



**AUSTRALIAN
ZIRCONIA LTD**

(A wholly owned subsidiary of Alkane Resources Ltd)

Dubbo Zirconia Project

Surface Water Assessment

Prepared by

**Strategic Environmental and Engineering
Consulting (SEEC) Pty Ltd**

August 2013

**Specialist Consultant Studies Compendium
Volume 1, Part 4**

This page has intentionally been left blank



**AUSTRALIAN
ZIRCONIA LTD**

(A wholly owned subsidiary of Alkane Resources Ltd)

Surface Water Assessment

Prepared for:

R.W. Corkery & Co. Pty Limited
62 Hill Street
ORANGE NSW 2800

Tel: (02) 6362 5411
Fax: (02) 6361 3622
Email: orange@rwcorkery.com

On behalf of:

Australian Zirconia Ltd
65 Burswood Road
BURSWOOD WA 6100

Tel: (08) 9227 5677
Fax: (08) 9227 8178
Email: mail@alkane.com.au

Prepared by:

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd
PO Box 1098
Bowral NSW 2576

Tel: (02) 4862 1633
Fax: (02) 4862 3088
Email: reception@seec.com.au

August 2013

This Copyright is included for the protection of this document

COPYRIGHT

© SEEC, 2013
and
© Australian Zirconia Ltd, 2013

All intellectual property and copyright reserved.

Apart from any fair dealing for the purpose of private study, research, criticism or review, as permitted under the Copyright Act, 1968, no part of this report may be reproduced, transmitted, stored in a retrieval system or adapted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without written permission. Enquiries should be addressed to SEEC.

CONTENTS

	Page
EXECUTIVE SUMMARY.....	4-9
1. INTRODUCTION.....	4-11
2. DESCRIPTION OF THE PROPOSAL	4-13
DZP SITE OPERATIONS	4-13
MACQUARIE RIVER WATER PIPELINE	4-16
TOONGI-DUBBO RAIL LINE AND NATURAL GAS PIPELINE CORRIDOR.....	4-16
OBLEY ROAD ALIGNMENT	4-19
3. ENVIRONMENTAL SETTINGS.....	4-21
3.1 DZP SITE	4-21
3.1.1 Topography	4-21
3.1.2 Drainage.....	4-21
3.1.3 Receiving Waters	4-27
3.1.4 Climate	4-30
3.1.5 Vegetation and Land use	4-34
3.1.6 Soils.....	4-34
3.2 TOONGI ROAD UPGRADE.....	4-34
3.3 OBLEY ROAD UPGRADES	4-34
3.4 MACQUARIE RIVER WATER PIPELINE CORRIDOR	4-36
3.5 TOONGI-DUBBO RAIL LINE AND GAS PIPELINE CORRIDOR	4-36
4. POTENTIAL SURFACE WATER IMPACTS.....	4-37
4.1 DZP SITE	4-37
4.1.1 Stream Flow Volumes (Surface Water)	4-37
4.1.2 Stream Flow Volumes (Groundwater Interaction).....	4-38
4.1.3 Stream Flow Rates.....	4-38
4.1.4 Sedimentation	4-39
4.1.5 Soil Stockpiles.....	4-45
4.1.6 Post Mining	4-45
4.1.7 Infrastructure Watercourse Crossings	4-45
4.1.8 Protection of Mine Facilities from Stormwater Run-on	4-46
4.1.9 Flooding	4-46
4.1.10 Potential Contamination of Surface Water.....	4-50
4.1.11 Dryland Salinity	4-54
4.2 OBLEY ROAD AND TOONGI ROAD UPGRADES	4-55
4.3 PIPELINE CORRIDOR	4-56
4.4 THE RAIL CORRIDOR	4-56
5. DZP SITE OPERATIONAL SURFACE WATER MANAGEMENT.....	4-57
5.1 LIQUID RESIDUE STORAGE FACILITY	4-57
5.1.1 General Description	4-57

CONTENTS

	Page
5.1.2 Operation.....	4-57
5.1.3 Modelling	4-57
5.2 PROCESSING PLANT AND DZP ADMINISTRATION AREA.....	4-60
5.2.1 Introduction.....	4-60
5.2.2 Area 1: DZP Site Administration Area	4-60
5.2.3 Area 2: Rail Container Laydown and Storage Area	4-60
5.2.4 Area 3: Processing Plant Area	4-62
5.2.5 Area 4: ROM Pad	4-62
5.2.6 The Haul Road	4-63
5.3 THE OPEN CUT.....	4-63
5.4 WASTE ROCK EMPLACEMENT.....	4-63
5.5 THE SOLID RESIDUE STORAGE FACILITY.....	4-63
5.6 SCHEDULE OF OPERATIONAL STORMWATER BASINS	4-64
5.7 POST-MINING SURFACE WATER MANAGEMENT	4-64
6. DZP WATER BALANCE	4-66
6.1 MINE SITE DEMAND.....	4-66
6.1.1 Processing.....	4-66
6.1.2 Dust Suppression	4-66
6.1.3 Offices, Workshops and Ablutions	4-66
6.2 MINE WATER SUPPLY	4-66
6.2.1 Pipeline.....	4-66
6.2.2 Harvestable Right.....	4-66
6.3 SURFACE WATER HARVESTING, LICENSING	4-68
6.4 WATER DISTRIBUTION.....	4-68
7. DZP SITE WASTE WATER MANAGEMENT.....	4-70
8. TOONGI AND OBLEY ROADS FLOOD MITIGATION.....	4-71
8.1 INTRODUCTION	4-71
8.2 TOONGI ROAD.....	4-71
8.3 OBLEY ROAD.....	4-71
9. SURFACE WATER MONITORING PROGRAM	4-72
9.1 INTRODUCTION.....	4-72
9.2 INFRASTRUCTURE MONITORING.....	4-72
9.2.1 Objectives.....	4-72
9.2.2 Inspections	4-72
9.3 SURFACE WATER QUALITY MONITORING	4-72
9.3.1 Objectives.....	4-72
9.3.2 Water Quality Sampling Locations	4-73

CONTENTS

	Page
9.4 SAMPLING FREQUENCIES AND PARAMETERS.....	4-75
9.4.1 Sampling Frequencies	4-75
9.4.2 Water Quality Triggers	4-75
9.5 SAMPLING PROCEDURES.....	4-77
9.6 POST- MINE CLOSURE.....	4-78
10. SURFACE WATER RESPONSE PLANS	4-79
10.1 LOCAL STREAMS (SW1 TO SW8).....	4-79
10.2 RE-USE DAM (SW9)	4-79
10.3 RAIL LAYDOWN AND STORAGE AREA, PROCESSING AREA (SW10 AND SW11)...	4-80
10.4 LIQUID RESIDUE STORAGE FACILITY (SW12, SW13 AND SW14).....	4-80
11. SUMMARY OF COMMITMENTS	4-81
11.1 DURING DZP SITE ESTABLISHMENT	4-81
11.2 OPERATIONAL STAGE	4-81
11.3 POST OPERATIONS.....	4-82
12. REFERENCES.....	4-83

APPENDICES

Appendix 1 Director General Requirements Checklist	4-85
Appendix 2 DZP Pre-development HEC-RAS Flood Modelling Data	4-91
Appendix 3 DZP Post-development HEC-RAS Flood Modelling Data	4-99

CONTENTS

	Page
FIGURES	
Figure 1 Locality Plan	4-12
Figure 2 DZP Site Layout	4-14
Figure 3 Macquarie River Water Pipeline and Pump Station	4-17
Figure 4 Toongi – Dubbo Rail Line and Gas Pipeline Corridor	4-18
Figure 5 Public Road Network	4-20
Figure 6 DZP Site Topography	4-22
Figure 7 Catchments, Dams and Stream Orders	4-23
Figure 8 Flood Extents within the DZP Site	4-26
Figure 9 Daily Water Flow in the Macquarie River at Dubbo (Gauging Station 421001)	4-28
Figure 10 Mean Annual Rainfall at Mentone (BOM Station 65030)	4-31
Figure 11 Rolling Five-Year Mean Annual Rainfall at Mentone (BOM Station 65030)	4-31
Figure 12 IFD Chart	4-32
Figure 13 Measured Mean Daily Pan Evaporation (Wellington)	4-33
Figure 14 Flood Levels Wambangalang Creek, Toongi Road Crossing	4-35
Figure 15 Flood Levels, Obley Road, Hyandra Creek Crossing	4-35
Figure 16 Flood Levels, Obley Road, Twelve Mile Creek Crossing	4-36
Figure 17 Conceptual Surface Water Management Sheet 1 (Index Plan)	4-41
Figure 18 Conceptual Surface Water Management Sheet 2	4-42
Figure 19 Conceptual Surface Water Management Sheet 3	4-43
Figure 20 Conceptual Surface Water Management Sheet 4	4-44
Figure 21 Liquid Residue Storage Facility Diversion Drainage	4-47
Figure 22 X-section through process area (black) & Watercourse C in 100yr Flood. (WS=Water Surface) Post Development.	4-48
Figure 23 DZP Flood extents after construction	4-49
Figure 24 Liquid Residue Storage Facility Storage Over Time (Model 1)	4-58
Figure 25 Liquid Residue Storage Facility Storage Over Time (Model 2)	4-59
Figure 26 Liquid Residue Storage Facility Storage Over Time (Model 3)	4-59
Figure 27 Layout of the Processing Plant and DZP Site Administration Area	4-61
Figure 28 Water Distribution Plan with Mean Annual Volumes	4-69
Figure 29 Water Quality Sampling Locations	4-74
Figure 30 DZP Site Catchment Plan and Flow Calculations	4-93
Figure 32 HEC-RAS Model, General Stream Geometry Layout – Pre-development	4-95
Figure 33 Catchment Plan and Flow Calculations - DZP Site, Post Development	4-101
Figure 34 HEC-RAS Model, General Stream Geometry Layout	4-102
Figure 35 Post-development HEC_R4 – River Station 1300	4-103
Figure 36 Post-development HEC_R4 – River Station 2000	4-104

CONTENTS

	Page
TABLES	
Table 1	2002 Stream Water Quality Testing..... 4-29
Table 2	2012 Stream Water Quality Testing..... 4-30
Table 3	Pan Evaporation (PAN), Potential Evapotranspiration (PET) and assumed Pond Evaporation (PPOND)..... 4-33
Table 4	Required Sediment Basin Volumes 4-40
Table 5	Predicted Changes in Channel Velocity; Watercourse C 4-48
Table 6	TCLP testing on crushed ore (orange = detectable)..... 4-52
Table 7	Predicted Times to Maximum Capacity 4-59
Table 8	Schedule of Operational Basins..... 4-64
Table 9	Water Quality Sampling Parameters and Frequency 4-75
Table 10	Water Quality Triggers Applied to SW1 to SW8 4-76
Table 11	Water Quality Triggers Applied to SW9 4-76
Table 12	Water Quality Triggers Applied to SW10 and SW11 4-77
Table 13	Water Quality Triggers Applied to SW12 to SW14 4-77
Table 14	Director-General's Requirements (related to surface water) (Department of Planning and Infrastructure – DZP Proposal SSD-5251) 4-87
Table 15	Dept. of Primary Industries. Office of Water Requirements (related to surface water) 4-88
Table 16	Catchment Management Authority (Central West) Surface Water Requirements 4-88
Table 17	NSW EPA Surface Water Requirements..... 4-89
Table 18	Pre-Development Hec-Ras Output Data 4-96
Table 19	Post-development HEC-RAS Output Data 4-105

This page has been intentionally left blank

EXECUTIVE SUMMARY

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd has been commissioned by Australian Zirconia Ltd (“the Applicant”) to provide this surface water assessment for the proposed Dubbo Zirconia Project (DZP or “the Proposal”), Toongi, NSW.

This report provides:

- background on the surface water environment at and in the vicinity of the DZP Site, including rainfall and runoff characteristics;
- an assessment of the availability of surface water for the DZP’s operational requirements;
- an assessment of the likely surface water impacts of the Proposal; and
- a conceptual integrated water management strategy that gives recommended management and mitigation measures to address potential surface water-related concerns.

Various activities / infrastructure of the DZP would quarantine approximately 640ha from the local catchments. This would reduce the volume of water shed as surface runoff from the DZP Site. However, calculations conclude any reduction would be very difficult to identify once masked by the total flow in the receiving waters.

The Proposal’s water supply would be assured by drawing water from surface (Macquarie River) and groundwater sources under licence(s) obtained in accordance with the relevant Water Sharing Plan(s). A relatively small amount of water (about 140MLy) would be harvested from the DZP Site itself for use as dust suppressant and, sometimes, in the processing plant.

The Proposal would produce a significant volume of highly saline water (liquid residue) that would be “disposed” by evaporation in a series of open cells. Modelling is submitted to show the effectiveness of the proposed Liquid Residue Storage Facility under a variety of rainfall patterns.

Soil and water would be managed to the requirements of the latest guidelines (e.g. Landcom, 2004, DECC, 2008 and DECC, 2008b) to ensure surface runoff does not cause elevated concentrations of pollutants in the local watercourses. A plan for water quality monitoring plus associated response plans is included to ensure the effectiveness of these measures.

Flood assessments for the receiving watercourses (Wambangalang Creek and Paddys Creek) are included, as are flood assessments of the three main watercourses on the DZP Site and two watercourse crossings on Obley Road that are to be upgraded.

This page has intentionally been left blank

1. INTRODUCTION

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd has been commissioned by Australian Zirconia Ltd (“the Applicant”) to provide this surface water assessment for the proposed Dubbo Zirconia Project (DZP or “the Proposal”), Toongi, NSW (**Figure 1**).

This report provides:

- background on the surface water environment at, and in the vicinity of, the DZP Site, including rainfall and runoff characteristics;
- an assessment of the availability of surface water for the DZP’s operational requirements;
- an assessment of the likely surface water impacts of the Proposal; and
- a conceptual integrated water management strategy that gives recommended management and mitigation measures to address potential surface water-related concerns.

In conducting this assessment SEEC has:

- conducted a review of the existing surface water conditions within the DZP Site and within its local context;
- conducted a field survey of the landforms of the DZP Site and its surrounds;
- estimated the existing site’s hydrology and runoff/infiltration characteristics;
- identified supply/demand figures for the DZP’s operational phase; and
- reviewed and recommended water quality targets and triggers that would apply to the operational DZP.

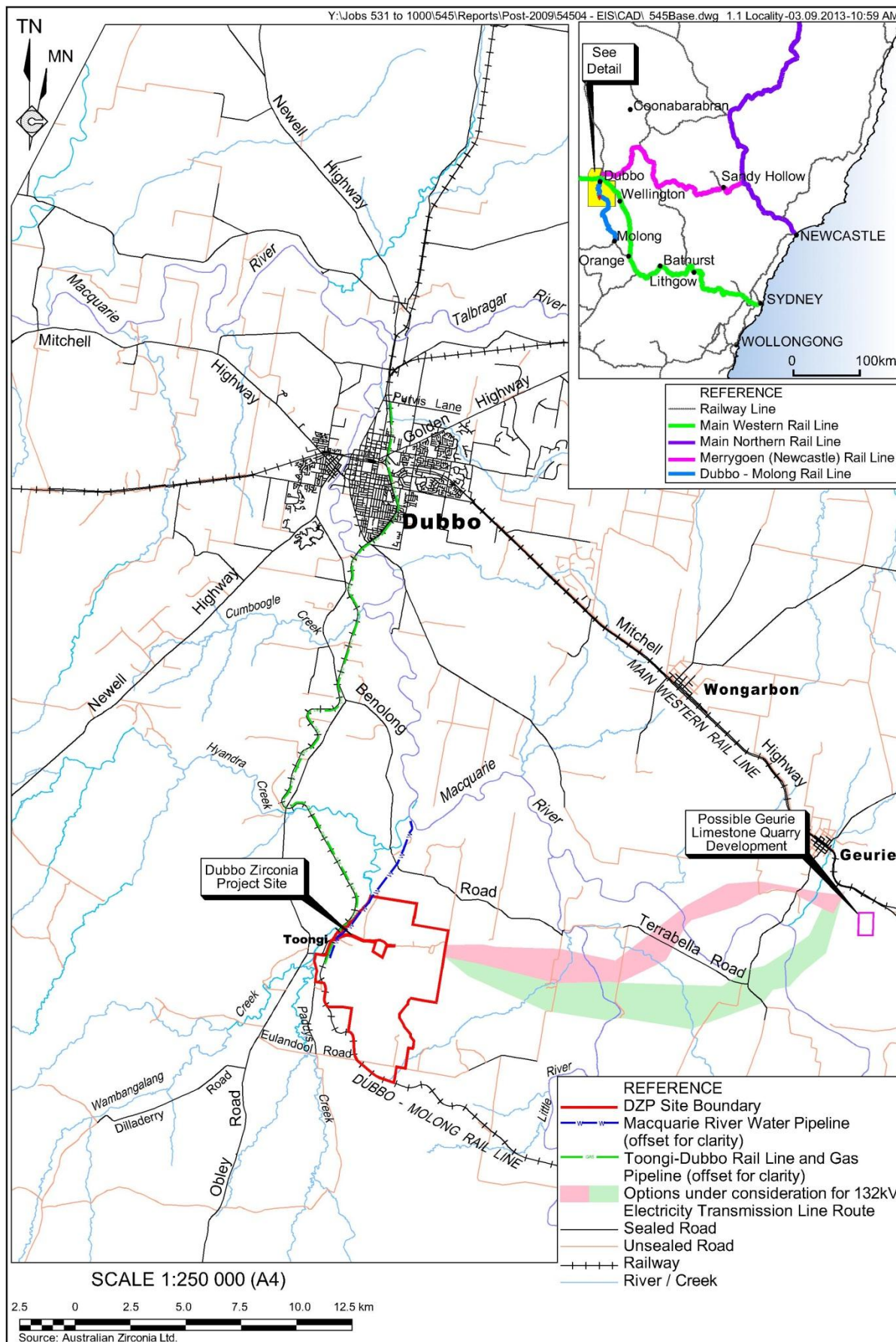


Figure 1 Locality Plan

2. DESCRIPTION OF THE PROPOSAL

The DZP would comprise a small scale open cut mine supplying approximately 1Mt of ore containing rare metals (zirconium and niobium) and rare earth elements (REE's) to a processing plant annually (18 million tonnes of ore over a period of up to 20 years). The land on which the proposed open cut, processing plant and associated facilities for the management of waste generated by these activities is collectively referred to as the DZP Site.

The Proposal also incorporates the following four component areas (see **Figure 1**).

- Upgrade and reactivation of the Toongi to Dubbo Section of the Dubbo-Molong Rail Line. AZL also proposes to construct a pipeline to deliver compressed natural gas (CNG) from the Central West Pipeline operated by APA Group within the 'Toongi-Dubbo Rail Line and Natural Gas Pipeline Corridor';
- Construction of a water pipeline to deliver up to 4.05GL of water from the Macquarie River to the processing plant (referred to hereafter as the Macquarie River Water Pipeline).
- Upgrades, including minor realignment, creek crossing upgrade and pavement strengthening, of the public road network (Toongi Road and Obley Road).
- Construction of a 132kV electricity transmission line (ETL) from a sub-station to the southwest of Geurie to the DZP Site. The construction of this ETL is to be assessed separately under Part 5 of the EP&A Act.

Excluding the 132kV ETL, the DZP Site and component areas identified above comprise the DZP Application Area.

The following provides an overview of the activities to be undertaken within each of these areas.

DZP Site Operations

The principal components and activities to be undertaken on the DZP Site (and illustrated on **Figure 2**) are as follows.

- Extraction of approximately 19.5Mt of ore at a maximum rate of 1Mt per year from a shallow open cut developed to a maximum depth of 32m (355m AHD) (remaining above the groundwater table). At the proposed rate of mining, the open cut design proposed would provide for a mine life of 20 to 22 years.
- Extraction and placement of approximately 3.5Mt of waste rock (primarily siltstone, sandstone and a highly siliceous rim or lower grade material) within a small waste rock emplacement (WRE) to the southwest of the open cut.
- Haulage of ore to a Run-of-Mine (ROM) Pad for crushing and grinding.
- Processing of the crushed and ground ore using the following methodology.
 - Sulphation roast of ore and leaching to dissolve sulphated metals.

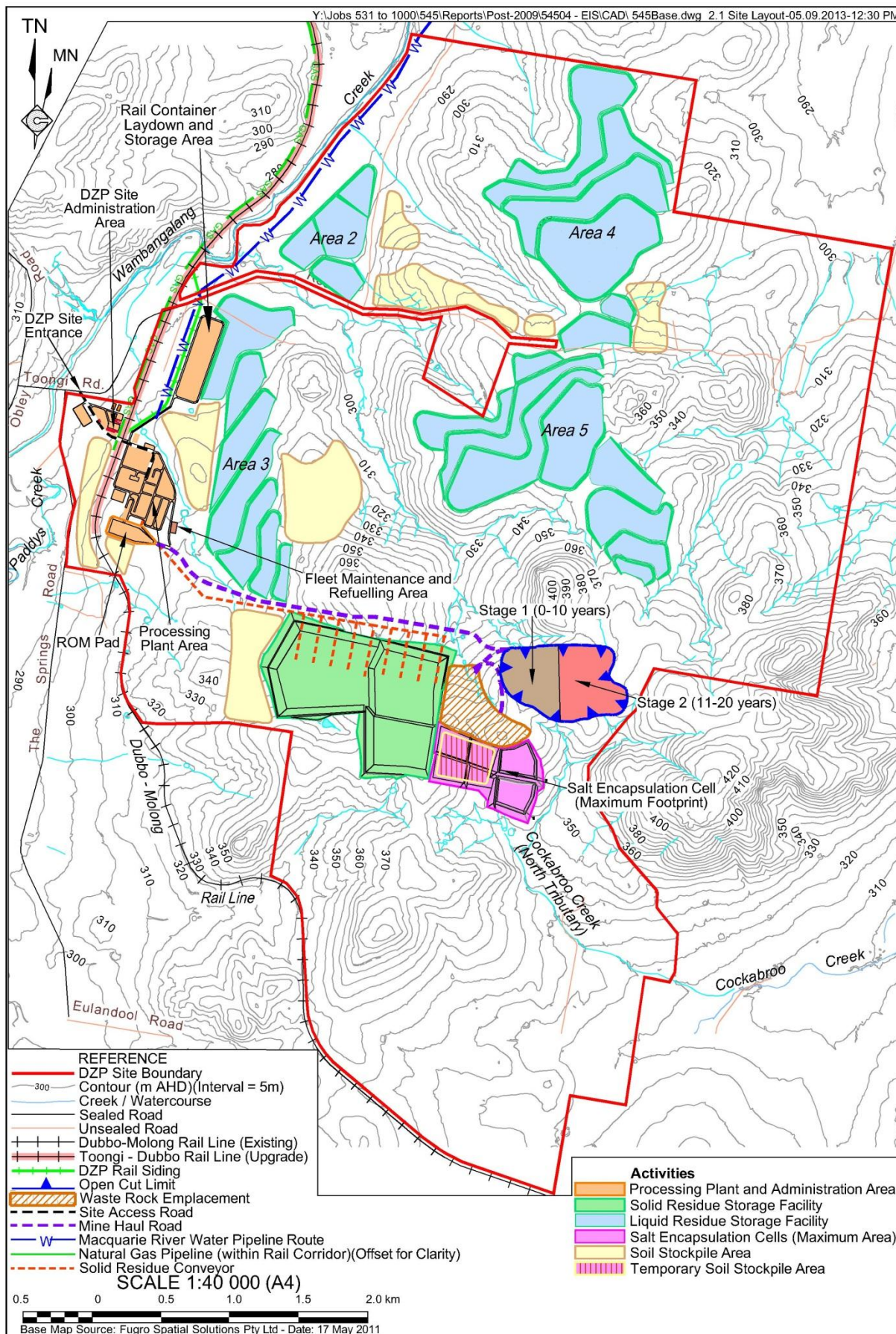


Figure 2 DZP Site Layout

- Solvent extraction, precipitation, thickening, washing and drying of the various rare metal and REE products.

The sulphuric acid required as part of the sulphation process would be manufactured within the DZP processing plant from imported raw sulphur.

- Construction and operation of a rail siding from the Toongi-Dubbo Rail Line and a Rail Container Laydown and Storage Area for the unloading and temporary storage of reagents and loading of products for despatch.
- Other reagents would be transported to the DZP Site via the public road network, with sections of Obley Road and Toongi Road to be upgraded to accommodate the proposed increase in heavy vehicle traffic.
- Mixing and neutralising of solid residues produced by the processing of the ore with crushed and washed limestone and transportation via conveyor to a Solid Residue Storage Facility (SRSF).
- Pumping of water used in the processing operations, which cannot be recycled, to a Liquid Residue Storage Facility (LRSF), comprising a series of terraced and lined crystallisation cells.
- Recovery and disposal of an estimated 6.7Mt of salt which would accumulate over the life of the Proposal within the LRSF within a series of Salt Encapsulation Cells adjoining the WRE and SRSF.
- Other ancillary activities including equipment maintenance, clearing and stripping of the areas to be disturbed and rehabilitation activities.

The maximum development footprint on the DZP Site would be approximately 808ha (within the DZP Site of 2,864ha - see **Figure 2**). Component areas of disturbance are as follows:

- Open Cut Mine – 40.3ha.
- Waste Rock Emplacement Area – 20.4ha.
- ROM Pad – 4.2ha.
- Processing Plant and DZP Site Administration Area (incorporating the processing plant and associated reagent storage areas, rail siding and container laydown areas and site offices and administration complex) – 43.3ha.
- Solid Residue Storage Facility – 102.8ha.
- Liquid Residue Storage Facility – 425.4ha.
- Salt Encapsulation Cell – up to 34.6ha.
- Soil Stockpile Areas – up to 129.4ha.
- Internal Haul Roads – 7.3ha

The ore body to be mined is a roughly elliptical stock in shape with outcrop dimension of 600m x 400m. Exploration completed by AZL has identified the ore body extends below a thin veneer of soil and recent sediments to be approximately 900m (east-west) x 500m (north-south) (surface area of 36ha) and appears to be a near vertical body of indeterminate depth.

While there is limited scope to modify the area of impact associated with the open cut, in order to minimise the impact of the mining operations, the Applicant has designed the mining sequence such that the initial 10 year mine plan develops the western section of the open cut, with the eastern section developed and mined during the second 10 year mining period (see **Figure 2**).

The size and location of the other components of the DZP Site has been the subject of more detailed review, with impact minimisation a key consideration.

Macquarie River Water Pipeline

Processing operations would require up to 4.05GL of make up water annually which would be sourced (partially or completely) from the Macquarie River (under licence) and transferred to the DZP Site by water pipeline.

Figure 3 provides the proposed alignment of the Macquarie River Water Pipeline, the key features of which are as follows.

- A pumping station which incorporates a dual water inlet, wet well and vertical mounted axial flow pump configuration.
- A 400mm to 450mm diameter HDPE pipeline within an embedded trench.

The easement to be created for the Macquarie River Water Pipeline Corridor would be approximately 15.2ha (20m x 7.6km), although the actual area of disturbance within this corridor would be much less. An area not exceeding 2 500m² would be disturbed on the river frontage of the “Mia Mia” property to allow for the construction of the pumping station for water from the Macquarie River.

Toongi-Dubbo Rail Line and Natural Gas Pipeline Corridor

The processing operations require significant volumes of chemical reagents and other raw materials. While significant volumes of these reagents and materials would be delivered by road, the Applicant has identified the upgrade and use of the Toongi to Dubbo section of the currently disused Dubbo-Molong Rail Line as an opportunity to reduce the volume of traffic on the public road network.

Figure 4 provides the proposed alignment of the Toongi-Dubbo Rail Line, the key features of which are as follows.

- Upgrade of the Toongi to Dubbo section of the Dubbo-Molong Rail Line to a Class 1 track (92t gross/67t pay load capacity).
- Replacement or upgrade of steel bridges, culvert structures, and timber bridges.
- Reinstatement, civil works and installation back to the required standard at each of the 26 level crossings. Of these, seven are major crossings (of local roads), four of which occur in Dubbo (Wingewarra Street, Cobra Street, Boundary Road and Macquarie Street) and three (Cumboogle, Glengarra and Toongi) between the Macquarie River and the proposed DZP Rail Siding.

Figure 4 also identifies the proposed natural gas pipeline between the Central West Pipeline (of APA Group) at Purvis Lane, Dubbo, and the DZP Site which would deliver up to 970TJ/year of natural gas for the heating of various circuits within the processing plant.

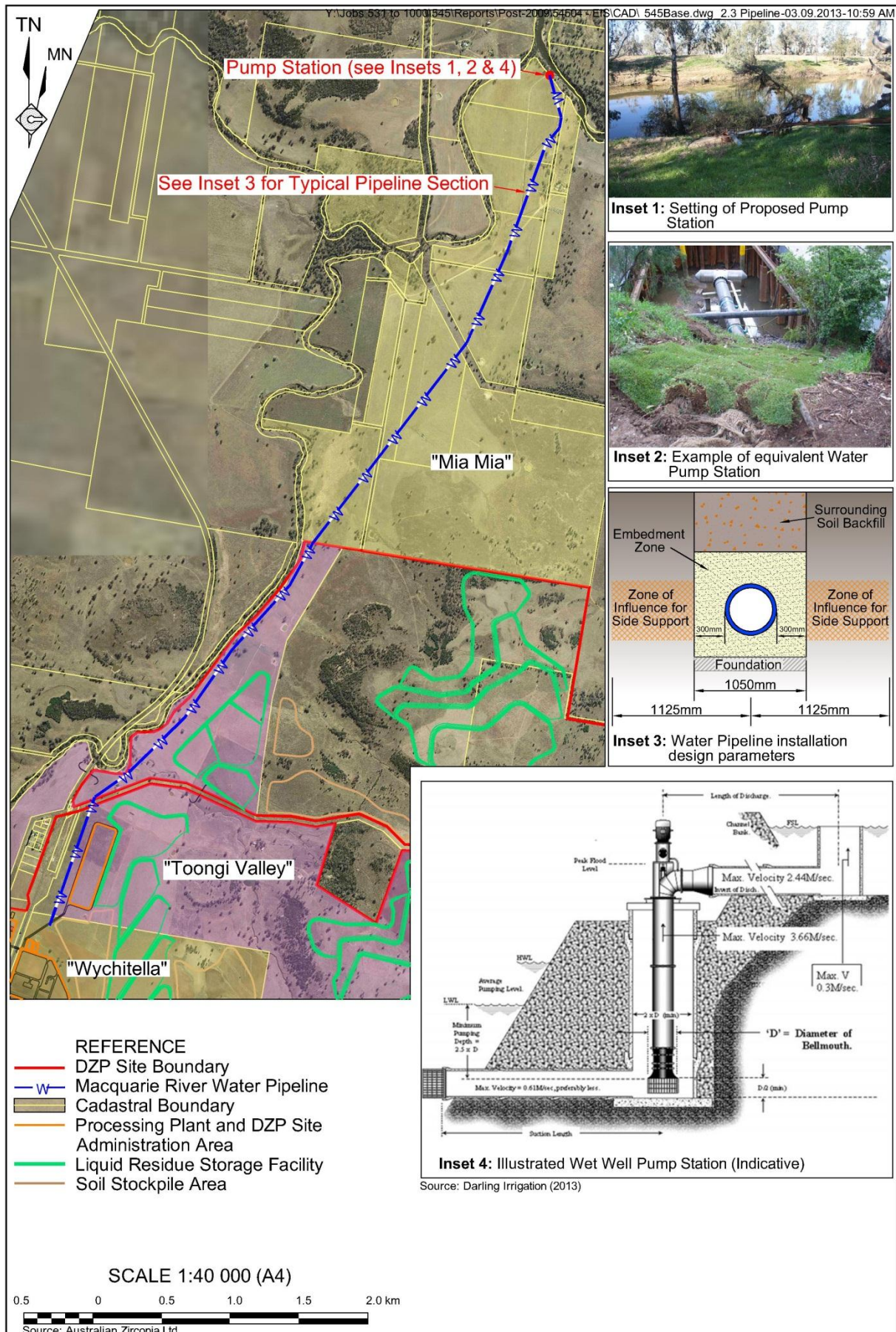


Figure 3 Macquarie River Water Pipeline and Pump Station

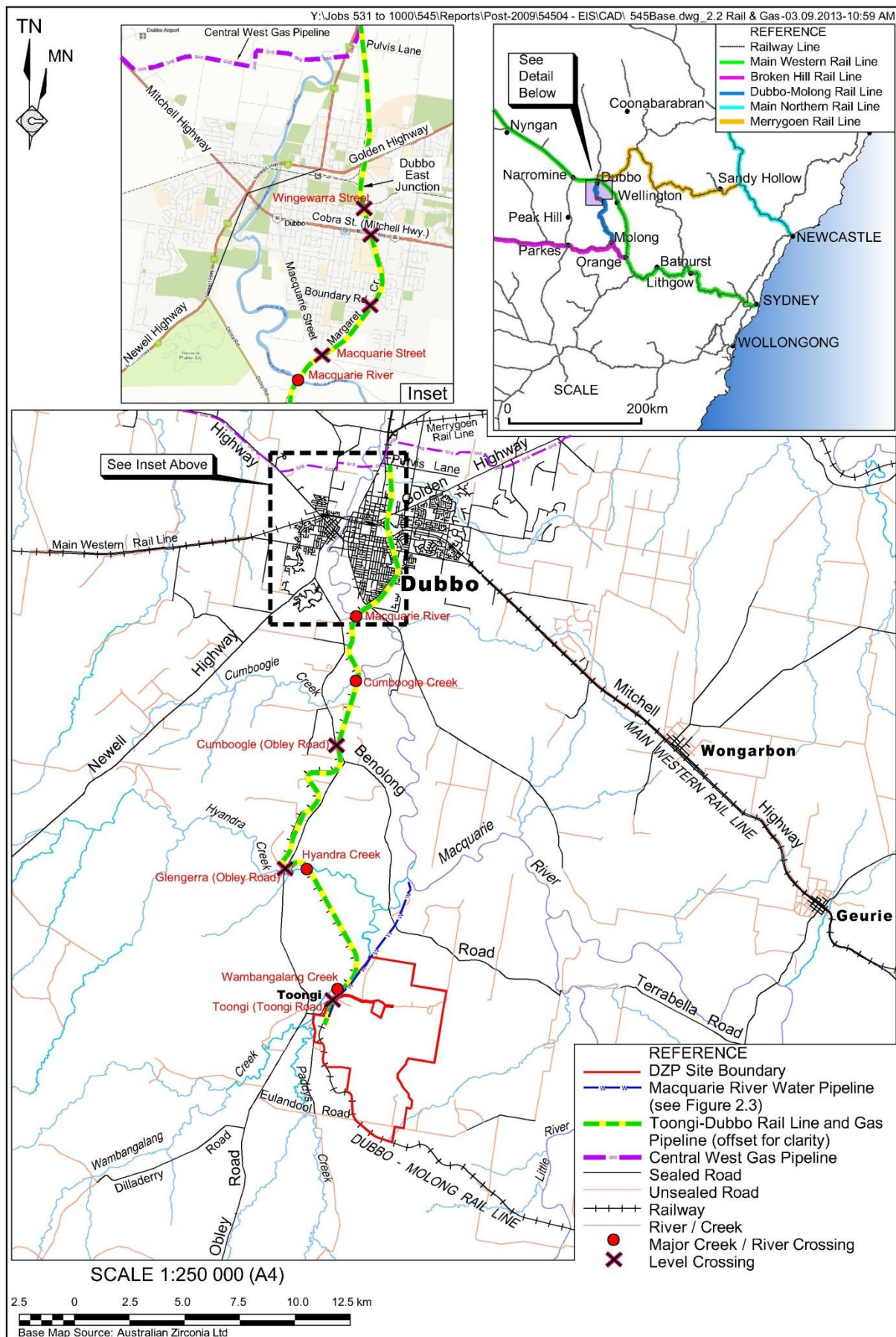


Figure 4 Toongi – Dubbo Rail Line and Gas Pipeline Corridor

Obley Road Alignment

Significant quantities of the processing reagents and other raw materials would be delivered by road, via the Newell Highway, Obley Road and Toongi Road. To accommodate the proposed heavy vehicle traffic associated with this transport, the alignment and pavement depth of the two roads would be improved in several locations, with a number of creek crossings, rail level crossings and intersections to be upgraded. **Figure 5** provides the locations of these works.

A more detailed description of the Proposal is provided by Section 2 of the EIS.

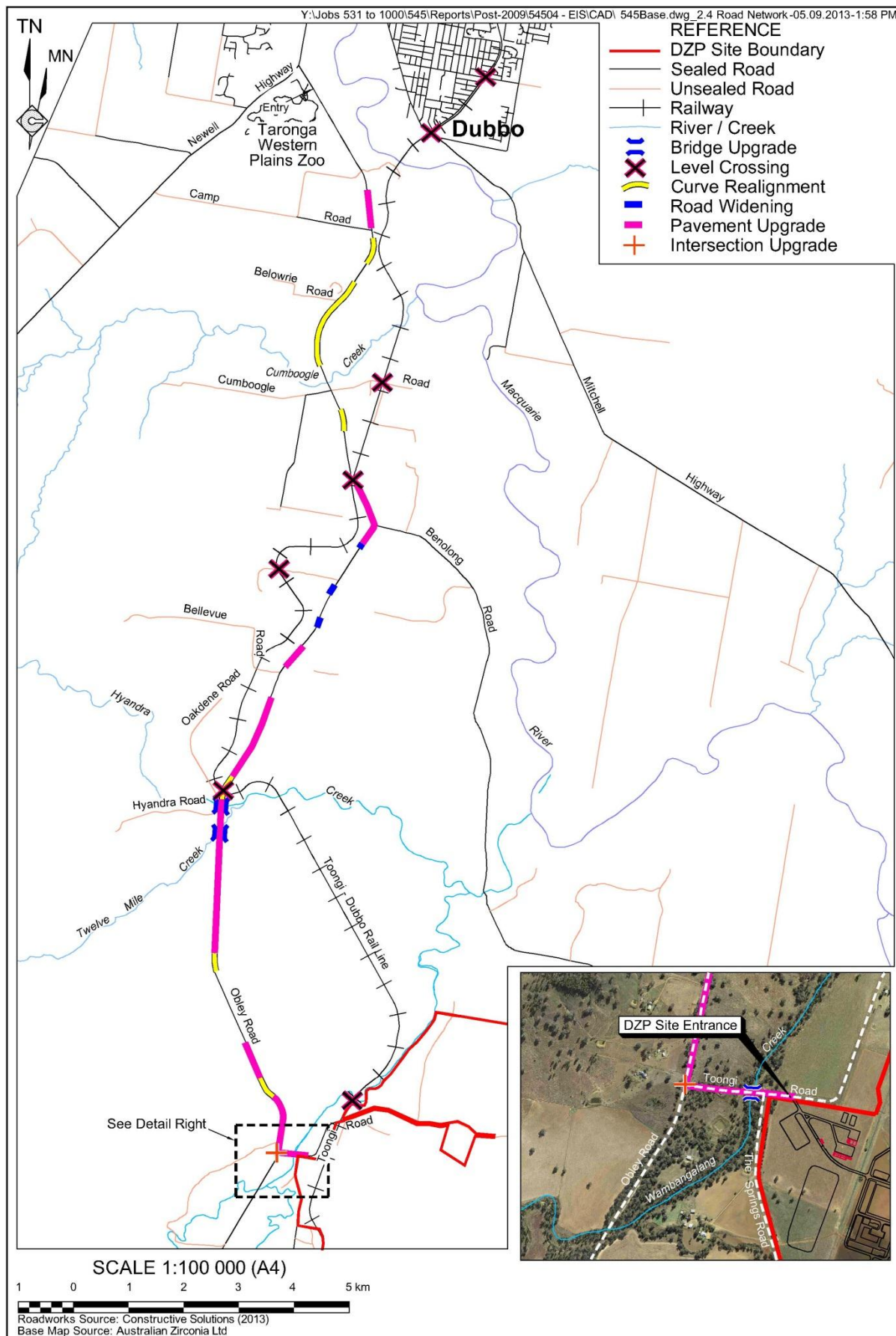


Figure 5 Public Road Network

3. ENVIRONMENTAL SETTINGS

3.1 DZP SITE

3.1.1 Topography

Figure 6 presents the topography and drainage within the DZP Site. In summary, the DZP Site is dominated by a series of hills with maximum elevations between 325m AHD and 400m AHD. Dowd's Hill, located immediately to the west of the DZP Site has an elevation of 425m AHD. The lowest sections of the DZP Site are located on the western boundary of the Site, with elevations of approximately 275m AHD, adjacent to the Wambangalang Creek.

Slopes within the DZP Site vary from approximately 1:60 (V:H) in the vicinity of Wambangalang Creek to approximately 1:5 (V:H) on the flanks of the higher hills. The surface of the steeper sections of the DZP Site varies from a common semi-continuous rock pavement to steeper outcrops of boulders.

The area immediately surrounding the DZP Site is characterised by undulating hills with moderate to gentle slopes, surrounded by creek flats and floodplains. Elevations vary between 546m AHD on Gilgal Hill approximately 12km south of the DZP Site and 275m AHD along the banks of the Macquarie River to the north and east of the DZP Site.

3.1.2 Drainage

3.1.2.1 General Description

A series of minor watercourses radiate out from a high point near the ore body to four main watercourses (**Figure 7**):

- Wambangalang Creek Catchment – 1,375ha of the DZP Site (48%) drains to Wambangalang Creek (partly by an unnamed stream hereon identified as Watercourse C) and ultimately to the Macquarie River;
- Paddys Creek Catchment – 240ha of the DZP Site (9%) drains to Paddys Creek and then to Wambangalang Creek and ultimately to the Macquarie River;
- Cockabroo Creek Catchment – 590ha of the DZP Site (20%) drains to Cockabroo Creek, then to the Little River and, ultimately, to the Macquarie River; and
- Macquarie River (undefined) catchment – 660ha of the DZP Site (23%) drains to one of two unnamed streams hereon identified as Watercourse A and Watercourse D, and ultimately to the Macquarie River.

There are four third-order watercourses on the DZP Site under the Strahler Stream Order System:

- Watercourse D (unnamed) draining northeast within the Macquarie River (undefined) catchment and only achieving third order status just before it leaves the DZP Site;

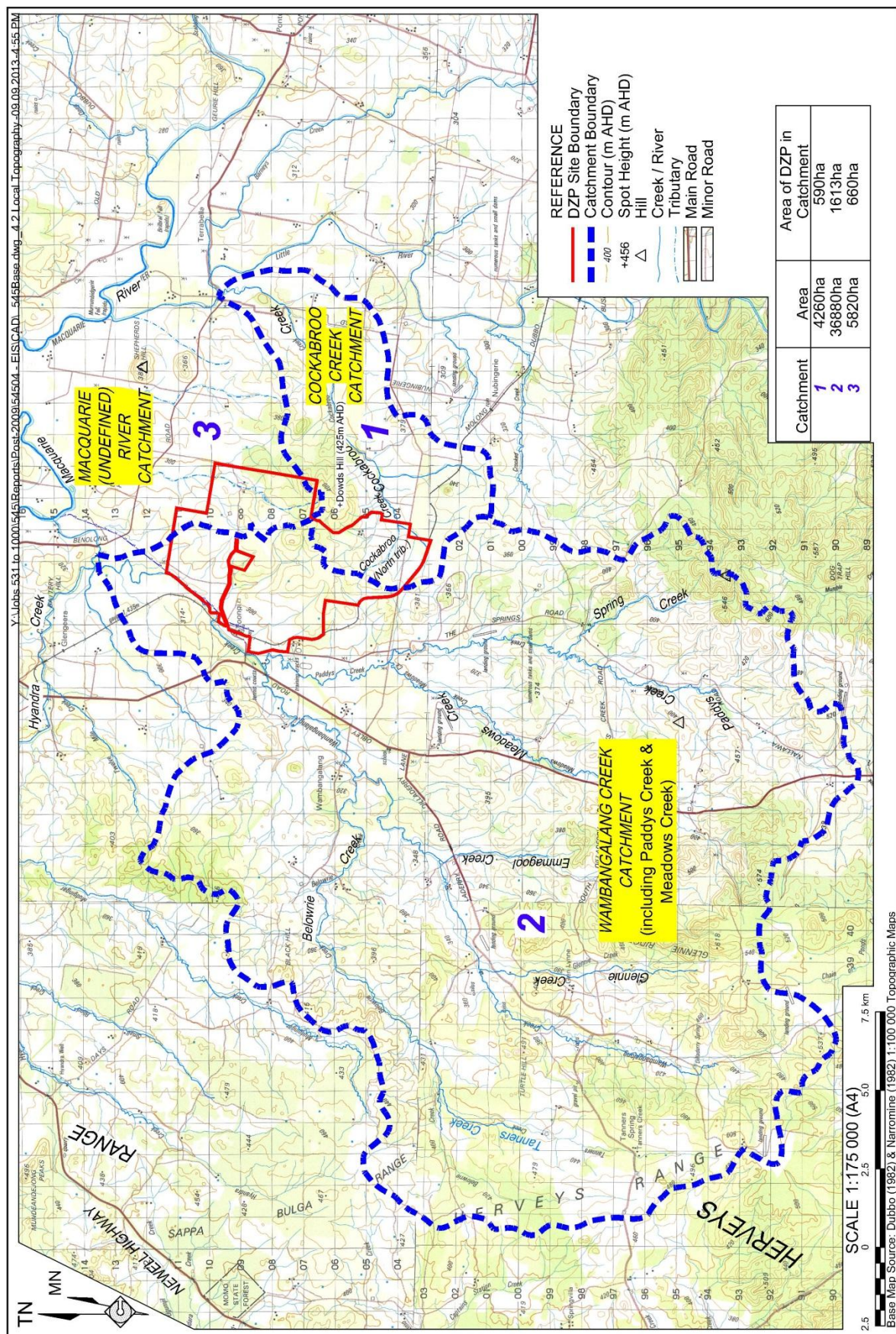


Figure 6 DZP Site Topography

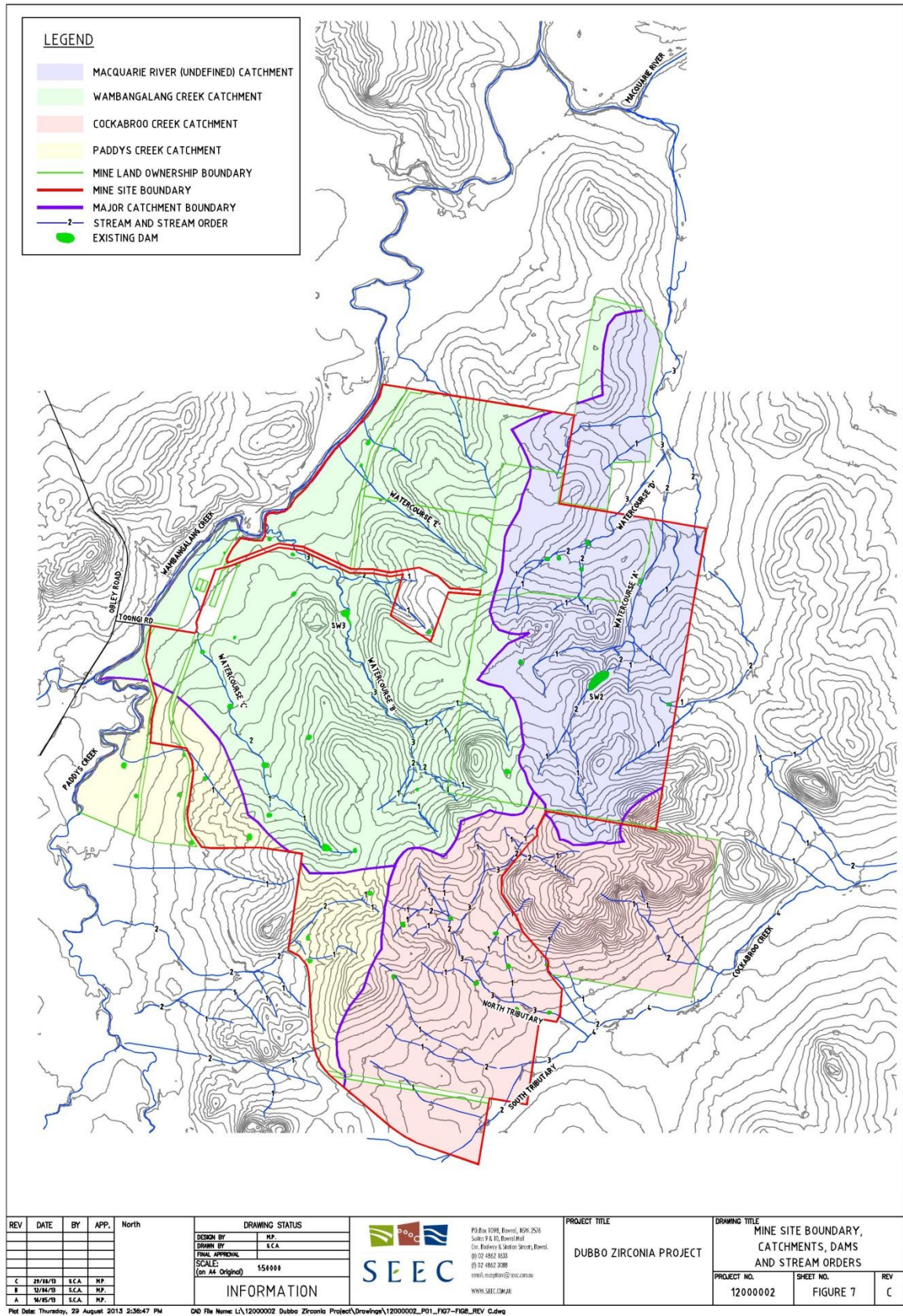


Figure 7 Catchments, Dams and Stream Orders

- Watercourse B (unnamed) draining northwest to Wambangalang Creek. This has a number of small dams on it. One of these dams is water sampling location SW3 (**Figure 7**); and
- The two tributaries of Cockabroo Creek, south of the ore body.

The remainder of the DZP Site's intermittent watercourses are first or second order streams (**Figure 7**).

3.1.2.2 Existing Dams

There are 64 dams located on land owned or under contract to the Applicant. Most are small (<1 ML) but the one at SW2 is approximately 16ML and the one at SW3 is approximately 3ML¹ (**Figure 7**). The estimated total volume of the existing dams is 82ML and their total area is approximately 10.3ha when full. All the existing dams would remain in place.

3.1.2.3 Groundwater Springs

All ephemeral creeks at the DZP Site have a high to moderate potential to be at least partially "reliant on surface expression of groundwater" (BOM, 2012). The Groundwater Dependant Ecosystem (GDE) map (BOM, 2012) shows that, in the vicinity of the DZP Site, Paddys Creek to the west of the DZP Site is listed as having a "high potential for groundwater interaction"².

Wambangalang Creek to the north of Obley Road and Cockabroo Creek to the north of Eulandool Road are both listed as having a "moderate potential for groundwater interaction". There is no vegetation in the vicinity of the DZP site listed as being reliant on groundwater, and no subterranean GDEs (caves or aquifers). Based on these findings, it can be concluded that the creek systems to the west and south of the DZP Site rely on groundwater discharge to support their ecosystems, but there are no other known GDEs within the DZP Site.

Detailed mapping of springs on the DZP Site has not been undertaken, however, in generating a conceptual site model (CSM) for the hydrogeological setting of the DZP Site, Environmental Earth Sciences Pty Ltd (EES, 2013) have identified that the groundwater table is likely to incise ground surface in low topographic areas such as break of slopes and drainage lines. Based on its undulating upper and mid catchment areas, the upper mid-slope environment of the DZP Site, is generally susceptible to small isolated areas of discharging groundwater. Such spring flows have been observed on Watercourses B, D and the north tributary of Cockabroo Creek see **Figure 7**).

EES (2013) note that although groundwater discharge is interpreted to be taking place from the bedrock in these watercourses, the seepage rate is considered to be relatively low such that the groundwater discharging from the bedrock passes through the colluvium in the base of the gullies. Hence, it does not result in continuous surface expression in the gullies. Groundwater discharge in these areas is likely sourced from temporal shallow lateral flow or local derived groundwater recharged from the immediate upper slopes and crest.

¹ Dam volumes have been estimated from the aerial survey

² Groundwater interaction refers to a surface water system that is reliant on surface expression of groundwater.

Discharge of groundwater, or spring flow, may also occur at the boundary between the alluvial sediments and bedrock which also happens to represent a significant break of slope to the lower alluvial flats (EES, 2013). These areas represent a high potential for groundwater discharge and possible salinity due to the change in geology (which may restrict groundwater flow), or locations where the groundwater level intercepts the ground surface. There was, however, no indication that groundwater or salt has encroached the surface at these locations during the investigation.

3.1.2.4 Surface Water Runoff Coefficient

The most accurate method of estimating the mean surface water runoff coefficient (i.e. the percentage of rainfall that flows off the DZP Site as surface flow) is to use calibrated data from nearby or similar catchments. In this case, Coolbaggie Creek (Gauging Station Number 421055, located 38km north-northwest of the DZP Site) is located in similar terrain to the DZP Site and so is considered an ideal representation of the DZP Site area.

The Rainfall Characteristic (RC) for this catchment is 4.7 and the base flow index (BFI) is 0.0 (Boughton, W.C. 2003). From these, and using the mean annual rainfall of 643.7 mm (Section 3.1.4.1), the estimated surface water runoff coefficient is calculated at 11%. This data suggests the DZP Site's watercourses would respond to rainfall events but they are not expected to carry significant base flow in dry periods.

3.1.2.5 Flooding

The DZP Site is bound along the western boundary by Paddys Creek and Wambangalang Creek. A flood assessment has been undertaken for these two creeks and for Watercourses B, C and E (see **Figure 7**). The aim is to identify the extents of the 100-year ARI storm flows and show diagrammatically how they would affect the DZP Site. The flood assessments involved the following;

- upstream catchment analysis;
- peak flow calculations; and
- flood modelling using software known as HEC-RAS.

A desktop study was undertaken to determine the upstream catchment areas draining to the streams. The catchment areas were determined using a series of 1:25,000 topographic maps sourced from the NSW Department of Lands, in particular Geurie (86335), Wellington (8632N), Peak Hill (8532N) and Sappa Bulga (8533S). Based on the catchment areas, the peak flows were determined in accordance with the Rational Method; as outlined in Institute of Engineers, Australia (2003).

A detailed survey with 1m contours was provided and to define flood levels and approximate flood extents a computer program known as "HEC-RAS" (Hydrologic Engineering Centres River Analysis System) was used. The inputs and results are given in **Appendix 3. Figure 8** provides a summary of the results. A discussion of impacts associated with flooding is provided in Section 4.1.9.

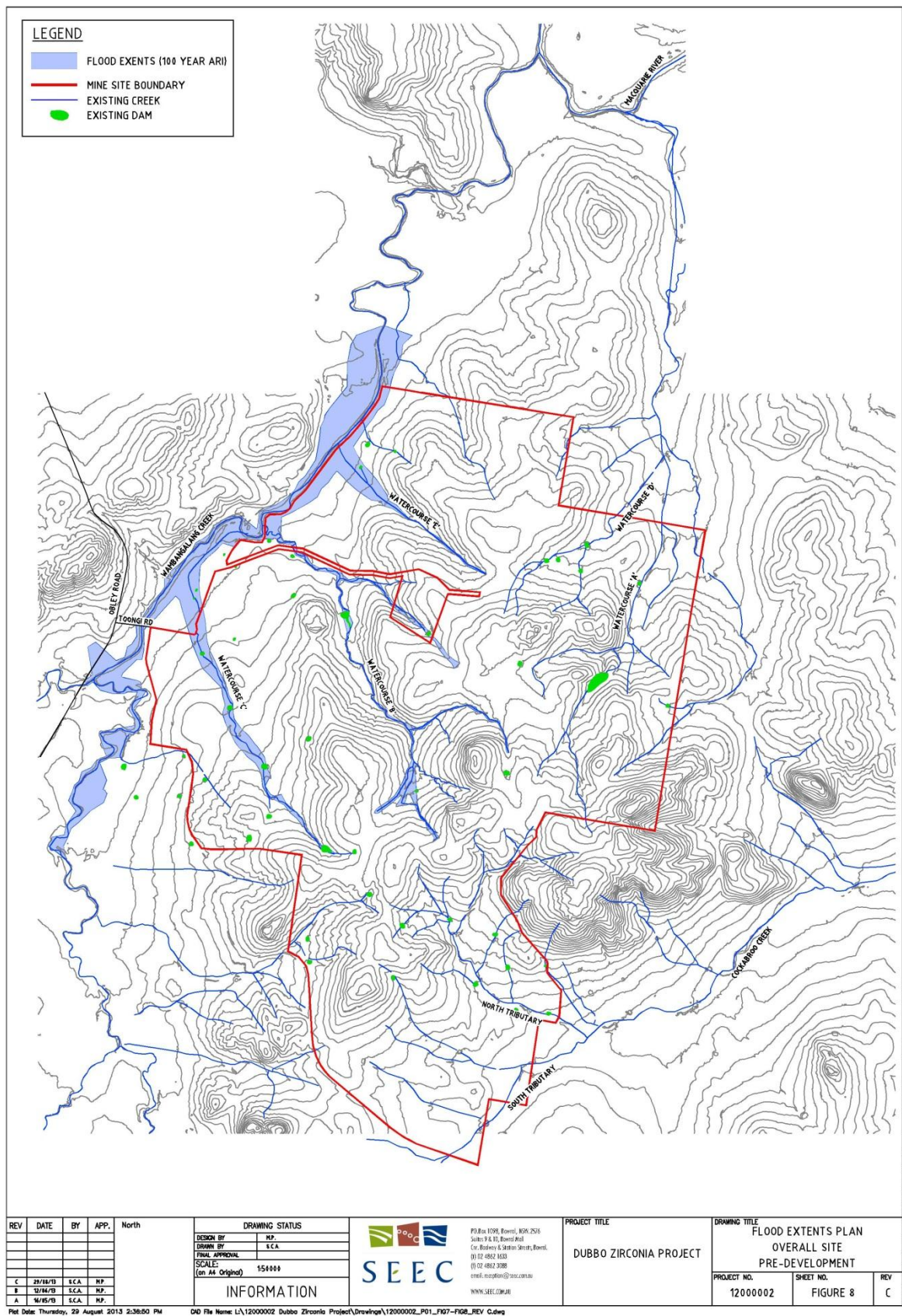


Figure 8 Flood Extents within the DZP Site

3.1.3 Receiving Waters

3.1.3.1 General Description

The receiving waters are described in the *Water Sharing Plan* (WSP) for the Macquarie Bogan Unregulated and Alluvial Water Sources. The Wambangalang Whyandra Creek Water Source is discussed in Report Card #29. It identifies five existing licenses with a total entitlement of 165 ML/year. 85% of that water is used for irrigation and 15% for domestic or stock use. A GIPA³ application determined that none of the five licenses are located on either Paddys Creek or Wambangalang Creek. The WSP advocates no further licenses in this catchment, although trading within it is permissible.

The Wambangalang Whyandra Creeks water source is described as non-perennial and often has no flow (the commence-to-flow estimate is 23%⁴). Water may be drained from it only when pools are at full capacity. Therefore, any surface water harvesting license (if available) would be 'unsecured' and so would not guarantee a reliable supply.

All the watercourses within the DZP Site drain to the Macquarie River upstream of Dubbo. Dubbo City Council draws most (85%) of its town water supply from the Macquarie River and so they are an interested user.

It is proposed to draw processing water directly from the Macquarie River. The Macquarie River is gauged at Dubbo (NSW Office of Water Gauge 421001). Long term flow data is readily available from NSW Office of Water and shows the mean daily flow is about 3,000 ML. However, the daily flow is highly variable (**Figure 9**). The 10th and 90th percentile flows are 244 ML/d and 5,247 ML/d respectively.

3.1.3.2 Salinity

Smithson (2001) identifies the Toongi Catchment as prone to significant salinity and the surface water in the Toongi Catchment is described as moderately saline to brackish. Both surface and groundwater flows appear to be controlled by basement geology. Surface water salinities average 2,000 to 3,000 μ S/cm but can be over 6,000 μ S/cm. Groundwater salinities range from 160 μ S/cm to over 6,000 μ S/cm, with a general increase in salinity downstream in the catchment. Smithson (2001) identified trends in groundwater levels during the 1990's that indicated they were rising at an average of 24 cm per year. Smithson (2001) infers there is open interaction between surface and groundwater in this catchment, as the two have similar salinities.

Groundwater systems within and surrounding the DZP Site consist of a combination of local, intermediate and regional groundwater. Potential groundwater discharge and saline sites within and surrounding the DZP Site have been identified as surface drainage lines, break of slope and on the valley floors or alluvial flats (Smithson, 2001). Areas at greatest risk of dryland salinity are those where the groundwater table is within five metres of the natural ground surface.

³ Government Information Public Access

⁴ Commence-to-flow estimates describe the percentage of time that a flow has been experienced.

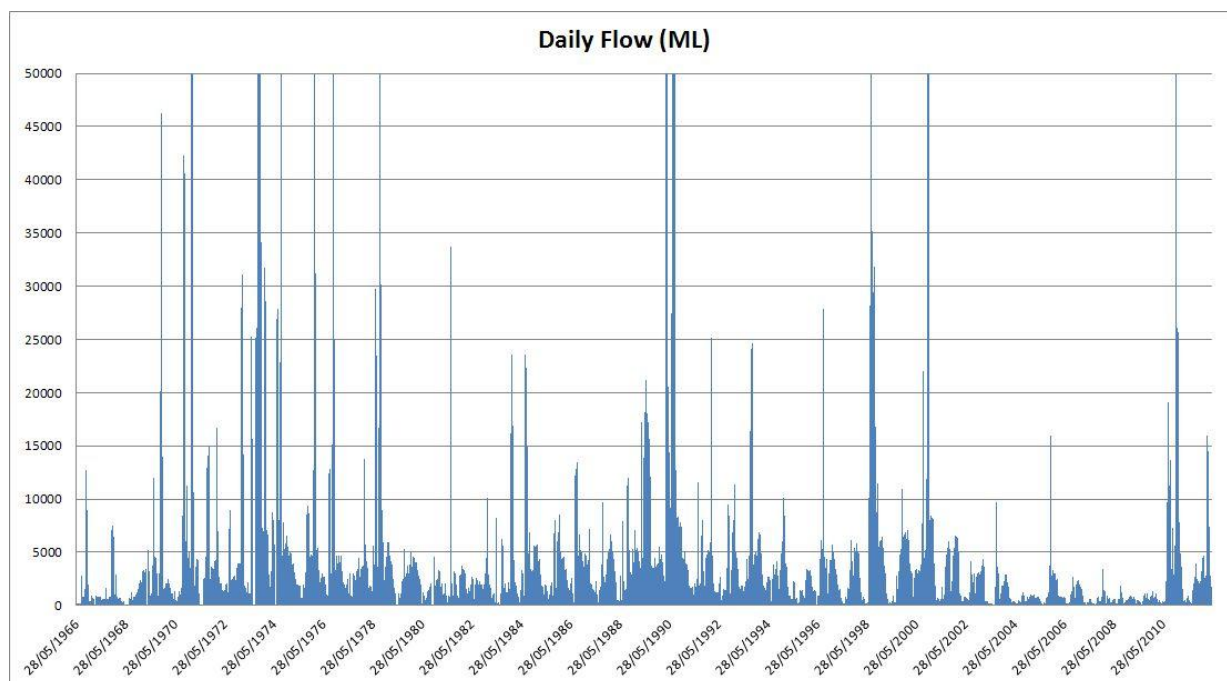


Figure 9 Daily Water Flow in the Macquarie River at Dubbo (Gauging Station 421001)

These areas have been mapped for the regional catchments including the DZP Site (Smithson, 2001). A review of *Figure 6* in Smithson (2001) indicates there are no recorded saline sites within the DZP Site, and *Figure 13* in Smithson (2001) shows that less than 5% of the DZP Site is expected to have water-tables within five metres of the natural ground surface (EES, 2013). Those 5% areas are all along the alluvium of Paddys, Wambangalang and possibly Cockabroo Creeks.

3.1.3.3 Existing Water Quality Data

Water quality sampling within the DZP Site and surrounding watercourses has been undertaken on two occasions, first by Golders in 2002 and later by SEEC in February 2012. **Figure 29** shows the location of the water sampling sites. Note that Location SW1 had to be moved to Location SW1b (a nearby farm dam) in the 2012 sampling program as there was no flow in the northern tributary of Cockabroo Creek on that day.

The results of the water sampling are given in **Tables 1** and **2**. They show:

- moderate salinity ($>2,300\mu\text{S}/\text{cm}$) in Paddys Creek and Wambangalang Creek in both sample sets;
- slightly alkaline pH (>8) in most of the 2002 samples and in one sample in 2012;
- elevated (above those given in ANZECC, 2000) nitrogen in most samples on both occasions;
- elevated (above those given in ANZECC, 2000) phosphorous in most of the 2012 samples; and
- elevated (above those given in ANZECC, 2000) turbidity in most of the 2012 samples.

Note that the 2012 sampling was done during a reasonably wet period. The elevated salinity noted by Smithson (2001) is reflected in the conductivity readings found in Wambangalang Creek (and the nearby Little River) during water quality testing. Conductivity was measured between 2,500µs/cm and 3,800µs/cm.

Table 1
2002 Stream Water Quality Testing

Parameter	Sampling Date	ANZECC 2000 Trigger Values Units mg/L ONO	SW1	SW1b	SW2	SW3	SW4	SW5	
Acidity as CaCO3	10th August 2001		14			467	469	385	
Ammonia(N)		0.013							
Conductivity (µS/cm)		350							
Oil & Grease (HEM)									
Phosphate ortho (P)									
Total Phosphorous		0.02	<0.01		<0.01	<0.01	<0.01	<0.01	
Turbidity (NTU)		<2 or >25	100			2.6	4.6	5.9	
Alkali Metals									
Calcium			2			71	93	72	
Magnesium			2			125	82	67	
Potassium			5			6	7	7	
Sodium			10			165	266	227	
Hardness Set									
Hardness mg equivalent CaCO3/L									
Major Anions									
Bicarbonate Alkalinity-mg CaCO3/L									
Carbonate Alkalinity-mg CaCO3/L									
Chloride			21			425	492	371	
Nitrate (as N)			0.02			0.24	0.02	0.02	
Sulphate (S)			2			36	44	56	
Metals M8 filtered									
Arsenic (filtered)			0.013	<0.01			<0.01	<0.01	<0.01
Cadmium (filtered)			0.0002	<0.001			<0.001	<0.001	<0.001
Chromium (filtered)		0.001	<0.001			<0.001	<0.001	<0.001	
Copper (filtered)		0.0014	0.003			0.002	0.001	0.001	
Lead (filtered)		0.0034	<0.001			<0.001	<0.001	<0.001	
Mercury (filtered)		0.00006	<0.0001			<0.0001	<0.0001	<0.0001	
Nickel (filtered)		0.011	0.003			0.003	<0.001	<0.001	
Zinc (filtered)		0.008	0.012			0.007	0.005	0.004	
Total Nitrogen (as N)									
Nitrate & Nitrite (N)		0.015	0.02			0.24	0.02	0.02	
Total Kjeldahl Nitrogen (N)		0.25	0.5			0.5	0.2	0.4	
Total Nitrogen (N)		0.25	0.5			0.5	0.2	0.4	
Field Measurements									
pH		<6.5 or >8	6.82			8.66	8.47	8.38	
Conductivity (µS/cm)		350	95			1970	2220	1830	
Temp									
Oxidation reduction Potential (mV)									

Table 2
2012 Stream Water Quality Testing

Parameter	Sampling Date	ANZECC 2000 Trigger Values Units mg/L ONO	SW1	SW1b	SW2	SW3	SW4	SW5	SW7	
Acidity as CaCO3	2nd February 2012			5	15	< 5	15	15	30	
Ammonia(N)		0.013	3.6	0.29	0.22	0.22	0.2	0.2		
Conductivity (µS/cm)		350	330	200	2300	2500	2800	3800		
Oil & Grease (HEM)			< 5	< 5	< 5	8	< 5	< 5		
Phosphate ortho (P)			< 0.005	0.006	< 0.005	<0.005	0.02	<0.005		
Total Phosphorous		0.02	0.06	0.03	0.06	0.04	0.08	<0.01		
Turbidity (NTU)		<2 or >25	26	11	11	30	26	18		
Alkali Metals										
Calcium				13	3.3	23	65	53	56	
Magnesium				5.3	3	73	47	63	58	
Potassium				13	5.3	3.2	3.8	3.9	3.7	
Sodium				4.5	8.7	120	150	190	260	
Hardness Set										
Hardness mg equivalent CaCO3/L				54.2	20.5	360	360	390	380	
Major Anions										
Bicarbonate Alkalinity-mg CaCO3/L				150	54	190	380	540	420	
Carbonate Alkalinity-mg CaCO3/L				< 5	< 5	88	<5	< 5	<5	
Chloride				< 1	< 1	19	19	80	120	
Nitrate (as N)				0.04	< 0.01	< 0.01	<0.01	< 0.01	<0.01	
Sulphate (S)				< 2	< 2	19	19	80	120	
Metals M8 filtered										
Arsenic (filtered)			0.013		0.002	< 0.001	0.004	0.002	0.003	0.001
Cadmium (filtered)			0.0002		< 0.0001	< 0.0001	< 0.0001	< 0.00001	< 0.0001	< 0.0001
Chromium (filtered)			0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper (filtered)			0.0014		0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lead (filtered)			0.0034		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mercury (filtered)			0.00006		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel (filtered)			0.011		0.008	0.002	0.003	0.002	0.001	<0.001
Zinc (filtered)			0.008		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Total Nitrogen (as N)										
Nitrate & Nitrite (N)			0.015		0.07	<0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total Kjeldahl Nitrogen (N)			0.25		4.1	1.1	0.9	0.7	0.5	0.3
Total Nitrogen (N)			0.25		4.2	1.1	0.9	0.7	0.5	0.3
Field Measurements										
pH			<6.5 or >8		7.86		8.38	7.74	7.94	7.3
Conductivity (µS/cm)			350		360	437	2078	2258	2516	3031
Temp					19.3	20.1	21.8	18	20.7	19.1
Oxidation reduction Potential (mV)					135	120	188	157	166	152

3.1.4 Climate

3.1.4.1 Rainfall

There are two nearby Bureau of Meteorology rainfall stations that have comprehensive sets of data. Those are Station 65030, Mentone (Elev. 330m, 11km to the southwest of the DZP Site) and Station 65000, Arthurville (Elev. 305m, 16km to the east-southeast of the DZP Site).

Mentone is slightly closer and experiences a wetter climate than Arthurville and so adopting its data represents a conservative approach for computer modelling the evaporation from the Liquid Residue Storage Facility. The mean annual rainfall is 647.3mm, the median rainfall is 643.7mm and the 95th percentile rainfall is 971mm. The wettest year on record (1950) was 1527.1mm.

There is a limited amount (12 years) of daily rainfall data from an automated weather station with the DZP Site. Unfortunately, during the period monitored (2001 to 2011 but not 2006) rainfall data for Mentone is incomplete and so a direct comparison is not possible.

Figure 10 gives the annual rainfall data since 1900 for Mentone. Two particularly wet years were 1950 and 1956. **Figure 11** gives the rolling 5-year mean annual rainfall. It shows a roughly 10-year cycle between wet and dry periods.

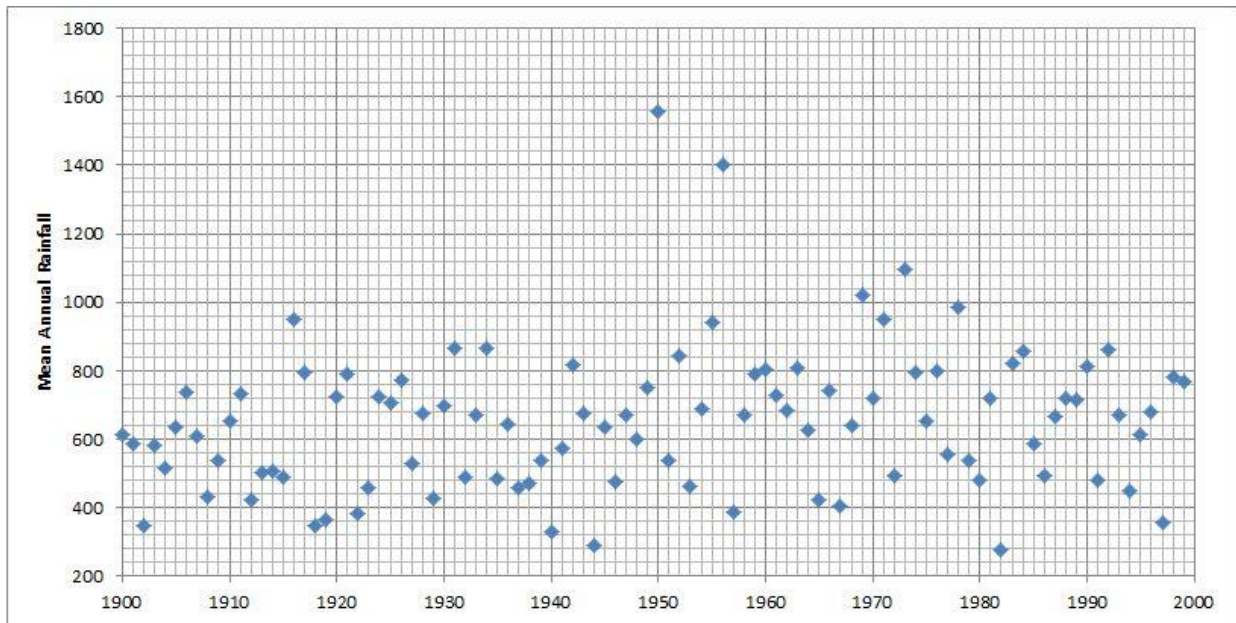


Figure 10 Mean Annual Rainfall at Mentone (BOM Station 65030)

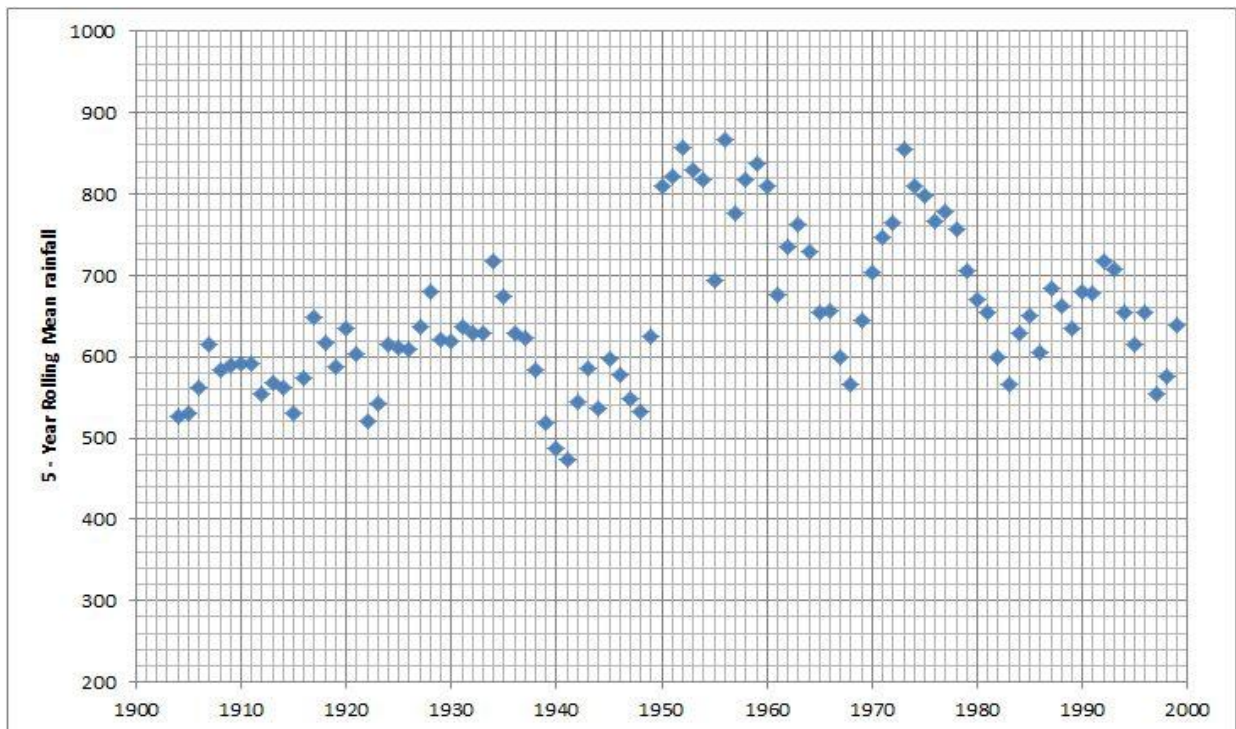


Figure 11 Rolling Five-Year Mean Annual Rainfall at Mentone (BOM Station 65030)

Figure 11 shows that relatively wet periods were encountered between 1950 and 1960 and again between 1970 and 1980. A relatively dry period occurred between 1900 and 1949.

The Rainfall Intensity Frequency and Duration (IFD) chart for the DZP Site is given in **Figure 12**. The rainfall erosivity (R-Factor) is 1,350 (low).

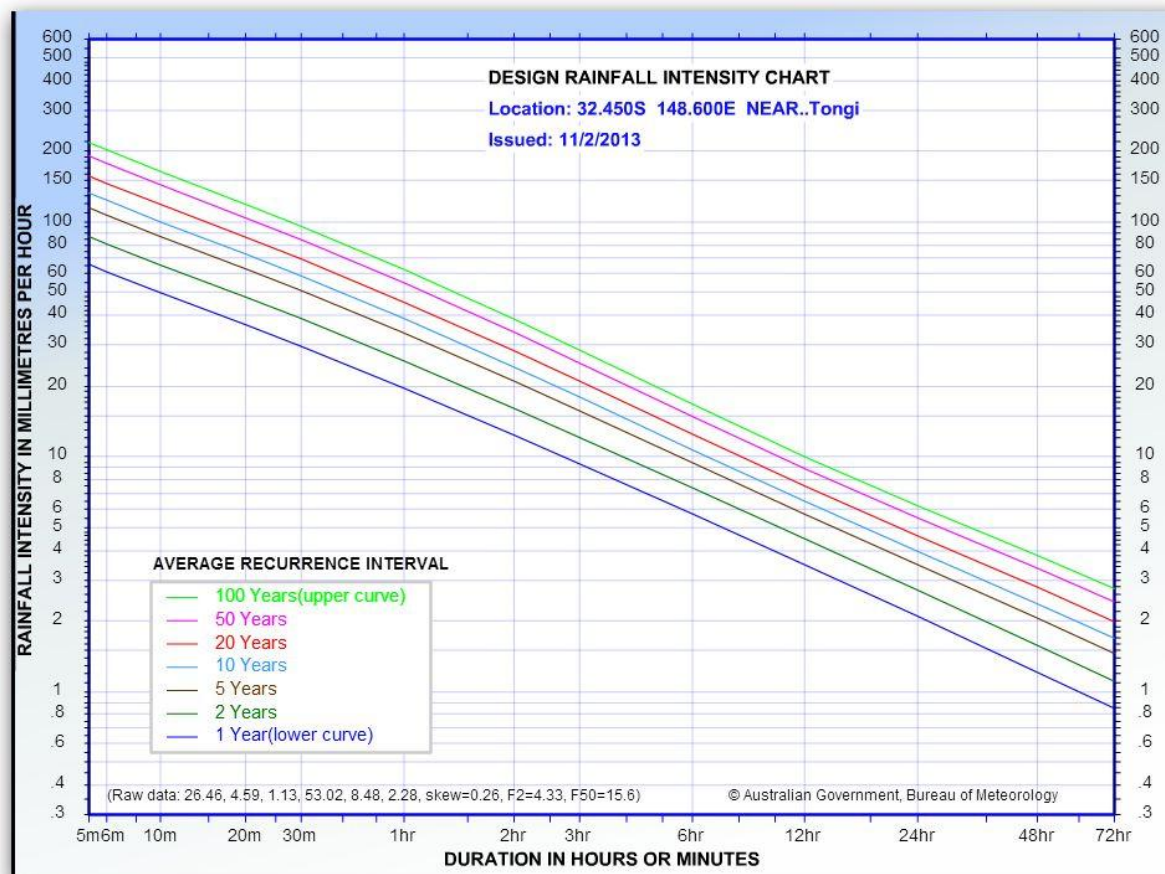


Figure 12 IFD Chart

3.1.4.2 Evaporation

Mean daily pan evaporation (PAN) is measured at Wellington Research Centre (BOM Station 065035, 35 km ESE of the DZP Site) (**Figure 13**). It is derived over a period of 40 years (1965 to 2005). Mean monthly potential areal evapotranspiration (PET) is available from the Climatic Atlas of Australia (Australian Government, Bureau of Meteorology, 2003).

Evaporation from a pond's surface (PPOND) is less than PAN, particularly for saline water. For the purpose of modelling it is assumed to be 72% of PAN (DECA, 2013). The relationship between PAN, PET and PPOND is given in **Table 3**.

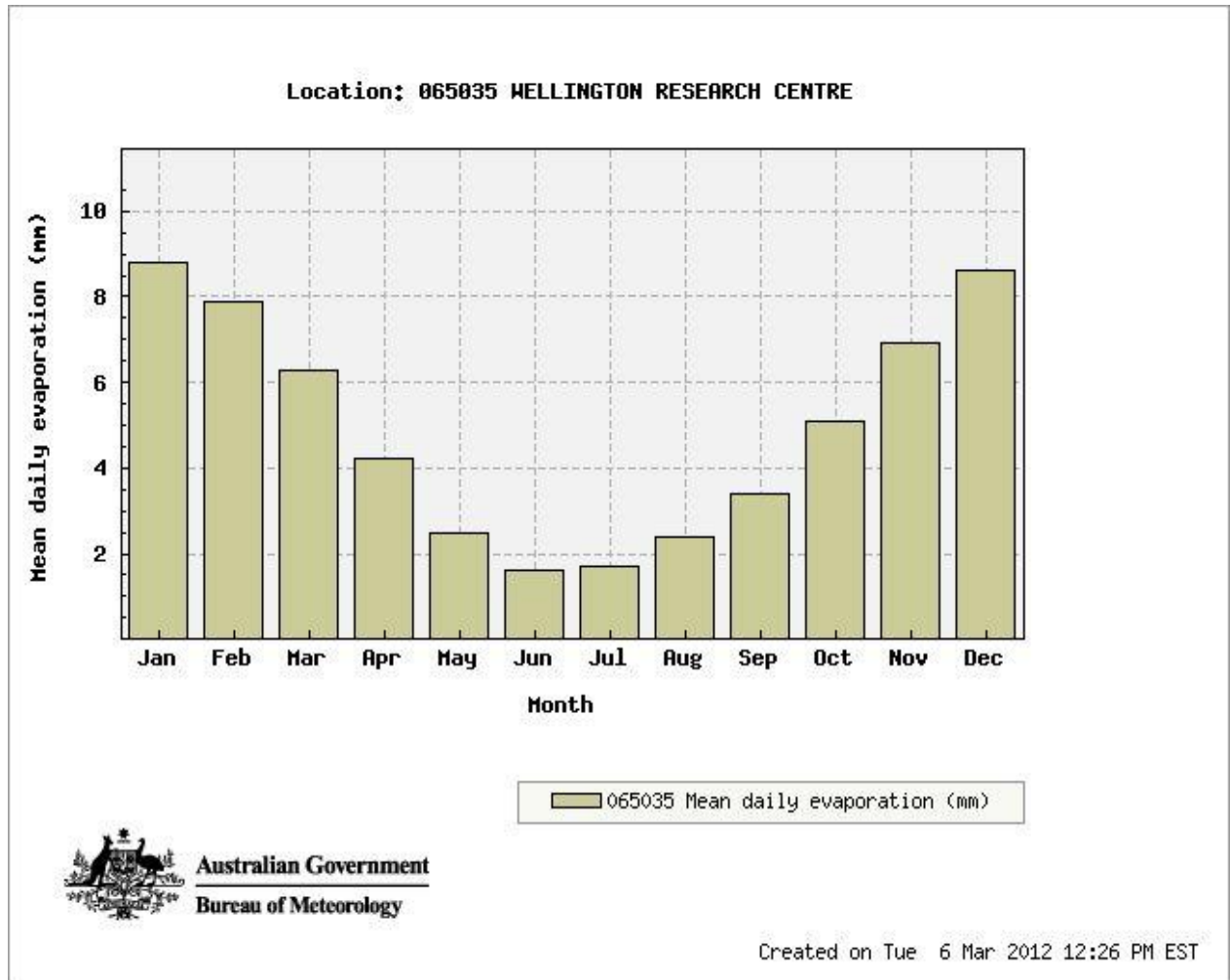


Figure 13 Measured Mean Daily Pan Evaporation (Wellington)

Table 3
Pan Evaporation (PAN), Potential Evapotranspiration (PET) and assumed Pond Evaporation (PPOND)

Month	Monthly PAN Evaporation (mm)	Potential Monthly Areal Evapotranspiration (PET) (mm)	Assumed Monthly Evaporation From Pond (PPOND) (mm)
January	273	174.6	196.6
February	218.4	128.8	157.3
March	195.3	120	140.6
April	126	81.6	90.7
May	77.5	56.3	55.8
June	48	45.9	34.6
July	52.7	49.4	37.9
August	74.4	65.7	53.6
September	102	87.3	73.4
October	158	126.2	113.8
November	207	150.1	149
December	266.6	159.3	192
Annual	1798.9	1245.2	1295.3

3.1.5 Vegetation and Land use

The majority of the DZP Site is categorised as farmland, cleared for grazing and occasional cropping. There are some stands of native timber, most notably in the east and, in particular, in the area of the proposed open cut.

3.1.6 Soils

Soils are described in Part 10 of the *Specialist Consultant Studies Compendium* (SSM, 2013). In summary, the comprehensive assessment of soil and landscape properties allowed assessments to be made of the land's agricultural capability and the likely performance of the soils when disturbed.

For the purpose of this surface water assessment, the soils are considered moderately erodible (with K-Factors between 0.03 and 0.04) and either fine grained (Type F) or significantly dispersible (Type D) (Landcom, 2004). This means sediment basins must be total-capture or "wet-type" basins and, for the purpose of their design, a K-Factor of 0.04 would be adopted in *Erosion and Sediment Control Plans*.

3.2 TOONGI ROAD UPGRADE

The DZP Site entrance requires crossing Wambangalang Creek at Toongi Road (**Figure 2**). The existing crossing consists of a relatively low-level concrete causeway with six 1050mm reinforced concrete low flow pipes.

A catchment analysis was conducted and the 100-year ARI storm flow was calculated by the Rational Method as outlined in Institute of Engineers, Australia (2003). The calculated flows were put into a flood modelling program (HEC-RAS) to determine the 100-year ARI pre-development flood levels at the creek crossing (**Figure 14**). It is required to raise the crossing so that it remains above the 100 year ARI flood level with appropriate clearance (**Section 8.2**).

3.3 OBLEY ROAD UPGRADES

There are three main watercourse crossings on the Obley Road between the Newell Highway and Toongi Road (**Figure 5**).

- Cumboogle Creek: a concrete bridge structure with 7m wide pavement elevated above the local flood plain. The Cumboogle Creek Crossing would not be upgraded.
- Hyandra Creek: a 12m span steel bridge. Flood modelling completed by SEEC (**Figure 15**) indicates that the elevation of the bridge is below the 1 in 5 ARI flood event. The crossings of Hyandra Creek and Twelve Mile Creek would be upgraded (**Section 8**).
- Twelve Mile Creek: a single 450mm reinforced concrete pipe low flow causeway. Flood modelling completed by SEEC (**Figure 16**) indicates that the elevation of the causeway and the road for several hundred meters in either direction is below the 1 in 5 ARI flood event.

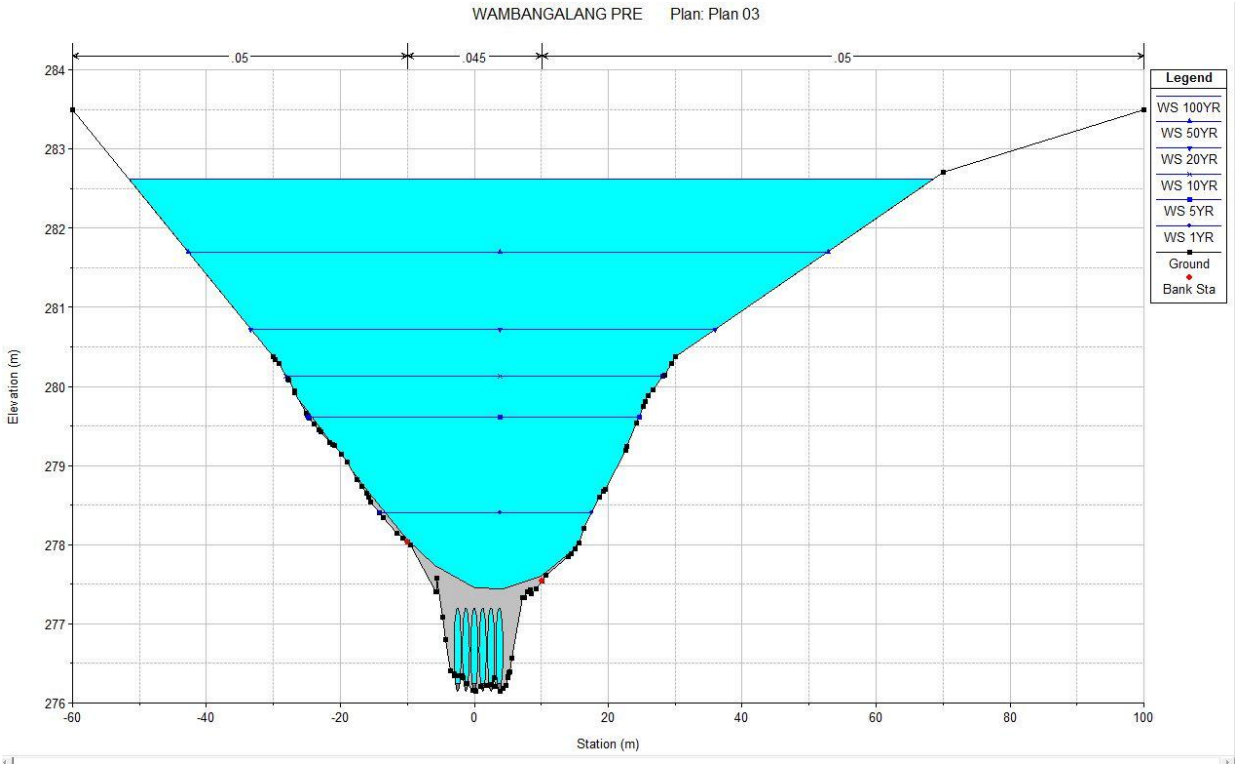


Figure 14 Flood Levels Wambangalang Creek, Toongi Road Crossing

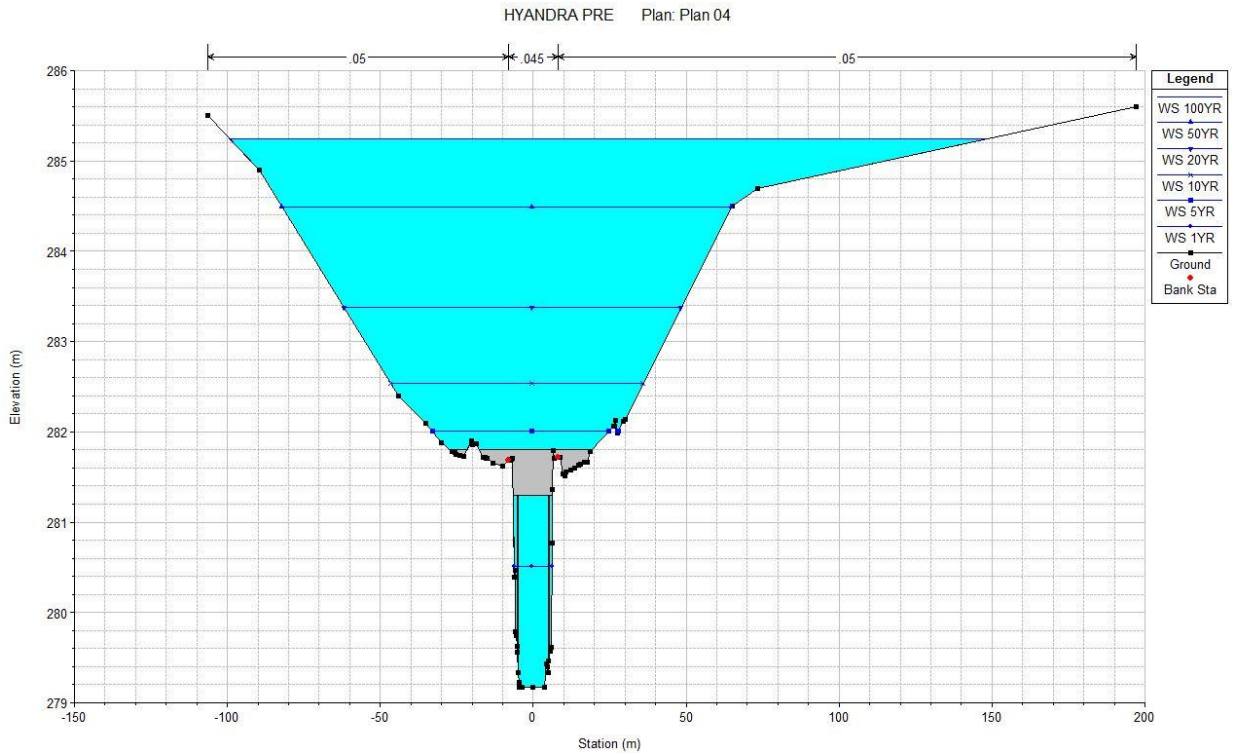


Figure 15 Flood Levels, Obley Road, Hyandra Creek Crossing

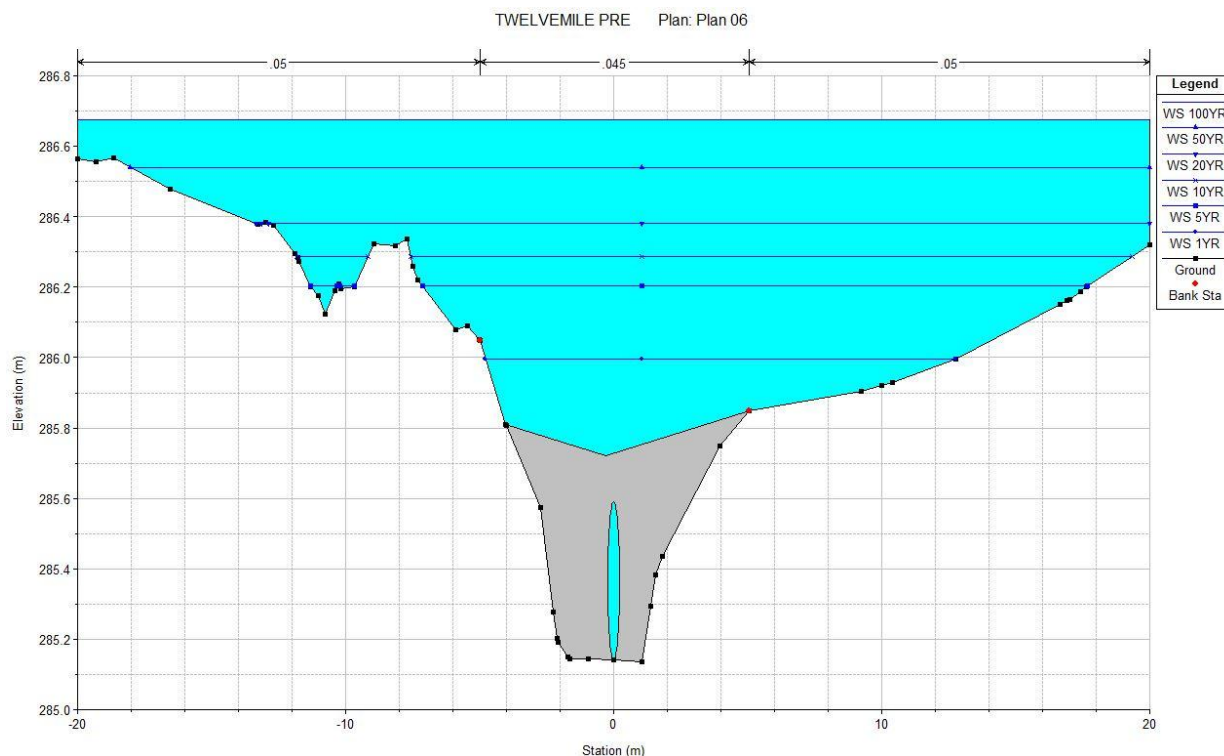


Figure 16 Flood Levels, Obley Road, Twelve Mile Creek Crossing

3.4 MACQUARIE RIVER WATER PIPELINE CORRIDOR

The Macquarie River Water Pipeline corridor is aligned approximately south to north (**Figure 3**). It would cross gently inclined agricultural land (0 to 6% slope) and would mostly be built on either the Mitchell Creek (alluvial) or the Ballimore (residual) soil landscapes. Despite their different origins both these soils landscapes generally consist of sandy loam topsoil over clay subsoil. Murphy and Lawrie (1998) classify the Ballimore Soil Landscape as moderately erodible and that is expected to be true of the Mitchell Creek Soil landscape. However, the gentle topography means the erosion risk during construction would be low (Landcom, 2004).

3.5 TOONGI-DUBBO RAIL LINE AND GAS PIPELINE CORRIDOR

The Toongi-Dubbo Rail Line and Gas Pipeline Corridor follow the existing Dubbo to Toongi Rail Line. There are five significant watercourse crossings on the alignment (**Figure 4**). Detailed designs for these crossings would be prepared following receipt of development consent.

4. POTENTIAL SURFACE WATER IMPACTS

4.1 DZP SITE

4.1.1 Stream Flow Volumes (Surface Water)

4.1.1.1 During Operation

Assuming a mean annual rainfall of 643.7mm and a runoff coefficient of 11% (**Section 3.2.2.4**), the mean annual runoff from the whole DZP Site (2,864ha) is approximately 2,027 ML/year. The proposed Liquid and Solid Residue Storage Facilities, Salt Encapsulation Cells, banded processing areas and the open cut represent a loss of approximately 640ha from local stream catchments and so this represents a mean annual runoff loss of approximately 453ML/year (a 22% reduction). The total 453ML/y of losses would be distributed approximately as follows:

- 338ML from Wambangalang Creek.
- 95ML from Macquarie River (undefined) Catchment.
- 20ML from Cockabroo Creek.

Therefore, most of the potential loss would be from the catchment to Wambangalang Creek.

At a point just downstream of the DZP site Wambangalang Creek has a catchment of 36,880ha. With a catchment-wide surface runoff coefficient of 11%, the mean annual flow *attributed to surface runoff* would be approximately 26,100ML. Therefore, the loss of 338ML represents a reduction in flow *attributed to surface runoff* of about 1.3%. It would be difficult to identify such a small change in the flows in Wambangalang Creek, particularly as it would be further masked by any base flow.

There are no existing Water Licenses downstream of the DZP Site and so there would be no predicted impacts to licensed users. There could be recreational users downstream but it's unlikely they would be using Wambangalang Creek when rainfall is sufficiently high to cause runoff into the creek. Therefore, it is unlikely they would be affected.

Surface flow losses to Watercourses A and D (which join) would be proportionally larger. The catchment of these within the DZP Site boundary is 660ha and so the existing mean estimated runoff is 467ML. A loss of 95ML represents a loss of 20% from the total flow. This could be noticeable to downstream users, although as noted above there are no registered users of surface water.

590ha of the DZP Site drains to Cockabroo Creek and so the existing mean estimated runoff is 188ML. A loss of 20ML represents a loss of 5% from the total flow. It would be difficult to identify such a small change in the flows in Cockabroo Creek, particularly as it would be further masked by additional flow derived from off-site catchments.

4.1.1.2 Post Mining

Post mining the only land quarantined from existing catchments would be the remnant open cut void which would have an area of approximately 40ha. The reduction in surface flow

attributed to this area would be (on average) approximately 28ML/year. This would represent a minimal impact on the local ephemeral streams and that impact would be reduced by increased groundwater base flow due to the void's catchment (**Section 4.1.2.2**).

4.1.2 Stream Flow Volumes (Groundwater Interaction)

4.1.2.1 During Operation

The proposed Liquid and Solid Residue Storage Facilities could act as impediments to shallow soil drainage, and, due to increased pore pressures, they could retard catchment groundwater movement. This could mean slightly elevated base flows to the local streams but that has not been quantified. The groundwater quality is very similar to the stream water quality and so the impact of slightly elevated base flows would be minimal.

4.1.2.2 Post Mining

Recharge derived from incident rain caught in the remnant open cut void could locally affect groundwater (refer to EES, 2013, Part 5 of the *Specialist Consultant Studies Compendium*). There could be minor increases in base flow in the local ephemeral streams but the impact is expected to be minimal.

4.1.3 Stream Flow Rates

4.1.3.1 During Operation

The reduction in surface runoff volume due to the DZP would be minor (**Section 4.1.1**) and so the effect on stream flow rates would also be minor. However, impervious areas increase the rate at which stormwater leaves a site and the most significant of these (the Processing Plant and the DZP Site Administration Area) are located quite close to Wambangalang Creek. Where necessary, stormwater flow rates derived from these areas would be controlled by stormwater detention to limit them to no more than those pre-development up to the 1:100 year ARI storm event. This would reduce the risk that increased runoff could cause erosion in Wambangalang Creek.

4.1.3.2 Post Mining

Post mining there would be minimal change to stream flow rates as it is proposed to return the land to its former landform. The open cut void would be located at the head of three catchments and so any impact it would have would be distributed between them. The loss of catchment to these three watercourses would be minimal.

4.1.4 Sedimentation

4.1.4.1 General

The soils of the DZP Site are moderately erodible and generally either fine grained or significantly dispersive (SSM, 2013). Areas of bare soil would be potential sources of erosion and subsequent sedimentation unless they are managed correctly.

4.1.4.2 Site Establishment Stage

Areas of land would be stripped to establish infrastructure within the DZP Site and the infrastructure that connects to it (gas and water pipelines, public roads, and railway). On the DZP Site some of the components would be expanded as the DZP is progressively developed as it would not be necessary to construct all the facilities at once. Nevertheless significant soil disturbance is required during the Proposal's establishment phase.

Soil and water would be managed during the establishment phase in accordance with the requirements of Landcom (2004), DECC (2008) and DECC (2008b). Before works begin a series of progressive *Erosion and Sediment Control Plans* would be prepared, each reflecting a different stage of earthworks. They would be prepared by a Certified Professional in Erosion and Sediment Control.

In summary, sediment loss would be controlled by a series of best management practices:

- diverting surface water run-on away from active works areas;
- minimising areas of disturbed ground by:
 - only disturbing land when works are required; i.e. working in stages and not opening up more land than can be effectively managed at once;
 - delineating no-go areas; i.e. controlling access to only those areas that would be worked; and
 - effectively and promptly stabilising ground that has reached its final design form or land that would not be re-worked within 20 days;
- using other tools such as:
 - reducing slope lengths on disturbed surfaces to control soil loss;
 - using sediment fence or similar sediment traps where necessary; and
 - using a series of “wet-type” sediment basins and actively managing them to the requirements of Landcom (2004) and DECC (2008).

The estimated sediment basin volumes for the DZP Site are given in **Table 4**. For all sediment basins collecting run-off from areas of disturbance not exposed to ore or waste rock, i.e. all basins except SB4, SB5 & SB12, the volumes are derived using the following data:

- A design rainfall depth of 35.6mm being the 90th percentile 5-day rainfall depth (Landcom, 2004);
- A rainfall erosivity factor (R-Factor) of 1,350;
- A soil erodibility factor (K-Factor) of 0.04;

- Slope lengths and gradients: Varies, as estimated from the plans; and
- Measurements of the various disturbed areas from the plans.

For sediment basins collecting run-off from ore stockpiles (ROM Pad) or waste rock (WRE), i.e. sediment basins SB4, SB5 and SB12, the volumes are derived using the following data:

- Twice the required volume of stormwater produced by the 100 year, time of concentration (tc) storm event.

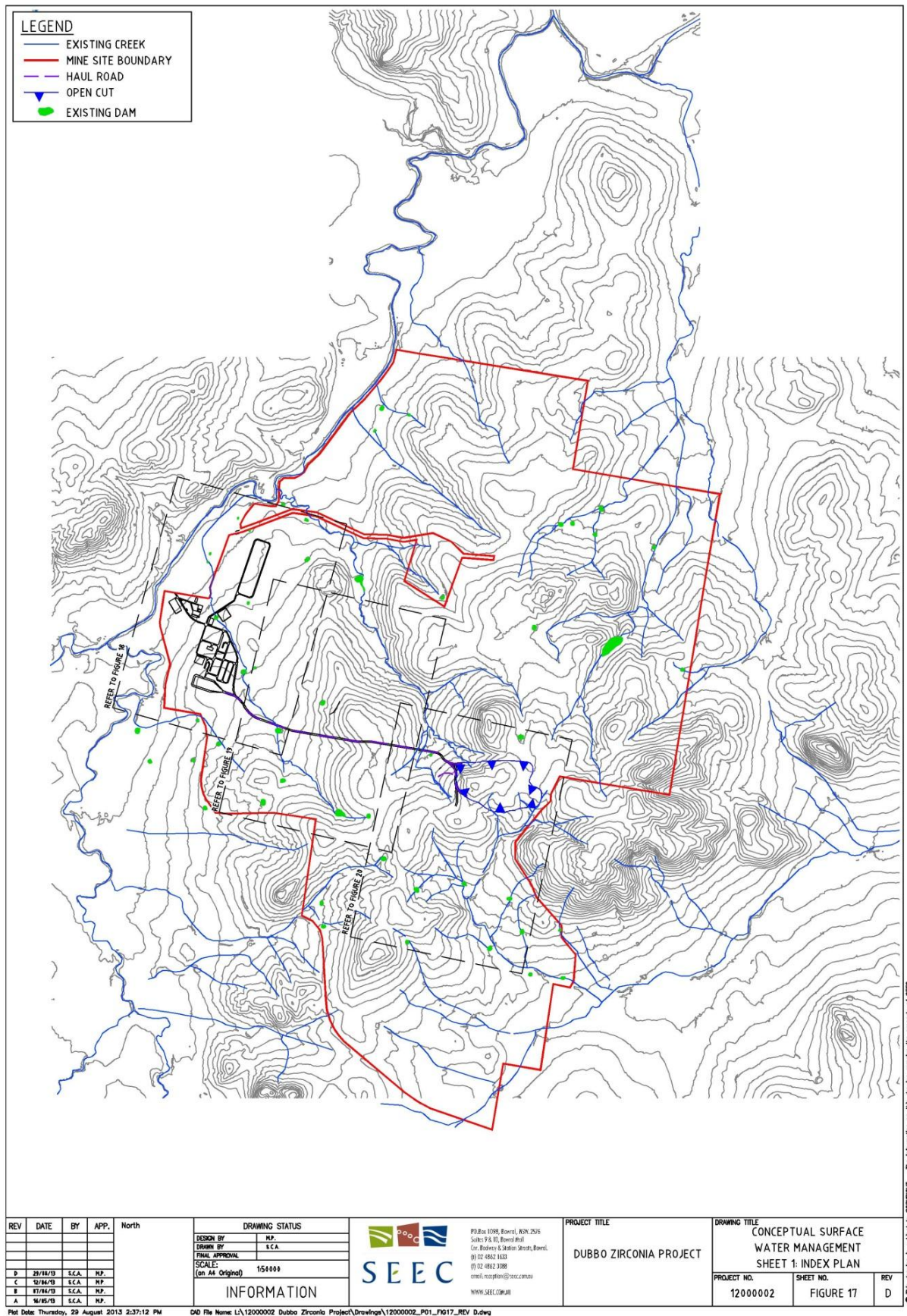
Table 4
Required Sediment Basin Volumes

Identification	Catchment	Water Volume (m ³)	Soil Volume (m ³)	Total Proposed Volume (m ³)
SB1	Admin Area	1,900	100	2,000
SB2	Rail Laydown	4,850	150	5,000
SB3	Process Area	4,850	150	5,000
SB4	WRE	10,000	100	10,100
SB5	WRE	5,000	50	5,050
SB6	Open Cut	2,600	500	3,100
SB7	Open Cut	1,350	150	1,500
SB8	Open Cut	2,900	300	3,200
SB9	Open Cut	2,500	600	3,100
SB10	Open Cut	1,100	300	1,400
SB11	SRSF	5,100	500	5,600
SB12	ROM	6,000	100	6,100

A conceptual arrangement of the various diversion drains, dirty water collection drains and Sediment Basins on the DZP Site, for initial operations on the DZP Site⁵, are shown in **Figures 17 to 20**. It is noted that the exact location and orientation of sediment basins would be defined in a *Progressive Erosion and Sediment Control Plan* for the DZP following receipt of development consent and prior to commencement of construction.

Sediment Basins would also be required to accompany the construction of the various stages of the Liquid Residue Storage Facility, Cells B and C of the Solid Residue Storage Facility and Salt Encapsulation Cells. These basins would be designed in accordance with the above guidelines and would be described in one or more *Progressive Erosion and Sediment Control Plans* prepared by a Certified Professional in Erosion and Sediment Control before construction begins.

⁵ **Figures 17 to 20** consider disturbance associated with the DZP Processing and Site Administration Area, open cut, WRE, Cell A of the SRSF, Mine Haul Road and various soil stockpiles. Erosion and sediment control for the LRSF, additional cells of the SRSF, Salt Encapsulation Cells and other disturbance not illustrated would be included in a *Progressive Erosion and Sediment Control Plan* for the DZP Site.



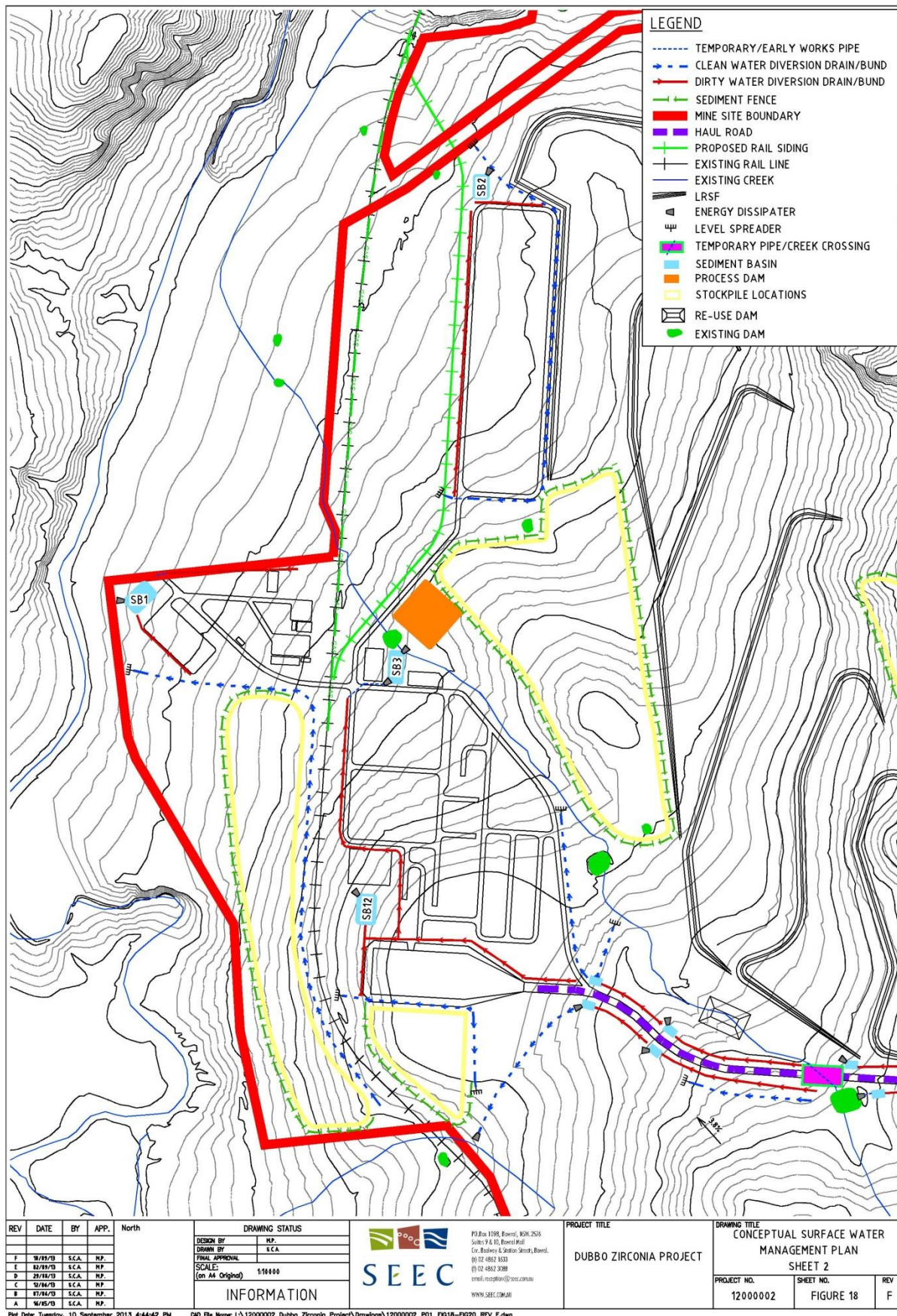


Figure 18 Conceptual Surface Water Management Sheet 2

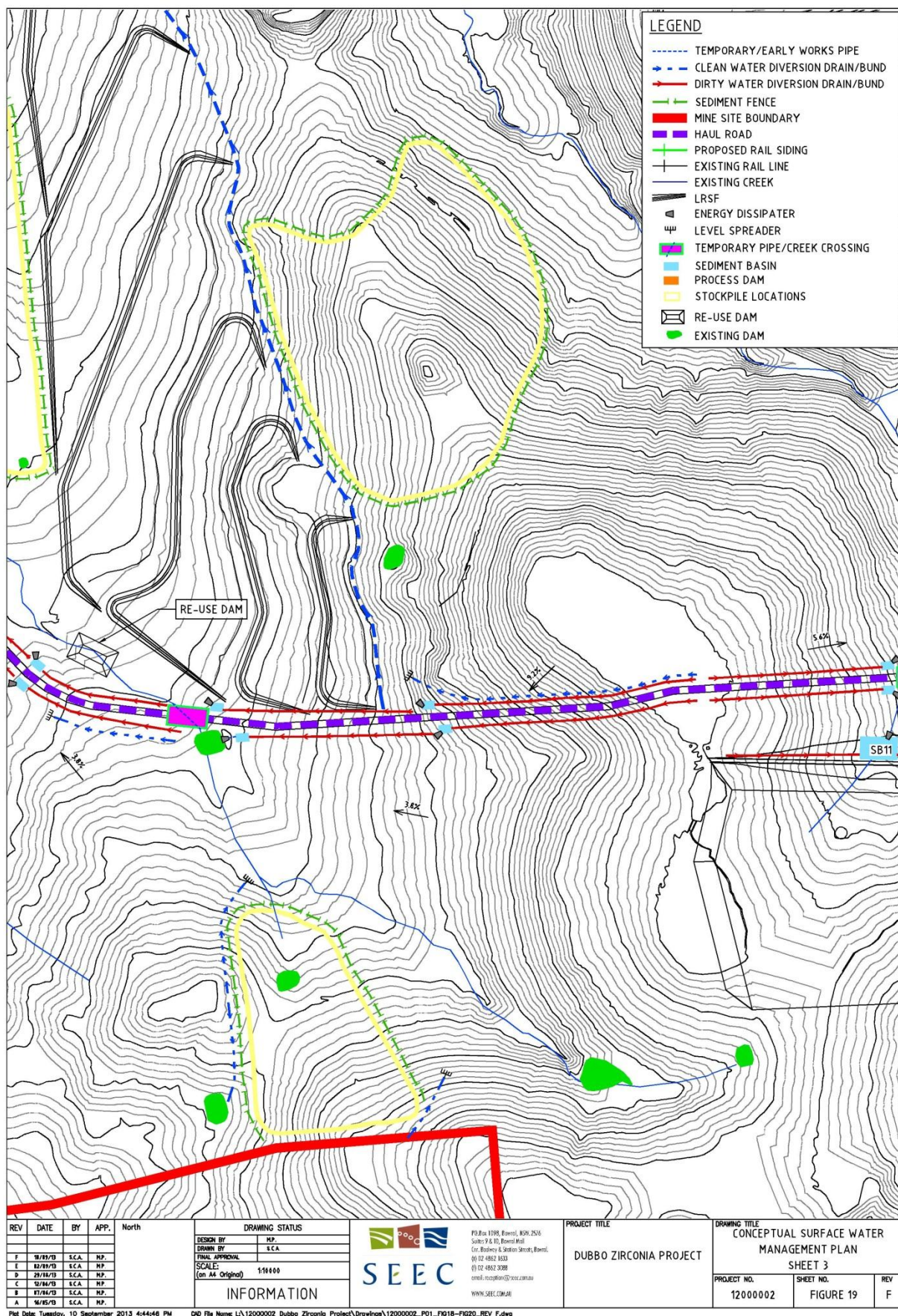


Figure 19 Conceptual Surface Water Management Sheet 3

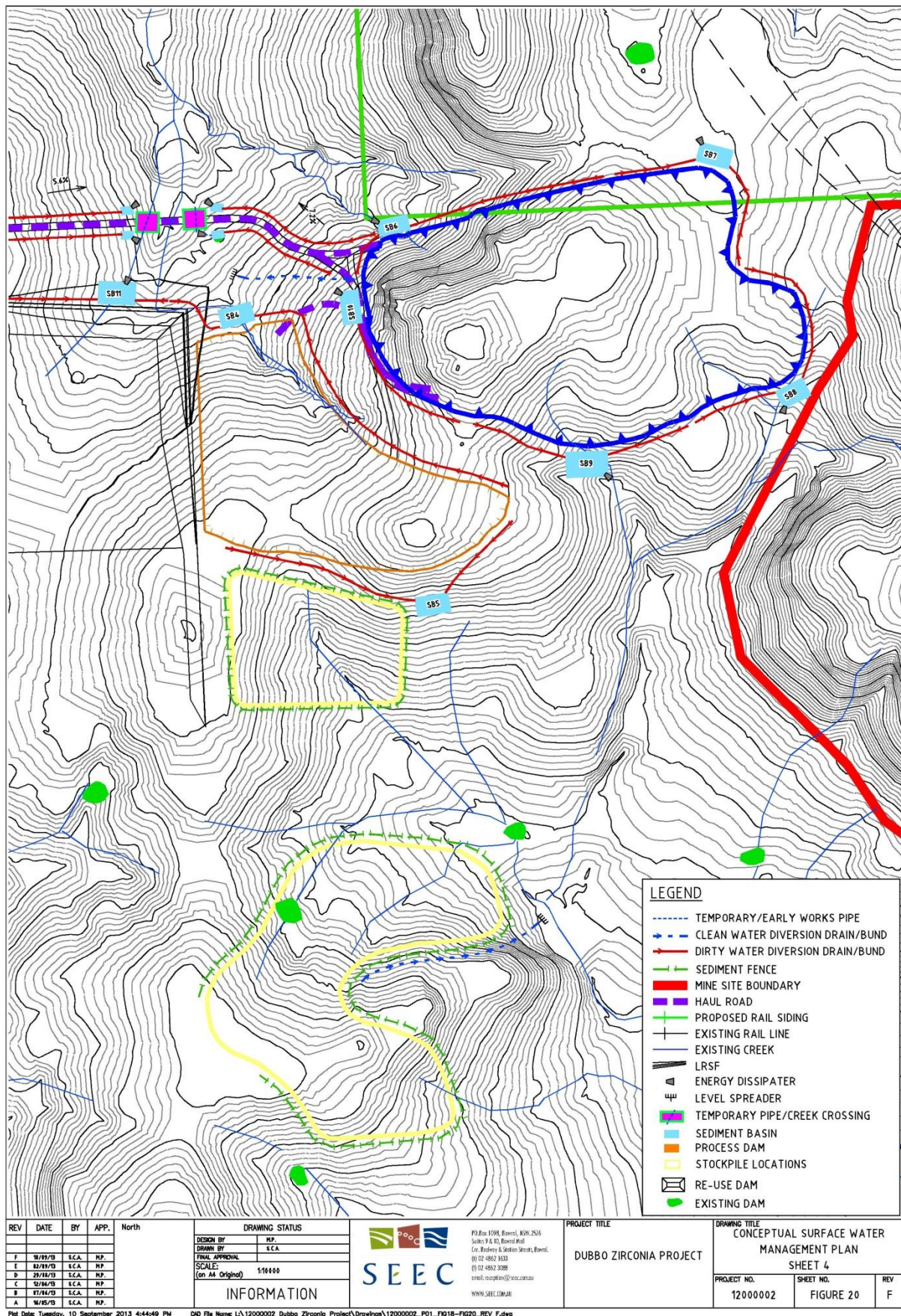


Figure 20 Conceptual Surface Water Management Sheet 4

4.1.4.3 Mining Operations Stage

Sediment Basins SB6 to SB11 would be temporary only, designed to manage runoff from the establishment stages of the open cut and Solid Residue Storage Facility until these areas become internally draining.

After establishment, the basins would be decommissioned and incident rainfall collected in these areas would be pumped (in preferred order) to the Liquid Residue Storage Facility or the Process Water Dam. **Section 5** discusses the configuration and management of the operational-stage sediment basins.

As development of the DZP progresses and new facilities are required (e.g. additional cells of the Solid Residue Storage Facility, Liquid Residue Storage Facility and Salt Encapsulation Cells), soil disturbance would continue. Temporary haul roads would be required to expand the facilities and significant earthworks would be undertaken. Each part of the works would be accompanied by a *Progressive Erosion and Sediment Control Plan* prepared by a Certified Professional in Erosion and Sediment Control.

4.1.5 Soil Stockpiles

Topsoil and subsoil would be stripped following the procedures identified in SSM (2013) (Part 10 of the *Specialist Consultant Studies* Compendium). Topsoil and subsoil would be stored in separate stockpiles. Stockpiles would be created progressively throughout the life of the Proposal as new cells are built in the Liquid Residue Storage Facility.

Stockpiles would be stabilised as soon as they are completed and vegetated with pasture grass. Stockpiles would be protected from stormwater run-on by stabilised diversion drains designed for the 20-year ARI storm flow (DECC, 2008). Sediment fence would be used downslope of all stockpiles until they are fully stabilised (i.e. until they have at least 70% ground cover). Stockpiles would be placed no closer than 20m from any concentrated water flow.

4.1.6 Post Mining

Rehabilitation after mine closure would require soil management and replacement to re-shape landforms prior to re-vegetation. One or more *Erosion and Sediment Control Plans* would be prepared by a Certified Professional in Erosion and Sediment Control (CPESC) before those works begin.

4.1.7 Infrastructure Watercourse Crossings

Watercourse crossings such as those on Obley Road, Toongi Road or the Toongi-Dubbo Rail Line would require specific *Erosion and Sediment Control Plans* prepared by a Certified Professional in Erosion and Sediment Control. Those plans would be considerate of the fact that works would be done within the riparian zones. The plans would show how soil and water would be managed during the construction of the new culverts to minimise erosion and sedimentation.

4.1.8 Protection of Mine Facilities from Stormwater Run-on

Mine facilities would be protected from surface water run-on by clean water diversion drains designed to be stable in the 1:100 ARI storm flow. Some of those drains would remain from the establishment stage (**Figures 17 to 20**). **Figure 21** shows the proposed drains to protect the Liquid Residue Storage Facility. All drains would be suitably lined to ensure their long-term stability.

Where necessary those structures which would remain permanently (the Salt Encapsulation Cells and the Solid Residue Storage Facility) would be protected with up-slope diversion drains designed to be stable in the Probable Maximum Flow (PMF). Note that these facilities have been located in elevated lands so that their upslope catchments are small.

4.1.9 Flooding

The Processing and DZP Site Administration Area would be located on relatively low-lying areas in the western section of the DZP Site. Flood assessments undertaken by SEEC (Section 3.1.2.5) (**Figure 8**) have shown areas adjacent to Watercourse C could be affected by localised flooding from this watercourse in a 100yr ARI storm event. The existing rail line and proposed rail loop could also be affected.

The Processing Plant and DZP Site Administration Area would be built on pads raised above the 100yr ARI storm event flood level. **Figure 22** shows a cross section through the eastern part of the Processing Plant Area where the perimeter road effectively forms the required embankment. The proposed Process Water Dam would also form part of that embankment. The proposed embankments would be at least 1m above the 100yr ARI storm event flood level. **Figure 23** shows the predicted flood extents on the DZP Site after construction. It takes into account the reductions in flow attributed to the reductions in catchments. To ensure there is no constraint to water flow at the proposed rail loop a new box culvert structure would be required on Watercourse C.

The construction of embankments into the floodplain of Watercourse C would result in a slight increase in flow. **Table 5** gives the predicted changes in flow at chainages (Ch) 1,100m to 2,500m (refer to **Figure 23**). Increases in flow are predicted at the northern end of the Processing Area (Ch1,200 to Ch1,500) as well as adjacent to several cells of Liquid Residue Storage Facility – Area 3 (Ch2,100 to Ch2,400). Flows are predicted to increase by about 0.4 to 0.5 m/sec but would remain under 1.6 m/s, which is below the accepted velocity for stability in naturally vegetated channels (Landcom, 2004).

Where parts of the Liquid Residue Storage Facility would be affected by flooding (**Figure 23**) rock-pitching (150-300mm) over geotextile fabric would be used to protect the embankments from scour.



Figure 21 **Liquid Residue Storage Facility Diversion Drainage**

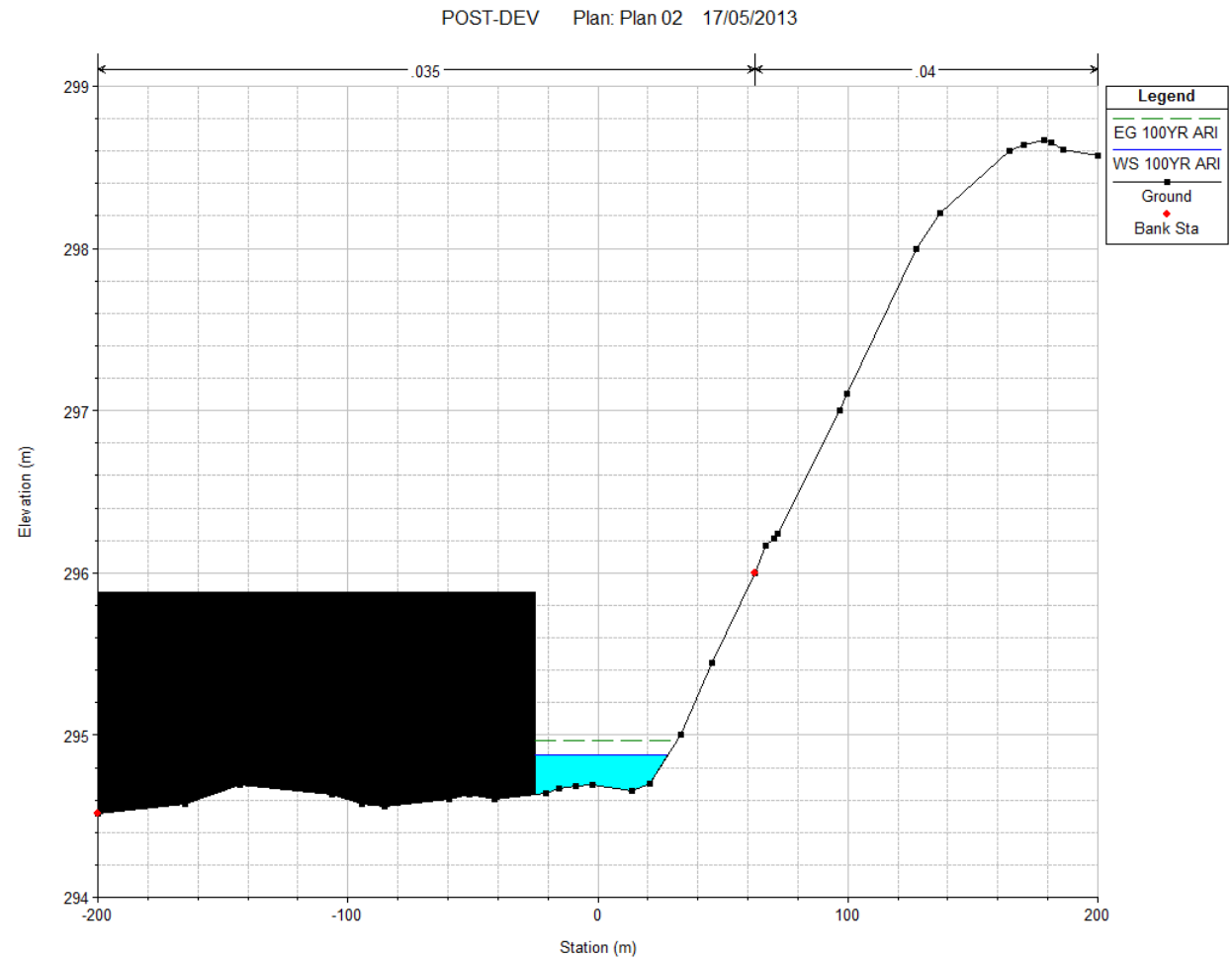


Figure 22 X-section through process area (black) & Watercourse C in 100yr Flood. (WS=Water Surface) Post Development.

Table 5 Predicted Changes in Channel Velocity; Watercourse C

Chainage (see Figure 23)	Pre development m ³ /s	Post Development m ³ /s	Change m ³ /s
2500	1.34	1.28	-0.1
2400	0.86	0.95	0.1
2300	0.99	1.06	0.1
2200	1.37	1.31	-0.1
2100	0.87	1.3	0.4
2000	1.43	1.32	-0.1
1900	1.56	1.36	-0.2
1800	1.26	1.18	-0.1
1700	1.1	0.98	-0.1
1600	1.3	1.2	-0.1
1500	1.13	1.5	0.4
1400	0.96	1.44	0.5
1300	0.9	1.32	0.4
1200	1.13	1.62	0.5
1100	1.34	0.99	-0.4

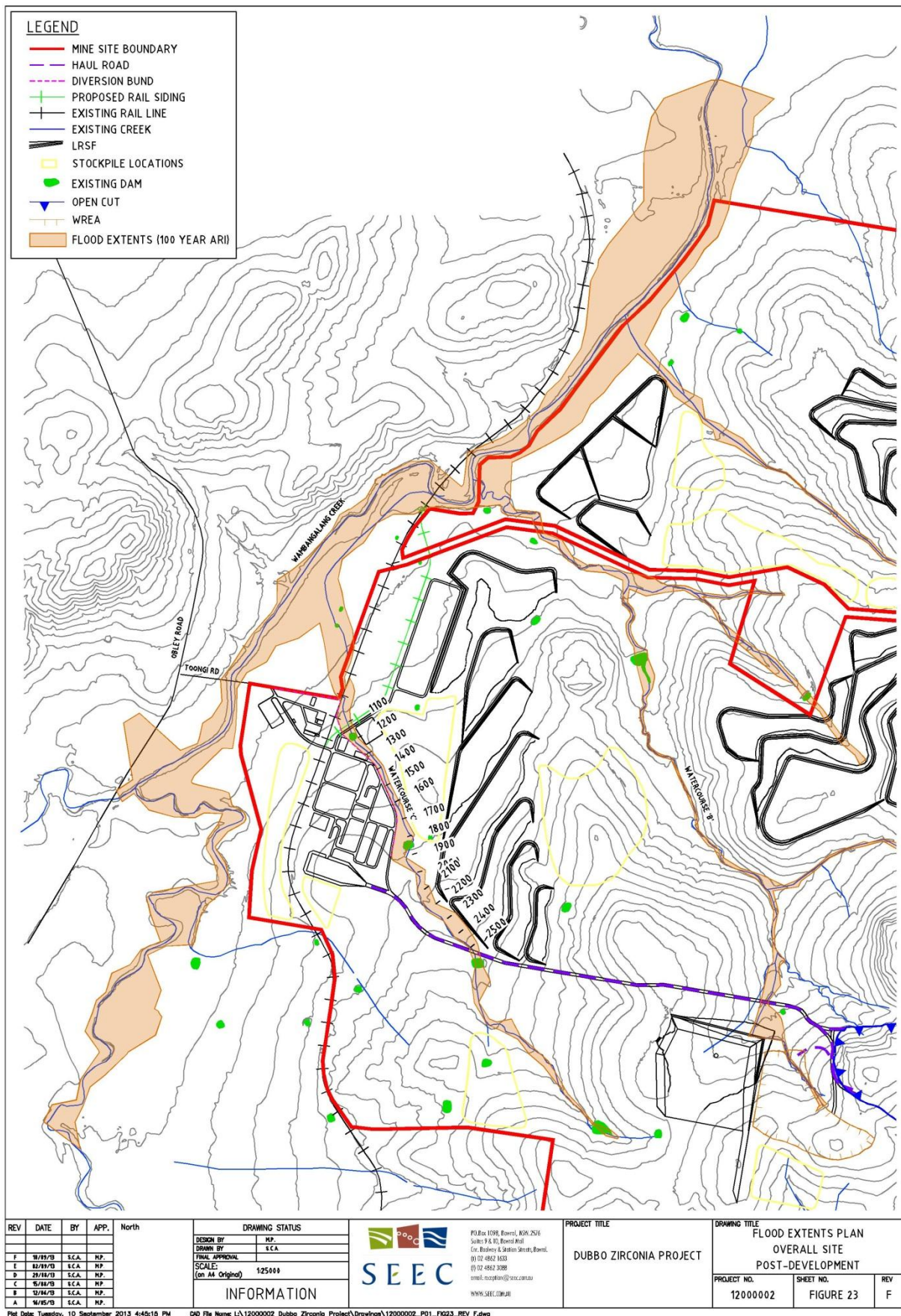


Figure 23 DZP Flood extents after construction

At the time of writing the proposed works in the floodplain would require an approval under Part 8 (s167) of the *Water Act 1912* as they would satisfy the definition of a controlled work under s165. However, there is a proposal to repeal Part 8 and that could occur before works commence. If so, former Part 8 works would become flood works under s90 of the *Water Management Act 2000* and the provisions of s89J of the *Environmental Planning and Assessment Act 1979* exempt this State Significant Development from approvals under s90. If not, then an application for a Controlled Activity would be submitted.

Construction would remain at least 20m from the top of the bank of Watercourse C, i.e. outside the 20m riparian zone applicable to a second-order stream.

4.1.10 Potential Contamination of Surface Water

4.1.10.1 Potential Contaminants

The following potential contaminants would be used within the DZP Site.

- Bulk reagents:
 - sulphur;
 - sulphuric acid (produced on site);
 - caustic soda;
 - hydrochloric acid; and
 - salt.
- Minor reagents:
 - sodium sulphite;
 - aluminium powder; and
 - anhydrous ammonia.
- Liquid Residue (saline discharge).
- Solid Residue.
- Fuels and other chemicals.

Solid reagents would be brought to site by rail or road in sealed containers. They would be unloaded into temporary storage areas and moved via a short haul road to dedicated long-term storage areas. All storage areas would be sealed and bunded.

The Rail Container Laydown and Storage Area would be concrete-paved and bunded. It would drain to a dedicated stormwater basin (SB3). As reagents are delivered in containers runoff from this area would be uncontaminated (apart from any sediment entrained in runoff). In the event of a reagent spill, the outlet to SB2 would be closed whilst the spill is removed. Any rainfall during that period would be collected within the bunded area and removed to the Liquid Residue Storage Facility.

The reagent storage areas in the Processing Plant would be concrete-lined and bunded. Sulphuric acid would be produced and stored on site in dedicated self-bunded tanks or in

roofed and bunded areas. If bunded areas were open to the weather, trapped incident water would be sent as soon as practicable, and in preferred order, to the Liquid Residue Storage Facility or the Processing Water Pond. Drainage from un-bunded areas not subject to potential contaminants would be directed to SB2 (Section 5.2.4).

4.1.10.2 Liquid Residue

The liquid residue would be pumped to the Liquid Residue Storage Facility which would be lined with HDPE liner. The cells would have 1m freeboard to allow for wave action (assumed maximum of 550mm) and the Probable Maximum Rainfall Event (450mm). Transfer pipes would be bunded to trap leaks should they occur.

4.1.10.3 Solid Residue

The solid residue would be transferred by conveyor belt to the Solid Residue Storage Facility which would be double-lined with HDPE or equivalently impermeable liner(s). Once dumped into the cell, a rubber-tyred dozer would be used to spread the material over the liner to provide a tipping face. The layers of residue would be progressively compacted to the required density using a self-propelled smooth-drum compactor.

The Solid Residue Storage Facility would have an internal drainage system to collect incident rainfall. The system would be similar to a decant tower in a normal tailings storage, however, there would be no rock mound. The slotted concrete tower sections would be wrapped in a geomembrane. The vertical well would house an electric submersible pump. The pump, controlled by float switches, would remove the water from the well. The water would be pumped to one of the cells at the Liquid Waste Storage Facility.

A leak detection system would be installed to monitor and collect any seepage, which would be returned to the surface of the facility. On mine completion the Solid Residue Storage Facility would be capped with a liner and a suitable layer of natural soil to allow rehabilitation.

4.1.10.4 Run Of Mine Pad

The Run of Mine (ROM) Pad would be located close to the immediate south of the Processing Area (**Section 5.2.5**). Here ore would be stored ready for processing. The ore would contain trace levels of radionuclides (principally Uranium and Thorium). Leachate testing shows they would not be readily leachable (**Table 6**) and would therefore be associated with the sediment (not the water). Runoff from this area would drain to a dedicated sediment basin (SB12) designed to exceed the 100year, time of concentration (t_c), storm volume (3ML) by a factor of two (Section 5.2.5).

Diesel pump(s) capable of 30kL/h⁶ would be installed to pump water (in preferred order) to one of the nearby Liquid Residue Storage Facility cells. Pumping would commence almost immediately after inflow. Together with the additional 3ML capacity this pump(s) would ensure there could be no overflow in any 100 year storm event.

⁶ Allowance for head loss and friction included

Table 6
TCLP testing on crushed ore (orange = detectable)

ELEMENT	UNITS	DETECTIO N LIMIT	DRY ORE SOLID
Ag	mg/L	0.1	<0.1
Al	mg/L	0.1	7.4
As	mg/L	0.1	<0.1
Ba	mg/L	0.1	0.4
Be	mg/L	0.1	<0.1
Ca	mg/L	0.1	28.3
Cd	mg/L	0.1	<0.1
Ce	mg/L	0.5	<0.5
Cr	mg/L	0.1	<0.1
Cu	mg/L	0.1	0.2
Fe	mg/L	0.1	0.7
K	mg/L	0.1	9.5
Mg	mg/L	1	18
Mn	mg/L	0.1	1.3
Mo	mg/L	0.1	<0.1
Na	mg/L	0.1	1300
Nb	mg/L	0.5	<0.5
Ni	mg/L	0.1	<0.1
P	mg/L	0.1	<0.1
Pb	mg/L	0.1	<0.1
S	mg/L	0.1	<0.1
Se	mg/L	0.1	<0.1
Si	mg/L	0.1	11.2
Sn	mg/L	0.1	<0.1
Sr	mg/L	0.1	0.6
Th	mg/L	0.1	<0.1
Ti	mg/L	0.1	<0.1
U	mg/L	0.1	<0.1
V	mg/L	0.1	<0.1
Y	mg/L	0.05	<0.05
Zn	mg/L	0.1	3.9
Zr	mg/L	0.1	<0.1
Dy	ppm	0.02	<0.02
Er	ppm	0.05	<0.05
Eu	ppm	0.02	<0.02
Gd	ppm	0.05	<0.05
Hf	ppm	1	<1
Ho	ppm	0.02	<0.02
La	ppm	0.5	<0.5
Lu	ppm	0.02	0.04
Nd	ppm	0.02	0.24
Pr	ppm	0.05	0.05
Rb	ppm	0.1	<0.1
Sm	ppm	0.02	0.04
Ta	ppm	0.5	<0.5
Tb	ppm	0.02	<0.02
Tm	ppm	0.05	<0.05
Yb	ppm	0.05	<0.05

Sediment would periodically (once per three months) be removed and placed in the Solid Residue Storage Facility. This would prevent a large accumulation of such material, which could contain radionuclide contaminants and which could otherwise be subject to re-mobilisation. To facilitate this, a sediment forebay would be designed into the basin's structure.

Assuming correct construction practices are adopted (including designing the spillway to handle the probable maximum flow) the risk of dam failure is considered very low. However, under exceptionally high rainfall (greater than any 100 year storm event) the dam could conceivably overtop.

In that unlikely event, the flow to Wambangalang Creek would be diluted there by flows exceeding $479\text{m}^3/\text{sec}$ (the 100 year peak storm flow). By comparison, the peak flow in any 100 year storm from SB12 would be approximately $1.64\text{m}^3/\text{s}$, which represents 0.3%. In addition Wambangalang Creek would continue to flow at a high volume after the pulse of water from SB12 finished, having a further significant dilution effect.

Under such circumstances the dilution effect would ensure there would be no identifiable increase in isotope concentrations in the stream's sediment (which would have been significantly affected by the high flow anyway).

4.1.10.5 Waste Rock Emplacement

The waste rock emplacement (WRE) would be located just west of the open cut and would occupy up to 24ha. Waste rock could contain trace concentrations of radionuclides and so runoff would be treated as potentially contaminated. The working face(s) would drain via catch drains designed to convey the 100-year ARI storm flow to sediment basins SB4 (10ML) and SB5 (5ML).

These would both be designed to have a volume twice that of the 100-year, tc, storm event⁷. Pumps capable of transferring at least 100kL/hour (SB4) and 45kL/hour (SB5) would pump trapped water (in preferred order) to Liquid Residue Storage Facility or the Process Water Dam. The pumps would start almost immediately after inflow to the basins. Sediment would be removed on no more than a three-monthly cycle and placed in the Solid Residue Storage Facility. This would prevent a large accumulation of such material, which could contain radionuclide contaminants and which could otherwise be subject to re-mobilisation. To facilitate this, a sediment forebay would be designed into the basins' structure.

Assuming correct construction practices are adopted (including designing the spillways to handle the probable maximum flows) the risk of dam failure is considered very low. Under exceptionally high rainfall (greater than any 100 year storm event) the dams could conceivably overtop. In that unlikely event, the flows to Wambangalang Creek and Cockabroo Creek would be diluted by the storm flows there. In the case of Wambangalang Creek that flow would exceed $479\text{m}^3/\text{sec}$ (the 100 year peak storm flow). By comparison, the peak flows in any 100 year storm from SB4 would be $3.6\text{m}^3/\text{s}$ which would represent 0.75%. Coupled with the conceivable peak flow for the ROM pad ($1.64\text{m}^3/\text{s}$), the total peak flow from sediment basins SB4 and SB12 could conceivably be $5.24\text{m}^3/\text{s}$ which would represent only 1% of the total flow in Wambangalang Creek under the same event.

⁷ Assumes 50% of the WRE is disturbed/impervious.

In addition, Wambangalang Creek would continue to flow at a high volume after the pulses of water from SB4 and SB12 finished, having a further significant dilution effect. Under such circumstances the dilution effect would ensure there would be no identifiable increase in isotope concentrations in the stream's sediment (which would have been significantly affected by the high flow anyway).

4.1.10.6 Hydrocarbons and Liquid Chemicals

Hydrocarbons and all other liquid chemicals would be stored on site in self-bunded tanks or under cover in bunded areas.

4.1.10.7 Other Potential Contaminants

Other minor contaminants (i.e. in containers $\leq 20\text{L}$) would be stored undercover on self-bunded spill trays. Spill control kits would be strategically placed around the facilities as necessary.

4.1.10.8 Potential Impacts Summary

Given the containment and monitoring measures proposed for potential contaminants (e.g. bunding, lining, freeboard, excess basin storages and high-volume pumps) the risk of environmental impact is considered minimal.

4.1.11 Dryland Salinity

Smithson (2001) identified the flowing contributors to dry-land salinity:

- geological complexity;
- the low storage capacity of fractured rock groundwater systems;
- relatively shallow marginally saline to brackish groundwater tables;
- variable soil and alluvium permeability;
- elevation range and irregular topography across the catchment;
- changes in slope angle;
- removal of native vegetation; and
- "leaky" agricultural land uses.

Of these, the first five are outside the control of the Applicant and would not be affected by it. The remaining three could be affected at the scale of the DZP Site and are discussed below.

Changes in slope angles: Significant earthworks would be required, particularly at each Liquid Residue Storage Facility cell which would be excavated into the natural slope of the land. Each Liquid Residue Storage Facility cell is approximately 200m wide which, on a 3% slope, equals a cut and fill balance of about 3m (3m cut, 3m fill). The weathered profile of the underlying geology (sub-grade) is typically greater than this so there would be no excavation into bedrock.

The proposed excavations would not result in incision or obstruction of the groundwater table and lateral flows which are at least 5m below surface for each of the four areas of the Liquid Residue Storage Facility. Assuming there is no breach of the liner of any cell, there would be no interconnectivity of leaking water and the underlying groundwater table which could lead to deposition of salt within the soil profile. The potential for a rising groundwater table as a result of a breach or leak from the Liquid Residue Storage Facility is considered in detail in EES (2013) (Part 5 of the *Specialist Consultant Studies Compendium*).

Removal of native vegetation: The most significant loss of deep-rooted native vegetation from the DZP Site would be at the open cut which is situated on a crest. Here approximately 40ha of vegetation would be removed. During the life of the Proposal this would not result in increased groundwater surcharge as entrained water would be pumped to one or more of the Liquid Residue Storage Facility cells for evaporation. However, post mining the open cut would be left and would collect incident rainfall either allowing it to evaporate or delivering it to groundwater.

Under post closure conditions, enhanced recharge is expected to be more significant than during mining operations and moderate increases in groundwater levels of several metres can be expected in the vicinity of the open cut. This could have the effect of locally increasing the hydraulic gradient away from the open cut which is likely to cause some groundwater discharge at higher levels in the incised gullies and creeks draining the high ground. These discharges are not saline and so would not lead to any increased salt load within the catchment. EES (2013) note that any rise in groundwater and increased rate of “spring” discharge is not predicted to extend to the alluvial sediments of the lower flats adjacent to Wambangalang Creek where the EC of the water is higher and which could potentially increase the effects of dryland salinity.

Leaky agricultural land uses (i.e. activities that result in excess groundwater re-charge): Given that 640ha of land would become isolated from groundwater re-charge this would result in a net reduction of infiltration into the landscape.

4.2 OBLEY ROAD AND TOONGI ROAD UPGRADES

The greatest potential for surface water impact would be during construction. During these works there would be a risk of erosion and sedimentation.

The DZP would be a State Significant Development and Clause 89J (G) of the *Environmental Planning Assessment Act 1979* states (amongst others) that the following authorisations are not required:

a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the Water Management Act 2000.

Therefore, Controlled Activity Assessments would **not** be required for these works. However, construction works would be done in accordance to the latest guidelines and best management practices. In particular site-specific *Erosion and Sediment Control Plans* would be implemented and monitored by a Certified Professional in Erosion and Sediment Control.

Once the upgrades are complete there would be minimal impact on surface water.

4.3 PIPELINE CORRIDOR

The greatest potential for surface water impact would be during construction of the Macquarie River Water Pipeline. During these works there would be a risk of on-site erosion and subsequent sedimentation. A site-specific *Erosion and Sediment Control Plan* would be implemented and monitored by a Certified Professional in Erosion and Sediment Control. The pipeline corridor would require one third-order watercourse crossing near the DZP Site at GR 32.4379 148.6017. A controlled activity assessment would not be required but the works would be done in accordance to the latest guidelines and best management practices.

Once the works are complete there would be minimal impact of surface water.

4.4 THE RAIL CORRIDOR

There would be five significant watercourse crossings for the rail corridor upgrade. Detailed designs for these crossings would be completed following receipt of development consent. However, the greatest potential for surface water impact would be during construction. During these works there would be a risk of on-site erosion and subsequent sedimentation. A site-specific *Erosion and Sediment Control Plan* would be implemented and monitored by a Certified Professional in Erosion and Sediment Control.

Once the upgrades are complete there would be minimal impact on surface water.

5. DZP SITE OPERATIONAL SURFACE WATER MANAGEMENT

5.1 LIQUID RESIDUE STORAGE FACILITY

5.1.1 General Description

Liquid waste would be generated from the plant at the rate of 2.5GL/year at peak processing production (1Mt/year). The liquid waste would contain a significant concentration of salt and would be sent to a series of storage cells designed to allow evaporation and enable the salt to precipitate. Precipitated salt would be removed progressively through the mine's life and disposed of in the Salt Encapsulation Cells. The estimated mass of salt is 900t per day, which, when precipitated, would occupy approximately 800m³.

The Liquid Residue Storage Facility is described in Section 2.9.3 of the EIS. In summary they would consist of a series of terraced cells grouped into four main areas (**Figures 2 and 21**). Each cell wall would be built from locally-borrowed soil and sub-grade and lined with an HDPE liner. Each cell embankment would be 6m high but 1m of that would be freeboard; the design depth is therefore 5m. The cells would have a flat base so that maximum evaporation is achieved as soon as liquid is placed in them.

The cells would have:

- a total catchment area of 425ha;
- an operating surface water area of 303ha; and
- a total operating volume of 1.4x10⁷ m³.

The total catchment area would consist of the cells and areas of land between them comprising the embankments and other pervious areas. The cells would trap incident rainfall over the entire 425ha⁸. This is the subject of modelling in **Section 5.1.3**. None of the cells are online to watercourses or depressions, all upslope water would be diverted away (**Figure 21**).

5.1.2 Operation

To maximise evaporation, the cells would be built as early works and liquid waste would be passed to all cells as necessary to ensure the full 303ha is actively used. Once all cells have some water in them, and as water levels drop in each, they would be topped up as necessary - up to the maximum permissible depth (5m).

5.1.3 Modelling

Computer modelling of the Liquid Residue Storage Facility was done using daily rainfall data from BOM's Station number 65030 (Mentone) and the assumed evaporation rates from a pond's surface (PPOND) given in **Table 1**. The computer model used was 'MUSIC' (Model for Urban Stormwater Improvement Conceptualisation) developed by eWater. The cells were assumed empty at the start of each model.

⁸ It is assumed that the land not under water would be vegetated and so the total 425ha would be about 71% impervious (303/425).

Section 3.1.4.1 identified a roughly 20-year cycle for a dry-to-wet-to-dry period. Therefore, given the life of the Proposal is 20 years, it is not possible to model either a distinctly dry or wet period. However, it is possible to model the DZP starting in different stages of such a cycle. To do that three models were run:

- Model 1: representing a reasonable consistent rainfall pattern over the life of the mine (1900 onwards). Mean annual rainfall over the modelled period = 579mm.
- Model 2: representing a period starting off wet and then becoming dry (1970 onwards and including 1974 which was very wet). Mean annual rainfall over the modelled period = 579mm.
- Model 3: A “worst case” model representing a period starting off wet (1949 onwards and including 1950 and 1955 both of which were extremely wet). Mean annual rainfall over the modelled period = 731mm.

The results of the models are given in **Figures 24, 25 and 26** respectively. They each show three outputs:

- The volume of the liquid (water) component only;
- The predicted salt volume after precipitation; and
- The combined volume of liquid (water) and precipitated salt.

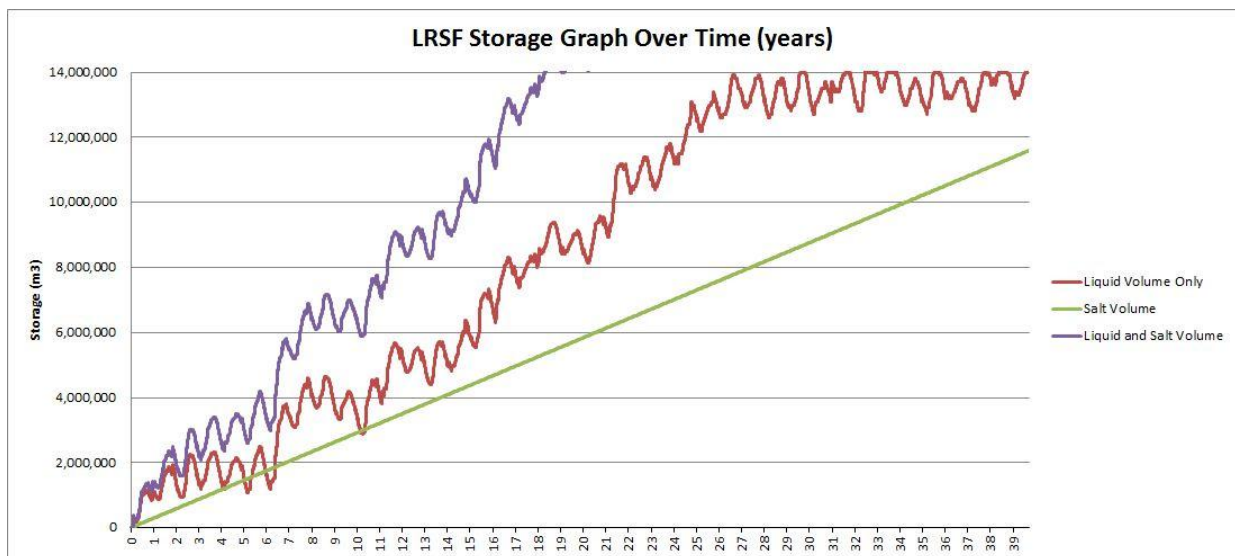


Figure 24 Liquid Residue Storage Facility Storage Over Time (Model 1).

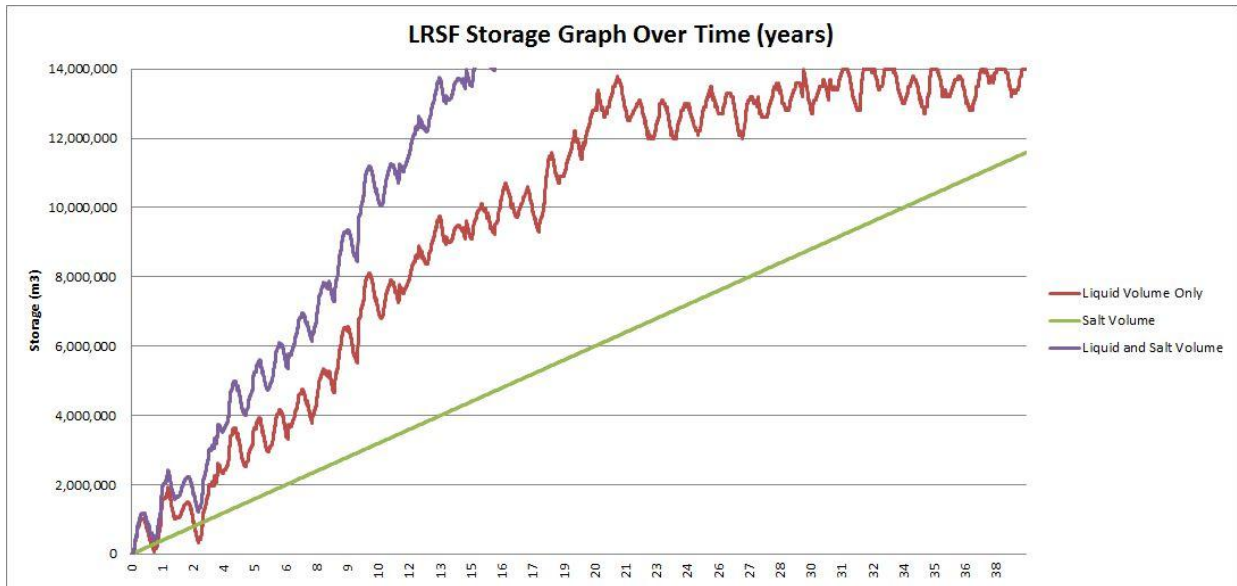


Figure 25 Liquid Residue Storage Facility Storage Over Time (Model 2)

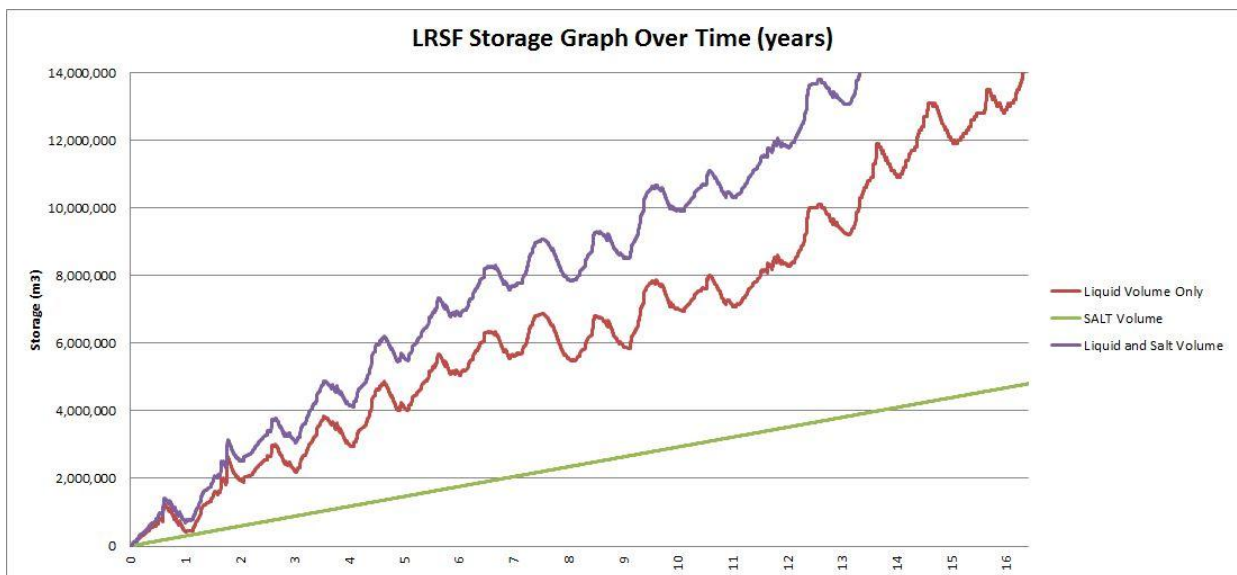


Figure 26 Liquid Residue Storage Facility Storage Over Time (Model 3)

Table 7 gives a summary of the findings.

Table 7
Predicted Times to Maximum Capacity

Model Number	Predicted Time to Max Capacity (Water Only)	Predicted Time to Max Capacity (Water and Salt)
1	29 years	18 years
2	29 years	15 years
3	16 years	13 years

Table 5 shows that with progressive harvesting of salt the required design life of 20 years is readily achievable. Only if closely-spaced extreme rainfall years are experienced, equivalent or greater than those of 1950 and 1955, would the design life be compromised. The risk of that is slight but, should it occur, or be predicted to occur, the Applicant would need to implement measures to increase evaporation (e.g. use spray-evaporators) and/or reduce production rates.

The overall life of the Proposal would be limited by prevailing climatic conditions and the rate at which salt is removed. Therefore, at least two pan evaporation sites would be located on the DZP Site. Data from them would be used to compare with actual evaporation rates from the cells (measured at fixed gauges). The correlated data would be used to revise the modelling (if necessary) and that would assist in planning for ongoing cell management.

5.2 PROCESSING PLANT AND DZP ADMINISTRATION AREA

5.2.1 Introduction

Figure 27 presents the layout of the Processing Plant and DZP Site Administration Area and the nature of each nominated area (e.g. bunded concrete pad, fully enclosed building with concrete floor, compacted gravel, etc.) The total area can be categorised into four separate areas as detailed below.

5.2.2 Area 1: DZP Site Administration Area

This area would be located on the western side of the rail line and would include the following component areas:

- Gatehouse and weighbridge;
- Administration building including offices and lunch rooms;
- Change rooms, wash house and ablutions;
- Staff and visitor parking; and
- Truck parking bays.

This area (8ha) would generate 'uncontaminated' stormwater runoff (sediment-laden only) and would drain to SB1 which was originally designed as a sediment basin during establishment. Once the catchment to SB1 was established to final design, trapped water would be allowed to settle or it could be sent to either the Re-use Dam for re-use. Discharge of excess stormwater would be directed to (ultimately) Wambangalang Creek via engineered outlets. If all water trapped was re-used modelling estimates the mean annual excess flow would be 3ML/year.

5.2.3 Area 2: Rail Container Laydown and Storage Area

This area (~21ha) would be located on the eastern side of the rail line, north of Watercourse C. It would provide a location for unloading reagents away from the active processing operations. The area would be a bunded concrete pad separated into an open area for truck manoeuvring and a series of bays for temporary storage of the bulk reagents delivered in containers by road or rail.

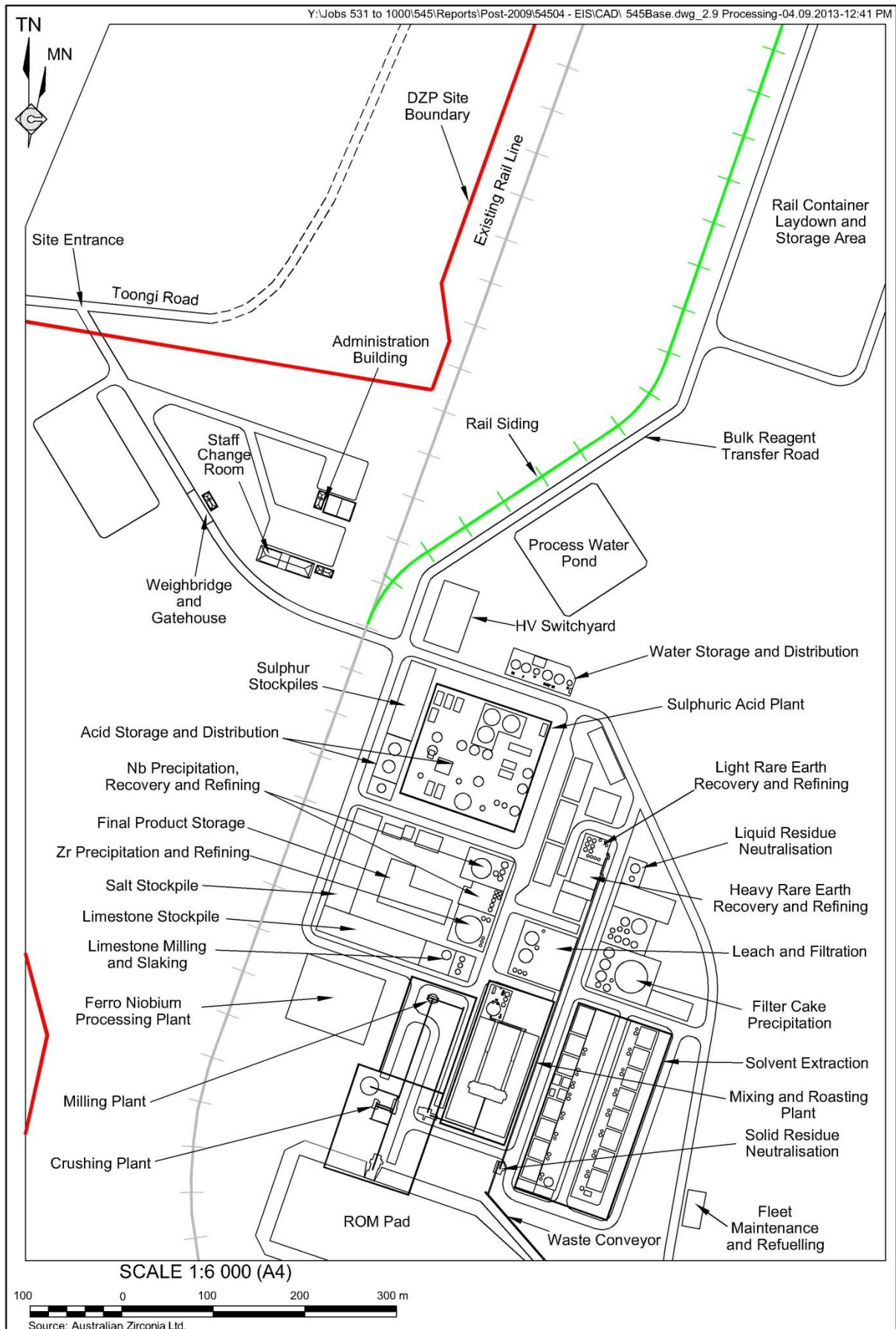


Figure 27 Layout of the Processing Plant and DZP Site Administration Area

The Rail Container Laydown and Storage Area would drain to SB3. Once the catchment to SB3 was established to final design, trapped water would be allowed to settle or it could be sent to either the Re-use Dam re-use. Discharge of excess stormwater would be directed to (ultimately) Wambangalang Creek via engineered outlets. If all water trapped was re-used modelling estimates the mean annual excess flow would be 18ML/year.

If there was a spill of reagents, the outlet to SB3 would be closed and any accumulated water collected and transferred to the Liquid Residue Storage Facility.

5.2.4 Area 3: Processing Plant Area

This area (~20ha) would be located on the eastern side of the rail line, southwest of Watercourse C and connected to the DZP Site Administration Area and Rail Container Laydown and Storage Area by the DZP Site Access Road and Bulk Reagent Transfer Road respectively. This area would contain many separate storages and buildings. Storage areas for reagents would be bunded and sealed. All bunded areas would have a sump from which potentially-contaminated runoff would be drawn and distributed to either the Process Water Dam or the Liquid Residue Storage Facility. Bunded areas that are open to the weather would have sufficient volume to trap 110% of the volume of the largest storage tank plus a volume of $0.2 \times \text{area (m}^3\text{)}$ to allow for 200mm of incident rainfall. At no time would water sourced from these bunded areas be released to the environment. Spill containment kits would also be kept on site.

Surfaces between bunded areas and roofs would generate 'uncontaminated' stormwater runoff (sediment-laden only). These surfaces would drain to SB2, which was originally designed as a sediment basin during establishment. Once the catchment to SB2 was established to final design, trapped water would be allowed to settle or it could be sent to either the Re-use Dam or the Process Water Dam for Re-use. Discharge of excess stormwater would be directed to (ultimately) Wambangalang Creek via engineered outlets. If all water trapped was re-used modelling estimates the mean annual excess flow would be 13ML/year.

5.2.5 Area 4: ROM Pad

This would be located in the south of the processing area and would occupy about 4.1ha. Here ROM ore would be stored ready to be crushed and processed. TCLP testing⁹ of a composite sample has been undertaken of a typical ore sample. The results are given in **Table 6**. The results show elements are not readily leachable and are bound with particulate material (sediment). However, the results show there can be detectable levels of some rare earth isotopes.

Runoff from this area would be treated as contaminated and would be drained to a dedicated dam (SB12) designed to exceed the 100year, time of concentration (t_c), storm volume (3ML) by a factor of two. In addition a diesel pump(s) capable of 30kL/hour would be installed to pump water to either the Dam or one of the active Liquid Residue Storage Facility cells if there was insufficient capacity. Together with the additional 3ML capacity this pump would ensure there could be no overflow in any 100 year storm event. Trapped water in SB12 would be pumped as soon as practicable after inflow commences.

⁹ Toxicity characteristic leaching procedure

5.2.6 The Haul Road

The Internal Haul Road would drain to a series of sediment basins designed to trap the 90th percentile 5-day rainfall depth (35.6mm). Trapped water would be completely removed by tanker, syphon or pump within 5-days of the conclusion of a rainfall event and taken/sent to the Re-use Dam. Markers would be placed in each basin to identify the minimum required water storage volume and the maximum permissible sediment storage volumes¹⁰. When the maximum sediment storage is reached sediment would be removed and placed on the waste rock emplacement area. Excess stormwater would be directed to the nearest watercourse in a stable manner. After re-use modelling estimates the mean annual excess flow would be 3ML/year.

5.3 THE OPEN CUT

Once established the open cut would be internally-draining¹¹. Incident rainfall would be trapped in the base of the pit and directed to a dedicated storage area. If the volume became unmanageable the water would be pumped to the Liquid Residue Storage Facility. The open cut would be located on a crest and so would not have a significant external catchment requiring diversion. However, a raised earth safety bund would be built around it and would perform that function where necessary.

5.4 WASTE ROCK EMPLACEMENT

The waste rock emplacement (WRE) would be located just west of the open cut and would occupy up to 24ha. Waste rock (which would contain trace concentrations of radionuclides within the siliceous rim material, similar to those identified in **Table 6**) would be placed from the crest of the hill working down the slope. The WRE would not have a significant external catchment requiring diversion.

The working face(s) would drain via catch drains designed to convey the 100-year ARI storm flow to sediment basins SB4 (10ML) and SB5 (5ML). These would be designed to have a volume twice that of the 100-year, t_c , storm event¹². Pumps capable of transferring at least 100kL/hour (SB4) and 45kL/hour (SB5) would pump trapped water (in preferred order) to Liquid Residue Storage Facility or the Process Water Dam. The pumps would start as soon as is practicable after inflow to the basins. The WRE would be progressively stabilised with soil and vegetation as soon as final levels are achieved.

5.5 THE SOLID RESIDUE STORAGE FACILITY

The Solid Residue Storage Facility is described in **Section 2.9.1** of the EIS. The Solid Residue Storage Facility would have an internal drainage system to collect incident rainfall. The system would be similar to a decant tower in a normal tailings storage, however, there would be no

¹⁰ These would be calculated by the Certified Professional in Erosion and Sediment Control

¹¹ Until that point runoff from this area would be managed by Sediment basins SB6 to SB10 (Section 4.1.4.2)

¹² And assuming 50% of the WRE is disturbed/impervious.

rock mound. The slotted concrete tower sections would be wrapped in a geomembrane. The vertical well would house an electric submersible pump. The pump, controlled by float switches, would remove the water from the well as required. The water would be pumped to (in preferred order) the Liquid Residue Storage Facility or the Process Water Dam.

5.6 SCHEDULE OF OPERATIONAL STORMWATER BASINS

In summary, **Table 8** gives the schedule of operational basins. As surface water could be re-used from all the basins they are all assessable as part of the Harvestable Right (**Section 6.2.2**).

Table 8
Schedule of Operational Basins

Identification	Catchment	Potential Re-use	Size (ML)	Discharge Point
Haul Road Basins	Haul Road	Dust Suppression Processing	1 (total)	Yes (for rainfall >36.5 mm in 5 days)
SB12	ROM	Processing	6	No
SB1	Admin Area	Dust Suppression Processing	2	Yes
SB2	Rail Laydown and Storage Area	Dust Suppression Processing	5	Yes
SB3	Processing Area	Dust Suppression Processing	5	Yes
SB4 and SB5	Waste Rock Emplacement	Processing	10 & 5	No
Re-use Dam	Pumped and 100ha natural catchment	Dust Suppression Processing	66ML	Yes (online to Watercourse C)
Total volume			100ML	
Process Water Dam	Pumped only	Processing	50ML	No

5.7 POST-MINING SURFACE WATER MANAGEMENT

The post mining landform is described in Section 2.17.4 of the EIS. To achieve the proposed final landform, all mining-related facilities with the exception of the proposed open cut, Solid Residue Storage Facility and the Salt Encapsulation Cells would be removed. Most likely the DZP Site Administration and Processing Area would be decommissioned first, leaving a skeleton facility for ongoing works. That would be followed by rehabilitation of the Solid Residue Storage Facility by placing soil and vegetation. Until the Solid Residue Storage Facility has at least 70% ground cover surface runoff would either be internally draining or would be directed to one or more sediment basins designed for the 90th percentile 5-day rainfall depth (36.5mm). The sediment basins would be managed according to Landcom (2004) and DECC (2008), or their successor guidelines.

During that period the Liquid Residue Storage Facility would still be operating and it is estimated that the water within the facility would be evaporated within 6 to 9 years of the

completion of processing operations, depending on prevailing climatic conditions and assuming they were full (5m deep) at the end of life.

The haul road would remain to access the Liquid Residue Storage Facility, Solid Residue Storage Facility and Salt Encapsulation Cells. Once all the saline water evaporates the Liquid Residue Storage Facility cells would be decommissioned. That would start in the lowest cells in any one group and progressively work upslope. Saline water would be pumped from the lower cells to the higher ones as capacity became available to expedite the work. As each cell was decommissioned the accumulated salt and HDPE liner would be removed and soil would be returned to mimic the original landform. Until each filled cell has at least 70% ground cover, sediment-laden runoff would be directed to one or more sediment basins designed for the 90th percentile 5-day rainfall depth. The sediment basins would be managed according to Landcom (2004) or its successor guideline.

Once filled, the Salt Encapsulation Cells would be covered with soil and re-vegetated. Until they have at least 70% ground cover, sediment-laden runoff would be directed to one or more sediment basins designed for the 90th percentile 5-day rainfall depth. The sediment basins would be managed according to Landcom (2004), or its successor guideline.

Finally any haul/access roads would be decommissioned and rehabilitated or reduced in width to only that required for ongoing land management. All such roads would be drained to sediment basins during their active life; these would only be removed once the rehabilitated land has at least 70% ground cover. In the meantime the sediment basins would remain and would be managed according to Landcom (2004).

The Re-use Dam would remain as it is permissible under the harvestable right.

The final landforms would, as much as possible, reflect the original landforms. The noticeable exceptions would be:

- the relatively steep slopes (compared to natural slopes on the DZP Site) of the Solid Residue Storage Facility; and
- the former open cut, which would remain as a steep sided void.

The former open cut would be open to incident rainfall. Trapped rainfall would evaporate and be a source of groundwater re-charge. However, EES (2013) (Part 4 of the *Specialist Consultant Studies Compendium*) consider that the effect of such re-charge would be minimal.

6. DZP WATER BALANCE

6.1 MINE SITE DEMAND

6.1.1 Processing

As indicated in Section 2.8 of the EIS, processing operations would require 4.05GL per year at peak production.

6.1.2 Dust Suppression

The estimated demand for dust suppression is taken as 50%¹³ the difference between the pan evaporation rate and the daily rainfall rate and multiplied by the combined surface areas to be treated. These areas are estimated as:

- 4ha - Haul road and ancillary access roads
- 2ha - active waste rock emplacement face
- 2ha - active ROM pad

Therefore, the mean annual demand would be about 48ML.

6.1.3 Offices, Workshops and Ablutions

Water for 'domestic' purposes would be sourced from the pipeline supply. The estimated demand (based on a 100 strong workforce) is 5,000 L/day (1.825 ML/year). Drinking water would be supplied by tanker or after processing of the water extracted from the Macquarie River.

6.2 MINE WATER SUPPLY

6.2.1 Pipeline

Water supply for the DZP would be supplied (in part or in full) by a pipeline from the Macquarie River. The license would be sufficient to ensure the DZP could continue to operate if it were the only supply. However, to reduce the dependency on it whenever possible, some surface water from the DZP Site could be harvested under the Applicant's harvestable right.

6.2.2 Harvestable Right

Section 53 of the *Water Management Act 2000* permits landholders to harvest and use a portion of the total runoff from their land without requiring a licence. The legislation is manifested by allowing a total harvestable right capacity for the property.

¹³ It is assumed that biodegradable dust suppressants would also be used to minimise water use.

Three factors determine the harvestable right dam capacity for a property namely:

- the property's geographical location (which determines the harvestable right multiplier value);
- the size of the property; and
- the availability of storage locations.

A property's harvestable right permits construction of dams up to the harvestable right capacity without the requirement for further approvals for the use of that water from NSW Office of Water, provided the dams or basins are either "off-line" from natural watercourses or are positioned on first or second-order streams only. Water captured within harvestable rights dams may be used for any purpose, including mining-related purposes.

The harvestable right multiplier for the DZP Site was determined using maps obtained from NSW Office of Water at http://www.farmdamscalculator.dnr.nsw.gov.au/cgi-bin/ws_postcode.epl. These maps show that the DZP Site lies in an area that has a multiplier value of 0.065ML/ha.

In calculating the harvestable right for the DZP, the footprint areas of the Solid and Liquid Waste Facilities, the Salt Encapsulation Cells, the Open Cut and bunded parts of the Processing Area have been excluded as these areas would become isolated from the catchment. They represent a total area of about 640ha.

The Applicant would own 3,452ha but reducing that by 640ha, the land area used in the harvestable right calculation is 2,812ha and so the permissible harvestable right is $0.065 \times 2,812 = 182\text{ML}$. There are 64 existing farm dams within this land with a total estimated volume of approximately 82ML. Therefore, an additional 100ML of storages could be built without exceeding the Harvestable Right.

Water trapped in the operational stormwater basins could be used for processing (via the Process Water Dam) or for dust suppression (via the Re-use Dam) and so their volumes would all be assessable as harvestable right. The combined volume of these basins would be 34ML (**Table 8**). The permanent pond volume of the Re-use Dam would, therefore, be 66ML. It would be located online on a first order watercourse, with a catchment of approximately 100ha. The Re-use Dam would also act as a stormwater detention basin to reduce peak flows through the DZP Site Administration Area.

Assuming all water collected in SB1, SB2 and SB3 is transferred for re-use, modelling shows on average 0.3ML/d (109ML/y) could be used for processing after that required for dust suppression. This represents about 0.2% of the total annual demand (4.05GL/y). The actual volume that could be used would vary daily depending on prevailing climatic conditions and the rate at which the water was pumped to the dams. In regard to the latter, the total volume of SB1, SB2 and SB3 would be 12ML and represents about 1.75 days supply.

Assuming all water collected in SB1, SB2 and SB3 is transferred for re-use, modelling shows the mean annual overflow from the re-use dam would be 155ML/yr. This represents less than 1% of mean annual flow in Wambangalang Creek.

6.3 SURFACE WATER HARVESTING, LICENSING

It is not proposed to extract surface water other than that permissible by the site's harvestable right. No additional surface water licences would be required.

6.4 WATER DISTRIBUTION

Figure 28 provides the water distribution plan for the DZP Site. It shows sources, uses, losses and movements of water between each part of the DZP Site and the receiving waters.

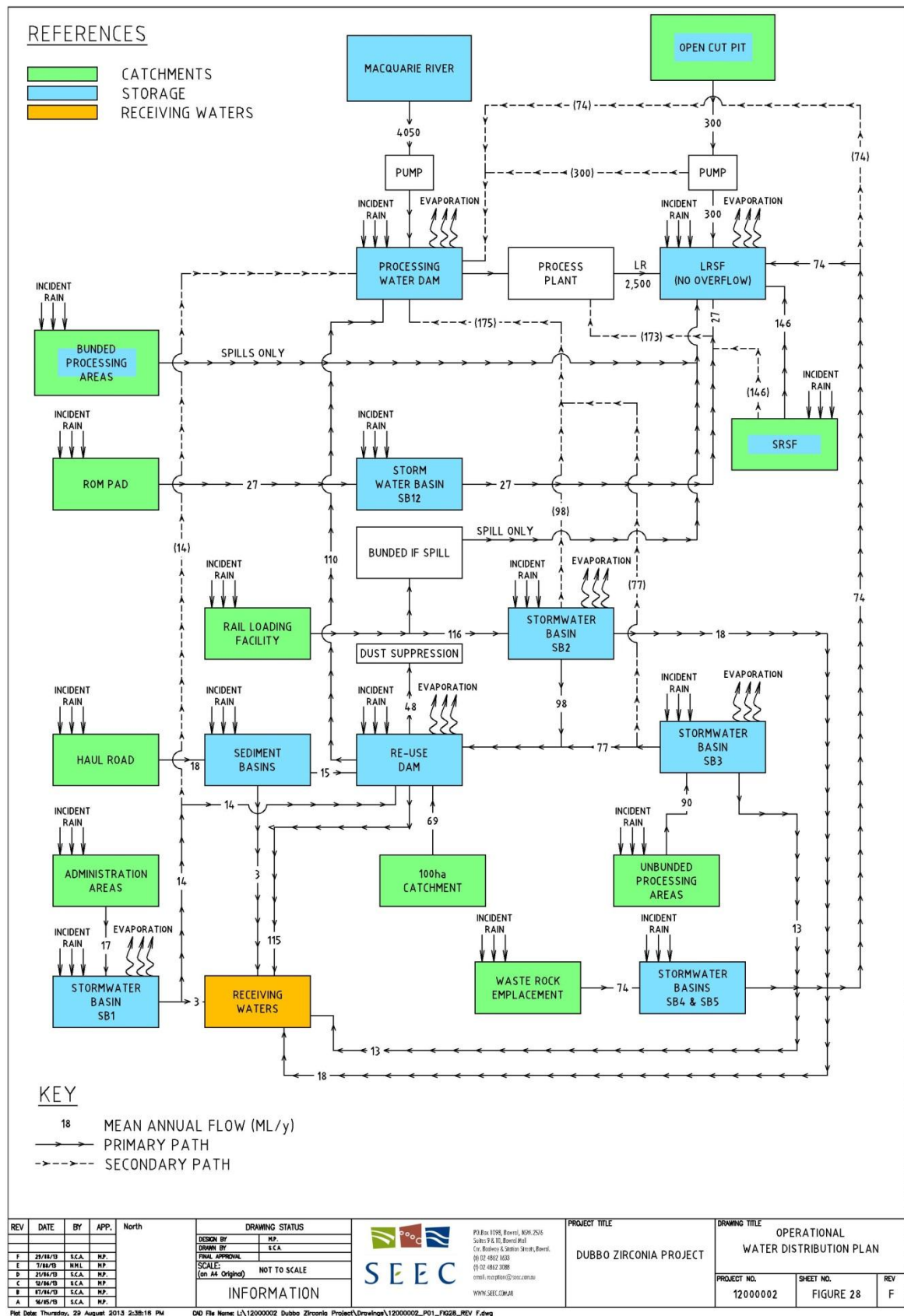


Figure 28 Water Distribution Plan with Mean Annual Volumes

7. DZP SITE WASTE WATER MANAGEMENT

The DZP Site would not be connected to reticulated sewer and so all 'domestic' waste water would be treated and disposed on site. A suitably-sized aerated waste water treatment system would be used to secondary-treat and disinfect all waste water. Subsequent to treatment, it would be disposed in a dedicated irrigation area sized to meet AS/NZS1547 (2012) or Dubbo City Council's current requirements if they should differ. The irrigation area would be more than 100m from Paddys Creek or Wambangalang Creek and 40m away from any other intermittent watercourse.

A Section 68 application under the *Local Government Act* 1993 would be made to Council to install and operate the facility. Most likely Council would require quarterly inspections and reports to be prepared and submitted by a qualified waste water contractor.

8. TOONGI AND OBLEY ROADS FLOOD MITIGATION

8.1 INTRODUCTION

In accordance with Dubbo City Council requirements, the Toongi Road Crossing at Wambangalang Creek (**Section 3.2**) and two watercourse crossings on Obley Road (**Section 3.3**) would be upgraded to provide for greater flood clearance than is currently provided. While the 100-year ARI storm event would be ideal, issues associated with local hydrology, topography, other site conditions and traffic levels require consideration in determining the flood level for which a minimum clearance of 300mm between the 100-year ARI flood level and the underside of any structure to allow for passage of debris without blockage.

8.2 TOONGI ROAD

Based on the flood modelling submitted in **Section 3.2**, a design level for a 1 in 100 ARI event for the new bridge is given in *Appendix D* of Part 11 of the *Specialist Consultant Studies Compendium* (Constructive Solutions, 2013). While final designs remain to be completed, in order to achieve clearance of the 1 in 100 flood level, the new crossing would consist of:

- A 40m span bridge would be constructed over Wambangalang Creek at an elevation slightly greater than the 1 in 100 ARI flood level (SEEC, 2013).
- Earthworks or additional spans would be required up to 80m to the west and 45m to the east to provide for an appropriate approach gradient of approximately 2%.

8.3 OBLEY ROAD

Based on the flood modelling submitted in **Section 3.3**, preliminary design levels for the two new bridge crossings are given in *Appendix D* of Part 11 of the *Specialist Consultant Studies Compendium* (Constructive Solutions, 2013). In summary, the new crossings would include the following.

- A 20m span bridge would be constructed over Hyandra Creek at an elevation slightly greater than the 1 in 20 ARI flood level. Earthworks or additional spans would be required up to 50m on either approach to provide for an appropriate approach gradient of 2.4%.
- Five 2400mm x 1500mm box culverts would replace the current 450mm diameter reinforced concrete pipe (RCP) at the Twelve Mile Creek crossing.

9. SURFACE WATER MONITORING PROGRAM

9.1 INTRODUCTION

This section provides a description of the surface water quality monitoring program that would be undertaken throughout the life of the Mine. There would be two parts:

- infrastructure; and
- water quality testing.

9.2 INFRASTRUCTURE MONITORING

9.2.1 Objectives

The objectives of the Surface Water Infrastructure Monitoring Program would include the following.

- Ensure surface water structures are stable and performing satisfactorily.
- Identify potential issues before they arise (e.g. the beginning of instability in drains).
- Ensure clean and dirty water are separated.
- Ensure contaminated water is effectively contained within the DZP Site.
- Ensure the effectiveness of spill containment measures.

9.2.2 Inspections

At least once per month and after significant (>12mm/d) rainfall, the DZP Site's Environmental Officer (or approved representative) would undertake a walk-over of the DZP Site and complete an assessment of all surface water structures using an appropriate Environmental Inspection Checklist. Where issues are identified, they would be noted on the checklist for immediate action. Non compliances would be reported to the Mine Manager and the relevant government agencies notified, if required. The completed checklists would be kept on file and a summary of the results of the inspections would form part of the *Annual Environmental Management Report* (or equivalent report).

9.3 SURFACE WATER QUALITY MONITORING

9.3.1 Objectives

The surface water quality monitoring would be designed to achieve the following objectives.

- Establish baseline (i.e. existing) water quality in local drainage lines.
- Monitor water quality in local drainage lines during and after mining operations.

- Monitor potential loss of contaminated water including contaminated drainage, leakages from storages and residue facilities and/or spillage from pipelines.
- Protect wildlife from exposure to unacceptable levels of contaminated water.
- Protect aquatic ecosystems downstream of the DZP Site.
- Monitor and control the quality of water released from the DZP Site.

9.3.2 Water Quality Sampling Locations

Figure 29 illustrates the 14 water quality monitoring points (SW*). There would be:

- Eight on natural watercourses (SW1 to SW8);
- One at the Re-use Dam (SW9);
- One at SB3 (processing area) (SW10);
- One at SB2 (rail container laydown and storage area) (SW11); and
- Three on minor drainage channels downstream of parts of the Liquid Residue Storage Facility (SW12, SW13 and SW14).

In addition, brine in one or more of the cells at the Liquid Residue Storage Facility would be periodically tested for salt concentration. This would provide information to the Mine Manager for future cell management.

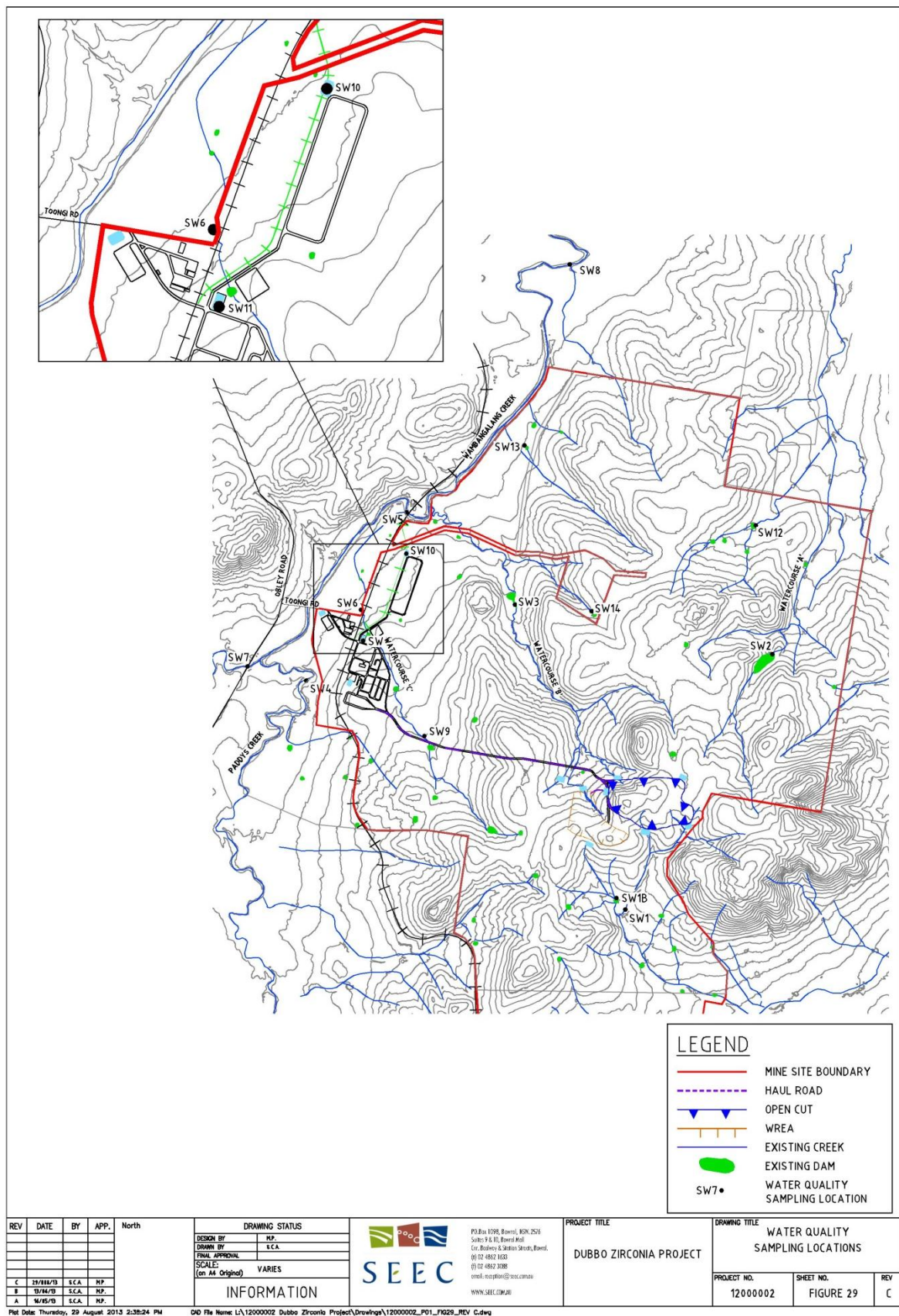


Figure 29 Water Quality Sampling Locations

9.4 SAMPLING FREQUENCIES AND PARAMETERS

9.4.1 Sampling Frequencies

Table 9 shows the sampling frequencies and parameters.

Table 9
Water Quality Sampling Parameters and Frequency

Monitoring Location	Location	Monitoring Frequency	Parameters
SW1	Northern tributary of Cockabroo Creek	Opportunistically after rain	Table 10
SW2	Watercourse A	Opportunistically after rain	Table 10
SW3	Watercourse B	Opportunistically after rain	Table 10
SW4	Paddys Creek	Monthly	Table 10
SW5	Wambangalang Creek (downstream of the DZP Site)	Monthly	Table 10
SW6	Watercourse C at Rail Facility	Opportunistically after rain	Table 10
SW7	Wambangalang Creek (Obley Road, upstream of the DZP Site)	Monthly	Table 10
SW8	Wambangalang Creek (downstream of the DZP Site)	Monthly	Table 10
SW9	Re-use Dam	After input from other basins	Table 11
SW10 & SW11	Rail Laydown/Storage and Processing Area	After >12 mm rainfall in 24 hours	Table 12
SW12 & SW13	Watercourses D and E Downstream of Liquid Residue Storage Facility cells	Monthly	Table 13
SW14	Downstream of Liquid Residue Storage Facility cells	Monthly	Table 14

9.4.2 Water Quality Triggers

9.4.2.1 SW1 to SW8 (Natural Watercourses)

Table 10 describes the water quality triggers that would be adopted for the sampling points on natural watercourses. With the exception of salinity the triggers are taken from ANZECC (2000). Surface water salinity is known to be high in the Toongi Catchment (Section 3.1.3.2) and so the adopted trigger for it would be increased from that given in ANZECC (2000) (350µS/cm) to 3,000µS/cm.

9.4.2.2 SW9 (Re-use Dam)

Table 11 gives the target water quality triggers that would be adopted for the sampling point at the Re-use Dam. This dam is designed to hold sediment-laden water only. Water from it would primarily be used for dust suppression or, if there was an excess, it could either be used for processing or settled (to yield TSS <50 mg/L) and released to receiving waters.

Table 10
Water Quality Triggers Applied to SW1 to SW8

Pollutant/parameter	Trigger Value (µg/L uno ⁹)
pH	<6.5 or >8
Electrical conductivity	>3,000 µS/cm
Total Phosphorus	>20
Total Nitrogen	>250
Dissolved Oxygen	<90% or >110%
Turbidity	2-25 NTU
aluminium	55
arsenic (as III)	24
zinc	8
copper	1.4
lead	3.4
silver	0.05
nickel	11
boron	370
manganese	1900
cadmium	0.2
Radioactivity Gross Alpha	Any detectable
Radioactivity Gross Beta	Any detectable

Table 11
Water Quality Triggers Applied to SW9

Pollutant/parameter	Trigger Value
pH	>6.5 and <8
Salinity (EC)	<3,000 µS/cm
TSS (if to be released to receiving waters)	<50mg/L
Visible Oils (if to be released to receiving waters)	Any detectable

9.4.2.3 SW10 and SW11 (Rail Laydown and Processing Areas)

Table 12 gives the target water quality triggers that would be adopted for the sampling points at SB2 and SB3. These basins collect runoff from the Rail Container Laydown and Storage Area and the Processing Area. Runoff should be sediment-laden only but there is the potential of contaminant spills.

Depending on the quality of the water it would be used for either dust suppression (if uncontaminated) or for processing (if contaminated). If there was an identified excess, it would be sent to the Liquid Residue Storage Facility.

Table 12
Water Quality Triggers Applied to SW10 and SW11

Pollutant/parameter	Trigger Value
Applicable Solvents	Any detectable
Salinity (EC)	Total <3000 µS/cm
Salinity species: sodium, calcium, magnesium, chloride, sulfate and carbonate	For interpretation (potential leakage)
pH	>6.5 and <8

9.4.2.4 SW12 to SW14

Table 13 gives the target water quality triggers that would be adopted for SW12 to SW14. They would be used as an indicator of leakage from the cells of the upslope Liquid Residue Storage Facility.

Table 13
Water Quality Triggers Applied to SW12 to SW14

Pollutant/parameter	Trigger Value
Salinity (EC)	Total <3000 µS/cm
Salinity species: sodium, calcium, magnesium, chloride, sulfate and carbonate	For interpretation (potential leakage)
pH	>6.5 and <8

9.5 SAMPLING PROCEDURES

The following procedures would be implemented during all surface water monitoring operations:

- Field monitoring equipment would be used and calibrated according to the manufacturer's instructions, and the dates recorded.
- Laboratory samples would be collected by appropriately trained personnel:
 - from a shallow depth using an extendable sampling arm if required;

- using bottles provided by the testing laboratory; and correctly labelled, preserved and transported to the laboratory within the appropriate Technical Holding Time under a *Chain of Custody Protocol* to the laboratory.
- If possible, water samples for metals would be filtered.

The results of all water quality testing would be recorded in the Mine's environmental database for submission in the *Annual Environmental Management Report*. They would be analysed as detailed in **Section 10**.

9.6 POST- MINE CLOSURE

The surface water monitoring programme, as amended, would continue until the Applicant and all relevant government agencies agree that final rehabilitation has been achieved.

10. SURFACE WATER RESPONSE PLANS

10.1 LOCAL STREAMS (SW1 TO SW8)

SW1 to SW8 are located on local streams and creeks (refer to **Table 9**). Initially a trigger for further investigation would be deemed to occur if the median concentration of an independent test exceeded the values given in **Table 10** (Note: if only one sample is taken then the result of that result would be used). However, once a background data set of at least 24 samples (two years) was collected, that data would be used in consultation with NSW Office of Water to develop a site-specific suite of trigger values for the DZP Site.

Following receipt of all stream water monitoring results, the Applicant would, within three business days, review that data against the relevant trigger values. In the event that one or more trigger value was exceeded, the Applicant would immediately:

- arrange for further check sampling (if possible) to be undertaken to confirm the initial monitoring result (the resultant median value would be adopted); and
- contact the relevant government agencies (Environment Protection Authority, the NSW Office of Water, the Division of Resources and Energy, Dubbo City Council) and advise them of the preliminary results and timeframes for completion of further check sampling and reporting.

Should the check sampling indicate that stream water quality remains outside the relevant trigger values the Applicant would immediately contact the above agencies to advise them of the result of the check sampling and determine, in consultation with them appropriate management actions. These would include but not be limited to:

- immediate implementation of appropriate management measures; and
- engagement of suitably qualified and experienced aquatic and environmental experts in consultation with the above agencies to further investigate and report on the exceedance(s), provide advice in relation to the significance of the exceedance(s) and recommended amelioration measures to be implemented. This would include comment on the comparison between upstream and downstream results.

In the event that the first-round of stream water quality results indicated a significant (>25%) exceedance of the relevant trigger values, the Applicant would implement the above measures immediately and not wait for check sampling to confirm the initial result.

A copy of any resulting expert's report would be provided to relevant government agencies and placed on the Mine's website.

10.2 RE-USE DAM (SW9)

Should a water quality test fall outside of the parameters nominated in **Table 11**, that water would not be used for dust suppression until it has been treated to meet the water quality targets. If it were not possible to meet the targets the water would be sent to the Liquid Residue Storage Facility.

10.3 RAIL LAYDOWN AND STORAGE AREA, PROCESSING AREA (SW10 AND SW11)

Should a water quality test fall outside of the parameters nominated in **Table 12** the water would be sent immediately to the Liquid Residue Storage Facility.

10.4 LIQUID RESIDUE STORAGE FACILITY (SW12, SW13 AND SW14)

Should a water quality test at SW12, SW13 or SW14 fall outside the parameters nominated in **Table 13**, it is possible that there is leakage from one or more of the cells of the Liquid Residue Storage Facility. As a result, the response plan described in **Section 10.1** would apply.

11. SUMMARY OF COMMITMENTS

11.1 DURING DZP SITE ESTABLISHMENT

During the establishment of the DZP there would be significant disturbance to the natural landform. Soil would be exposed to erosion and there could be subsequent sediment movement/loss. During this period soil and water would be managed to the requirements of Landcom (2004), DECC (2008) and DECC (2008b).

To ensure that is so, an *Erosion and Sediment Control Plan* (ESCP) would be developed that would describe the over-arching soil and water management requirements for the DZP. Individual construction stages would be the subject of a series of Progressive ESCPs. All plans would be prepared by a Certified Professional in Erosion and Sediment Control.

11.2 OPERATIONAL STAGE

During the operational stage, surface water would be managed to the requirements of Sections 5 and 6. Surface water derived from the DZP Site Administration Area, the Rail Container Laydown and Storage Area, the un-bunded parts of the Processing Area and all haul roads would be directed to sediment basins. Depending on the basin, trapped water would be:

- re-used in the processing plant;
- re-used for dust suppression; or
- settled and released to receiving waters.

Runoff generated in any bunded area that stores potential pollutants and from the Solid Residue Storage Facility would be directed to the Liquid Residue Storage Facility or, if of suitable quality, re-used in the processing plant. It would not be released from the DZP Site. Similarly it would be possible to contain spills at the Rail Container Laydown and Storage Area for treatment and disposal to the Liquid Residue Storage Facility if necessary.

Runoff from the ROM Pad and Waste Rock Emplacement would be contained in Sediment Basins each designed to have a capacity of at least twice the 1 in 100 t_c storm event. Trapped water would be pumped to (in order of preference) the Liquid Residue Storage Facility or the Process Water Dam. These basins would be supplemented with suitably-sized pumps designed to ensure overflow could not occur under any 100 year storm event. In the unlikely event that rainfall exceeded any 1 in 100 storm event, the significant dilution of any sediment in the receiving waters would ensure no significant impact on that environment.

A comprehensive water quality monitoring program would be implemented to:

- Ensure the satisfactory operation of all water quality structures;
- Identify any leakages from contaminated water storages;
- To monitor water quality in the receiving waters; and
- To implement response plans as necessary.

11.3 POST OPERATIONS

On completion, the DZP Site would be rehabilitated to a form as close as possible to the existing natural landform. The exceptions would be the former open cut (void), the Waste Rock Emplacement, the Solid Residue Storage Facility and the Salt Encapsulation Cells.

The remnant void would be left and entrained rainfall would either evaporate or become groundwater re-charge. The Waste Rock Emplacement would be profiled to appear an extension of the ridge feature against which it would be constructed. The Solid Residue Storage Facility and the Salt Encapsulation Cells would be covered with a liner and with a suitable soil layer to allow rehabilitation.

During the rehabilitation works soil would be exposed to erosion and there could be subsequent sediment movement/loss. During this period soil and water would be managed to the requirements of Landcom (2004) and DECC (2008). Individual rehabilitation stages would be the subject of a series of Progressive ESCPs. All plans would be prepared by a Certified Professional in Erosion and Sediment Control (CPESC).

12. REFERENCES

- ANZECC (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality
- Australian Government, Bureau of Meteorology (BoM) (2012). *Atlas of groundwater dependent ecosystems.*
- Australian Government, Bureau of Meteorology, (2003). *Climatic Atlas of Australia, Evapotranspiration.*
- Australian Government. Dept of Resources Energy and Tourism (2008). *Leading Practice Sustainable Development Program for the Mining Industry. Water Management.*
- BOM, (2012). Website Reference. National Groundwater Information System.
<http://www.bom.gov.au/water/groundwater/ngis/>
- Boughton, W.C. (2003). *Calibrations of the AWBM for use on ungauged catchments.* Cooperative Research Centre for Catchment Hydrology.
- DE Cooper & Associates Pty Ltd (2013). Solid and liquid residue management, Australian Zirconia Limited – Dubbo Project. Final report dated June 2013.
- DECC (2008). Managing Urban Stormwater: Soils and Construction Volume 2e, Mines and Quarries. Department of Environment and Climate Change, NSW. Sydney, Australia.
- DECC (2008b). Managing Urban Stormwater: Soils and Construction Volume 2c, Unsealed Roads. Department of Environment and Climate Change, NSW. Sydney, Australia.
- Environmental Earth Sciences (2013). *Hydrogeological Investigation of the Dubbo Zirconia Project, Via Toongi, NSW.*
- Institute of Engineers, Australia (2003). Australian Rainfall and Runoff; *A Guide to Flood Estimation.*
- Landcom (2004). Managing Urban Stormwater: Soils and Construction Volume 1.
- Murphy and Lawrie (1998). *Soil Landscapes of the Dubbo 1:250 000 Sheet.* Department of Land and Water Conservation, Cowra, NSW.
- Minerals Council of Australia (1997). *Minesite Water Management Handbook.* Minerals Council of Australia, ACT, Australia.
- NSW DPI Office of Water (NOW) (2013). *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources.*
- Smithson (2001). *Hydrogeological Investigation of Dryland Salinity in the Toongi Catchment, Central West Region, NSW.* Groundwater Unit, Central West Region, DLWC, Dubbo, NSW.

This page has intentionally been left blank

Appendix 1

Director-General Requirements Checklist

This page has intentionally been left blank

Table 14
Director-General's Requirements (related to surface water)
(Department of Planning and Infrastructure – DZP Proposal SSD-5251)

Paraphrased Requirement	Relevant Section(s)
A detailed assessment of potential impacts on the quality and quantity of existing surface and ground water resources, including: <ul style="list-style-type: none"> impacts on affected licensed water users and basic landholder rights; and impacts on riparian, ecological, geomorphological and hydrological values of watercourses, including environmental flows. 	Section 4
A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures.	Sections 5 & 6
An assessment of proposed water discharge quantities and quality/ies against receiving water quality and flow objectives.	Sections 5 & 9
An assessment of proposed modifications to surface water management, including modelling the redistribution of waters and an assessment of the impact on neighbouring properties and the associated watercourse and floodplain.	Sections 4 & 5
Identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000	Section 6.3
Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant <i>Water Sharing Plan</i> (WSP).	Section 6
A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo.	Section 6.3
A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.	Section 9

Table 15
Dept. of Primary Industries. Office of Water Requirements (related to surface water)

Paraphrased Requirement	Relevant Section(s)
Confirm water supplies for construction and operation are sourced from an appropriately authorised and reliable supply	Section 6
Identify site water demands, water sources, disposal methods, water storage structures. Detail water reticulation infrastructure to and within the DZP Site. Maximise Reuse.	Sections 5 & 6
An impact assessment on adjacent licensed water users, Riparian ecosystems.	Section 4
An assessment of the existing base flow contributions to surface water systems.	Section 3.1.2.3
An impact assessment on the construction, operation and final landform of the proposed on-site waste rock emplacement, evaporative basins, residue storage and other potentially contaminating activities.	Section 4
An assessment of any proposed modification to surface water management including modelling of redistribution of waters.	Sections 4 to 6
An impact assessment of any proposed works within or adjacent to watercourses. Assessment of "Controlled Activities".	Section 4
Prepare a <i>Surface Water Management Plan</i> to integrate the proposed water balance and management for the DZP Site and identify mitigating and monitoring requirements for water quality and volume.	Sections 5, 6, 9 & 10. Figure 27.
Provide details on existing and proposed water licencing requirements.	Section 6.3
Ensure adequate mitigating and monitoring requirements to address surface water impacts.	Sections 9 & 10

Table 16
Catchment Management Authority (Central West) Surface Water Requirements

Paraphrased Requirement	Relevant Section(s)
An assessment of the surface water impacts particularly in terms of flow and potential for contamination	Section 4
An assessment of the potential water demands during operation.	Section 6
Demonstrate adequate water supply.	Section 6
A Flood Assessment	Appendices 2 & 3

Table 17
NSW EPA Surface Water Requirements

Paraphrased Requirement	Relevant Section(s)
<p>The EIS should address the following:</p> <ul style="list-style-type: none"> There is no pollution of waters (including surface and groundwater) 	<p>Section 4.1.4 Section 4.1.10</p>
<ul style="list-style-type: none"> Polluted water (including process waters, wash down waters, polluted stormwater or sewage) is captured onsite and collected, treated and beneficially' reused, where safe and practical to do so. 	<p>Section 6 Section 7</p>
<ul style="list-style-type: none"> The Project is assessed in relation to the relevant NSW Water Quality Objectives as defined in the individual catchment action plans and against ANZECC 2000 water quality criteria. 	<p>Section 9</p>
<p>Construction activities will need to demonstrate best practice sediment and erosion control and management in accordance with the reference document Managing Urban Stormwater: Soils and Construction (NSW Landcom 2004).</p>	<p>Section 4.1.4 Section 4.2 Section 4.3 Section 4.4</p>
<p>The EIS should identify potential impact on watercourses and the management and mitigation measures that will be implemented where works are conducted in the vicinity of watercourses.</p>	<p>Sections 4.2 to 4.4</p>
<p>The EIS should demonstrate how the project will contribute to achieving the most current government endorsed Water Quality and River Flow Objectives for each of the relevant catchments and should utilise the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).</p>	<p>Section 9</p>
<p>A detailed water balance must be prepared to model water management through the life cycle of the project.</p>	<p>Section 6</p>
<p>Where an off-site discharge is proposed, the EIS will need to identify:</p> <ul style="list-style-type: none"> Details regarding proposed discharges i.e. treatment requirements, infrastructure to enable a discharge etc. All proposed discharge points; Estimates of the frequency and volume of discharges; and Likely water quality to be discharged. 	<p>Section 5 Table 7</p>

This page has intentionally been left blank

Appendix 2

DZP Pre-development HEC-RAS Flood Modelling Data

Note: A copy of this Appendix is available on the Project CD

This page has intentionally been left blank

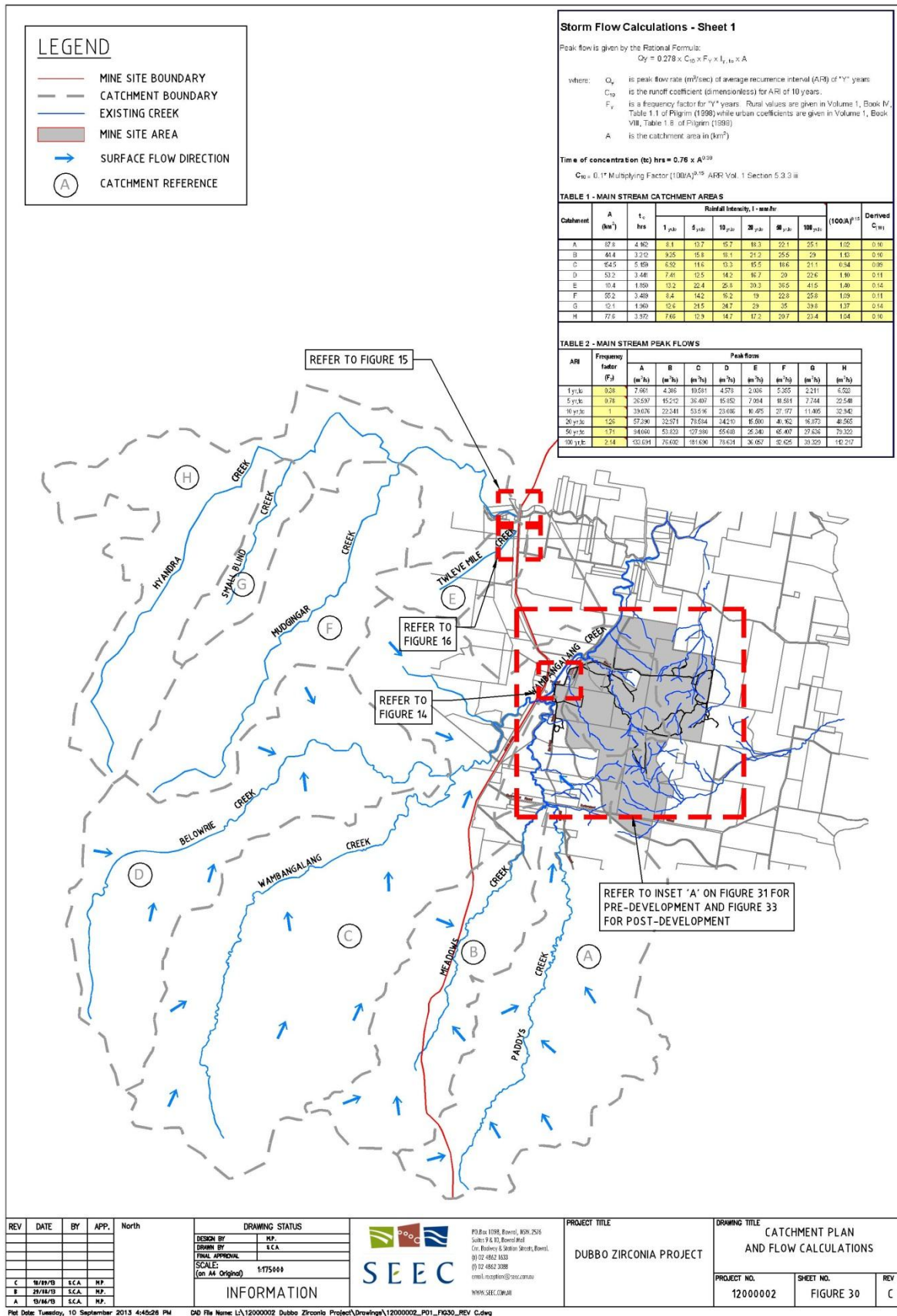


Figure 30 DZP Site Catchment Plan and Flow Calculations



Figure 31 Catchment Plan and Flow Calculations DZP Site – Pre Development

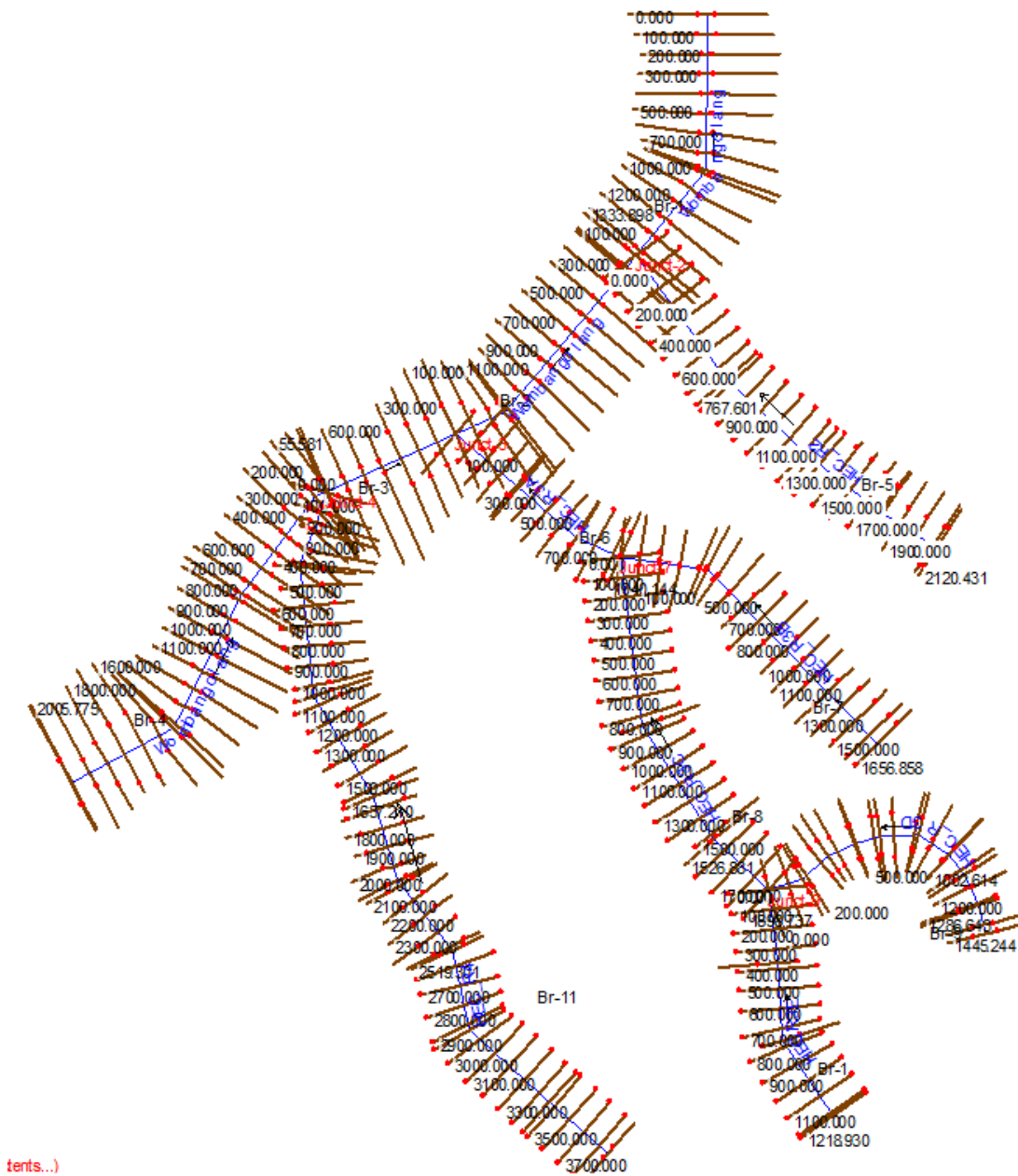


Figure 31 HEC-RAS Model, General Stream Geometry Layout – Pre-development

Table 18
Pre-Development Hec-Ras Output Data

Dubbo Zirconia Project - Pre-development HEC-RAS Output Data														
Profile HEC-RAS	Output Plan:	Table Plan	Standard 1 Profile:	Table 100YR	ARI	1								
#	Rivers	=	8											
#	Hydraulic	Reaches	=	11										
#	River	Stations	=	235										
#	Plans	=	1											
#	Profiles	=	1											
	River (m3/s)	Reach (m)	River (m)	Sta (m)	Profile (m)	Q (m3/s)	Total (m/s)	Min (m2)	Ch (m)	El	W.S.	Elev	Crit	W.S.
	Wambangalang	Br-4	2005.775	100YR	ARI	476.24	279	284.09	284.57	0.007	3.070	154.89	69.51	0.66
	Wambangalang	Br-4	2000	100YR	ARI	476.24	279	283.9	284.51	0.008	3.480	136.77	57.77	0.72
	Wambangalang	Br-4	1900	100YR	ARI	476.24	279	284.21	284.25	0.000	0.920	523.37	185.99	0.15
	Wambangalang	Br-4	1800	100YR	ARI	476.24	280	284.15	284.2	0.001	1.020	505.32	574.58	0.23
	Wambangalang	Br-4	1700	100YR	ARI	476.24	279	284.05	284.1	0.001	0.970	503.66	639.21	0.26
	Wambangalang	Br-4	1600	100YR	ARI	476.24	279	283.95	284	0.001	0.990	479.29	243.64	0.23
	Wambangalang	Br-4	1500	100YR	ARI	476.24	278	283.67	283.85	0.003	1.860	255.74	139.16	0.44
	Wambangalang	Br-4	1422.297	100YR	ARI	476.24	278	283.45	283.64	0.002	1.910	249.28	103.9	0.39
	Wambangalang	Br-4	1400	100YR	ARI	476.24	279	283.33	283.56	0.004	2.150	221.18	116.42	0.5
	Wambangalang	Br-4	1300	100YR	ARI	476.24	278	283.07	283.27	0.002	1.980	244.06	155.59	0.38
	Wambangalang	Br-4	1200	100YR	ARI	476.24	277.41	282.84	283.05	0.002	2.010	236.88	90.29	0.4
	Wambangalang	Br-4	1100	100YR	ARI	476.24	277	282.68	282.84	0.002	1.770	269.76	99.53	0.34
	Wambangalang	Br-4	1000	100YR	ARI	476.24	277	282.43	282.66	0.002	2.120	229.12	89.82	0.36
	Wambangalang	Br-4	900	100YR	ARI	476.24	277	282.33	282.48	0.001	1.730	283.89	149.7	0.31
	Wambangalang	Br-4	800	100YR	ARI	476.24	276	282.11	282.32	0.002	2.030	240.08	144.74	0.36
	Wambangalang	Br-4	700	100YR	ARI	476.24	276.93	281.96	282.15	0.002	2.000	285.02	215.45	0.34
	Wambangalang	Br-4	662.176	100YR	ARI	476.24	276	281.83	282.05	0.002	2.140	261.23	188.67	0.36
	Wambangalang	Br-4	600	100YR	ARI	476.24	276	281.71	281.91	0.002	2.070	276.26	213.57	0.35
	Wambangalang	Br-4	500	100YR	ARI	476.24	276	281.69	281.76	0.001	1.240	453	325.14	0.24
	Wambangalang	Br-4	400	100YR	ARI	476.24	276	281.46	281.63	0.002	1.910	309.31	274.4	0.36
	Wambangalang	Br-4	300	100YR	ARI	476.24	276	281.1	281.4	0.003	2.420	209.19	205.51	0.44
	Wambangalang	Br-4	200	100YR	ARI	476.24	276	280.78	281.01	0.005	2.130	223.93	149.05	0.55
	Wambangalang	Br-4	100	100YR	ARI	476.24	275	280.66	280.77	0.001	1.480	336.66	166.96	0.27
	Wambangalang	Br-4	55.581	100YR	ARI	476.24	275	280.65	280.72	0.001	1.180	423.61	201.99	0.21
	Wambangalang	Br-4	0	100YR	ARI	476.24	275	280.62	280.68	0.001	1.150	430.45	200.84	0.21
	Wambangalang	Br-3	711.552	100YR	ARI	505.15	275	280.61	280.68	0.001	1.220	428.49	199.92	0.23
	Wambangalang	Br-3	700	100YR	ARI	505.15	275	280.58	280.67	0.001	1.350	392.91	193.72	0.25
	Wambangalang	Br-3	600	100YR	ARI	505.15	275	280.29	280.53	0.002	2.190	246.2	153.45	0.38
	Wambangalang	Br-3	500	100YR	ARI	505.15	275	280.13	280.33	0.002	1.970	271.53	219.27	0.36
	Wambangalang	Br-3	400	100YR	ARI	505.15	275	279.38	278.58	279.970	0.007	3.41	147.95	55.68
	Wambangalang	Br-3	300	100YR	ARI	505.15	274	279.14	279.31	0.004	1.830	275.31	199.31	0.5
	Wambangalang	Br-3	200	100YR	ARI	505.15	274	279.07	279.13	0.001	1.100	460.33	184.19	0.22
	Wambangalang	Br-3	100	100YR	ARI	505.15	273	278.91	279.03	0.001	1.520	333.39	119.42	0.29
	Wambangalang	Br-3	0	100YR	ARI	505.15	274	278.95	278.97	0.000	0.560	906.96	314.12	0.1
	Wambangalang	Br-2	1296.494	100YR	ARI	570.38	274	278.95	278.97	0.000	0.630	905.46	314.05	0.12
	Wambangalang	Br-2	1200	100YR	ARI	570.38	273	278.69	278.9	0.003	2.070	294.78	155.51	0.42
	Wambangalang	Br-2	1100	100YR	ARI	570.38	273	278.56	278.71	0.001	1.730	343.07	148.31	0.3
	Wambangalang	Br-2	1022.736	100YR	ARI	570.38	273	278.52	278.63	0.001	1.440	407.58	166.55	0.24
	Wambangalang	Br-2	1000	100YR	ARI	570.38	273	278.51	278.61	0.001	1.410	416.39	168.88	0.24
	Wambangalang	Br-2	900	100YR	ARI	570.38	272	278.32	278.5	0.001	1.880	325.94	182.99	0.32
	Wambangalang	Br-2	800	100YR	ARI	570.38	272	278.22	278.38	0.001	1.800	377.53	209.55	0.28
	Wambangalang	Br-2	700	100YR	ARI	570.38	271	278.06	278.26	0.001	2.030	355.49	258.31	0.32
	Wambangalang	Br-2	600	100YR	ARI	570.38	271	277.89	278.12	0.001	2.190	323.26	220.93	0.34
	Wambangalang	Br-2	500	100YR	ARI	570.38	272	277.7	277.96	0.002	2.300	303.1	251.23	0.37
	Wambangalang	Br-2	400	100YR	ARI	570.38	271	277.54	277.79	0.002	2.260	309.7	254.58	0.36
	Wambangalang	Br-2	300	100YR	ARI	570.38	270	277.45	277.63	0.001	1.890	371.73	317.36	0.3
	Wambangalang	Br-2	200	100YR	ARI	570.38	270	277.12	275.08	277.450	0.002	2.57	250.47	330.84
	Wambangalang	Br-2	100	100YR	ARI	570.38	270	277.1	277.25	0.001	1.770	431.72	385.56	0.27
	Wambangalang	Br-2	80.867	100YR	ARI	570.38	270	277.07	277.23	0.001	1.830	405.46	410.06	0.29
	Wambangalang	Br-2	0	100YR	ARI	570.38	270	276.96	277.12	0.002	1.830	389.88	312.54	0.35
	Wambangalang	Br-1	1333.898	100YR	ARI	582.67	270	276.97	277.11	0.003	1.790	391.65	314	0.4
	Wambangalang	Br-1	1300	100YR	ARI	582.67	270	276.89	277.05	0.001	1.990	445.91	370.19	0.31
	Wambangalang	Br-1	1200	100YR	ARI	582.67	271	276.73	276.92	0.001	2.120	420.07	402.99	0.34
	Wambangalang	Br-1	1100	100YR	ARI	582.67	270	276.66	276.78	0.001	1.730	530.46	432.72	0.28
	Wambangalang	Br-1	1000	100YR	ARI	582.67	269	276.6	276.68	0.001	1.560	613.9	435.21	0.24
	Wambangalang	Br-1	900	100YR	ARI	582.67	269.56	276.29	276.37	0.001	1.490	535.08	420.61	0.3
	Wambangalang	Br-1	800	100YR	ARI	582.67	269	276.21	276.29	0.001	1.390	657.37	434.91	0.21
	Wambangalang	Br-1	778.899	100YR	ARI	582.67	269	276.16	276.26	0.001	1.560	532.64	431.03	0.26
	Wambangalang	Br-1	700	100YR	ARI	582.67	269	276.12	276.2	0.001	1.420	633.22	460.47	0.23
	Wambangalang	Br-1	600	100YR	ARI	582.67	269	275.91	276.01	0.001	1.630	571.71	475.74	0.27
	Wambangalang	Br-1	500	100YR	ARI	582.67	269	275.77	275.89	0.001	1.860	533.07	508.26	0.3
	Wambangalang	Br-1	400	100YR	ARI	582.67	270	275.57	273.96	275.750	0.002	2.14	478.92	557.83
	Wambangalang	Br-1	300	100YR	ARI	582.67	269.94	274.84	273.76	275.410	0.006	3.37	172.82	63.73
	Wambangalang	Br-1	200	100YR	ARI	582.67	268	274.57	273.05	274.940	0.003	2.78	279.15	357.31
	Wambangalang	Br-1	100	100YR	ARI	582.67	268	274.46	273.19	274.620	0.002	1.96	454.81	604.71
	Wambangalang	Br-1	0	100YR	ARI	582.67	268	272.88	272.88	274.040	0.016	4.77	122.11	52.95
	HEC_R4	Br-11	3857.907	100YR	ARI	17.95	346	347.17	347.17	347.450	0.015	2.35	7.64	13.93
	HEC_R4	Br-11	3800	100YR	ARI	17.95	346	346.28	346.28	346.420	0.019	1.61	11.11	41.68
	HEC_R4	Br-11	3700	100YR	ARI	17.95	341.81	343.04	343.04	343.350	0.015	2.48	7.24	11.78

HEC_R4	Br-11	3600	100YR	ARI	17.95	337.97	338.74	338.74	339.010	0.015	2.31	7.76	14.48
HEC_R4	Br-11	3500	100YR	ARI	17.95	336	336.67	336.67	336.880	0.017	2.03	8.83	21.34
HEC_R4	Br-11	3468.873	100YR	ARI	17.95	335.19	335.92	335.92	336.130	0.017	2.01	8.94	22.07
HEC_R4	Br-11	3400	100YR	ARI	17.95	334	334.46	334.46	334.620	0.017	1.78	10.09	31.15
HEC_R4	Br-11	3300	100YR	ARI	17.95	332.14	332.61	332.61	332.740	0.019	1.58	11.36	44.29
HEC_R4	Br-11	3200	100YR	ARI	17.95	330	330.34	330.34	330.460	0.019	1.53	11.71	48.57
HEC_R4	Br-11	3100	100YR	ARI	17.95	327	327.6	327.6	327.770	0.017	1.85	9.72	28.16
HEC_R4	Br-11	3000	100YR	ARI	17.95	325.52	325.84	325.82	325.900	0.015	1.13	15.87	88.43
HEC_R4	Br-11	2925.901	100YR	ARI	17.95	324.05	324.47	324.47	324.580	0.021	1.47	12.21	57.32
HEC_R4	Br-11	2900	100YR	ARI	17.95	323.2	323.75	323.75	323.910	0.020	1.79	10	33.35
HEC_R4	Br-11	2800	100YR	ARI	17.95	321	321.69	321.83	0.012	1.660	10.84	27.63	0.84
HEC_R4	Br-11	2700	100YR	ARI	17.95	319.93	320.15	320.15	320.220	0.023	1.2	14.9	101.07
HEC_R4	Br-11	2600	100YR	ARI	17.95	317	317.36	317.33	317.480	0.013	1.55	11.58	34.69
HEC_R4	Br-11	2519.301	100YR	ARI	17.95	315.93	316.23	316.21	316.320	0.016	1.36	13.21	56.84
HEC_R4	Br-11	2500	100YR	ARI	17.95	315.59	315.9	315.9	315.990	0.019	1.34	13.37	67.31
HEC_R4	Br-11	2400	100YR	ARI	17.95	314.04	314.38	314.34	314.420	0.013	0.86	20.87	153.33
HEC_R4	Br-11	2300	100YR	ARI	17.95	312.53	312.56	312.56	312.660	0.025	0.25	12.44	62.01
HEC_R4	Br-11	2200	100YR	ARI	17.95	310.38	311.31	311.32	0.000	0.200	59.4	167.92	0.15
HEC_R4	Br-11	2100	100YR	ARI	17.95	308.79	308.95	308.95	309.040	0.021	0.87	14.19	78.58
HEC_R4	Br-11	2073.693	100YR	ARI	17.95	308	308.48	308.54	0.006	1.100	16.36	45.76	0.59
HEC_R4	Br-11	2000	100YR	ARI	17.95	307.41	307.71	307.71	307.810	0.020	1.43	12.58	60.28
HEC_R4	Br-11	1900	100YR	ARI	17.95	304.97	305.22	305.21	305.310	0.018	1.29	13.94	71.15
HEC_R4	Br-11	1800	100YR	ARI	17.95	303	303.26	303.26	303.340	0.022	1.26	14.25	87.54
HEC_R4	Br-11	1700	100YR	ARI	17.95	301	301.36	301.43	0.009	1.100	16.32	64.26	0.7
HEC_R4	Br-11	1637.21	100YR	ARI	17.95	300.16	300.49	300.49	300.590	0.020	1.42	12.61	60.77
HEC_R4	Br-11	1600	100YR	ARI	17.95	299.3	299.83	299.78	299.920	0.011	1.3	13.76	48.65
HEC_R4	Br-11	1500	100YR	ARI	17.95	298.15	298.34	298.34	298.410	0.021	1.13	15.82	110.99
HEC_R4	Br-11	1400	100YR	ARI	17.95	296.35	296.6	296.57	296.650	0.015	0.96	18.75	130.99
HEC_R4	Br-11	1300	100YR	ARI	17.95	294.52	294.71	294.7	294.750	0.025	0.9	19.91	221.03
HEC_R4	Br-11	1200	100YR	ARI	17.95	292.29	292.7	292.68	292.770	0.016	1.13	15.83	90.96
HEC_R4	Br-11	1100	100YR	ARI	17.95	290.35	290.82	290.82	290.920	0.021	1.34	13.38	72.64
HEC_R4	Br-11	1051.679	100YR	ARI	17.95	287.67	288.2	288.19	288.330	0.018	1.6	11.18	41.53
HEC_R4	Br-11	1000	100YR	ARI	17.95	286.57	287.22	287.22	287.380	0.019	1.74	10.31	33.84
HEC_R4	Br-11	900	100YR	ARI	17.95	284.85	285.29	285.28	285.380	0.017	1.34	13.44	62.81
HEC_R4	Br-11	800	100YR	ARI	17.95	282.98	283.54	283.53	283.670	0.017	1.58	11.39	40.91
HEC_R4	Br-11	700	100YR	ARI	17.95	282.44	282.89	282.77	282.920	0.004	0.77	23.33	82.28
HEC_R4	Br-11	600	100YR	ARI	17.95	281.82	282.06	282.06	282.120	0.024	1.08	16.65	139.95
HEC_R4	Br-11	500	100YR	ARI	17.95	281.22	281.61	281.62	0.002	0.470	38.37	158.99	0.3
HEC_R4	Br-11	400	100YR	ARI	17.95	280.17	281.08	281.08	281.140	0.040	1.08	16.56	198.86
HEC_R4	Br-11	380.015	100YR	ARI	17.95	276	280.69	280.69	0.000	0.110	167.59	56.4	0.02
HEC_R4	Br-11	300	100YR	ARI	17.95	276	280.69	280.69	0.000	0.100	174.91	61.55	0.02
HEC_R4	Br-11	200	100YR	ARI	17.95	276	280.69	280.69	0.000	0.090	209.64	143.7	0.02
HEC_R4	Br-11	159.438	100YR	ARI	17.95	276	280.69	280.69	0.000	0.080	242.73	165.86	0.01
HEC_R4	Br-11	100	100YR	ARI	17.95	276	280.69	280.69	0.000	0.060	327.59	183.63	0.01
HEC_R4	Br-11	0	100YR	ARI	17.95	275	280.69	280.69	0.000	0.040	488.95	227.46	0.01
HEC_R3E	Br-1	1218.93	100YR	ARI	11.42	374.21	374.52	374.52	374.600	0.023	1.22	9.4	63.7
HEC_R3E	Br-1	1200	100YR	ARI	11.42	372.57	373.14	373.14	373.250	0.022	1.45	7.87	39.44
HEC_R3E	Br-1	1100	100YR	ARI	11.42	365	365.48	365.48	365.650	0.018	1.84	6.21	18.29
HEC_R3E	Br-1	1000	100YR	ARI	11.42	359.15	359.94	359.94	360.160	0.017	2.11	5.43	12.38
HEC_R3E	Br-1	900	100YR	ARI	11.42	354	354.55	354.55	354.750	0.017	1.95	5.85	15.47
HEC_R3E	Br-1	800	100YR	ARI	11.42	350.73	351.34	351.34	351.510	0.018	1.79	6.39	19.82
HEC_R3E	Br-1	764.249	100YR	ARI	11.42	347.69	348.05	348.05	348.170	0.019	1.53	7.51	32.32
HEC_R3E	Br-1	700	100YR	ARI	11.42	344.08	344.76	344.76	344.940	0.017	1.89	6.04	16.76
HEC_R3E	Br-1	600	100YR	ARI	11.42	339.55	340.22	340.22	340.380	0.018	1.77	6.45	20.06
HEC_R3E	Br-1	500	100YR	ARI	11.42	336.37	337.05	337.05	337.220	0.018	1.84	6.22	18.64
HEC_R3E	Br-1	400	100YR	ARI	11.42	333.76	334.19	334.23	0.007	0.900	12.73	54.48	0.59
HEC_R3E	Br-1	371.002	100YR	ARI	11.42	332.73	333.27	333.27	333.410	0.019	1.71	7.19	26.74
HEC_R3E	Br-1	300	100YR	ARI	11.42	330.35	331.01	331.01	331.220	0.016	2.02	5.65	13.58
HEC_R3E	Br-1	200	100YR	ARI	11.42	327	327.8	327.8	328.010	0.017	2.02	5.66	14.02
HEC_R3E	Br-1	100	100YR	ARI	11.42	325	325.77	325.77	325.910	0.018	1.66	6.9	23.92
HEC_R3E	Br-1	0	100YR	ARI	11.42	322	322.95	322.98	0.001	0.650	17.69	27.26	0.26
HEC_R3D	Br-9	1445.244	100YR	ARI	10.26	367.38	367.9	367.9	368.040	0.019	1.67	6.15	22.18
HEC_R3D	Br-9	1400	100YR	ARI	10.26	366.02	366.44	366.44	366.580	0.019	1.63	6.31	23.73
HEC_R3D	Br-9	1300	100YR	ARI	10.26	359	359.43	359.43	359.610	0.018	1.96	5.53	15.57
HEC_R3D	Br-9	1286.643	100YR	ARI	10.26	358.33	358.88	358.88	359.040	0.016	1.86	5.97	18.76
HEC_R3D	Br-9	1200	100YR	ARI	10.26	354	354.59	354.59	354.780	0.017	1.93	5.32	14.04
HEC_R3D	Br-9	1127.824	100YR	ARI	10.26	351.18	351.75	351.75	351.910	0.017	1.8	5.71	17.21
HEC_R3D	Br-9	1100	100YR	ARI	10.26	351	351.27	351.27	351.390	0.020	1.52	6.76	29.05
HEC_R3D	Br-9	1002.614	100YR	ARI	10.26	346.74	347.3	347.3	347.450	0.018	1.71	6	20.05
HEC_R3D	Br-9	1000	100YR	ARI	10.26	346.6	347.18	347.18	347.330	0.019	1.68	6.11	22.09
HEC_R3D	Br-9	900	100YR	ARI	10.26	343.97	344.52	344.45	344.650	0.010	1.6	6.43	15.27
HEC_R3D	Br-9	818.845	100YR	ARI	10.26	343	343.39	343.39	343.540	0.019	1.71	5.98	21.18
HEC_R3D	Br-9	800	100YR	ARI	10.26	342	342.38	342.38	342.490	0.020	1.47	6.97	31.39
HEC_R3D	Br-9	700	100YR	ARI	10.26	339	339.53	339.53	339.720	0.017	1.94	5.27	13.88
HEC_R3D	Br-9	626.136	100YR	ARI	10.26	337	337.73	337.89	0.011	1.740	5.89	13.26	0.83
HEC_R3D	Br-9	600	100YR	ARI	10.26	337	337.38	337.38	337.510	0.019	1.61	6.37	24
HEC_R3D	Br-9	500	100YR	ARI	10.26	334	334.67	334.67	334.910	0.016	2.18	4.71	9.82
HEC_R3D	Br-9	495.583	100YR	ARI	10.26	334	334.57	334.57	334.790	0.016	2.06	4.97	11.45
HEC_R3D	Br-9	400	100YR	ARI	10.26	332	332.55	332.55	332.760	0.017	2.01	5.09	12.45
HEC_R3D	Br-9	349.933	100YR	ARI	10.26	331	331.55	331.55	331.740	0.017	1.94	5.28	13.9
HEC_R3D	Br-9	300	100YR	ARI	10.26	330	330.58	330.58	330.760	0.017	1.89	5.43	15.22
HEC_R3D	Br-9	200	100YR	ARI	10.26	327.04	327.56	327.53	327.680	0.013	1.51	6.78	21.91
HEC_R3D	Br-9	172.22	100YR	ARI	10.26	326.63	327.16	327.16	327.250	0.017	1.36	7.52	34.51
HEC_R3D	Br-9	100	100YR	ARI	10.26	324.69	325.21	325.21	325.370	0.019	1.73	5.94	20.06

AUSTRALIAN ZIRCONIA LTD

Dubbo Zirconia Project

Report No. 545/05

SPECIALIST CONSULTANT STUDIES

Part 4: Surface Water Assessment

HEC_R3D	Br-9	0	100YR	ARI	10.26	320.39	322.98	322.98	0.000	0.060	166.78	97.1	0.01
HEC_R3C	Br-8	1898.737	100YR	ARI	33.7	322	322.67	322.67	322.950	0.015	2.33	14.45	26.19
HEC_R3C	Br-8	1800	100YR	ARI	33.7	319	319.94	319.94	320.260	0.014	2.53	13.31	20.71
HEC_R3C	Br-8	1700	100YR	ARI	33.7	316	317.35	317.35	317.760	0.014	2.83	11.9	14.83
HEC_R3C	Br-8	1600	100YR	ARI	33.7	314.55	315.72	315.72	315.990	0.016	2.3	14.67	28.11
HEC_R3C	Br-8	1526.881	100YR	ARI	33.7	312	313.2	313.2	313.580	0.014	2.73	12.34	16.6
HEC_R3C	Br-8	1500	100YR	ARI	33.7	312	312.79	312.79	313.120	0.014	2.52	13.37	20.91
HEC_R3C	Br-8	1400	100YR	ARI	33.7	309.05	310.52	310.52	310.960	0.013	2.94	11.48	13.38
HEC_R3C	Br-8	1300	100YR	ARI	33.7	307	308.6	308.6	309.040	0.014	2.96	11.4	12.93
HEC_R3C	Br-8	1200	100YR	ARI	33.7	305	306.54	306.77	0.006	2.160	15.58	14.58	0.67
HEC_R3C	Br-8	1100	100YR	ARI	33.7	303.78	305.37	305.37	305.930	0.013	3.29	10.23	9.43
HEC_R3C	Br-8	1000	100YR	ARI	33.7	302	303.82	303.82	304.380	0.013	3.3	10.21	9.25
HEC_R3C	Br-8	900	100YR	ARI	33.7	300	302.12	302.28	0.004	1.780	18.9	17.51	0.55
HEC_R3C	Br-8	850.418	100YR	ARI	33.7	299	300.78	300.78	301.380	0.013	3.62	10.18	8.69
HEC_R3C	Br-8	800	100YR	ARI	33.7	298	299.68	299.94	0.006	2.240	15.01	13.81	0.69
HEC_R3C	Br-8	700	100YR	ARI	33.7	297	298.5	298.5	299.050	0.014	3.28	10.26	9.5
HEC_R3C	Br-8	600	100YR	ARI	33.7	296	297.29	297.4	0.003	1.480	22.7	24.4	0.49
HEC_R3C	Br-8	500	100YR	ARI	33.7	296	296.78	296.87	0.011	1.350	25.01	83.08	0.78
HEC_R3C	Br-8	400	100YR	ARI	33.7	295	295.33	295.33	295.470	0.018	1.69	19.94	69.32
HEC_R3C	Br-8	300	100YR	ARI	33.7	292	292.88	292.88	293.250	0.014	2.68	12.6	17.49
HEC_R3C	Br-8	200	100YR	ARI	33.7	290	291.25	291.25	291.620	0.014	2.68	12.59	17.51
HEC_R3C	Br-8	100	100YR	ARI	33.7	289	290.13	290.36	0.010	2.090	16.09	24.43	0.82
HEC_R3C	Br-8	0	100YR	ARI	33.7	287.76	288.86	288.86	289.170	0.015	2.48	13.57	22.23
HEC_R3B	Br-7	1656.858	100YR	ARI	8.63	344.5	345.16	345.16	0.064	0.330	25.96	83.68	0.19
HEC_R3B	Br-7	1600	100YR	ARI	8.63	342	343.16	343.16	0.022	0.310	28.19	46.07	0.12
HEC_R3B	Br-7	1500	100YR	ARI	8.63	338.71	339.46	339.47	0.074	0.480	17.93	36.73	0.22
HEC_R3B	Br-7	1400	100YR	ARI	8.63	334.63	336.05	336.05	0.020	0.300	28.91	44.78	0.12
HEC_R3B	Br-7	1300	100YR	ARI	8.63	331	331.76	331.78	0.156	0.670	12.91	28.27	0.32
HEC_R3B	Br-7	1200	100YR	ARI	8.63	327	327.95	327.95	0.017	0.300	28.36	38.11	0.11
HEC_R3B	Br-7	1100	100YR	ARI	8.63	324	325.04	325.06	0.061	0.500	17.13	28.34	0.21
HEC_R3B	Br-7	1000	100YR	ARI	8.63	320.41	321.29	321.29	0.026	0.320	26.97	45.9	0.13
HEC_R3B	Br-7	900	100YR	ARI	8.63	314	314.63	314.7	0.427	1.160	7.45	15.17	0.53
HEC_R3B	Br-7	800	100YR	ARI	8.63	310	311.15	311.16	0.012	0.270	32.51	41.55	0.1
HEC_R3B	Br-7	700	100YR	ARI	8.63	308	308.95	308.96	0.053	0.490	17.77	27.69	0.19
HEC_R3B	Br-7	600	100YR	ARI	8.63	304	305.25	305.3	0.027	0.440	12.93	28.36	0.15
HEC_R3B	Br-7	500	100YR	ARI	8.63	301	302.44	302.45	0.029	0.430	20.22	24.15	0.15
HEC_R3B	Br-7	440.614	100YR	ARI	8.63	300	301.32	301.33	0.007	0.230	24.68	60.71	0.07
HEC_R3B	Br-7	400	100YR	ARI	8.63	298	299.58	299.61	0.008	0.270	17.93	36.46	0.08
HEC_R3B	Br-7	300	100YR	ARI	8.63	295	296.16	296.03	296.350	0.564	1.66	4.87	13.72
HEC_R3B	Br-7	200	100YR	ARI	8.63	293	293.96	293.37	293.990	0.007	0.2	22.51	54
HEC_R3B	Br-7	100	100YR	ARI	8.63	291	291.3	291.3	291.400	2.027	1.45	5.94	27.88
HEC_R3B	Br-7	0	100YR	ARI	8.63	287.18	288.94	288.94	0.000	0.040	52.46	76.2	0.01
HEC_R3A	Br-6	1040.144	100YR	ARI	45.88	287.7	288.87	288.94	0.004	1.180	38.93	76.33	0.53
HEC_R3A	Br-6	1000	100YR	ARI	45.88	287	288.49	288.68	0.010	1.910	24.05	44.8	0.83
HEC_R3A	Br-6	900	100YR	ARI	45.88	286	287.41	287.33	287.620	0.011	2.04	22.48	39.41
HEC_R3A	Br-6	800	100YR	ARI	45.88	285	286.07	286.07	286.330	0.015	2.27	20.19	38.91
HEC_R3A	Br-6	795.55	100YR	ARI	45.88	285	285.89	286.03	0.005	1.630	28.09	37.76	0.6
HEC_R3A	Br-6	700	100YR	ARI	45.88	284	284.94	284.94	285.260	0.015	2.51	18.28	30.12
HEC_R3A	Br-6	600	100YR	ARI	45.88	283	283.96	284.1	0.006	1.620	28.36	47.37	0.67
HEC_R3A	Br-6	500	100YR	ARI	45.88	282	282.87	282.87	283.140	0.015	2.3	19.93	37.67
HEC_R3A	Br-6	415.369	100YR	ARI	45.88	281	281.56	281.67	0.006	1.450	31.67	59.83	0.64
HEC_R3A	Br-6	400	100YR	ARI	45.88	280.26	281.32	281.28	281.530	0.012	2.02	22.69	43.75
HEC_R3A	Br-6	300	100YR	ARI	45.88	279	279.9	279.9	280.170	0.015	2.28	20.08	38.55
HEC_R3A	Br-6	200	100YR	ARI	45.88	277	278.95	278.98	0.000	0.670	68.76	56.79	0.19
HEC_R3A	Br-6	100	100YR	ARI	45.88	274.5	278.97	278.97	0.000	0.100	507.95	309.21	0.02
HEC_R3A	Br-6	0	100YR	ARI	45.88	273	278.97	278.97	0.000	0.050	1035.91	325.51	0.01
HEC_R2	Br-5	2120.431	100YR	ARI	12.29	324.49	325.09	325.09	325.240	0.018	1.74	7.08	23.55
HEC_R2	Br-5	2100	100YR	ARI	12.29	322.42	323.23	323.23	323.430	0.017	2.01	6.11	15.26
HEC_R2	Br-5	2000	100YR	ARI	12.29	318	318.43	318.43	318.570	0.019	1.69	7.29	25.5
HEC_R2	Br-5	1900	100YR	ARI	12.29	314.62	315.15	315.15	315.290	0.019	1.67	7.37	26.76
HEC_R2	Br-5	1800	100YR	ARI	12.29	311	311.66	311.77	0.011	1.510	8.15	22.16	0.79
HEC_R2	Br-5	1784.115	100YR	ARI	12.29	311	311.4	311.4	311.560	0.018	1.76	7	22.25
HEC_R2	Br-5	1700	100YR	ARI	12.29	309	309.37	309.37	309.520	0.018	1.73	7.11	23.33
HEC_R2	Br-5	1600	100YR	ARI	12.29	306.85	307.24	307.24	307.360	0.019	1.58	7.76	30.2
HEC_R2	Br-5	1500	100YR	ARI	12.29	303.86	304.36	304.36	304.500	0.019	1.66	7.38	26.8
HEC_R2	Br-5	1400	100YR	ARI	12.29	301	301.52	301.52	301.720	0.017	1.98	6.22	15.83
HEC_R2	Br-5	1351.698	100YR	ARI	12.29	300	300.61	300.61	300.840	0.016	2.12	5.79	12.62
HEC_R2	Br-5	1300	100YR	ARI	12.29	298	298.88	298.88	299.200	0.015	2.51	4.9	7.72
HEC_R2	Br-5	1200	100YR	ARI	12.29	296	296.79	296.79	297.100	0.015	2.46	5	8.23
HEC_R2	Br-5	1100	100YR	ARI	12.29	294	294.69	294.66	294.890	0.014	1.98	6.2	13.33
HEC_R2	Br-5	1000	100YR	ARI	12.29	293	293.33	293.3	293.430	0.015	1.42	8.68	33.89
HEC_R2	Br-5	900	100YR	ARI	12.29	291.59	291.91	291.88	291.980	0.014	1.1	11.17	58.97
HEC_R2	Br-5	800	100YR	ARI	12.29	290	290.18	290.18	290.250	0.022	1.22	10.1	66.69
HEC_R2	Br-5	767.601	100YR	ARI	12.29	288.59	289.14	289.2	0.009	1.070	11.47	47.81	0.7
HEC_R2	Br-5	700	100YR	ARI	12.29	287.92	288.19	288.19	288.280	0.021	1.33	9.24	50.8
HEC_R2	Br-5	600	100YR	ARI	12.29	285.74	285.96	285.95	286.010	0.024	0.99	12.39	114.91
HEC_R2	Br-5	500	100YR	ARI	12.29	283.4	283.63	283.63	283.710	0.023	1.21	10.14	67.19
HEC_R2	Br-5	400	100YR	ARI	12.29	281.05	281.32	281.32	281.400	0.022	1.28	9.63	58.78
HEC_R2	Br-5	300	100YR	ARI	12.29	278.89	279.34	279.28	279.410	0.010	1.13	10.84	44.07
HEC_R2	Br-5	200	100YR	ARI	12.29	277.5	277.89	277.89	278.000	0.020	1.46	8.44	38.81
HEC_R2	Br-5	100	100YR	ARI	12.29	276.22	277.13	277.13	0.000	0.150	79.85	237.8	0.08
HEC_R2	Br-5	0	100YR	ARI	12.29	270	277.13	277.13	0.000	0.010	1248.73	400	0

Appendix 3

DZP Post-development HEC-RAS Flood Modelling Data

Note: A copy of this Appendix is available on the Project CD

This page has intentionally been left blank

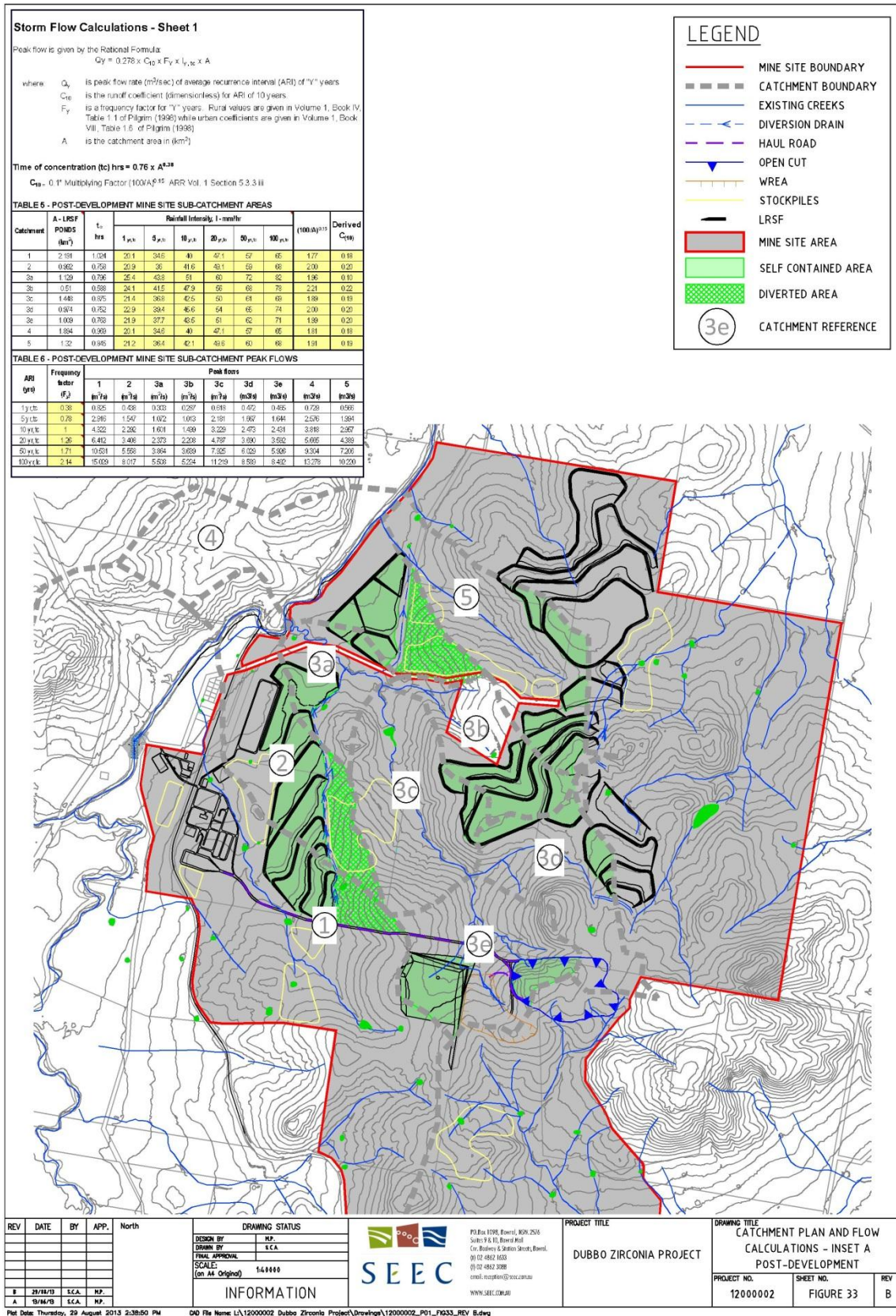


Figure 32 Catchment Plan and Flow Calculations - DZP Site, Post Development

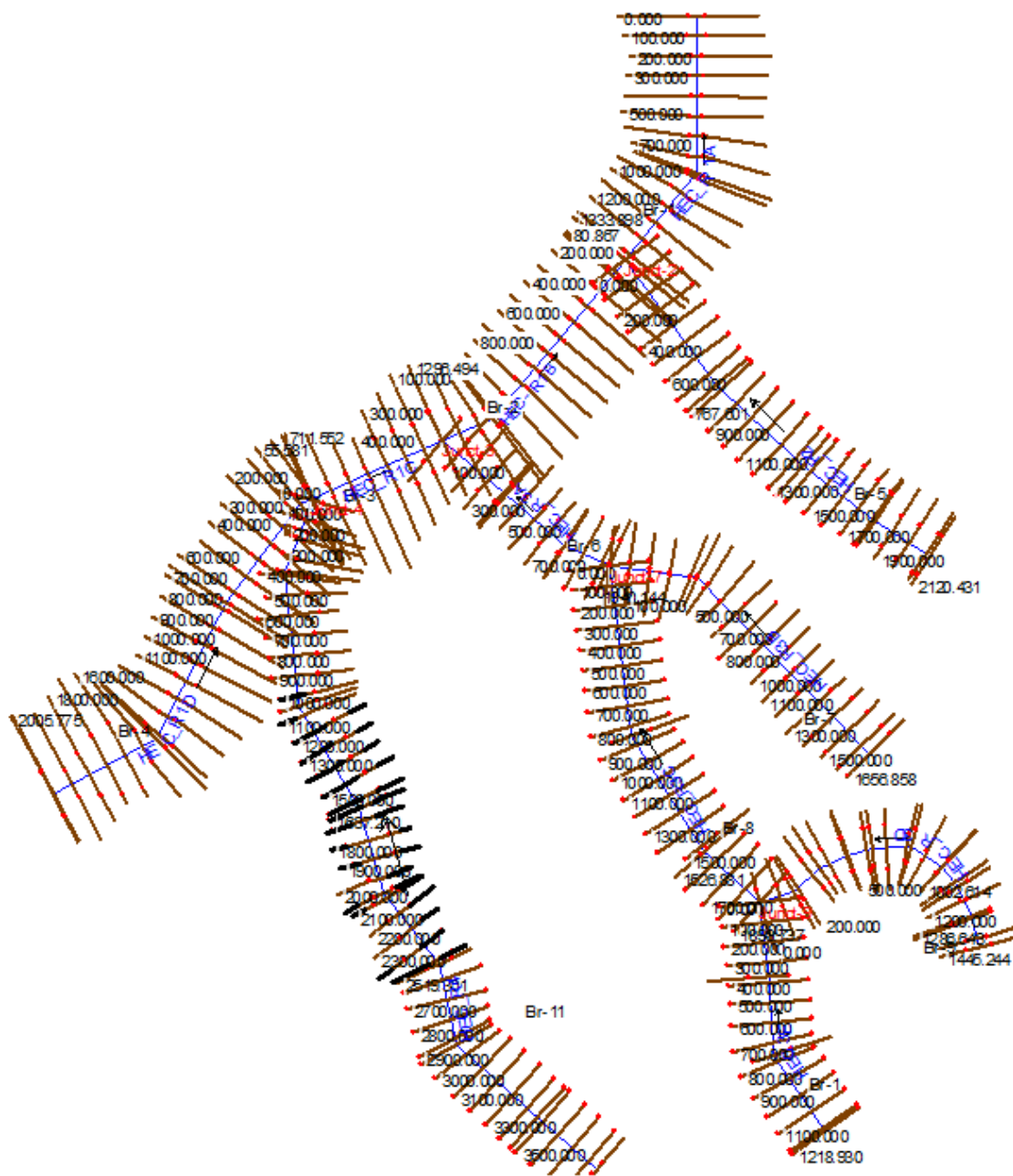


Figure 33 HEC-RAS Model, General Stream Geometry Layout

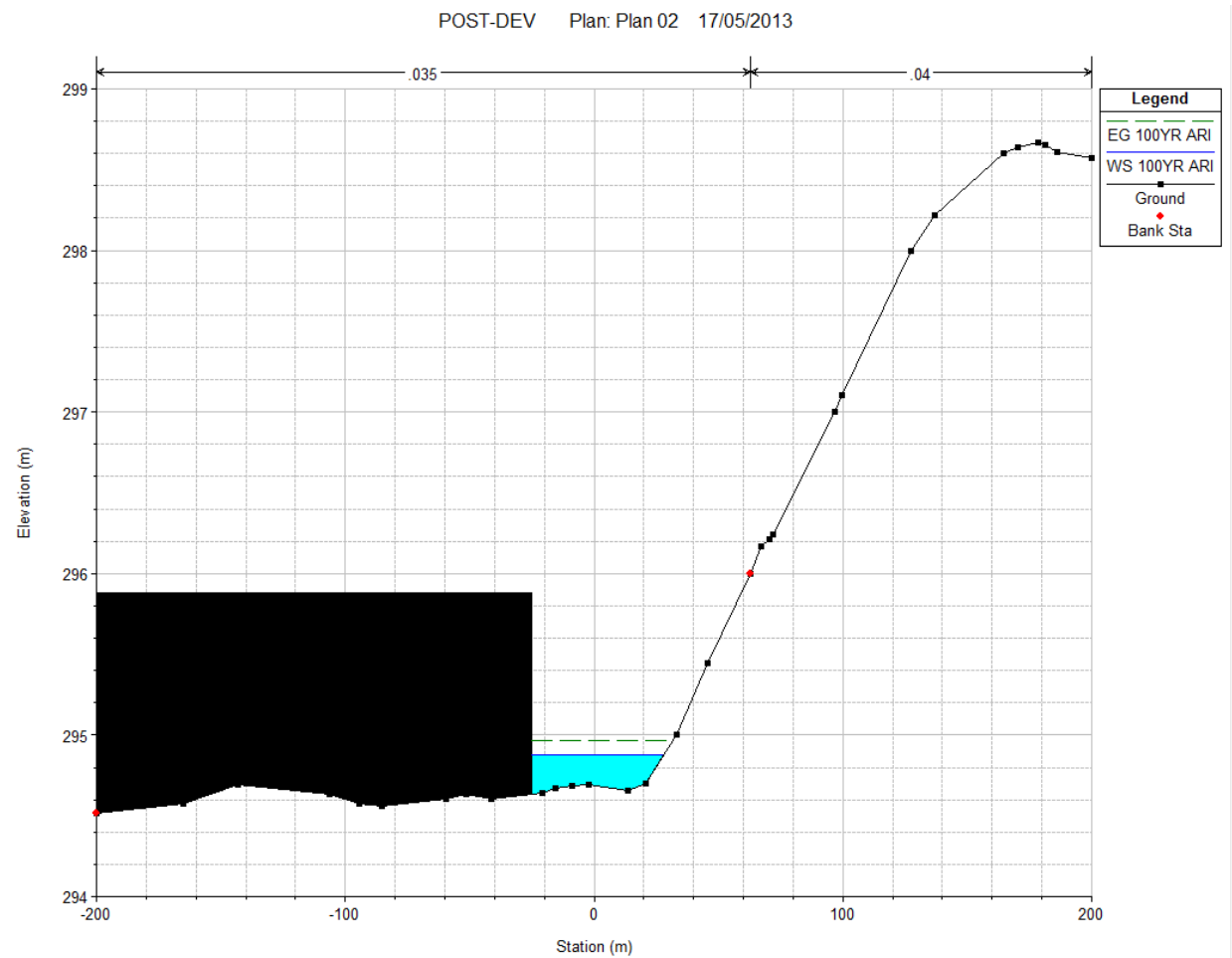


Figure 34 Post-development HEC_R4 – River Station 1300

Figure 35 shows the DZP Site as an obstruction to the left. To the right is an LRSF cell. The level of the DZP Site area/bunding would have a minimum freeboard of 1m from the 100yr ARI storm event top water level (typical).

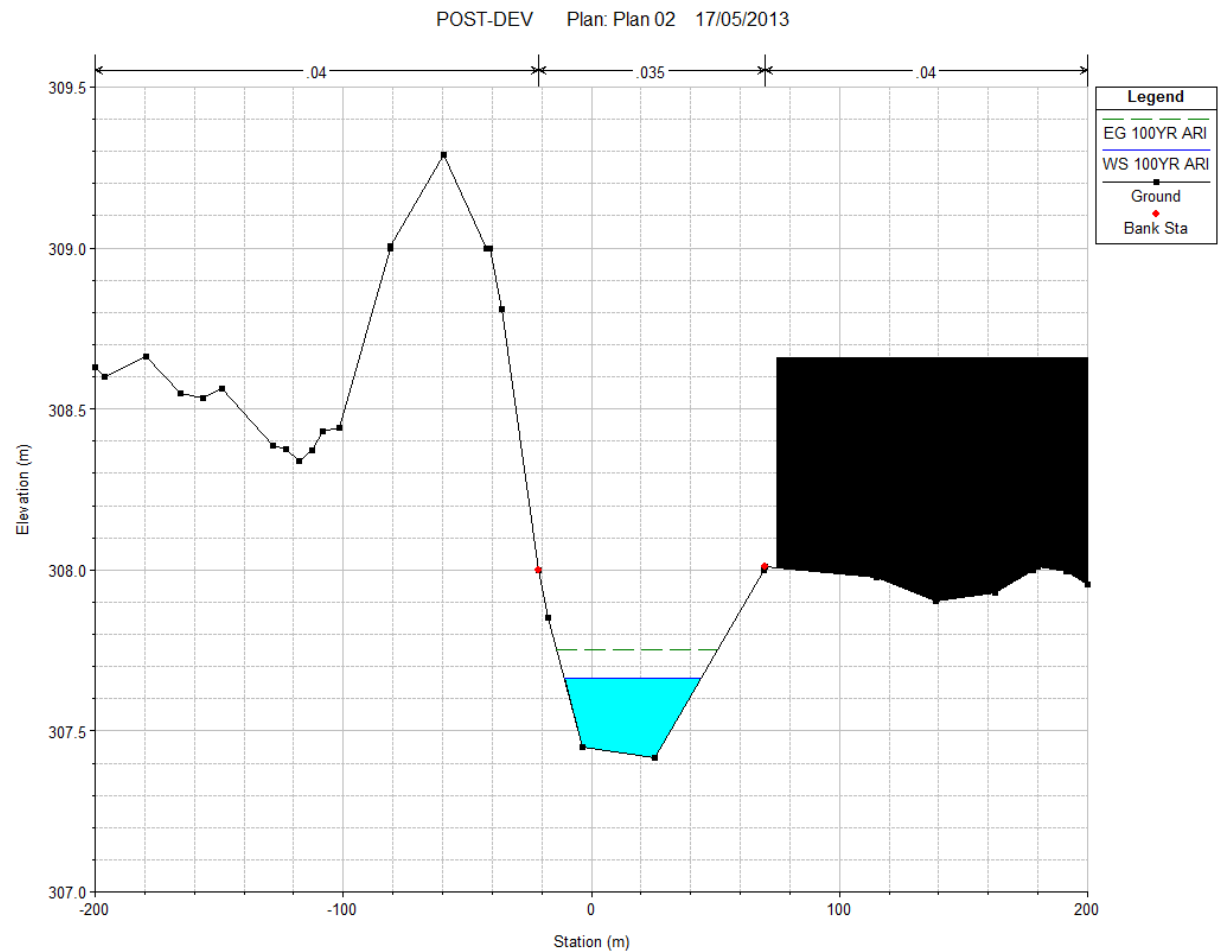


Figure 35 Post-development HEC_R4 – River Station 2000

Figure 36 shows LRSF pond as an obstruction to the right. The level of the LRSF area/bunding would have a minimum freeboard of 1m from the 100yr ARI storm event top water level (typical).

Table 19
Post-development HEC-RAS Output Data

Profile HEC-RAS	Output Plan:	Table Plan	-	Standard 2 Profile:	Table 100YR	1 ARI											
#	Rivers	=		11													
#	Hydraulic	Reaches	=		11												
#	River	Stations	=		235												
#	Plans	=		1													
#	Profiles	=		1													
	River (m3/s)	Reach (m)	River (m)	Sta (m)	Profile (m)	Q (m3/s)	Total (m/s)	Min (m2)	Ch (m)	El	W.S.	Elev	Crit	W.S.	E.G.		
HEC_R4	Br-11	3857.907	100YR	ARI	13	346	347.08	347.05	347.29	0.013136	2.03	6.41	12.93	0.92			
HEC_R4	Br-11	3800	100YR	ARI	13	346	346.23	346.23	346.34	0.019861	1.46	8.91	40.77	1			
HEC_R4	Br-11	3700	100YR	ARI	13	341.81	342.67	342.88	343.32	0.048654	3.58	3.63	8.28	1.73			
HEC_R4	Br-11	3600	100YR	ARI	13	337.97	338.48	338.61	338.92	0.038827	2.92	4.45	11.79	1.52			
HEC_R4	Br-11	3500	100YR	ARI	13	336	336.57	336.57	336.75	0.0173	1.9	6.85	19	1.01			
HEC_R4	Br-11	3468.873	100YR	ARI	13	335.19	335.75	335.83	336.03	0.031434	2.33	5.57	17.76	1.33			
HEC_R4	Br-11	3400	100YR	ARI	13	334	334.39	334.38	334.52	0.017478	1.63	8	28.51	0.98			
HEC_R4	Br-11	3300	100YR	ARI	13	332.14	332.55	332.55	332.66	0.019557	1.48	8.76	38.73	1			
HEC_R4	Br-11	3200	100YR	ARI	13	330	330.26	330.28	330.39	0.026755	1.58	8.22	41.76	1.14			
HEC_R4	Br-11	3100	100YR	ARI	13	327	327.45	327.5	327.68	0.027475	2.08	6.24	21.39	1.23			
HEC_R4	Br-11	3000	100YR	ARI	13	325.52	325.8	325.78	325.85	0.01554	1.01	12.81	84.27	0.83			
HEC_R4	Br-11	2925.901	100YR	ARI	13	324.05	324.43	324.43	324.52	0.021163	1.32	9.84	54.9	1			
HEC_R4	Br-11	2900	100YR	ARI	13	323.2	323.63	323.68	323.84	0.032779	2.02	6.44	26.44	1.3			
HEC_R4	Br-11	2800	100YR	ARI	13	321	321.61	321.55	321.72	0.010633	1.47	8.86	25.14	0.79			
HEC_R4	Br-11	2700	100YR	ARI	13	319.93	320.12	320.12	320.18	0.024116	1.08	12.04	100.24	0.99			
HEC_R4	Br-11	2600	100YR	ARI	13	317	317.23	317.26	317.4	0.032019	1.84	7.08	32.89	1.26			
HEC_R4	Br-11	2519.301	100YR	ARI	13	315.93	316.2	316.17	316.26	0.013402	1.15	11.26	54.55	0.81			
HEC_R4	Br-11	2500	100YR	ARI	13	315.59	315.89	315.88	315.98	0.016488	1.28	10.15	48.86	0.9			
HEC_R4	Br-11	2400	100YR	ARI	13	314.04	314.47	314.44	314.51	0.012873	0.95	13.68	86.15	0.76			
HEC_R4	Br-11	2300	100YR	ARI	13	312.53	312.94	312.92	313	0.018321	1.06	12.22	84.66	0.89			
HEC_R4	Br-11	2200	100YR	ARI	13	310.38	311.22	311.22	311.31	0.015655	1.31	9.9	44.34	0.89			
HEC_R4	Br-11	2100	100YR	ARI	13	308.79	309.07	309.08	309.15	0.031582	1.3	10.04	77.88	1.15			
HEC_R4	Br-11	2073.693	100YR	ARI	13	308	308.41	308.29	308.46	0.005367	0.97	13.42	42.6	0.55			
HEC_R4	Br-11	2000	100YR	ARI	13	307.41	307.66	307.66	307.75	0.021219	1.32	9.85	55.15	1			
HEC_R4	Br-11	1900	100YR	ARI	13	304.97	305.16	305.17	305.25	0.029873	1.36	9.54	65.74	1.14			
HEC_R4	Br-11	1800	100YR	ARI	13	303	303.22	303.22	303.29	0.022865	1.18	11	76.9	1			
HEC_R4	Br-11	1700	100YR	ARI	13	301	301.31	301.25	301.36	0.008981	0.99	13.16	59.69	0.67			
HEC_R4	Br-11	1637.21	100YR	ARI	13	300.16	300.44	300.44	300.54	0.020598	1.4	9.27	46.96	1.01			
HEC_R4	Br-11	1600	100YR	ARI	13	299.3	299.78	299.72	299.85	0.009887	1.2	10.85	39.81	0.73			
HEC_R4	Br-11	1500	100YR	ARI	13	298.16	298.52	298.5	298.63	0.015016	1.5	8.66	30.53	0.9			
HEC_R4	Br-11	1400	100YR	ARI	13	296.52	296.83	296.83	296.94	0.019449	1.45	8.99	40.94	0.99			
HEC_R4	Br-11	1300	100YR	ARI	13	294.63	294.88	294.87	294.96	0.019879	1.31	9.89	52.88	0.97			
HEC_R4	Br-11	1200	100YR	ARI	13	292.44	293.07	293.05	293.2	0.015654	1.62	8.05	26.38	0.93			
HEC_R4	Br-11	1100	100YR	ARI	13	290.97	291.14	291.14	291.2	0.025844	0.99	13.1	130.15	1			
HEC_R4	Br-11	1051.679	100YR	ARI	13	287.67	287.99	288.13	288.51	0.127609	3.2	4.06	22.81	2.42			
HEC_R4	Br-11	1000	100YR	ARI	13	287.72	287.84	287.84	287.9	0.029471	1.12	11.62	106.59	1.08			
HEC_R4	Br-11	900	100YR	ARI	13	284.85	285.24	285.23	285.32	0.017	1.21	10.76	57.89	0.89			
HEC_R4	Br-11	800	100YR	ARI	13	282.98	283.47	283.46	283.59	0.017713	1.48	8.77	35.51	0.95			
HEC_R4	Br-11	700	100YR	ARI	13	282.44	282.85	282.73	282.87	0.003657	0.67	19.36	79.49	0.43			
HEC_R4	Br-11	600	100YR	ARI	13	281.82	282.04	282.04	282.09	0.025769	0.97	13.39	137.19	0.99			
HEC_R4	Br-11	500	100YR	ARI	13	281.22	281.57	281.42	281.58	0.001624	0.41	32.05	152.88	0.28			
HEC_R4	Br-11	400	100YR	ARI	13	280.17	281.06	281.06	281.11	0.045736	1	13.06	197.75	1.24			
HEC_R4	Br-11	380.015	100YR	ARI	13	276	280.65	276.52	280.65	0.000002	0.08	172.2	60.93	0.01			
HEC_R4	Br-11	300	100YR	ARI	13	276	280.65	280.65	0.000001	0.07	203.42	138.12	0.01				
HEC_R4	Br-11	200	100YR	ARI	13	276	280.65	280.65	0.000001	0.06	235.5	161.47	0.01				
HEC_R4	Br-11	159.438	100YR	ARI	13	276	280.65	280.65	0.000001	0.04	319.56	179.75	0.01				
HEC_R4	Br-11	0	100YR	ARI	13	275	280.65	280.65	0	0.03	479.05	220.61	0				
HEC_R3D	Br-9	1445.244	100YR	ARI	10	367.38	367.89	367.89	368.03	0.018854	1.66	6.04	21.99	1.01			
HEC_R3D	Br-9	1400	100YR	ARI	10	366.02	366.34	366.44	366.64	0.056861	2.4	4.16	19.85	1.68			
HEC_R3D	Br-9	1300	100YR	ARI	10	359	359.27	359.43	359.78	0.083656	3.28	3.2	13.3	2.09			
HEC_R3D	Br-9	1286.643	100YR	ARI	10	358.33	358.8	358.87	359.06	0.031854	2.36	4.56	16.6	1.34			
HEC_R3D	Br-9	1200	100YR	ARI	10	354	354.4	354.58	354.97	0.076174	3.32	3.01	10.96	2.02			
HEC_R3D	Br-9	1127.824	100YR	ARI	10	351.18	351.7	351.74	351.91	0.02545	2.05	4.87	16.04	1.19			
HEC_R3D	Br-9	1100	100YR	ARI	10	351	351.27	351.27	351.38	0.019727	1.5	6.65	28.94	1			
HEC_R3D	Br-9	1002.614	100YR	ARI	10	346.74	347.15	347.29	347.63	0.02555	3.07	3.26	16.75	2.22			
HEC_R3D	Br-9	1000	100YR	ARI	10	346.6	347.09	347.18	347.38	0.056394	2.38	4.19	20.08	1.67			
HEC_R3D	Br-9	900	100YR	ARI	10	343.97	344.51	344.44	344.64	0.010105	1.59	6.29	15.17	0.79			
HEC_R3D	Br-9	818.845	100YR	ARI	10	343	343.39	343.39	343.53	0.018948	1.69	5.93	21.11	1.02			
HEC_R3D	Br-9	800	100YR	ARI	10	342	342.24	342.38	342.72	0.0146009	3.07	3.26	21.78	2.54			
HEC_R3D	Br-9	700	100YR	ARI	10	339	339.53	339.53	339.72	0.016928	1.93	5.18	13.78	1			
HEC_R3D	Br-9	626.136	100YR	ARI	10	337	337.55	337.66	337.92	0.037058	2.7	3.7	10.64	1.46			
HEC_R3D	Br-9	600	100YR	ARI	10	337	337.38	337.38	337.51	0.018733	1.6	6.25	23.86	1			
HEC_R3D	Br-9	500	100YR	ARI	10	334	334.54	334.66	334.96	0.035636	2.88	3.47	8.78	1.46			
HEC_R3D	Br-9	495.583	100YR	ARI	10	334	334.51	334.56	334.78	0.022898	2.32	4.32	10.89	1.17			
HEC_R3D	Br-9	400	100YR	ARI	10	332	332.52	332.55	332.75	0.019389	2.11	4.73	12.13	1.08			
HEC_R3D	Br-9	349.933	100YR	ARI	10	331	331.51	331.54	331.74	0.021262	2.09	4.78	13.3	1.11			
HEC_R3D	Br-9	300	100YR	ARI	10	330	330.56	330.57	330.75	0.018126	1.9	5.25	14.99	1.03			
HEC_R3D	Br-9	200	100YR	ARI	10	327.04	327.42	327.52	327.75	0.057845	2.56	3.91	17.17	1.71			
HEC_R3D	Br-9	172.22	100YR	ARI	10	326.63	327.15	327.15	327.24	0.017215	1.35	7.42	34.44	0.93			
HEC_R3D	Br-9	100	100YR	ARI	10	324.69	325.13	325.21	325.4	0.04097	2.28	4.38	17.65	1.46			
HEC_R3D	Br-9	0	100YR	ARI	10	320.39	322.97	320.73	322.97	0.000002	0.06	165.65	96.87	0.01			
HEC_R3C	Br-8	1898.737	100YR	ARI	33	322	322.66	322.66	322.94	0.014974	2						

HEC_R3C	Br-8	1526.881	100YR	ARI	33	312	312.91	313.19	313.83	0.051364	4.26	7.74	14.36	1.85
HEC_R3C	Br-8	1500	100YR	ARI	33	312	312.78	312.78	313.1	0.014367	2.51	13.16	20.8	1.01
HEC_R3C	Br-8	1400	100YR	ARI	33	309.05	310.28	310.5	311.05	0.030119	3.89	8.48	11.92	1.47
HEC_R3C	Br-8	1300	100YR	ARI	33	307	308.55	308.58	309.03	0.014615	3.04	10.86	12.43	1.04
HEC_R3C	Br-8	1200	100YR	ARI	33	305	305.95	306.21	306.82	0.035279	4.15	7.96	11.38	1.58
HEC_R3C	Br-8	1100	100YR	ARI	33	303.78	305.36	305.36	305.9	0.013503	3.28	10.07	9.37	1.01
HEC_R3C	Br-8	1000	100YR	ARI	33	302	303.7	303.8	304.37	0.017326	3.63	9.09	8.72	1.13
HEC_R3C	Br-8	900	100YR	ARI	33	300	302.09	301.57	302.26	0.003718	1.79	18.4	16.72	0.55
HEC_R3C	Br-8	850.418	100YR	ARI	33	299	300.77	300.77	301.35	0.01311	3.6	10.02	8.63	1.02
HEC_R3C	Br-8	800	100YR	ARI	33	298	299.66	299.37	299.92	0.005927	2.23	14.77	13.72	0.69
HEC_R3C	Br-8	700	100YR	ARI	33	297	298.49	298.49	299.03	0.013644	3.27	10.1	9.46	1.01
HEC_R3C	Br-8	600	100YR	ARI	33	296	297.28	296.86	297.39	0.003034	1.47	22.47	24.33	0.49
HEC_R3C	Br-8	500	100YR	ARI	33	296	296.78	296.87	0.010858	1.33	24.76	82.63	0.78	
HEC_R3C	Br-8	400	100YR	ARI	33	295	295.32	295.32	295.47	0.018517	1.68	19.64	69.12	1.01
HEC_R3C	Br-8	300	100YR	ARI	33	292	292.74	292.87	293.28	0.025053	3.25	10.15	16.43	1.32
HEC_R3C	Br-8	200	100YR	ARI	33	290	291.24	291.24	291.6	0.013956	2.67	12.35	17.27	1.01
HEC_R3C	Br-8	100	100YR	ARI	33	289	290.11	289.95	290.34	0.00955	2.11	15.64	23.51	0.83
HEC_R3C	Br-8	0	100YR	ARI	33	287.76	288.85	288.85	289.16	0.014818	2.47	13.36	22.12	1.01
HEC_R3B	Br-7	1656.858	100YR	ARI	3	344.5	344.91	344.7	344.91	0.085405	0.31	9.61	42.08	0.21
HEC_R3B	Br-7	1600	100YR	ARI	3	342	342.72	342.72	0.021842	0.24	12.33	28.13	0.12	
HEC_R3B	Br-7	1500	100YR	ARI	3	338.71	339.17	339.18	0.067082	0.34	8.78	27.97	0.19	
HEC_R3B	Br-7	1400	100YR	ARI	3	334.63	335.61	335.61	0.022082	0.24	12.56	29.67	0.12	
HEC_R3B	Br-7	1300	100YR	ARI	3	331	331.52	331.52	0.099699	0.43	6.96	21.06	0.24	
HEC_R3B	Br-7	1200	100YR	ARI	3	327	327.52	327.53	0.021379	0.23	13.27	33.23	0.11	
HEC_R3B	Br-7	1100	100YR	ARI	3	324	324.72	324.28	324.73	0.038265	0.32	9.27	20.95	0.16
HEC_R3B	Br-7	1000	100YR	ARI	3	320.41	320.92	320.92	0.037921	0.26	11.6	36.61	0.15	
HEC_R3B	Br-7	900	100YR	ARI	3	314	314.49	314.5	0.131794	0.56	5.4	13.68	0.28	
HEC_R3B	Br-7	800	100YR	ARI	3	310	310.66	310.67	0.017968	0.22	13.91	32.87	0.11	
HEC_R3B	Br-7	700	100YR	ARI	3	308	308.7	308.7	0.021407	0.26	11.43	22.86	0.12	
HEC_R3B	Br-7	600	100YR	ARI	3	304	304.8	304.82	0.091151	0.58	5.14	9.02	0.25	
HEC_R3B	Br-7	500	100YR	ARI	3	301	302.02	302.02	0.013346	0.26	11.49	16.05	0.1	
HEC_R3B	Br-7	440.614	100YR	ARI	3	300	300.75	300.75	0.039222	0.38	7.93	14.38	0.16	
HEC_R3B	Br-7	400	100YR	ARI	3	298	299.29	299.3	0.010372	0.25	9.85	18.8	0.09	
HEC_R3B	Br-7	300	100YR	ARI	3	295	295.87	295.93	0.393135	1.09	2.75	5.38	0.49	
HEC_R3B	Br-7	200	100YR	ARI	3	293	293.75	293.19	293.75	0.00698	0.17	13.01	33.17	0.07
HEC_R3B	Br-7	100	100YR	ARI	3	291	291.16	291.16	291.23	2.555564	1.15	2.61	20.6	1.03
HEC_R3B	Br-7	0	100YR	ARI	3	287.18	288.95	287.64	288.95	0.000018	0.02	52.74	76.37	0
HEC_R3A	Br-6	1040.144	100YR	ARI	46	287.7	288.87	288.55	288.94	0.004186	1.18	39.02	76.43	0.53
HEC_R3A	Br-6	1000	100YR	ARI	46	287	288.49	288.68	0.010318	1.91	24.1	44.86	0.83	
HEC_R3A	Br-6	900	100YR	ARI	46	286	287.41	287.33	287.62	0.010875	2.04	22.54	39.46	0.86
HEC_R3A	Br-6	800	100YR	ARI	46	285	286.07	286.07	286.34	0.015272	2.28	20.21	38.92	1.01
HEC_R3A	Br-6	795.55	100YR	ARI	46	285	285.44	285.66	286.16	0.065635	3.75	12.26	33.33	1.98
HEC_R3A	Br-6	700	100YR	ARI	46	284	284.92	284.92	285.26	0.016128	2.57	17.87	29.81	1.06
HEC_R3A	Br-6	600	100YR	ARI	46	283	283.96	283.79	284.1	0.006365	1.62	28.41	47.42	0.67
HEC_R3A	Br-6	500	100YR	ARI	46	282	282.87	282.87	283.14	0.015201	2.3	19.97	37.7	1.01
HEC_R3A	Br-6	415.369	100YR	ARI	46	281	281.56	281.42	281.67	0.006013	1.45	31.73	59.84	0.64
HEC_R3A	Br-6	400	100YR	ARI	46	280.26	281.33	281.29	281.53	0.012036	2.02	22.74	43.77	0.9
HEC_R3A	Br-6	300	100YR	ARI	46	279	279.91	279.91	280.17	0.015322	2.29	20.1	38.57	1.01
HEC_R3A	Br-6	200	100YR	ARI	46	277	278.89	277.92	278.92	0.000496	0.71	65.14	55.4	0.21
HEC_R3A	Br-6	100	100YR	ARI	46	274.5	278.91	278.91	0.000004	0.1	488.63	304.57	0.02	
HEC_R3A	Br-6	0	100YR	ARI	46	273	278.91	278.91	0.000001	0.05	1015.46	324.38	0.01	
HEC_R2	Br-5	2120.431	100YR	ARI	11	324.49	325.06	325.06	325.21	0.018837	1.7	6.47	22.65	1.01
HEC_R2	Br-5	2100	100YR	ARI	11	322.42	322.9	323.19	324.18	0.211264	5.02	2.19	9.22	8.29
HEC_R2	Br-5	2000	100YR	ARI	11	318	318.98	318.41	318.55	0.023619	1.79	6.14	23.55	1.12
HEC_R2	Br-5	1900	100YR	ARI	11	314.62	315.05	315.13	315.31	0.046833	2.26	4.88	22.12	1.53
HEC_R2	Br-5	1800	100YR	ARI	11	311	311.63	311.56	311.74	0.010300	1.45	7.59	21.44	0.78
HEC_R2	Br-5	1784.115	100YR	ARI	11	311	311.37	311.37	311.52	0.018238	1.71	6.42	21.63	1
HEC_R2	Br-5	1700	100YR	ARI	11	309	309.29	309.34	309.51	0.032421	2.04	5.4	21.84	1.3
HEC_R2	Br-5	1600	100YR	ARI	11	306.85	307.21	307.21	307.34	0.019777	1.54	7.12	29.83	1.01
HEC_R2	Br-5	1500	100YR	ARI	11	303.86	304.26	304.34	304.51	0.043005	2.19	5.02	22.25	1.47
HEC_R2	Br-5	1400	100YR	ARI	11	301	301.47	301.49	301.68	0.019911	2.03	5.41	15.05	1.08
HEC_R2	Br-5	1351.698	100YR	ARI	11	300	300.56	300.57	300.79	0.017219	2.12	5.2	12.14	1.03
HEC_R2	Br-5	1300	100YR	ARI	11	298	298.58	298.82	299.31	0.050527	3.79	2.91	6.1	1.75
HEC_R2	Br-5	1200	100YR	ARI	11	296	296.74	296.74	297.03	0.015217	2.38	4.62	8	1
HEC_R2	Br-5	1100	100YR	ARI	11	294	294.52	294.62	294.88	0.032595	2.66	4.13	11.04	1.39
HEC_R2	Br-5	1000	100YR	ARI	11	293	293.3	293.29	293.4	0.015495	1.38	7.97	32.95	0.9
HEC_R2	Br-5	900	100YR	ARI	11	291.59	291.9	291.87	291.96	0.013412	1.06	10.37	57.19	0.79
HEC_R2	Br-5	800	100YR	ARI	11	290	290.16	290.16	290.24	0.022919	1.18	9.3	64.97	1
HEC_R2	Br-5	767.601	100YR	ARI	11	288.59	288.97	289.07	289.24	0.04203	2.28	4.83	19.89	1.48
HEC_R2	Br-5	700	100YR	ARI	11	287.92	288.17	288.17	288.26	0.021564	1.29	8.55	50.26	1
HEC_R2	Br-5	600	100YR	ARI	11	285.74	285.95	285.95	286	0.023653	0.95	11.53	113.93	0.96
HEC_R2	Br-5	500	100YR	ARI	11	283.4	283.59	283.62	283.7	0.049064	1.51	7.31	62.85	1.41
HEC_R2	Br-5	400	100YR	ARI	11	281.05	281.3	281.3	281.38	0.022872	1.24	8.89	57.7	1.01
HEC_R2	Br-5	300	100YR	ARI	11	278.89	279.32	279.27	279.38	0.009923	1.08	10.17	42.98	0.71
HEC_R2	Br-5	200	100YR	ARI	11	277.5	277.87	277.87	277.98	0.02104	1.44	7.66	37.17	1.01
HEC_R2	Br-5	100	100YR	ARI	11	276.22	277.08	276.58	277.08	0.000165	0.16	68.39	235.35	0.1
HEC_R2	Br-5	0	100YR	ARI	11	270	277.08	277.08	0	0.01	1229.4	400	0	
HEC_R1D	Br-4	2005.775	100YR	ARI	476.24	279	284.09	283.22	284.57	0.006718	3.08	154.86	69.5	0.66
HEC_R1D	Br-4	2000	100YR	ARI	476.24	279	283.9	284.51	0.007975	3.48	136.74	57.76	0.72	
HEC_R1D	Br-4	1900	100YR	ARI	476.24	279	284.21	284.25	0.000312	0.92	523.29	185.91	0.15	
HEC_R1D	Br-4	1800	100YR	ARI	476.24	280	284.15	284.2	0.000877	1.02	505.04	574.44	0.23	
HEC_R1D	Br-4	1700	100YR	ARI	476.24	279	284.05	284.1	0.001148	0.97	503.27	639.16	0.26	
HEC_R1D	Br-4	1600	100YR	ARI	476.24	279	283.95	284	0.000819	0.99	479.12	243.56	0.23	
HEC_R1D	Br-4	1500	100YR	ARI	476.24	278	283.67	283.85	0.003153	1.86	255.61	139.07	0.44	
HEC_R1D	Br-4	1422.297	100YR	ARI	476.24	278	283.45	283.64	0.002331	1.91	249.16	103.85	0.39	

HEC_R1D	Br-4	1000	100YR	ARI	476.24	277	282.43	282.65	0.001794	2.12	228.8	89.58	0.37	
HEC_R1D	Br-4	900	100YR	ARI	476.24	277	282.32	282.48	0.001357	1.73	283.28	148.93	0.31	
HEC_R1D	Br-4	800	100YR	ARI	476.24	276	282.11	282.32	0.00173	2.03	239.33	142.84	0.36	
HEC_R1D	Br-4	700	100YR	ARI	476.24	276.93	281.95	282.15	0.00158	2	283.58	213.75	0.34	
HEC_R1D	Br-4	662.176	100YR	ARI	476.24	276	281.82	282.05	0.001741	2.15	259.88	187.22	0.36	
HEC_R1D	Br-4	600	100YR	ARI	476.24	276	281.7	281.91	0.001637	2.08	274.59	212.08	0.35	
HEC_R1D	Br-4	500	100YR	ARI	476.24	276	281.68	281.75	0.000853	1.25	450.22	324	0.24	
HEC_R1D	Br-4	400	100YR	ARI	476.24	276	281.45	281.62	0.00183	1.92	305.66	273.06	0.36	
HEC_R1D	Br-4	300	100YR	ARI	476.24	276	281.08	281.38	0.002811	2.45	204.61	203.59	0.45	
HEC_R1D	Br-4	200	100YR	ARI	476.24	276	280.74	280.98	0.005618	2.18	218.07	144.16	0.57	
HEC_R1D	Br-4	100	100YR	ARI	476.24	275	280.61	280.73	0.001113	1.51	329.34	163.69	0.28	
HEC_R1D	Br-4	55.581	100YR	ARI	476.24	275	280.61	280.68	0.000644	1.2	414.64	196.92	0.22	
HEC_R1D	Br-4	0	100YR	ARI	476.24	275	280.57	280.64	0.000684	1.17	421.12	196.42	0.22	
HEC_R1C	Br-3	711.552	100YR	ARI	494	275	280.56	280.64	0.000741	1.21	419.91	195.84	0.23	
HEC_R1C	Br-3	700	100YR	ARI	494	275	280.54	280.63	0.000854	1.34	384.63	189.32	0.25	
HEC_R1C	Br-3	600	100YR	ARI	494	275	280.25	280.49	0.002013	2.17	239.83	147.72	0.38	
HEC_R1C	Br-3	500	100YR	ARI	494	275	280.09	280.28	0.001847	1.96	261.93	213.25	0.36	
HEC_R1C	Br-3	400	100YR	ARI	494	275	279.35	278.54	0.006458	3.38	146.19	55.3	0.66	
HEC_R1C	Br-3	300	100YR	ARI	494	274	279.07	279.25	0.004836	1.88	262.43	193.26	0.52	
HEC_R1C	Br-3	200	100YR	ARI	494	274	279	279.07	0.000726	1.1	448.99	178.5	0.22	
HEC_R1C	Br-3	100	100YR	ARI	494	273	278.85	278.97	0.001207	1.52	326.02	117.25	0.29	
HEC_R1C	Br-3	0	100YR	ARI	494	274	278.89	278.9	0.000155	0.56	887.22	313.26	0.1	
HEC_R1A	Br-1	1333.898	100YR	ARI	562	270	276.92	277.07	0.002453	1.8	375.96	300.87	0.39	
HEC_R1A	Br-1	1300	100YR	ARI	562	270	276.84	277.01	0.001172	1.97	429.1	361.7	0.3	
HEC_R1A	Br-1	1200	100YR	ARI	562	271	276.68	276.87	0.00145	2.11	401.84	390.05	0.34	
HEC_R1A	Br-1	1100	100YR	ARI	562	270	276.61	276.73	0.001013	1.72	509.9	430.07	0.28	
HEC_R1A	Br-1	1000	100YR	ARI	562	269	276.55	276.63	0.000759	1.55	593	434.12	0.24	
HEC_R1A	Br-1	900	100YR	ARI	562	269.56	276.24	276.33	0.001415	1.49	516.15	419.44	0.31	
HEC_R1A	Br-1	800	100YR	ARI	562	269	276.17	276.24	0.000578	1.38	637.94	432.26	0.21	
HEC_R1A	Br-1	778.899	100YR	ARI	562	269	276.12	276.22	0.000923	1.54	513.35	429.3	0.26	
HEC_R1A	Br-1	700	100YR	ARI	562	269	276.07	276.15	0.000684	1.41	612.44	458.13	0.23	
HEC_R1A	Br-1	600	100YR	ARI	562	269	275.87	275.97	0.001006	1.62	551.66	473.73	0.27	
HEC_R1A	Br-1	500	100YR	ARI	562	269	275.72	275.85	0.001252	1.87	509.22	504.67	0.31	
HEC_R1A	Br-1	400	100YR	ARI	562	270	275.5	273.9	0.00184	2.21	438.49	554.29	0.37	
HEC_R1A	Br-1	300	100YR	ARI	562	269.94	274.8	273.69	0.005968	3.29	170.59	63.03	0.64	
HEC_R1A	Br-1	200	100YR	ARI	562	268	274.53	272.99	0.002904	2.74	265.79	324.69	0.46	
HEC_R1A	Br-1	100	100YR	ARI	562	268	274.39	273.12	0.002481	2.02	415.77	593.7	0.41	
HEC_R1A	Br-1	0	100YR	ARI	562	268	272.8	272.8	0.015985	4.77	117.62	51.64	1.01	
HEC_3E	Br-1	1218.93	100YR	ARI	12	374.21	374.53	374.53	0.029017	1.22	9.82	65.64	1.01	
HEC_3E	Br-1	1200	100YR	ARI	12	372.57	373.03	373.15	0.0231741	3.24	3.7	32.27	3.06	
HEC_3E	Br-1	1100	100YR	ARI	12	365	365.38	365.49	0.038558	2.6	4.61	14.5	1.47	
HEC_3E	Br-1	1000	100YR	ARI	12	359.15	359.75	359.96	0.076428	3.63	3.3	10.52	2.07	
HEC_3E	Br-1	900	100YR	ARI	12	354	354.46	354.57	0.04149	2.72	4.42	13.77	1.53	
HEC_3E	Br-1	800	100YR	ARI	12	350.73	351.31	351.36	0.026203	2.09	5.73	18.79	1.21	
HEC_3E	Br-1	764.249	100YR	ARI	12	347.69	347.87	348.06	0.074693	4.68	2.56	22.08	4.39	
HEC_3E	Br-1	700	100YR	ARI	12	344.08	344.74	344.77	0.021447	2.08	5.77	16.39	1.12	
HEC_3E	Br-1	600	100YR	ARI	12	339.55	340.03	340.23	0.115928	3.68	3.26	13.98	2.43	
HEC_3E	Br-1	500	100YR	ARI	12	336.37	337.06	337.06	0.017872	1.86	6.47	19	1.02	
HEC_3E	Br-1	400	100YR	ARI	12	333.76	334.2	334.13	0.00676	0.91	13.18	54.59	0.59	
HEC_3E	Br-1	371.002	100YR	ARI	12	332.73	333.28	333.28	0.018903	1.73	7.47	27.07	1.02	
HEC_3E	Br-1	300	100YR	ARI	12	330.35	330.98	331.03	0.02318	2.34	5.13	12.93	1.19	
HEC_3E	Br-1	200	100YR	ARI	12	327	327.68	327.82	0.043988	2.95	4.06	11.66	1.6	
HEC_3E	Br-1	100	100YR	ARI	12	325	325.78	325.78	0.017235	1.67	7.2	24.18	0.97	
HEC_3E	Br-1	0	100YR	ARI	12	322	322.94	322.44	0.001077	0.69	17.28	26.96	0.28	
HEC_R1B	Br-2	1296.494	100YR	ARI	552	274	278.88	278.9	0.000198	0.62	885.87	313.2	0.12	
HEC_R1B	Br-2	1200	100YR	ARI	552	273	278.63	278.84	0.00259	2.06	285.15	151.17	0.42	
HEC_R1B	Br-2	1100	100YR	ARI	552	273	278.51	278.65	0.001162	1.71	334.7	143.21	0.29	
HEC_R1B	Br-2	1022.736	100YR	ARI	552	273	278.46	278.57	0.000781	1.42	398.23	159.56	0.24	
HEC_R1B	Br-2	1000	100YR	ARI	552	273	278.45	278.55	0.00074	1.39	406.91	162.56	0.24	
HEC_R1B	Br-2	900	100YR	ARI	552	272	278.27	278.44	0.0013	1.86	316.03	177.67	0.31	
HEC_R1B	Br-2	800	100YR	ARI	552	272	278.17	278.32	0.00103	1.77	366.23	202.41	0.28	
HEC_R1B	Br-2	700	100YR	ARI	552	271	278.01	278.2	0.001279	2.01	341.54	247.94	0.32	
HEC_R1B	Br-2	600	100YR	ARI	552	271	277.84	278.06	0.001453	2.17	311.81	212.16	0.34	
HEC_R1B	Br-2	500	100YR	ARI	552	272	277.65	277.9	0.001716	2.27	290.46	237.05	0.36	
HEC_R1B	Br-2	400	100YR	ARI	552	271	277.49	277.73	0.001678	2.23	297.01	242.39	0.36	
HEC_R1B	Br-2	300	100YR	ARI	552	270	277.4	277.57	0.001131	1.86	355.95	301.72	0.3	
HEC_R1B	Br-2	200	100YR	ARI	552	270	277.07	275.04	0.002454	2.53	235.46	328.04	0.43	
HEC_R1B	Br-2	100	100YR	ARI	552	270	277.06	277.2	0.00096	1.75	413.28	382.33	0.27	
HEC_R1B	Br-2	80.867	100YR	ARI	552	270	277.02	277.18	0.001052	1.81	385.86	407.3	0.29	
HEC_R1B	Br-2	0	100YR	ARI	552	270	276.91	277.07	0.001776	1.82	374.78	299.85	0.35	

This page has intentionally been left blank