastern laydown area results in lower overflows rates at Bellambi Lane and the Princes Highway. Full blockage of the 1800 mm diversion pipe for the existing conditions results in up to 22.8 m3/s flow through stockpile areas while in the proposed scenario this flow is reduced to 22.2 m3/s. Overflows at the Princes Highway are also reduced in both blockage scenarios when compared to existing conditions, from 13.1 m3/s to 9.5 m3/s with 20% blockage and 24.5 m3/s to 16.9 m3/s with 100% blockage.

The primary factor driving the reduction in overflows at Bellambi Lane and the Princes Highway is the extended detention of flows behind the upstream levee and within the eastern laydown area. This effectively reduces the peak flow arriving at the Princes Highway and subsequent overtopping flow rates and associated flood depths.

8.2.6 Water Quality Assessment

Historical flood events which have resulted in partial blockage of the Bellambi Gully Diversion Pipeline, have also had a consequence on water quality leaving the site. This has primarily been a result of flood flows and local runoff in the stockpile areas leaving the site with minimal treatment.

It should be noted that measures to address turbid water ingress to the Bellambi Gully Diversion Pipeline from seepage/groundwater inflows is addressed in a separate report – "Bellambi Gully Diversion Pipeline Review" dated December 2018.

The proposed flood mitigation measures include various methods to improve water quality leaving the site during flood events. These include: the upstream levee; debris control structures at the major pipe inlets; and conveyance of site flows, where possible, through the Stormwater Control Dam.

The modelling indicates that the proposed solution will reduce peak flows through the stockpile area during the 100 year ARI storm event, even with 100% pipe blockage (refer to Table 8.2), primarily by the separation of clean water (i.e. additional conveyance of flows to the Bellambi Gully Diversion Pipeline by utilising detention behind the proposed levee). In addition, the construction of debris control structures should significantly reduce the risk of 100% blockage. The modelled peak flow rates for the 20% blockage scenario with the 100 year ARI storm event results in flow rates reducing by over 60% (i.e. 9.2 m^3/s to 3.5 m^3/s) through the stockpile area. The result of lower peak flows through the stockpile area will reduce associated erosion potential and sediment transport.

The modelling also indicates significant additional detention of flows within the site. This is apparent by the reduction in modelled peak flow rates at both Bellambi Lane and the Princes Highway culverts. Additional containment / retention of flows within the water management system during flood events has the potential to provide additional sediment capture.

8.3 Comparison to Cardno Solution

8.3.1 Peak Flow Rates

The preferred Cardno option modelling results show flows down Bellambi Lane and dirty water not captured by the water management system redirected into the proposed swale.

The modelling also shows an improvement in peak flows downstream of the site with the refinement of the design of the dry detention basin (refer to Section 7.3).

There is no change to flow rates through the 1800 mm diversion pipeline from existing conditions for the preferred Cardno option. The modelling results indicate that the proposed solution provides better outcomes in regards to reducing peak flows downstream of the site when compared to the preferred Cardno option.

Table 8.3 Peak Flow Comparison

	1800 mm Pipe Peak Flow (m^3/s)			Princes Highway Culvert (m^3/s)			Princes Highway Overflow (m^3/s)		
Event	Existing	Cardno Proposed	Proposed	Existing	Cardno Proposed	Proposed	Existing	Cardno Proposed	Proposed
10 year ARI	11.8	11.8	12.0	11.4	11.5	11.3	0.6	0.4	0.3
100 year ARI	15.6	15.6	18.1	14.1	13.9	13.9	10.0	7.4	6.4

8.3.2 Comparison of Flood Levels

Modelling indicates that the preferred Cardno option does not result a change to flood behaviour in the upstream areas of the site. As a result, there is no change to flood levels at the inlet to the Bellambi Gully Diversion Pipeline.

There are no changes to flows in the Broker Street area with the preferred Cardno option. As indicated above there is a slight decrease to flood levels along Bellambi Lane, downstream of the Princes Highway - between 0.01 and 0.02 m - however this is offset by an increase to levels downstream of the Bellambi Gully culverts of approximately 0.02 m.

Table 8.4 Flood Level Comparison

	Upstream of Bellambi Gully Diversion (mAHD)			Princes Highway at Bellambi Gully Culvert (mAHD)			Princes Highway at Bellambi Lane (mAHD)		
Event	Existing	Cardno Proposed	Proposed	Existing	Cardno Proposed	Proposed	Existing	Cardno Proposed	Proposed
10 year ARI	64.294	64.294	64.348	25.562	25.563	25.548	27.092	27.082	27.080
100 year ARI	66.450	66.450	68.209	25.818	25.835	25.775	27.114	27.099	27.096

Modelling results indicate that the proposed solution provides better outcomes in regards to minor reductions in peak flood levels downstream of the site when compared to the preferred Cardno option.

Appendix C contains flood afflux maps for each modelled option versus current conditions.

8.3.3 Blockage Analysis

The Cardno report adopted the Wollongong Council blockage policy. That is, culverts with a diagonal cross section less than 6 m are considered to be fully blocked.

As per section 8.2.5, two blockage scenarios were analysed:

1. A 20% blockage applied to all pipes with a cross sectional diameter less than 6 m; and

2. A 100% blockage applied to all pipes with a cross sectional diameter less than 6 m.

Table 8.5 shows the comparison of flows for each modelled blockage scenario.

Table 8.5 Blockage Analysis Comparison – 100 Year ARI

Event	Flow Through Stockpile Areas (m^3/s)			Bellambi Lane Overflow (m^3/s)			Princes Highway Overflow (m^3/s)		
	Existing	Cardno Proposed	Proposed	Existing	Cardno Proposed	Proposed	Existing	Cardno Proposed	Proposed
Unblocked	6.1	6.1	3.5	9.4	4.2	4.0	10.0	7.4	6.4
20% blockage	9.2	9.3	3.5	11.4	4.9	4.2	13.1	10.7	9.5
100% blockage	22.8	22.8	22.2	20.1	7.3	11.8	24.5	19.0	16.9

Applying a blockage to modelled pipes tends to result in an increase in flows crossing the Princes Highway. Where the proposed option discussed in Section 8.1 indicates an increase in flood levels behind the upstream levee, this is not observed in the modelling of the preferred Cardno option. This is due to there being no net increase to upstream storage. That is, the preferred Cardno option, has less flood detention that the proposed option.

9. SUMMARY AND CONCLUSIONS

9.1 Proposed Management Measures

The proposed site water management strategy for Bellambi Gully is as follows (refer to Figure 8.1):

- Separation of clean and dirty water systems:
  - Construct upstream levee to detain and divert upslope catchment runoff through the Bellambi Gully Diversion Pipeline.
  - Construct self-cleaning debris control structures at the inlets to both the 1800 mm and 600 mm pipes.
- Control of flows through dirty water areas:
  - Regrade eastern laydown area to form a dry detention basin. This basin will enable management of runoff within the laydown areas and minimise spills to Bellambi Lane. The basin would have an effective capacity in the order of 2.1 ML. The detailed design of the dry detention basin should consider the refinements made to the design of the Cardno dry detention basin (refer to Section 7.3).
  - Construct channel from laydown area to Stormwater Control Dam to manage and divert flows in excess of the capacity of Dam 1 and Dam 2 and the new dry detention basin in the laydown area to the Stormwater Control Dam.
- Maintenance
  - The above structures and existing controls will be included on regular maintenance schedules.

The above measures will be included in the Russell Vale Surface Facilities Water Management Plan following approval of the Modification.

It should be noted in addition to the measures proposed above, Cardno (2015) indicated that upgrades should be undertaken to the 600 mm diversion pipe. It is considered that the current modelling, which considers flow paths and the detention behind the upstream levee in more detail, is more accurate than the previous study. The outcomes of the current modelling do not indicate that the 600 mm pipe needs to be upgraded.

In addition, Cardno (2015), proposed an upgrade of road drainage along Bellambi Lane, including the installation of a 6 m span culvert to convey site runoff across the access road. The current modelling, as discussed above, does not indicate that these measures are required as the flows down Bellambi Lane do not typically flow into the dirty water systems and will increase flood impacts at the Princes Highway.

The flood modelling indicates that the proposed flood management measures will have negligible impacts on downstream properties or Bellambi Gully. In addition, the modelling indicates that the proposed flood measures will improve flood access along the Princes Highway and Bellambi Lane during the 100 year ARI event. The modelling also indicates that the changes to flow regimes within the site, associated with improved clean and dirty water separation, as well as construction of the dry detention basin and increased flow conveyance via the Stormwater Control Dam, is expected result in improvements in water quality leaving the site during flood events.

As discussed in Section 8.2.6, measures to address the potential ingress of turbid stormwater to the Bellambi Gully Diversion Pipeline from seepage/groundwater inflows is addressed in a separate report – "Bellambi Gully Diversion Pipeline Review" dated December 2018.

9.2 OEH Recommendations, Approach and Outcomes

A summary of the OEH recommendations and associated responses are included in Table 9.1.

Table 9.1 OEH Recommendations, Approach and Outcomes

OEH Recommendations	Response
Detailed survey to be undertaken, and modelling updated to reflect current site conditions.	NSW Government LiDAR survey of the site dated April 2013, pipeline survey (as used by Cardno) and 2017 site supplied survey information was be used in the analysis, as well as recent aerial photographs.
Flow paths upstream of the hydraulic modelling extent to be confirmed through simulation of a direct rainfall model for the catchment.	The modelling context is shown in Figure 1.1. The upper catchment areas, i.e. where it was considered that a direct rainfall model would not add much to the level of analysis due to the limited survey data, steep slopes and dense vegetation, were modelled in a hydrology model. The breakup of the catchments within the hydrology modelled were informed by LiDAR data, site inspections and the BECA (2009) assessment. The hydrology model was used to provide inflows into the hydraulic model. A two dimensional hydraulic model was used, which was extended to consider areas where multiple flow paths could occur.
Relevant local flood related development controls and best available flood information held by Council to be incorporated into the assessment.	There is one existing flood study for the catchment area held by Council: *Combined Catchments of Whartons, Collins and Farrahars Creeks, Bellambi Gully and Bellambi Lake Flood Study,* 2010, Lyall & Associates Consulting Water Engineers (i.e. Council approved flood study). Data from the Council study has been used and referenced in the assessment. Engeny met with Council to discuss the study and confirm that this was the latest flood modelling data relevant for the catchment area.

OEH Recommendations	Response
Off-site flood impacts including those associated with any flow diversions be assessed and strategies to off-set these impacts be identified and incorporated into any future approval.	The modelling indicates that the proposed flood management measures will produce no adverse impacts off-site.
Mitigation measures be reviewed with consideration of updated survey, modelling and blockage assumptions.	The flood modelling is based on updated survey as referenced in earlier sections of this report. The blockage assumptions utilised are consistent with the Cardno (2015) study which was accepted by Wollongong Council as appropriate (refer to DPE Addendum Report, 2015). As discussed, the blockage analysis has been undertaken as per the Cardno (2015) study and the current Council DCP (dated 2009). The blockage analysis is considered to be a conservative assessment of blockage impacts as contains the worst case scenario of full (100%) blockage for a watercourse in the upper reaches of the catchment.
The report scope be extended to include consideration of the water quality measures proposed in the BECA 2009 report.	The modelling indicates that clean water and dirty water separation and management will be improved with the proposed flood measures. The reduction of flows of upslope clean water through the dirty water management system and provision of additional settling areas and flow management controls will assist in reducing dirty water discharges from the site and improvement to downstream water quality during flood events.
There is a clear strategy to manage downstream flood and water quality impacts from the site.	The strategy to manage downstream flood and water quality impacts from the site is discussed in Sections 8 and 9 of this report and includes a range of measures to relating to separation of clean and dirty water systems, maintenance of flows and management of flow paths, as well as water quality devices. The proposed strategy has been developed based on the original work by BECA (2009) and Cardno (2015) and provides an integrated site water management strategy for Bellambi Gully.

10. QUALIFICATIONS

- In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

- Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

- Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

  (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

  (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

- Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

- This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report.

- If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

- This report does not provide legal advice.

11. REFERENCES

BECA, 2009. *Gujarat NRE Stormwater Hydrology Review, Edited for Part3A submission*.

BMT WBM, 2015. *Review of Towradgi Creek Flood Study – Final Report*.

Bureau of Meteorology, 2003. *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*.

Cardno, 2015. *Bellambi Gully Flood Study Report*.

Engeny Water Management, 2018. *Bellambi Gully Pipeline Diversion Review*, prepared for Wollongong Coal Ltd.

Hatch, 2014. *Dambreak and Consequence Category Assessment for the Russell Vale Colliery – Stormwater Control Dam*.

IEAUST, 1987, *Australian Rainfall and Runoff*.

Lyall & Associates Consulting Water Engineers 2010. *Combined Catchments of Whartons, Collins and Farrahars Creeks, Bellambi Gully and Bellambi Lake Flood Study*.

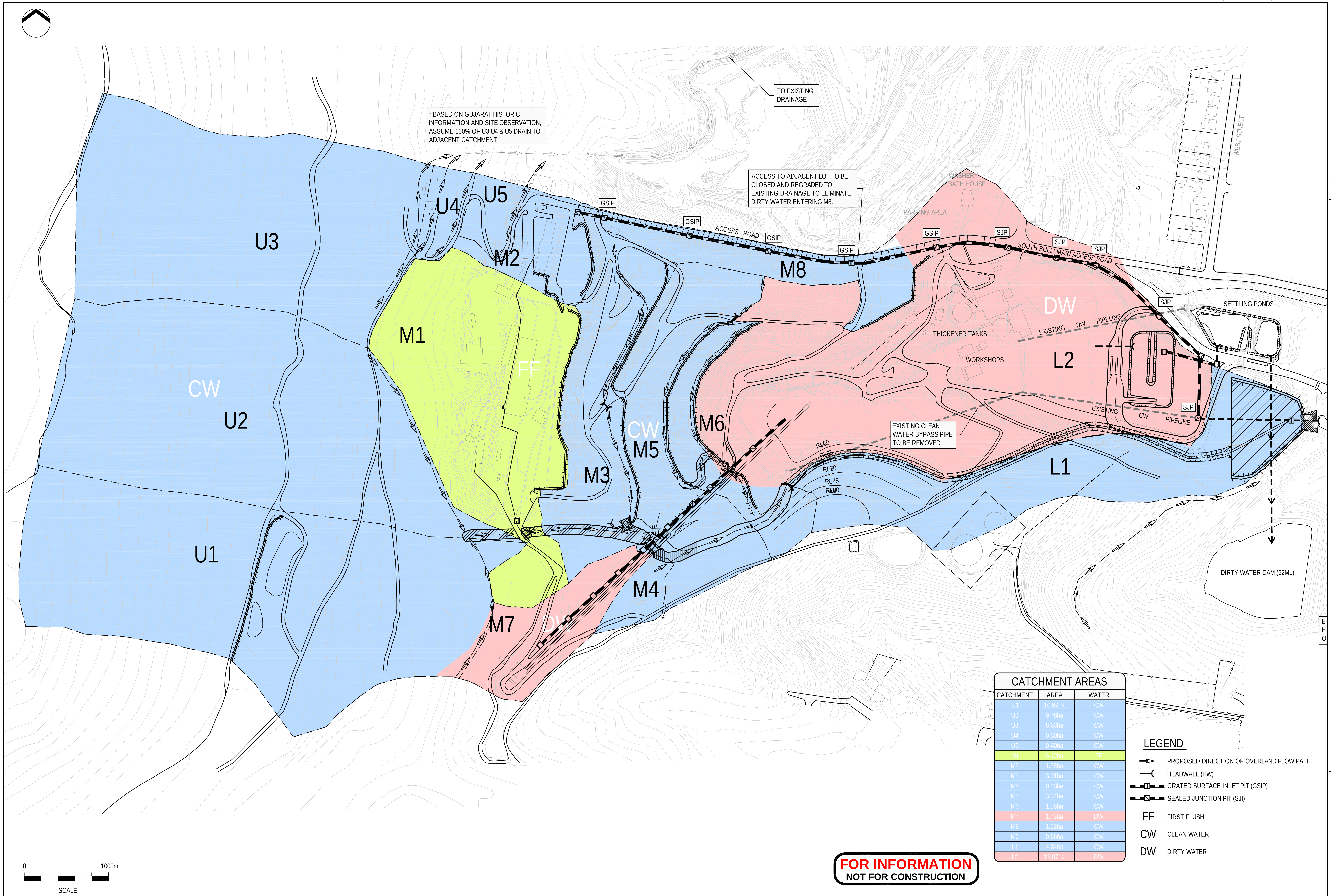
NSW Government, 2005. *NSW Floodplain Development Manual.*

Umwelt (Australia) Pty Limited, 2018. *Section 75W Modification to Project Approval MP10_0046 – Russell Vale Colliery Preliminary Works Project*.

APPENDIX A

Cardno (2015) Catchments and Proposed Mitigation Measures

Drawing Plotted: 04 May 2010 13:51



CATCHMENT AREAS

CATCHMENT	AREA	WATER
U1	10.69ha	CW
U2	9.76ha	CW
U3	8.63ha	CW
U4	0.50ha	CW
U5	0.40ha	CW
M1	6.12ha	FF
M2	1.28ha	CW
M3	3.31ha	CW
M4	0.43ha	CW
M5	3.34ha	CW
M6	1.36ha	CW
M7	1.73ha	DW
M8	1.12ha	CW
M9	0.66ha	CW
L1	4.84ha	CW
L2	12.07ha	DW

LEGEND

- PROPOSED DIRECTION OF OVERLAND FLOW PATH
- HEADWALL (HW)
- GRATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)
- FF FIRST FLUSH
- CW CLEAN WATER
- DW DIRTY WATER

FOR INFORMATION
NOT FOR CONSTRUCTION

www.beca.com

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:2000
Reduced Scale (A3) 1:4000

Design	PI	23/7/09
Drawn	SK	23/7/09
Dsg Verifier	SM	29/9/09
Dwg Check		Date

Approved For Construction*
* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT CLEAN/DIRTY WATER REGIONS

Discipline: CIVIL

Drawing No. 2591308-C-SK7 Rev. B

Document No. 2591308-C-SK7.dwg

DO NOT SCALE

IF IN DOUBT ASK.

WOLLONGONG COAL

Proposed Flood Mitigation

BELLAMBI GULLY FLOOD STUDY

1:3,000 Scale at A3

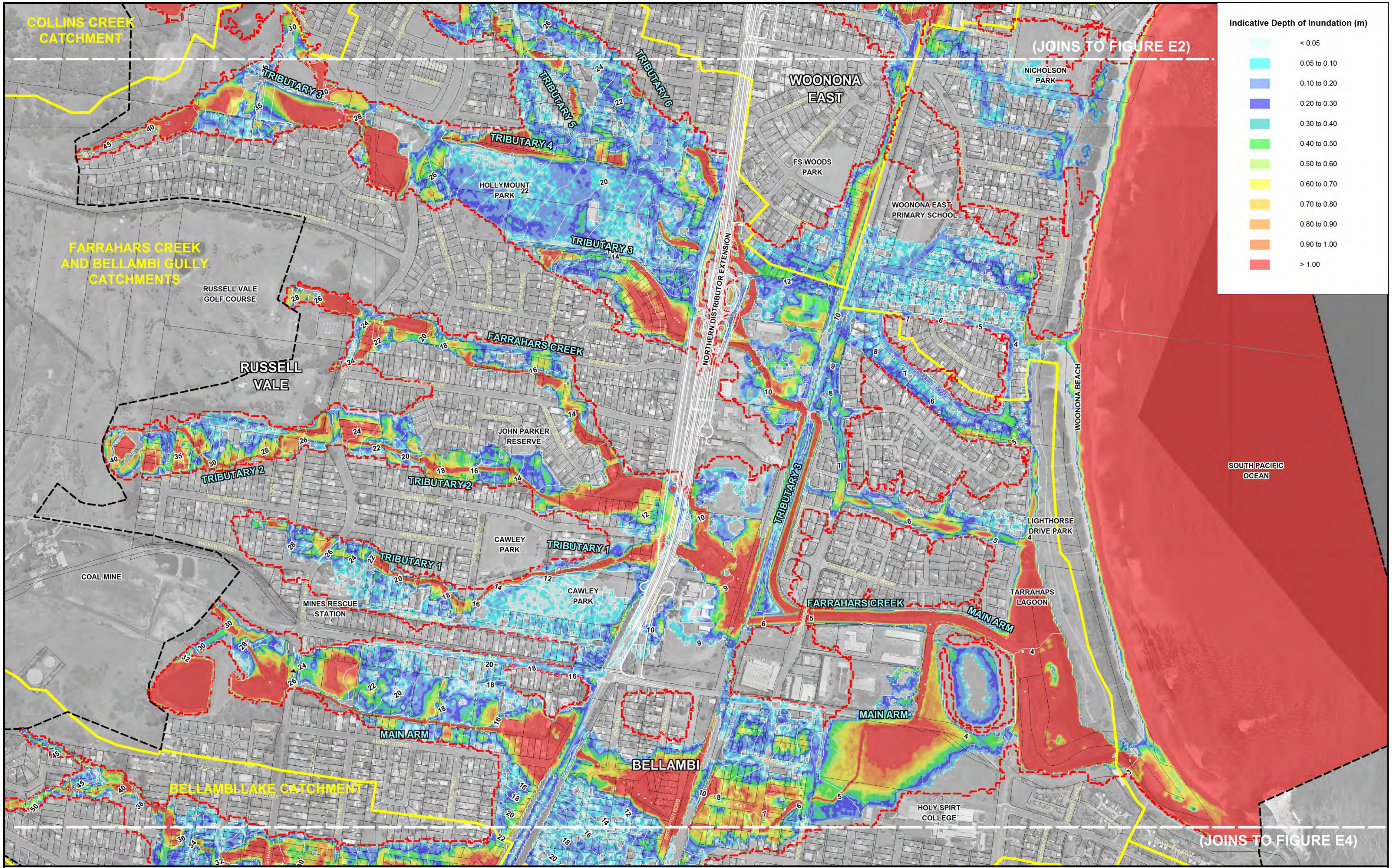
Metres: 0, 50, 100, 150, 200

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2014-07-01
Coordinate System: GDA 1994 MGA Zone 56
Project: 82014089-01
Map: G1004_ProposedFloodMitigation.mxd 02
Aerial imagery supplied by nearmap (July 2013)

APPENDIX B

Council Flood Study Modelled Flood Levels



N

Scale: 1:8,000 @ A3

100 0 100 200 300m

Metres

NOTE ON HYDRAULIC MODEL RESULTS:

THE GROUND SURFACE MODEL INCORPORATED IN THE HYDRAULIC MODEL IS BASED ON AIRBORNE LASER SCANNING SURVEY WHICH HAS BEEN SAMPLED ON A 5m GRID AND DOES NOT NECESSARILY INCORPORATE LOCALISED FEATURES WHICH CAN INFLUENCE FLOODING BEHAVIOUR IN INDIVIDUAL ALLOTMENTS.

FLOOD LEVELS, DEPTHS AND VELOCITIES ARE THEREFORE APPROXIMATE ONLY AND REQUIRE INTERPRETATION BY A SUITABLY QUALIFIED ENGINEER TO DETERMINE FLOODING BEHAVIOUR IN INDIVIDUAL ALLOTMENTS. ANY ASSESSMENT OF FLOODING IN INDIVIDUAL ALLOTMENTS MAY ALSO REQUIRE A SITE SURVEY.

LEGEND

Extent of Hydraulic Model

Extent of Flood Prone Land

22 Water Surface Level Contour (m AHD)

WHARTONS, COLLINS AND FARRAHARS CREEK, BELLAMBI GULLY AND BELLAMBI LAKE FLOOD STUDY

Figure E3

HYDRAULIC MODEL RESULTS - 1 IN 100 YEAR FLOOD FARRAHARS CREEK AND BELLAMBI GULLY CATCHMENTS

APPENDIX C

Hydraulic Model Results

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

5 Year ARI Flood Event
Maximum Modelled Flood Depth
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

10 Year ARI Flood Event
Maximum Modelled Flood Depth
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
20% Blockage- Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
100% Blockage- Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

200 Year ARI Flood Event
Maximum Modelled Flood Depth
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

500 Year ARI Flood Event
Maximum Modelled Flood Depth
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300

PO Box 787 Newcastle NSW 2300

www.engeny.com.au

P: 02 4926 1225

F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

PMF Year ARI Flood Event
Maximum Modelled Flood Depth
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
Cardno Preferred Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

5 Year ARI Flood Event
Maximum Modelled Flood Depth
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

10 Year ARI Flood Event
Maximum Modelled Flood Depth
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
20% Blockage- Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Depth
100% Blockage- Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

5 Year ARI Flood Event
Maximum Modelled Flood Velocity
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

10 Year ARI Flood Event
Maximum Modelled Flood Velocity
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
20% Blockage- Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
100% Blockage- Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

200 Year ARI Flood Event
Maximum Modelled Flood Velocity
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

500 Year ARI Flood Event
Maximum Modelled Flood Velocity
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300

PO Box 787 Newcastle NSW 2300

www.engeny.com.au

P: 02 4926 1225

F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

PMF Year ARI Flood Event
Maximum Modelled Flood Velocity
Existing Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
Cardno Preferred Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

5 Year ARI Flood Event
Maximum Modelled Flood Velocity
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

10 Year ARI Flood Event
Maximum Modelled Flood Velocity
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
20% Blockage- Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

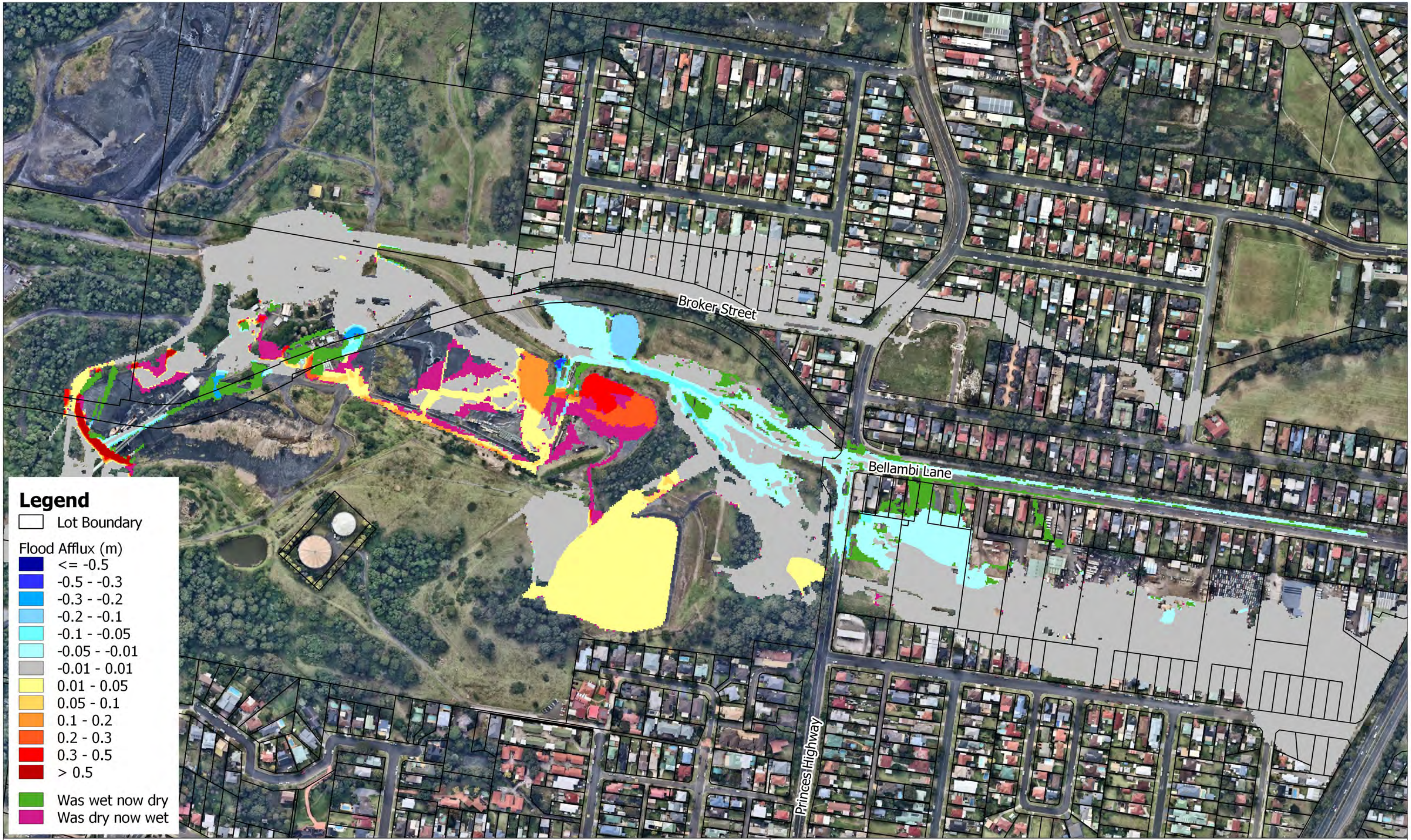
Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Maximum Modelled Flood Velocity
100% Blockage- Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018



Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

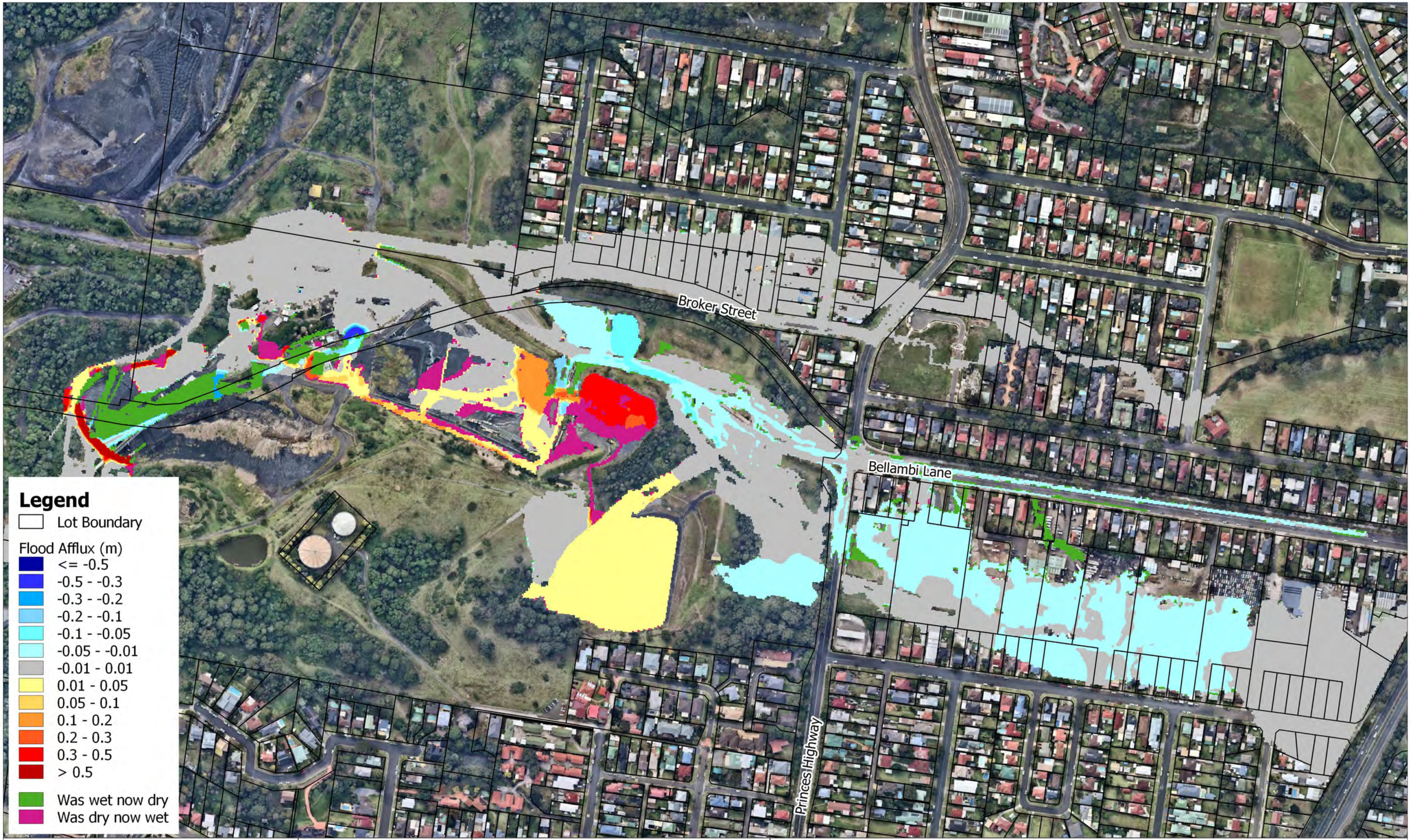
Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

5 Year ARI Flood Event
Flood Afflux
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018



Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

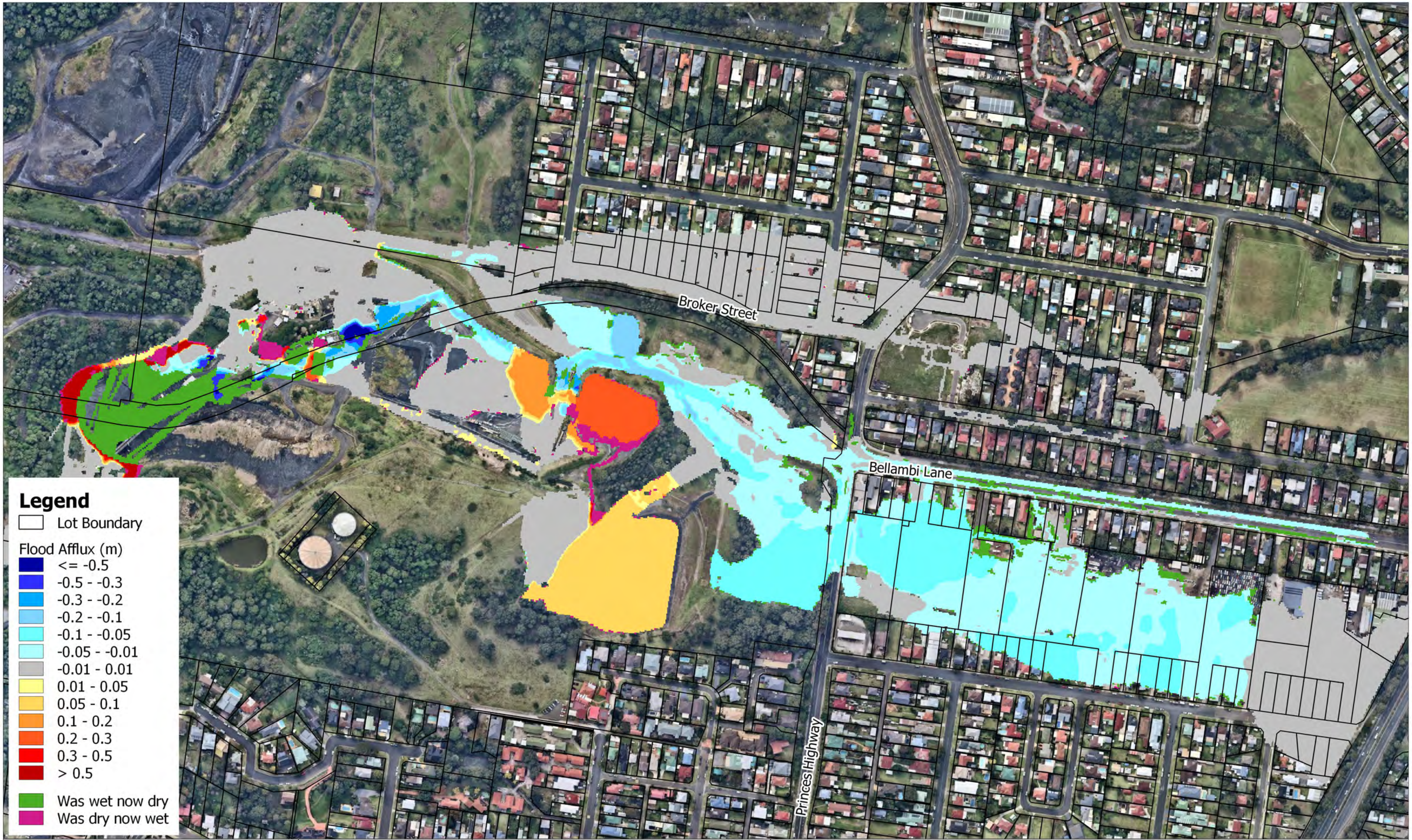
Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

10 Year ARI Flood Event
Flood Afflux
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018



Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

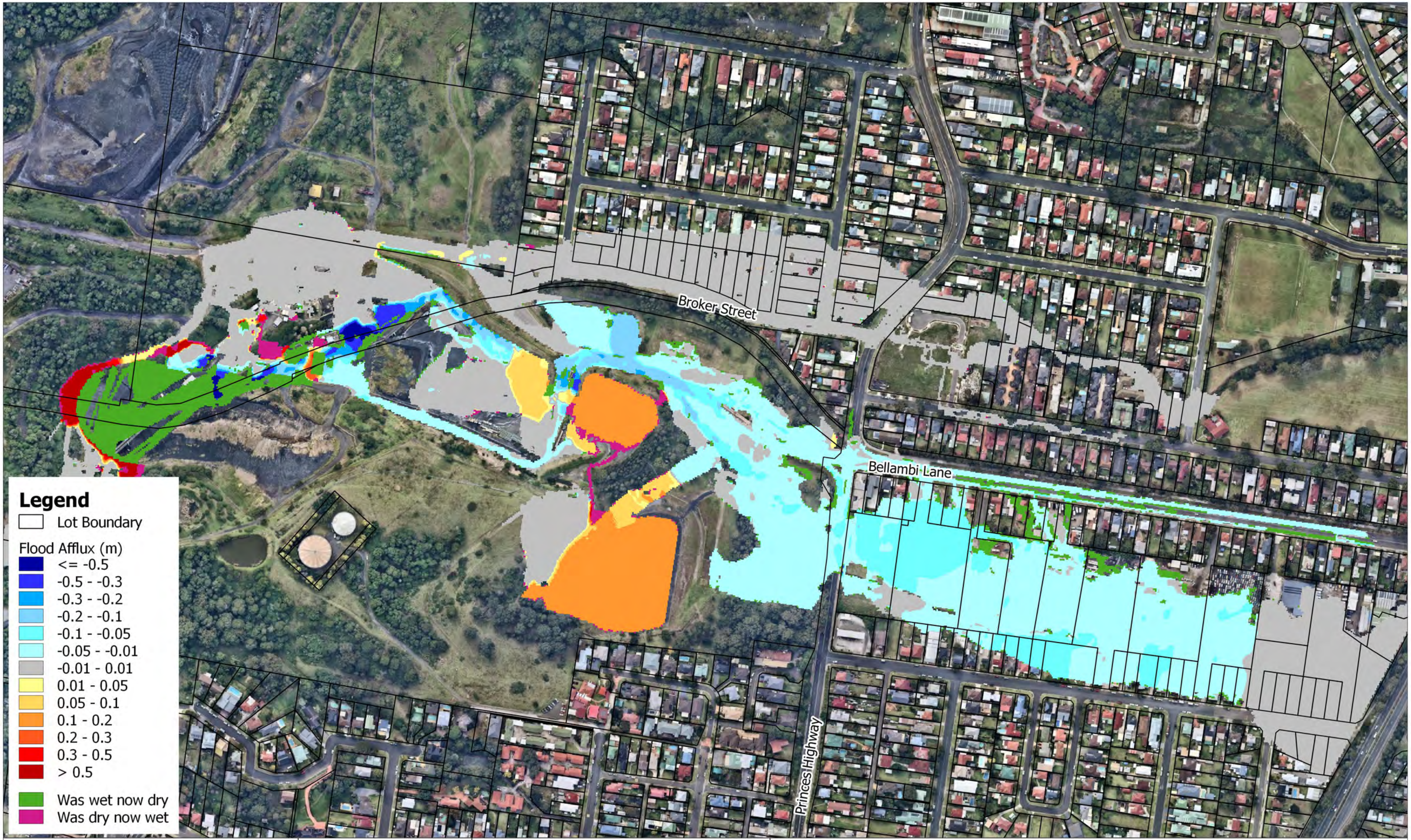
Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Flood Afflux
Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018



Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

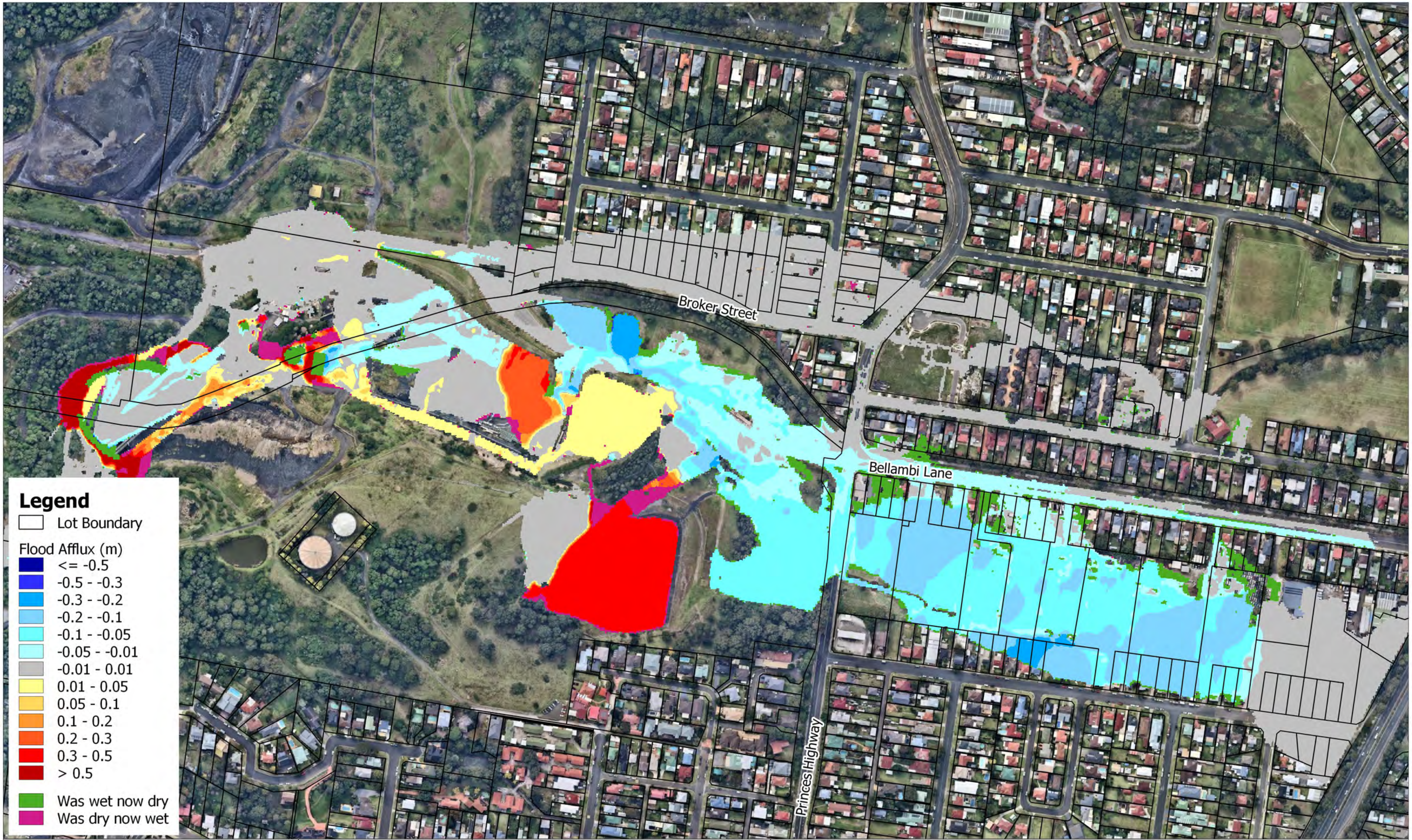
Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Flood Afflux
20% Blockage-Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018



Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY
WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

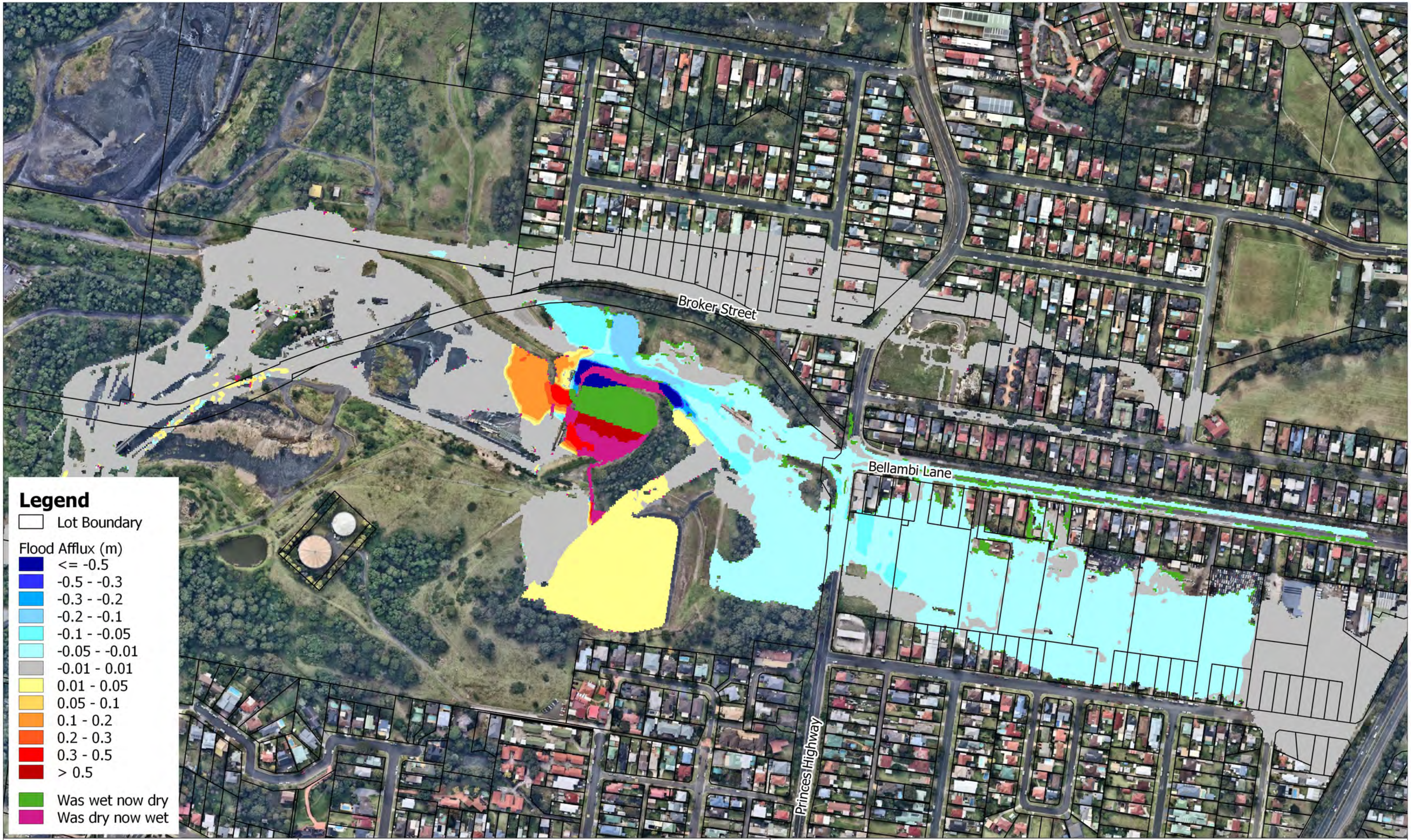
Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Flood Afflux
100% Blockage- Proposed Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018



Level 1, 19 Bolton Street Newcastle NSW 2300
PO Box 787 Newcastle NSW 2300
www.engeny.com.au
P: 02 4926 1225
F: 02 8322 4068

ENGENY WATER MANAGEMENT

WOLLONGONG COAL

100 0 100 m

Scale in metres (1:4000 @ A4)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Bellambi Gully Flood Assessment

100 Year ARI Flood Event
Flood Afflux
Cardno Preferred Scenario

Job Number: N1800_006
Revision: 2
Drawn: GH/MB
Checked: SS
Date: 18 /12 /2018

Environmental & Social Consultants

Newcastle
75 York Street
Teralba NSW 2284

Perth
First Floor
12 Prowse Street
West Perth WA 6005
PO Box 783
West Perth WA 6872

Canberra
2/99 Northbourne Avenue
Turner ACT 2612
PO Box 6135
O'Connor ACT 2602

Sydney
50 York Street
Sydney NSW 2000

Brisbane
Level 13
500 Queen Street
Brisbane QLD 4000

Orange
Office 1
3 Hampden Street
Orange NSW 2800

T| 1300 793 267 E| info@umwelt.com.au www.umwelt.com.au