APPENDIX 10

Surface Water Impact Assessment




MT OWEN OPEN CUT

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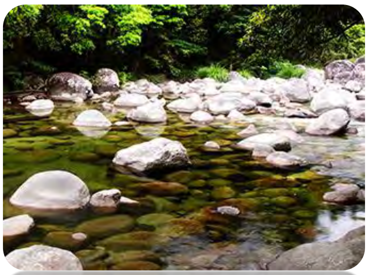
UMWELT (AUSTRALIA) PTY LTD

Mount Owen Continued Operations – Modification 2

Surface Water Impact Assessment



July 2018

N1600_005

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1. INTRODUCTION

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres (km) north-west of Singleton, 24 km south-east of Muswellbrook and to the north of Camberwell. Mt Owen Pty Limited (Mount Owen), a subsidiary of Glencore Coal Pty Limited (Glencore), currently owns three existing open cut operations in the Mount Owen Complex; Mount Owen (North Pit) and associated infrastructure, Ravensworth East (Bayswater North Pit (BNP)) and Glendell (Barrett Pit).

Mount Owen received development consent (SSD-5850) from the Planning Assessment Commission for the Mount Owen Continued Operations Project (Continued Operations Project) in November 2016. The Continued Operations Project development consent incorporates all previously approved operations at the Mount Owen Mine and Coal Handling and Preparation Plant (CHPP) and Ravensworth East Mine and allows for continued and expanded mining until 2031, now referred to as the 'Approved Operations'. Glendell Mine operates under a separate consent (DA 80/952) and does not form part of the Approved Operations.

In September 2017 Mount Owen modified SSD-5850 (Modification 1) to allow for the construction of a water pipeline from the Integra Underground Mine to the Mount Owen Complex and allow the integration of the Integra Underground Mine into the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS). Mount Owen now proposes to further modify development consent SSD-5850 to allow for the optimisation of the North Pit mine plan to access coal reserves from the mining tenements obtained by Glencore through its acquisition of the Integra Underground Mine (the Proposed Modification).

1.1 Proposed Modification Details

The Proposed Modification will enable access to approximately 35 million tonnes (Mt) of additional run-of-mine (ROM) coal from the North Pit. Recovery of the additional coal reserves will result in approximately 46 hectares (ha) of additional disturbance (Proposed Disturbance Area), representing an increase of approximately 1.8 per cent to the total disturbance area currently approved, and require an increased depth in the North Pit to provide for mining down to the Hebden Seam. The change to the North Pit mine plan will require the extension of the mine life through to 2037 (an additional 6 years).

Prior to the acquisition of the Integra Underground mining tenements, the mine plan design for the North Pit did not allow access to the deeper coal seams and was restricted to the east of the approved North Pit footprint. This resulted in the pit floor 'stepping up' as it progressed further southwards and the 'stepping in' of the mine plan along its eastern boundary. The acquisition of the Integra Underground Mine and associated mining tenements has removed this previous constraint and allows for deeper and extended coal extraction across the proposed modified North Pit.

The Proposed Disturbance Area extends further east from the Proposed Modification pit boundary to provide for additional infrastructure such as water management structures and access. In addition, the northern extent of the Proposed Disturbance Area is to provide for earthworks to shape and improve the final landform of the North Pit to tie into the surrounding topography, these works are located in proximity to the existing approved Bettys Creek diversion. It is not proposed to modify the existing Bettys Creek diversion in this area which continues through the South East Offset and South East Corridor Offset areas into Main Creek.

No changes are proposed to current mining methods, extraction limits, transportation methods, operational hours or workforce numbers. The Proposed Modification will utilise existing and approved infrastructure with the exception of proposed water management structures to manage water from the mining operation.

Table 1.1 provides a comparison between the Approved Operations and the Proposed Modification.

Table 1.1 Comparison between the Approved Operations and the Proposed Modification

Component	Approved Operations	Proposed Modification
Mining Method	Truck and excavator	No change to mining methods
Target Seams	Down to Hebden Seam Down to approximately 300 m depth	No change to target seams Down to approximately 380 m depth (average 340 m)
Total Reserve Recovered	Total of 257 Mt ROM coal (Ravensworth East – 48 Mt Mount Owen – 209 Mt)	Additional approximately 35 Mt ROM coal over the life of the mine (approximately 13% of total approved reserve)
Disturbance Area	Approved Disturbance Area of 2534 ha	Additional 46 ha disturbance (increase of 1.8% of total Approved Disturbance Area) Modification to SSD-5850 consent boundary to include Proposed Disturbance Area
Annual Production	Ravensworth East – 4 Mtpa Mount Owen – 10 Mtpa	No change to annual production limit
Mine Life	2031	2037
CHPP Capacity	Up to 17 Mtpa	No change to CHPP capacity
Management of Mining Waste	Emplacement of waste in-pit and out-of-pit, up to maximum existing approved height of 230 m. Tailings emplacement in Ravensworth East	Emplacement of waste in Approved Disturbance Areas (up to maximum existing approved height) Tailings emplacement within West Pit, in-pit

Component	Approved Operations	Proposed Modification
	voids (including West Pit), within in-pit tailings cells in North Pit and/or BNP, and transfer under the GRAWTS to Liddell (subject to relevant approvals)	tailings cells in North Pit and/or BNP, and transfer under the GRAWTS
Water Management	Upper and Middle Bettys Creek Diversions Management of water within the water management system and GRAWTS Works to provide flood attenuation for Yorks Creek	No changes to existing approved creek diversions Extension of water management system to Proposed Disturbance Area and continued management of water within the GRAWTS Proposed amendments to design of existing water management system to provide flood attenuation for Yorks Creek
Operational Workforce	Up to approximately 660 at Mount Owen and up to 260 at Ravensworth East	Continued employment of existing Mount Owen workforce (up to approximately 660) for an additional 6 years
Hours of Operation	24 hours, 7 days per week	No change to hours of operation
Interactions with Integra Underground	Minimum 250 m separation subject to strict safety and operational controls	No change to minimum separation – implementation of safety and operational controls through integration of Glencore owned mining operations
Final Landform	Final voids at BNP and North Pit Final landform approved with commitments relating to landform design (including micro relief), conservation and water management considerations as part of further detailed mine design	No additional void in final landform Proposed changes to the final void arrangement in North Pit Final landform to be designed to incorporate detailed design commitments relating to landform design (including micro relief), conservation and water management considerations and be consistent with the existing progressive rehabilitation objectives in the development consent

A Statement of Environmental Effects (SEE) has been prepared for the Proposed Modification. This Surface Water Assessment forms a component of the SEE.

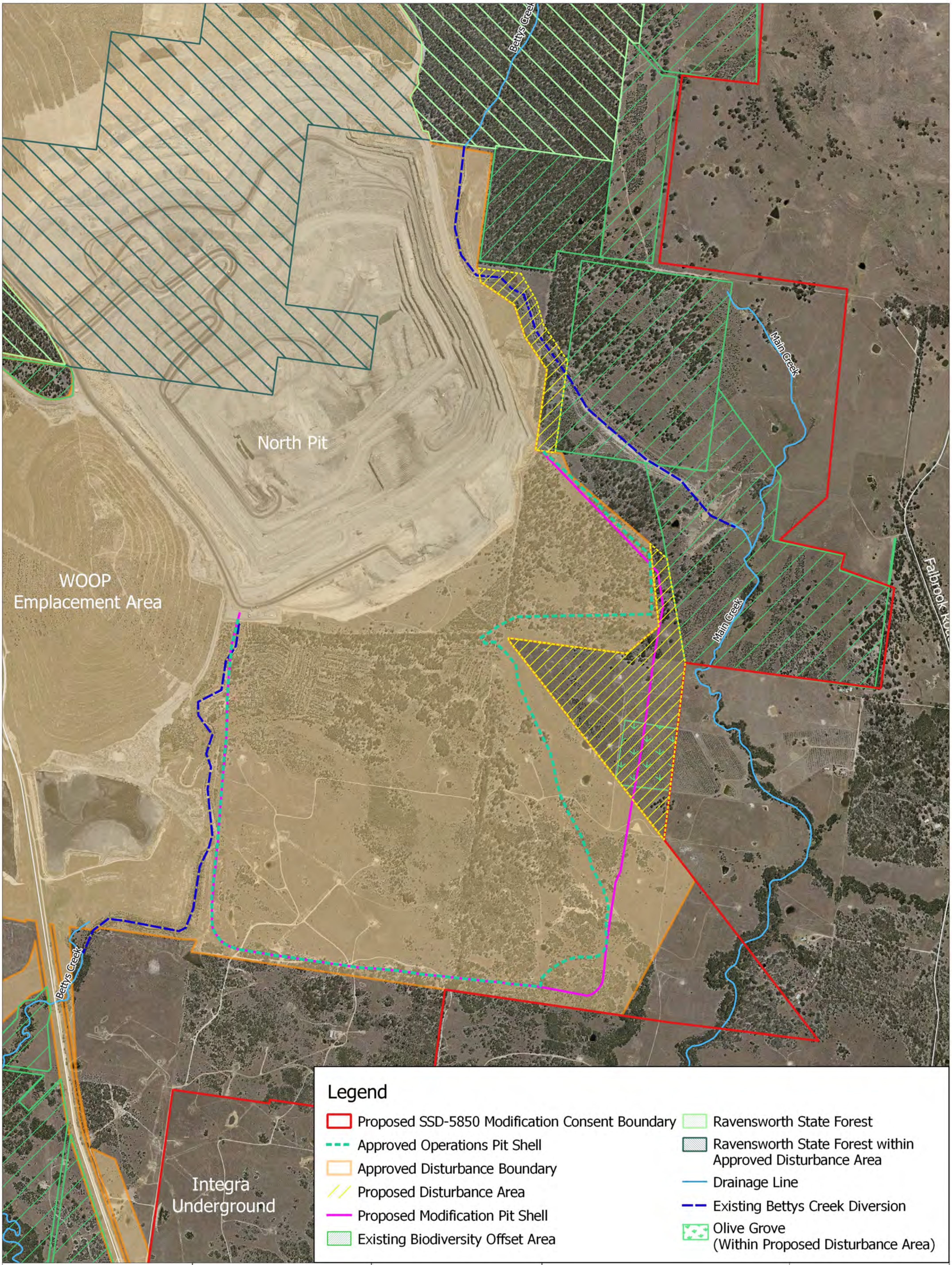

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Figure 1.1

Proposed Modification Overview

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1.2 Measures to Minimise or Avoid Potential Surface Water Impacts

Detailed environmental studies undertaken to inform the conceptual design for the Approved Operations have been updated to inform the Proposed Modification. The consideration of the outcomes of these studies in the design of the Proposed Modification, along with a range of other key factors minimise the potential for the Proposed Modification to impact on surface water resources. These factors include:

- The management of impacts within the regime established by NSW water and pollution control legislation, which provides for sustainable water take from water sources and management of water quality by licensing of discharges under the Hunter River Salinity Trading Scheme (HRSTS).
- By maintaining buffer distances to Main Creek (approximately 160 m from the top of bank to the Proposed Modification Pit Shell and ensuring the pit crest is located outside the extent of the alluvial aquifer). The Proposed Disturbance Area extends to approximately 23 m from the Main Creek top of bank (at the closest point). Works within the area extending from the highwall to the disturbance limit include earthworks associated with establishing the final landform and drainage structures.
- Integration into the existing approved water management system (WMS) at the Mount Owen Complex and the GRAWTS.
- Design of WMS components to meet legislative requirements and relevant guidelines (e.g. guidelines for treatment of runoff from disturbed areas) (as described above).
- Minimisation of disturbance / works within the floodplain of Main Creek to minimise the potential impact on flood behaviour.
- Continued maximised water recycling and sharing across the WMS and the GRAWTS to minimise the total volume of water extracted from the Hunter River and excess water discharged to the Hunter River under the HRSTS.

These factors also reduce the potential for the Proposed Modification to result in a significant impact on existing surface water resources (refer to Sections 1.3 and 5).

1.3 Potential Surface Water Impacts

Notwithstanding the measures to minimise impacts, the following aspects of the Proposed Modification have the potential to impact on surface water resources:

- Landform changes as a result of the open cut mining operations, including:
  - Open cut mining
  - Overburden emplacement areas

  - Clean water management
  - Flood protection works.

- Changes to the water balance for the Mount Owen Complex, including the import and export of water to and from the site.

- Changes to the approved flood mitigation controls on Yorks Creek.

The Proposed Disturbance Area associated with changes to the mining operations is located in the Main Creek catchment (a subcatchment of Glennies Creek). There are negligible changes associated with the proposed mining operations that have the potential to impact on surface water catchments within the Bowmans Creek system. As such the impact assessment provides only context in regards to potential impacts in Bowmans Creek and it's subcatchments and focusses on the potential impacts in Main Creek and Glennies Creek.

The following surface water aspects in Main Creek were reviewed as part of the Surface Water Impact Assessment:

- Catchment areas and flow regimes.

- Flooding, including flow rates, velocities and depths.

- Water quality.

- Geomorphological and hydrological values.

- Riparian and ecological values.

- Water users.

A detailed assessment of these potential impacts has been undertaken for the Proposed Modification (refer to Section 5) for Main Creek with consideration of downstream impacts on Glennies Creek.

In addition, the potential impacts associated with the proposed changes to the approved flood mitigation measures on Yorks Creek have also been assessed (refer to Section 5).

1.4 Structure of this Report

The Surface Water Impact Assessment Report includes the following sections:

- Surface water context, including regulatory framework, catchments and watercourses, flow regimes, water quality and water users (refer to Section 2).

- Water Management System (refer to Section 3).
- Water Balance, including operational water balance and final void water recovery analysis (refer to Section 4).
- Potential impacts, including consideration of cumulative impacts and proposed mitigation measures (refer to Section 5).
- Summary of assessment against Commonwealth Significant Impact Guidelines (refer to Section 6).
- Management, Monitoring, Licensing and Reporting (refer to Section 7).

2. SURFACE WATER CONTEXT

The Mount Owen Complex is located within the catchments of Bowmans Creek and Glennies Creek, both tributaries of the Hunter River. Both Bowmans Creek and Glennies Creek flow into the Hunter River to the south of the Mount Owen Complex. Bowmans Creek catchment is located to the north and west of the Mount Owen Complex, while Glennies Creek, a regulated watercourse, is located to the east and south (refer to Figure 2.1).

The changes to mining operations associated with the Proposed Modification are located within and adjacent to the sub catchment areas of Bettys Creek (a tributary of Bowmans Creek) and Main Creek (a tributary of Glennies Creek), as well as within the catchment area of the existing approved Mount Owen Complex WMS. The extent of the Mount Owen Complex WMS is shown on Figure 2.2.

In addition, changes to the approved Yorks Creek flood mitigation measures are proposed.

2.1 Regulatory Framework

2.1.1 Commonwealth Legislation

The aspects of the Proposed Modification required approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were referred to the Commonwealth Department of the Environment and Energy (DoEE) in October 2017 to determine whether or not the Proposed Modification was a controlled action. In December 2017, the Proposed Modification was determined not to be a controlled action and therefore the Proposed Modification does not require approval under the EPBC Act.

A summary of the potential surface water impacts against the Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resources (DoE 2013) undertaken to support the referral referenced above is included in Section 6.

2.1.2 Relevant NSW Legislation

The Approved Operations and Proposed Modification exist within a well-regulated system that has been designed to provide for the sustainable management of the State's water resources. This includes licensing of allowable water take with consideration of environmental flow requirements of watercourses and the needs of other water users; control of water pollution, including management of sustainable salt loads associated with all water sources, including mine water discharges; and guidelines that govern the appropriate design of water management systems for mines to provide for appropriate water quality in accordance with Environment Protection Licence (EPL) requirements.

Further details of the NSW surface water regulatory framework and how it will continue to be applied to the Proposed Modification is provided below.

There are two key acts that provide the regulatory framework for water management in NSW. These acts are the *Water Management Act 2000* (WM Act) and the *Water Act 1912*. The key provisions of these acts relevant to the Proposed Modification are outlined in Section 2.1.3.

At a State level, there is one other key water management regulation relevant to mining operations: *Protection of the Environment Operations Act 1997* (POEO Act). The POEO Act is the key piece of environmental protection legislation administered by the NSW Environment Protection Authority (EPA). The key components of the POEO Act relevant to surface waters are outlined in Section 2.1.6.

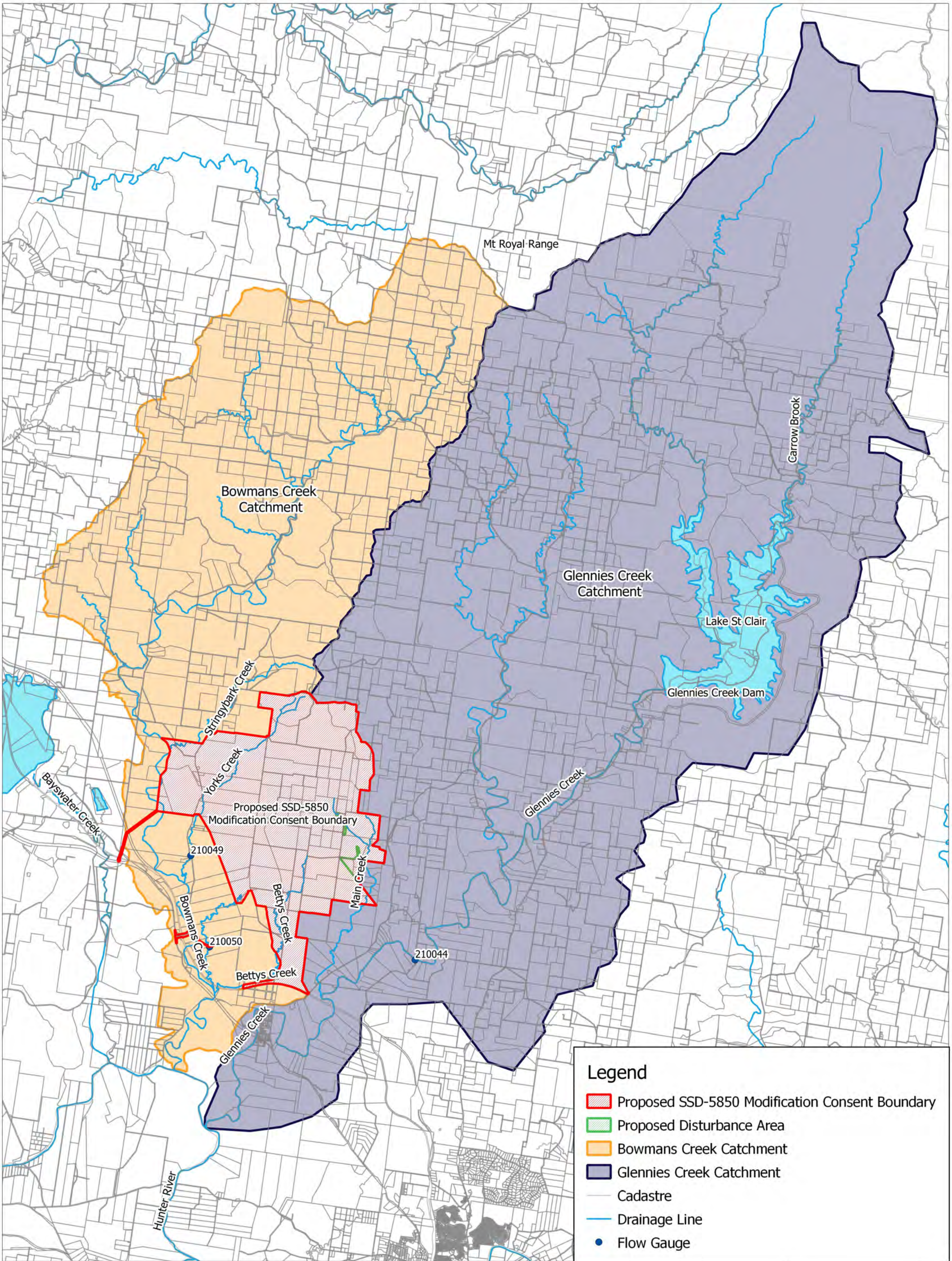

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Figure 2.1
Surface Water Context

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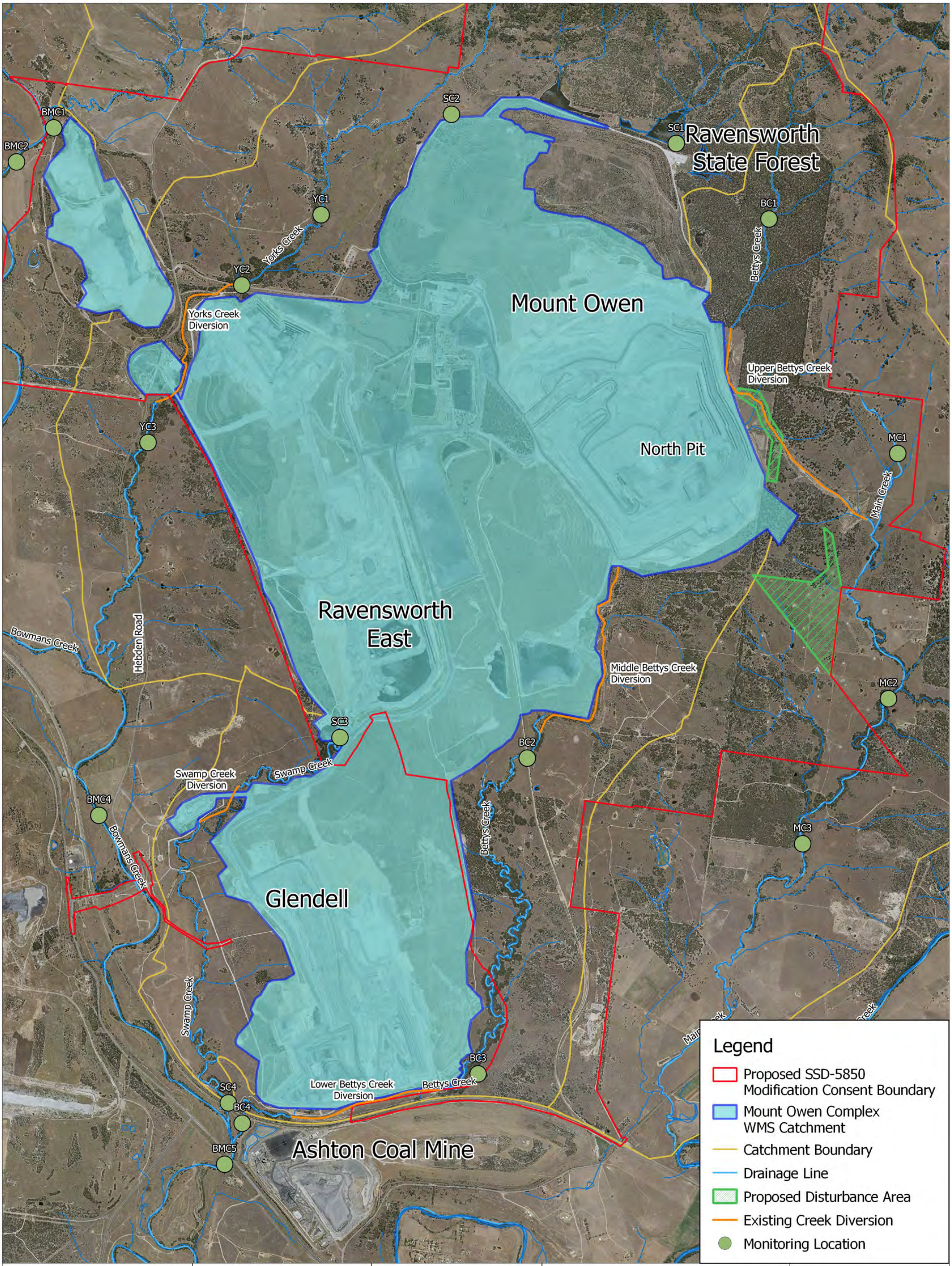

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Figure 2.2

Mount Owen Complex WMS Catchment Context

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2.1.3 NSW Regulatory Requirements - Water Use/Take

The objective of the WM Act is the sustainable and integrated management of water in NSW and is based on the concept of ecologically sustainable development. The WM Act defines water access and water sharing strategies within NSW. The WM Act supersedes the provisions of the *Water Act* 1912 in regard to water take when a Water Sharing Plan (WSP) is in place and in regard to works adjacent to or within watercourses.

As part of the WM Act, WSP's have been developed across NSW to protect the health of rivers, whilst at the same time securing sustainable access to water for all users. The WSP's specify maximum water extractions and allocations. By complying with the requirements of the WSP's, water take will be within the sustainable yield for the water system as determined by the NSW government. This in turn provides for sustainable environmental flows within the water systems.

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* (Hunter Unregulated and Alluvial Water Sources WSP) applies to watercourses and alluvial groundwater in the vicinity of Mount Owen Complex. The catchment of Bettys Creek is located within the Jerrys Water Source and the catchment of Main Creek is located within the Glennies Water Source.

Extractions from Glennies Creekare managed under the *Hunter Regulated River Water Sharing Plan 2004* (Hunter Regulated River WSP).

As such water use from surface and alluvial waters in and adjacent to the Approved Operations are governed by the WM Act.

The *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* (North Coast Fractured and Porous Rock Groundwater Sources WSP) commenced on 1 July 2016. The coal measure aquifers for the Approved Operations and Proposed Modification are covered by this WSP (refer to Groundwater Impact Assessment (AGE, 2018)).

2.1.4 Licensing

All water extraction in NSW, apart from some exemptions for government authorities and basic landholder rights extractions, must be authorised by a water licence. Harvestable rights, which are a Basic Landholder Right under the WM Act, allow a landholder to capture and use up to 10 per cent of the average regional runoff from a landholding. Basic landholder rights are exempt from licensing requirements.

Each water licence, referred to under the WSP system as a Water Access Licence (WAL), specifies a share component. The share components of specific purpose licences such as local water utility, major utility and domestic and stock are expressed as a number in megalitres per year. The share components of high security, general security and supplementary WAL's are expressed as a number of unit shares for the water source. The value of each unit share is subject to Available Water Determinations (AWD's) as specified by Crown Land and Water Division (CLWD) (formerly known as DPI Water).

In accordance with Condition 21 of the current development consent (SSD-5850) for Approved Operations, Mount Owen must *'ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of operations on site to match its available water supply.'* Further the development consent notes that Mount Owen is required to obtain all necessary water licences for the development, and to consult with CLWD regarding licencing required for the final landform.

Details of the licences currently held by Mount Owen are included in Section 3 and licences required for the Proposed Modification are discussed in Section 7.2.2.

2.1.5 Works Adjacent to or Within Watercourses

Controlled Activity Approvals (CAA) are required under the WM Act to carry out controlled activities in, on or under waterfront land. State Significant Development (SSD) projects approved under Part 4 of the EP&A Act (including this Proposed Modification) do not require controlled activity approvals as the requirements for works are assessed in detail as part of the assessment process and any specific further requirements can be addressed in the consent conditions.

2.1.6 Environment Protection Licences

Activities that may lead to pollution of waters in NSW are regulated by the EPA under the POEO Act. Where discharge of waters is permitted it is controlled by licence conditions such that discharges do not result in significant impacts on water resources.

Under Section 120 of the POEO Act, it is an offence to pollute waters or cause harm unless licensed to do so. Pollution in NSW is regulated by the POEO Act with discharges from mine water management systems requiring licensing by an EPL if the discharge would otherwise constitute a pollution of waters (Section 120 of the POEO Act).

The Mount Owen Complex does not have a licensed discharge point and is not permitted to discharge water under its EPL (EPL 4460). The export of surplus water at the Mount Owen Complex is possible via transfers to other mines in the GRAWTS. Mount Owen currently shares water within the GRAWTS and utilises discharges under the HRSTS for the Approved Operations either via the Ravensworth Operations or the Liddell mines.

Discharges from Ravensworth Operations and Liddell mines are licensed under their respective EPLs, as well as operating in accordance with the HRSTS. The HRSTS is a cap-and-trade system designed to facilitate saline discharges into the Hunter River, without compromising sustainable water quality. The HRSTS is administered under the

Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002.

The WMS at the Mount Owen Complex (Mount Owen, Ravensworth East and Glendell Mines) is an integrated system. In addition, the Mount Owen Complex is an integral part of the GRAWTS with the Ravensworth Operations, Integra Underground and Liddell mining operations. The GRAWTS allows greater flexibility in the mine water management by the Mount Owen Complex.

A summary of water export requirements for the Mount Owen Complex for the Approved Operations and for the Proposed Modification is included in Section 4.

2.2 Catchment Areas and Watercourses

As discussed earlier, the Mount Owen Complex is located within the catchments of Bowmans Creek and Glennies Creek. The existing approved Mount Owen Complex WMS is located within the catchment areas of Yorks Creek, Swamp Creek and Bettys Creek (all sub catchments of Bowmans Creek) and Main Creek (a sub catchment of Glennies Creek). The extent of the Mount Owen Complex WMS is shown on Figure 2.2.

Land uses within and immediately surrounding the Mount Owen Complex include other mining operations, State Forest, biodiversity offset areas and rural residential land holdings. Downstream water users are discussed further in Section 2.4.

Previous mining operations have modified local catchments through the capture of runoff from mining areas within the WMS and diversion of upslope runoff around the mining operations. For each catchment area intersected by the Approved Operations, the stream order, pre-mining catchment area and current approved final landform catchment area are included in Table 2.1. No new catchment areas will be intersected by the Proposed Modification.

The Proposed Disturbance Area is in the catchment area of Glennies Creek within the sub catchment area of Main Creek.

Table 2.1 Catchment Areas

Watercourse	Schedule (order)[1]	Catchment Areas	
		Pre-mining[2] (ha)	Approved Operations Final Landform[3,4] (ha)
Bowmans Creek	3 (6th order)	25,055	20,510
Yorks Creek	2 (3rd order)	1,230	1,910
Swamp Creek	2 (4th order)	2,380	1,160

Watercourse	Schedule (order)[1]	Catchment Areas	
		Pre-mining[2] (ha)	Approved Operations Final Landform[3,4] (ha)
Bettys Creek	2 (4th order)	1,810	850
Glennies Creek[5]	3 (6th order)	51,580	52,110
Main Creek	2 (4th order)	2,000	2,530

Notes 1) Strahler watercourse ordering classification.
2) Based on 1:25,000 LPI topographical map series.
3) Does not include WMS catchment areas that are internally draining.
(including other mine operations), interpolated from 1:25,000 LPI topographical map series, 2012 LiDAR survey and aerial photographs.
4) Including existing approved creek diversions.
5) Glennies Creek catchment area based on CLWD information.

2.2.1 Bowmans Creek

The headwaters of Bowmans Creek are in the Mt Royal Range and the upper catchment is deeply incised in steep bedrock terrain. The lower reaches of Bowmans Creek meander through a broad alluvial floodplain and terrace sequence that is up to 1 km wide. Bowmans Creek has a catchment area of approximately 25,000 ha.

Bowmans Creek has four major tributaries in the vicinity of the Mount Owen Complex, namely Stringybark Creek, Yorks Creek, Swamp Creek, and Bettys Creek (refer to Figure 2.1). Before mining was undertaken in this catchment, the land use within the Bowmans Creek catchment was typically farming and grazing. Although previously disturbed by agriculture and mining activities, Bowmans Creek has sufficient contributing catchment to maintain flows under most climate conditions and has a well-established channel.

The Approved Operations components located within the Bowmans Creek catchment include the construction of a rail overpass for road traffic adjacent to the existing level crossing where Hebden Road crosses the Main Northern Rail Line. Additionally, a new bridge is being constructed over Bowmans Creek on Hebden Road to allow for two-way traffic movements.

The only works proposed in the Bowmans Creek catchment associated with the Proposed Modification are changes to the approved flood mitigation measures on Yorks Creek, this is discussed further in Section 5.3.1.

The Proposed Modification will have no impact on Stringybark Creek or Swamp Creek or their catchment areas.

Yorks Creek

Yorks Creek is a third order tributary of Bowmans Creek and is an ephemeral creek system (refer to Figure 2.1). Yorks Creek typically has a defined channel several metres in width and approximately 1 to 1.2 m in depth, with a relatively wide floodplain. The creek varies from highly vegetated and sinuous, to some sections that are hydraulically steep with limited vegetation.

Before mining was undertaken in the Yorks Creek catchment, the land use within the catchment was typically farming and grazing. The existing Yorks Creek catchment includes the approved diversion of the upper catchment of Swamp Creek (approximately 500 ha) to Yorks Creek. Approximately 120 ha of the catchment is incorporated into the WMS for the Mount Owen Complex.

To minimise the potential impacts of the additional catchment area flowing to Yorks Creek from the North Pit emplacement area, additional off-line detention capacity adjacent to the Ravensworth East MIA and flow conveyance upgrades at Hebden Road were approved as part of SSD-5850. It is proposed to change the approved flood mitigation measures discussed above as part of this Proposed Modification (refer to Section 5.3.1).

Bettys Creek

Bettys Creek is a tributary of Bowmans Creek. Bettys Creek is an ephemeral creek system with flows only occurring during storm events or after prolonged periods of heavy rain. Generally, the creek system is dry in between rainfall events, however, some pools of standing water tend to be present in the downstream reaches. These pools typically exhibit high salinity as a result of evapo-concentration.

The catchment of Bettys Creek is highly modified, and a large proportion of Bettys Creek catchment is currently incorporated into the Mount Owen Complex WMS. Approximately 490 ha of the upper catchment of Bettys Creek has been diverted to the east of the Mount Owen Mine into Main Creek (refer to Figure 2.2). The middle reaches of Bettys Creek have also been diverted to the east around the Western Out of Pit (WOOP) emplacement area.

2.2.2 Glennies Creek

Glennies Creek flows from headwaters in the Mt Royal Range to the Hunter River. Glennies Creek has a catchment area of approximately 51,580 ha and has sufficient contributing catchment to maintain flows under most climatic conditions.

Glennies Creek Dam is located approximately 17 km upstream of the confluence of Main Creek with Glennies Creek (refer to Figure 2.1). Approximately 23,300 ha (i.e. 45 per cent of the catchment) is located upstream of Glennies Creek Dam.

The construction of Glennies Creek Dam was completed in 1983 and forms part of the Hunter Regulated River System. The Hunter Regulated River System is managed by the Hunter Regulated River WSP regulated under the WM Act. Water from Glennies Creek Dam is managed to meet downstream requirements for environmental, irrigation, stock and domestic, town water and water conservation usages. As such the flow regimes in Glennies Creek downstream of Glennies Creek Dam are highly modified.

Mount Owen currently holds WALs to extract water from Glennies Creek as a raw water supply to the Mount Owen Complex (refer to Section 3.1.1).

The Proposed Modification includes an increase in the disturbance area, mining operations and associated water management infrastructure in the Main Creek catchment, a subcatchment of Glennies Creek.

Main Creek

Main Creek is a fourth order tributary of Glennies Creek and is an ephemeral creek system. Main Creek flows in a southerly direction and joins Glennies Creek downstream of Glennies Creek Dam and approximately 6.5 km upstream of the Glennies Creek confluence with the Hunter River (refer to Figure 2.1). The majority of the catchment is open grasslands, and the riparian zone is mostly well vegetated along the mid portion with a well-defined creek line. The lower portion of the catchment is used for grazing and with sections of the creek line poorly defined (refer to Figure 2.3 to Figure 2.7).

The upper catchment of Bettys Creek, upslope of the Mount Owen Mine has been diverted via the Upper Bettys Creek Diversion into the Main Creek catchment through a channel and dam system (refer to Figure 2.2) increasing the Main Creek catchment area by approximately 490 ha. Approval was given for the Upper Bettys Creek Diversion as part of the 2004 Mount Owen Project development consent. In the currently approved final landform, approximately 130 ha of the upper Swamp Creek catchment is also diverted to Main Creek via the Upper Bettys Creek Diversion.

Figure 2.3 Upper Bettys Creek Diversion – Looking Downstream towards Main Creek

Figure 2.4 Upper Bettys Creek Diversion – Looking Downstream towards Main Creek (Detention Basin in view)

Figure 2.5 Main Creek – Looking Downstream (adjacent to Proposed Disturbance Area)

Figure 2.6 Main Creek – Looking Downstream (south of Proposed Disturbance Area)

Figure 2.7 Main Creek – Looking Downstream (downstream of Glennies Creek Road)

2.3 Water Quality

2.3.1 Monitoring Program

Mount Owen monitor surface water quality in accordance with the Mount Owen Complex Surface Water Management and Monitoring Plan (approved October 2017). This plan includes monitoring of the following elements of the WMS and surrounding creeks:

- Surface water flows (by way of visual observation) and quality in upstream and downstream watercourses;
- Channel stability in upstream and downstream watercourses;
- Condition of creek diversion channels;
- Stream health conditions in upstream and downstream watercourses; and
- On-site water management.

The surface water monitoring program covers all three water category areas within the Mount Owen Complex: clean; dirty; and mine water systems. The clean water system consists of runoff from undisturbed or rehabilitated areas. The dirty water system consists of runoff from disturbed areas (excluding mine water). The mine water system consists of runoff from areas exposed to coal or water used in coal processing or from coal stockpile areas (refer to Section 3).

The Surface Water Management and Monitoring Plan requires monthly monitoring at all monitoring locations within the clean water system for the following parameters:

- Flow (by way of visual observation as streams are ephemeral);
- pH;
- Electrical conductivity (EC);
- Total suspended solids (TSS); and
- Total dissolved solids (TDS).

Mount Owen also monitors a number of organic and metal/metalloid parameters in the dirty and mine water systems.

The low risk of metal/metalloid contamination has such as to not require specific monitoring of these substances as part of the routine monitoring program. The use of the primary monitoring parameters (pH, EC, TSS and TDS), with additional testing of analytes only required in the event of anomalous pH results (i.e. low pH), has been supported by the results from the recent monitoring programs, geochemical studies and potential low risk of overflows.

2.3.2 Trigger Values

The NSW Water Quality and River Flow Objectives (as published by the Office of Environment and Heritage (OEH)) are the agreed environmental values and long-term goals for NSW surface waters. The objectives are consistent with the agreed national framework for assessing water quality as set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Guidelines (2000) (ANZECC guidelines).

The ANZECC guidelines provide default trigger values and methods to determine site specific trigger values. The ANZECC guidelines indicate the preferred use of site specific trigger values. Trigger values can be used to characterise the water quality and estimate the ecological integrity of a water resource.

Using historical data sets and methods outlined in the ANZECC guidelines, site specific water quality triggers have been developed for pH, EC, TSS and TDS and are included in the approved Mount Owen Complex Surface Water Management and Monitoring Plan. The adopted trigger values which are consistent with the Continued Operations Project Surface Water Impact Assessment (Umwelt 2016c) are shown in Table 2.2.The relevant

ANZECC guidelines default trigger values have also been included in Table 2.2 for comparison. These trigger levels have previously been approved by NSW Government Agencies as part of consultation associated with the Surface Water Management and Monitoring Plan. The trigger levels are still considered relevant for the Proposed Modification as there will be no material changes to the water management system. The trigger levels are periodically reviewed, in consultation with relevant agencies, as additional monitoring information becomes available.

Table 2.2 Water Quality Parameters and Trigger Levels

Water Quality Variable	ANZECC Default Trigger Value	Bowmans Creek	Ephemeral Creek Systems	
			Flow Conditions	No Flow Conditions
pH	6.5 – 8.0	6.5 – 8.0[1]	6.5[1] – 8.32	6.5[1] – 8.6
EC (µS/cm)	2,200	2,200[1]	2,200[1]	6,668
TSS (mg/L)	50	21	50[1]	68
TDS (mg/L)	4,000 – 5,000[2]	890	1,006	4,384

Notes 1) *Use ANZECC guidelines criteria for ecosystem protection.*
2) *ANZECC guidelines - recommended concentration of TDS in drinking water for beef cattle as no default trigger value is provided by the ANZECC guidelines for ecosystem protection.*

2.3.3 Geochemical Influences

A geochemical assessment was undertaken by Environmental Geochemistry International Pty Ltd (EGI) for the Continued Operations Project (EGI, 2013). This assessment was expanded to support the Proposed Modification (EGI, 2018). The assessments provided an indication of the inherent acidity and salinity of waste material when initially exposed in waste emplacement areas. The assessments also considered the likely elements to be present in surface water/seepage generated within the mining areas. Within the approved North Pit, coal is currently extracted from the Ravensworth seams down to the Hebden seams, to a depth of approximately 300 m below the current ground surface (at the deepest point). The Proposed Modification proposes additional mining of the same stratigraphic sequence down to the floor of the Hebden seam, approximately 380 m below the current ground surface at the deepest point. Consistent with the Approved Operations, the vast majority of overburden/interburden, coal and washery wastes for the Proposed Modification are expected to be non-acid forming (NAF) with excess acid neutralising capacity (ANC) and are not expected to require special handling. Dilution and mixing during mining is expected to be sufficient to mitigate acid rock drainage (ARD) from any occasional thin zones of pyrite that may be present in pit walls and pit backfill to prevent any significant impacts on downstream water quality.

The key observations and results relevant to surface water quality are summarised below:

- pH ranged from 4.2 to 9.6, with 96% of samples showing no inherent acidity with a pH >6.
- EC ranged from 90 to 2,100 µS/cm, with 96% of samples classified as non-saline with an EC of <800 µS/cm.
- Elements that are typically considered to be of environmental concern, including aluminium, arsenic, manganese and molybdenum, although being detected in the majority of samples, had median concentrations that were generally low.
- Significant metal/metalloid release would likely only be associated with generation of Acid Rock Drainage (ARD). The solubility of metals/metalloids will largely be determined by pH and therefore control of acid generation will effectively control metal leaching. Initial metal/metalloid released associated with ARD generated from pyritic materials would include cobalt, iron, manganese, nickel and zinc.
- The majority of weathered Permian materials are expected to be non-acid forming (NAF) with excess acid neutralisation capacity (ANC) and are not expected to require special handling. The process of mixing and dilution through mining is expected to be sufficient to mitigate ARD from any occasional thin zones of pyrite that may be present.
- The overburden materials are typically NAF and are likely to be a source of alkalinity in leachate and unlikely to release significant concentrations of metals/metalloids. Alkaline leachate will also provide an additional factor of safety in management of any ARD.
- Weathered Permian materials are likely to be sodic and dispersive, which may be subject to surface crusting and high erosion rates. Treatment of materials with gypsum or lime if being used as a plant growing horizon, exposed on dump surfaces or used in engineering structures may be required.

2.3.4 Historical Surface Water Quality Monitoring Results

Water quality monitoring data for pH, EC, TSS and TDS are reported in the Mount Owen Complex Annual Environmental Management Reports (AEMRs). Integra Underground Mine also monitors water quality in Glennies Creek. Data presented in the AEMRs indicates that mining activities had negligible impact on the water quality in downstream creek systems, including Bowmans Creek, Yorks Creek, Swamp Creek, Bettys Creek, Glennies Creek or Main Creek.

Monitoring results for pH, EC, TDS and TSS are presented graphically in Appendix A. The results are presented for the clean water system, the dirty water system and the mine water system. For the mine water system, the statistical analysis of metals, nutrients and organics has also considered water that was sampled in mine water storages and transfer points (mine), North Pit (mine pit) and West Pit (tailings).

The monitoring results indicate the following for the routine parameters of pH, EC, TDS and TSS (note: the typical ranges presented below correspond to 20^{th} percentile and 80^{th} percentile values):

- pH typically ranges between 7.2 to 7.9 in the clean water systems, 8.0 to 8.9 in the dirty water system and 8.3 to 9.2 in the mine water systems. As such waters are typically neutral to alkaline in the various systems. The lowest recorded reading of pH has occurred in the mine water system (pH of 3.36) with one isolated reading occurring in 2014 in the Pollution Control Dam at Glendell Mine. Refer to Figure A in Appendix A.

- pH within the clean water systems typically lie within the site specific trigger values of 6.5 to 8.32 for flow conditions. Two readings from MC2 (Main Creek mid-stream) fall between the high trigger for flow of 8.32 and no flow of 8.65. These two readings were recorded in consecutive months in 2012 with flow recorded as being at the lower limit of reading at the time of sampling. There are three readings from BC3 (Betty Creek prior to Ashton) that fall between the high trigger for flow of 8.32 and no flow of 8.65. These readings were also recorded in late 2012 / early 2013 with low flows in the creek at the time of sampling. Refer to Figure E in Appendix A.

- There are no visible temporal trends in the data available for pH for the clean, dirty or mine water management systems. Refer to Figures E and F in Appendix A.

- EC typically ranges between 350 to 1,680 µS/cm in the clean water systems, 600 to 4,170 µS/cm in the dirty water system and 790 to 5,900 µS/cm in the mine water systems. As such waters are typically more saline in the dirty and mine water management systems. Refer to Figure B in Appendix A.

- EC is typically lower than the site specific trigger value of 2,200 µS/cm in the clean water system during flow conditions. Refer to Figure H in Appendix A.

- TDS records typically range between 400 to 1,090 mg/L in the clean water systems, 500 to 2,680 mg/L in the dirty water system and 440 to 7,220 mg/L in the mine water system. TDS recorded in the clean water systems is typically lower than within the dirty water and mine water systems. The clean water systems are typically within the TDS range for the site specific trigger. Refer to Figures C, K, L and M in Appendix A.

- TSS records typically range between 5 to 70 mg/L in the clean water systems, 5 to 50 mg/L in the dirty water system and 5 to 60 mg/L in the mine water system. TSS is typically below the site specific trigger of 50 mg/L for flow conditions in ephemeral creeks in all systems. Refer to Figure D, N, O and P in Appendix A.

A recent campaign of surface water quality monitoring has been undertaken to gather more data in regard to nutrients and metals/metalloids. The samples were gathered at monitoring points in the clean water systems, specific sediment dams in the dirty water system and within the North Pit (mine pit) and West Pit (tailings)in the mine water system. Graphs of the analysis are presented in Figures Q to AE in Appendix A and the key outcomes presented below.

In regard to nutrients the monitoring results have found:

- The total of Nitrates and Nitrites as N typically ranged between 0.02 to 0.04 mg/L in the clean water systems, 0.02 to 9.23 mg/L in the dirty water system, 10.69 to 12.21 mg/L in the mine pit and 7.06 to 10.76 mg/L in the tailings (refer to Figure Q in Appendix A). Typically, water in both the dirty and mine water systems are considerably higher in Nitrates and Nitrites as N than the clean water systems. In the higher total readings, the majority of the total N is present as Nitrate as N.

- Total phosphate as P is typically low in all of the monitored systems, with 0.01 to 0.02 mg/L in clean water systems, 0.01 to 0.03 mg/L in the dirty water system and 0.01 to 0.04 mg/L in the mine water system (refer to Figure R in Appendix A).

In regard to monitoring of metals/metalloids the following can be found (refer to Table 2.3):

- Aluminium values are typically higher in the clean water system than the ANZECC 95% ecosystem protection level. With Aluminium typically elevated in all systems monitored (refer to Figure S in Appendix A).

- Arsenic is slightly higher in the mine water storages, mine pit and tailings compared to the clean and dirty water systems. This is likely due to presence of arsenic in the coal seams/groundwater (refer to Figure T in Appendix A).

- Barium is slightly higher in the mine pit and tailings water quality samples compared to the mine water storage samples which are comparable to the dirty water system and clean water systems (refer to Figure U in Appendix A).

- Cadmium water quality samples are at the limit of detection for the clean, dirty and mine storages as well as the mine pit samples (0.0001 µg/L). Slightly higher (trace) cadmium concentrations were sampled in the tailings (refer to Figure V in Appendix A).

- Copper is within ANZECC 95% ecosystem protection values for the clean water system (refer to Figure W in Appendix A).

- Cobalt has low concentrations recorded in the clean and dirty water systems (close to the limit of detection) will higher concentrations of Cobalt measured in the mine storages, mine pit and tailings (refer to Figure X in Appendix A).

- Iron levels vary across the different water systems with higher iron concentrations typically in the clean water systems compared to the dirty and mine water systems (Figure Y in Appendix A).
- Minimal to no Lead or Mercury were recorded in any of the water quality samples (refer to Figure Z and Figure AB in Appendix A).
- Manganese levels are typically higher in the clean water systems than the dirty or mine water systems (refer to Figure AA in Appendix A).
- Nickel is present typically in higher concentrations in the mine pit and tailings systems compared to the dirty water and clean water systems (refer to Figure AC in Appendix A).
- Only traces, typically at the limit of reporting, of Selenium have been recorded in the clean, dirty, mine storages and mine pit. Slightly higher Selenium levels have been recorded in the mine tailings (refer to Figure AD in Appendix A).
- Higher concentrations of Zinc were recorded in the mine pit compared to the dirty water and clean water systems (refer to Figure AE in Appendix A).

Table 2.3 Summary of Statistical Analysis - Metals

Analyte	Median Concentration (mg/L)				
	Clean	Dirty	Mine	Mine Pit	Tailings
Aluminium (Al)	0.150	0.135	0.315	0.135	0.345
Arsenic (As)	0.001	0.002	0.007	0.008	0.020
Barium (Ba)	0.049	0.057	0.060	0.134	0.100
Cadmium (Cd)	0.000	0.000	0.000	0.000	0.000
Cobalt (Co)	0.001	0.001	0.002	0.001	0.004
Copper (Cu)	0.001	0.002	0.002	0.002	0.004
Iron (Fe)	0.320	0.165	0.215	0.275	0.295
Lead (Pb)	0.001	0.001	0.001	0.001	0.001
Manganese (Mn)	0.020	0.009	0.011	0.007	0.016
Mercury (Hg)	0.000	0.000	0.000	0.000	0.000

Analyte	Median Concentration (mg/L)				
	Clean	Dirty	Mine	Mine Pit	Tailings
Nickel (Ni)	0.001	0.002	-	0.005	0.012
Selenium (Se)	0.010	0.010	0.010	0.010	0.020
Zinc (Zn)	0.005	0.005	0.006	0.295	0.005

Note: No data for Nickel in the mine water storages.

2.4 Water Users

The majority of land adjacent to the Approved Operations is owned by Glencore subsidiaries. There is one private landholder with access to Main Creek located downstream of the Approved Operations. However, there are no known licensed water users on Main Creek downstream of the Approved Operations.

Water is extracted from Glennies Creek downstream of the Approved Operations by Ashton Coal Operations Limited (Ashton). Ashton also hold irrigation licences for Bowmans Creek and domestic and stock licences. Water is also extracted from Glennies Creek by Integra Underground Mine by use of a licence agreement with Mount Owen. Potential impacts on downstream water users from the Proposed Modification are discussed in Section 5.7.

3. WATER MANAGEMENT SYSTEM

The Mount Owen Complex has an extensive existing WMS, which includes mine dewatering systems, water storages, sedimentation and retention basins, settling and tailings ponds, diversion drains, levee banks and earth bunding around the main stockpile, laydown hardstand areas and fuelling areas.

The WMS at the Mount Owen Complex is an integrated system, that is, the water from the Mount Owen, Ravensworth East and Glendell mines are managed together within that integrated WMS. In addition, the Mount Owen Complex is an integral part of the GRAWTS with the Ravensworth Operations, Integra Underground and Liddell mining operations. The GRAWTS allows greater flexibility in the management of water by Mount Owen and other participating operations.

The use and management of water within the Glendell Mine does not form part of the Approved Operations and will continue to be managed pursuant to the existing Glendell development consent. Notwithstanding, the WMS proposed for the Proposed Modification allows for the continued integration across the Mount Owen Complex.

3.1 Approved WMS

The approved Mount Owen Complex WMS has the following key objectives and functions:

- Diversion of clean water around mining operations to minimise capture of upslope runoff and separate clean water runoff from mining activities.
- Segregating mine impacted water and runoff from undisturbed and revegetated areas with better water quality to minimise the volume of mine impacted water that requires reuse.
- Reuse of mine impacted water within the WMS and within the GRAWTS to reduce reliance on raw/clean water (e.g. extraction from Glennies Creek and the Hunter River).
- Minimising adverse effects on downstream waterways (i.e. hydraulic and water quality impacts).
- Reducing the discharge of contaminants from the mine to the environment.

Water management at the Mount Owen Complex considers three categories of water, each with different potential to cause environmental harm. The target design criteria for each of the three categories of water are summarised in Table 3.1.

Table 3.1 WMS – Design Criteria

Water Category	Water Description	Target Design Criteria
Clean	Runoff from undisturbed or rehabilitated areas.	Release, where practicable, to downstream environment.
Dirty	Runoff from disturbed areas (does not include water captured in mining pit areas or runoff from mine infrastructure areas).	Managed in line with the Blue Book (Managing Urban Stormwater: Soils and Construction Volumes 1 and 2E). Designed to manage runoff from the 5 day, 95th percentile rainfall event.
Mine	Runoff from areas exposed to coal or water used in coal processing or from coal stockpile areas.	Contained for events up to and including the 1% annual exceedance probability (AEP) 24-hour storm event.

One of the key objectives of the WMS is to convey clean water around the mining operations or, when runoff water from rehabilitated areas becomes clean, enable the runoff from these rehabilitated areas to flow directly to the downstream environment instead of being managed as part of the WMS.

Dirty water (i.e. runoff from disturbed areas outside the mining pit and infrastructure areas, such as overburden emplacement areas (both active and under rehabilitation) captured in the sediment dams) is pumped to storages within the WMS.

Mine water (i.e. runoff from areas exposed to coal or water used in coal processing or from coal stockpile areas) is managed as part of the mine WMS.

The Mount Owen EPL does not authorise any discharges of water to the environment and does not allow for discharge of mine water under the HRSTS. There are no licensed discharge points from the Mount Owen Complex to any creek systems. In addition, no discharges have occurred from the Mount Owen Complex WMS over the last 12 years under the HRSTS. Discharges from the GRAWTS occur from Narama Dam at Ravensworth Operations.

Water within the WMS is reused on site with surplus water transferred from the Mount Owen Complex to storages within the GRAWTS in accordance with existing approvals.

Conceptual WMS Layouts for Year 5 and Year 10 for the Approved Operations (Umwelt, 2016) are included in Appendix B.

3.1.1 Water Licences

The current surface water licences held by Mount Owen are listed in Table 3.2.

Mount Owen currently has licences to extract up to 1,056 ML/yr of High Security, 858 ML/yr of General Security, 31.2 ML/yr of Supplementary and 11 ML/yr of Domestic and Stock water from Glennies Creek under the Hunter Regulated River WSP (total based on 100% available water determinations). In addition, Mount Owen has licences to take up to 200 ML/yr of water (total based on 100% available water determinations) from the Jerrys water source and up to 17 ML/yr of water (based on 100% of available water determinations) from the Glennies water source under the Hunter Unregulated and Alluvial Water Sources WSP.

Table 3.2 Current Surface Water Licences

Licence Number	Type	Units
WAL704	High Security	3
WAL1118	High Security	3
WAL7814	High Security	1000
WAL9521	High Security	50
	Total High Security	1056
WAL612	General Security	147
WAL613	General Security	192
WAL637	General Security	384
WAL705	General Security	27
WAL1119	General Security	60
WAL1215	General Security	48
	Total General Security	858
WAL1364	Supplementary	2.2
WAL1420	Supplementary	29
	Total Supplementary	31.2
WAL706	Domestic and Stock	8
WAL1218	Domestic and Stock	3
WAL7823	Domestic and Stock	9
	Total Domestic and Stock	11
WAL18310	Unregulated River Licence – Jerrys water source	200
WAL18000	Unregulated River Licence – Glennies water source	17

3.2 Changes with the Proposed Modification

It is proposed to continue to utilise the existing WMS for the Proposed Modification. That is, the WMS for the Proposed Disturbance Area will extend and integrate into the existing approved WMS and will continue to be part of the GRAWTS. In addition, excess water that cannot be reused at the mining operations within the GRAWTS will continue to be discharged at Ravensworth Operations in accordance with regulatory arrangements.

The WMS components (major dams and drains only) in the Proposed Disturbance Area for Years 2, 8 and 15 are presented in Figure 3.1 to Figure 3.3. The conceptual drainage system for the proposed conceptual final landform is shown on Figure 3.4.

It is important to note that the plans presented in Figure 3.1 to Figure 3.3 are concept designs. While the concept designs establish the design objectives and performance standards the detailed designs will be determined by construction and mining schedules. The WMS will be constructed and modified as and when required so as to support the infrastructure and mine development. Further, the plans indicate only the components of the WMS which are required for a particular stage of the mine and does not preclude the construction of some components earlier.

Similarly, the conceptual storage capacities recommended for the various water management dams have been sized for the purposes of meeting environmental compliance requirements. The actual dam configuration and geometry for both the dirty water dams and dryland attenuation basins (detention basins) will be determined during future detailed engineering design stages.

The existing WMS will continue to be used to manage runoff with all pit water and mine surface runoff directed to the WMS. The existing approved clean water diversions will continue to divert runoff from the upper catchments of Swamp Creek, Yorks Creek and Bettys Creek around the WMS. There are no new diversions proposed or required as part of the Proposed Modification.

During the operational mine life there are no proposed changes to WALs or licensing (EPL) of the Mount Owen Complex with the Proposed Modification. The SWIA has demonstrated that the existing approved WMS with the proposed additional water management system components (including sediment dams, pumps and pipelines) will enable water at the Mount Owen Complex to be managed in accordance with the current EPL and WALs.

3.2.1 Year 2

The proposed conceptual WMS for Year 2 is shown on Figure 3.1. During Year 2 the North Pit will continue to progress south, with overburden material being placed within the North Pit and WOOP emplacement areas. Runoff from the active mining and overburden emplacement areas will be managed within the pit and sediment dams located at the overburden emplacements areas.

A clean water drain will be constructed upslope of the proposed haul road to the WOOP emplacement area with runoff draining to the existing Middle Bettys Creek Diversion.

Three dirty water dams (M2, M3 and M4) and associated drains will be constructed to the south of the North Pit to manage dirty water runoff associated with pre-strip operations as the disturbance area moves south. Similarly, a dirty water dam (M1) and drainage system will manage runoff from the haul road to the WOOP emplacement area. The shaping of the emplacement area at Year 2 will start to include a dryland attenuation basin (D1) which will provide flow attenuation for the final landform (refer to Section 3.2.4).

3.2.2 Year 8

The proposed conceptual WMS for Year 8 is shown on Figure 3.2. North Pit will continue to progress south and east reaching the proposed eastern limit. The WOOP emplacement area has been rehabilitated with overburden material being placed within the North Pit emplacement area progressing south. Shaping of emplacement areas and progressive rehabilitation within the North Pit will continue. Three additional dirty water dams (M5, M6 and M7) and associated drains will to be constructed to manage potentially dirty runoff from overburden emplacement areas and pre-stripping operations. The shaping of the emplacement area at Year 8 will include an additional dryland attenuation basin (D2) which will provide flow attenuation for the final landform (refer to Section 3.2.4). Initially D2 will act as a dedicated dirty water dam (M7).

3.2.3 Year 15

The proposed conceptual WMS for Year 15 is shown on Figure 3.3. North Pit will continue to progress south and east reaching the proposed southern limit. Overburden material will continue to be placed within the North Pit emplacement area progressing south. Shaping of emplacement areas and progressive rehabilitation within the North Pit continues when the final landform is achieved. An additional dirty water dam (M8) and any required associated drainage systems will to be constructed ahead of the pre-stripping operations to manage any potentially dirty runoff from the disturbed areas. Detention basin D3 will also start to be formed into the final landform contours at year 15 which will provide flow attenuation (refer to Section 3.2.4). This continued southern progression of mining and the ongoing construction of dirty water dams will continue through to the completion of proposed mining operations.

3.2.4 Final Landform

When the final landform is achieved, all operations will be complete, and the disturbance areas will be completely rehabilitated. The proposed conceptual final landform drainage system is shown on Figure 5.4. The proposed conceptual final landform drainage systems include clean water dams and dryland attenuation basins (i.e. detention basins). Dryland attenuation basins are proposed in the final landform to reduce flow velocities whilst maintaining drainage and creek line stability and as such will not permanently store water. A final void will remain within the North Pit.

Drainage systems will be established on the final sections of the rehabilitated overburden emplacement area, as well as around the perimeter of the North Pit final void in order to convey upstream catchment runoff away from the final void and to downstream watercourses, particularly Main Creek.

The final detail of dam configuration, design of the drainage systems and associated licencing will be further investigated and resolved during preparation of the relevant stages of the Mining Operations Plan and in the detailed closure planning process.

Licensing of water take for the final landform is discussed in 7.2.2.

3.2.5 Additional Water Management Infrastructure During Operations

The conceptual WMS for the Proposed Modification includes eight additional sediment dams to manage runoff from disturbed areas (refer to Figure 3.1, Figure 3.2 and Figure 3.3) during the operations. The conceptual design sizes for each of these dams is included in Table 3.3.

The dirty water management system, including sediment dams, will be designed in accordance with Managing Urban Stormwater: Soils and Construction (the Blue Book), Volumes 1 and 2E - Mines and Quarries (Landcom 2004 and DECC 2008) to manage runoff from the 5 day, 95th percentile rainfall event. The selected design criteria is in excess of the minimum recommended design criteria for sediment dams as outlined in Volume 2E of the Blue Book (DECC, 2008). Volume 2E of the Blue Book (DECC, 2008) indicates that for the 95th percentile design storm event the indicative average annual sediment dam overflow frequency will be 1 to 2 overflows per year. The receiving waters in the event of overflows from the sediment dams during events that exceed the design criteria (refer to Table 3.1) associated with the Proposed Modification are Bettys Creek (via the Middle Bettys Creek Diversion) (sediment dam M1) and Main Creek (sediment dams M2 to M8).

Table 3.3 Proposed Modification – Sediment Dams – Conceptual Design Sizes

Dam	Settling Volume (ML)	Sediment Volume (ML)	Total Volume (ML)	Pump Out Rate (L/s)
M1	3.9	2.0	5.9	9.1
M2	3.7	1.9	5.6	8.6
M3	3.5	1.7	5.2	8.0
M4	3.8	1.9	5.7	8.8
M5	5.7	2.8	8.5	13.2
M6	19.6	9.8	29.4	45.4
M7	7.8	3.9	11.7	18.1
M8	34.2	15.1	45.3	70

Pump and pipe infrastructure to support the management of existing and new water management dams/storages will also be constructed as part of the Proposed Modification.

There are three dryland attenuation basins (i.e. detention basins) proposed as part of the final landform. These detention basins are shown on Figure 3.4 (labelled D1, D2 and D3).

The final detail of dam configuration, design of the drainage systems and associated licencing will be further investigated and resolved during preparation of the relevant stages of the Mining Operations Plan and in the detailed closure planning process.

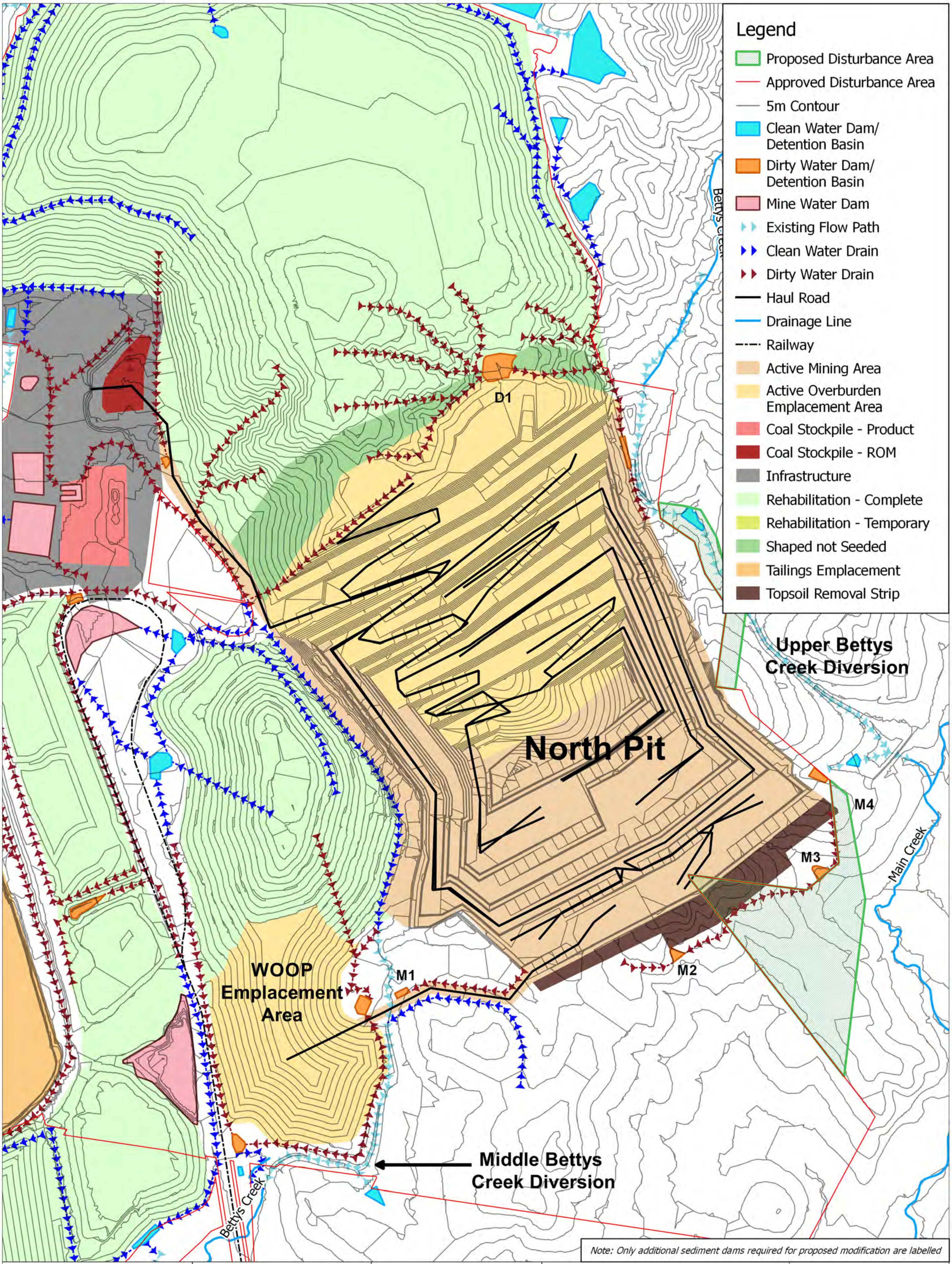

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Figure 3.1

Proposed Conceptual Water Management System - Year 2

Job Number: N1600_005
Revision: 6
Drawn: MB
Checked: SS
Date: 12/6/2018

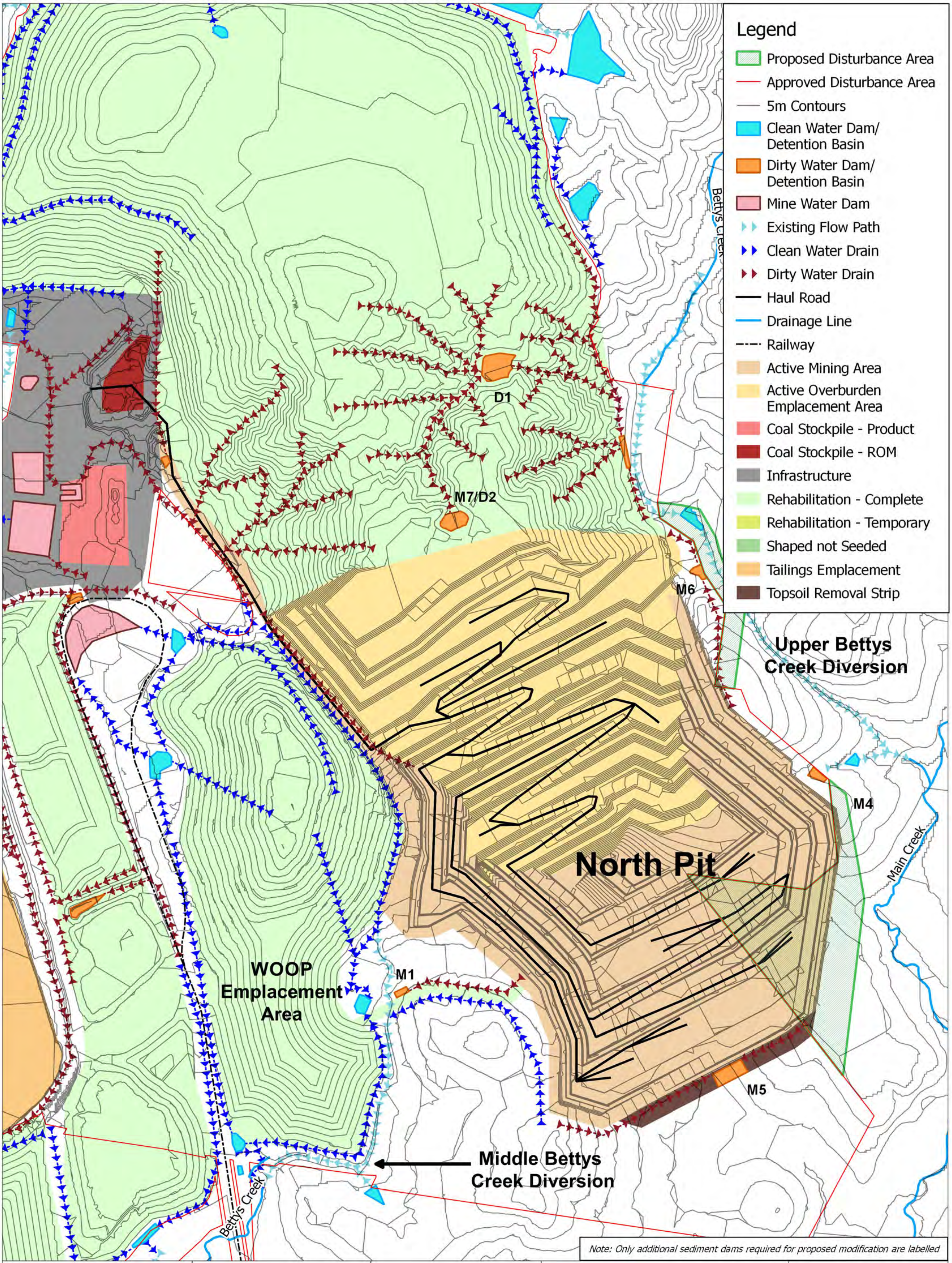

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Figure 3.2

Proposed Conceptual Water Management System - Year 8

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Revision: 6
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Date: 12/6/2018

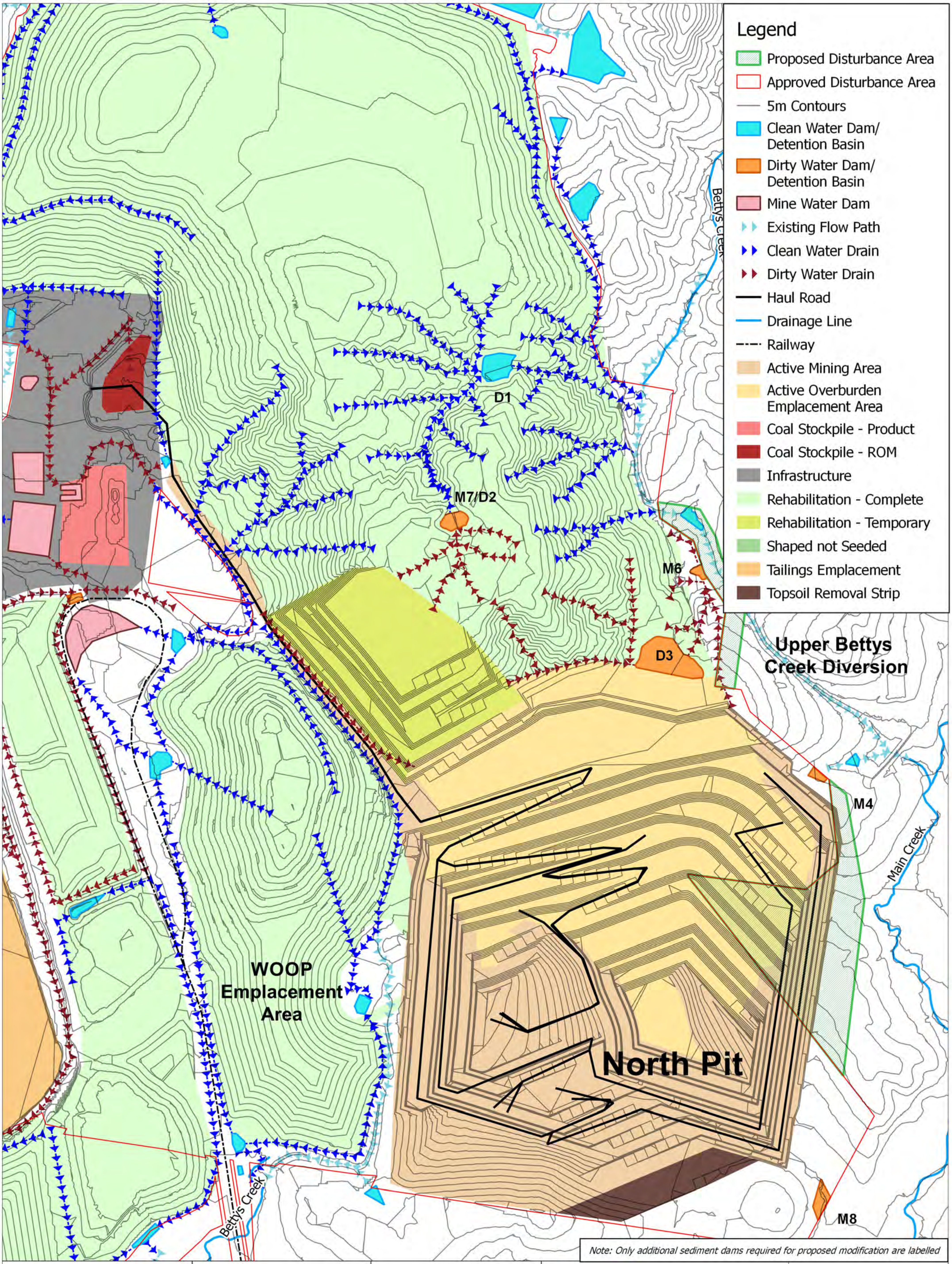

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Figure 3.3
Proposed Conceptual Water Management System - Year 15

Job Number: N1600_005
Revision: 6
Drawn: MB
Checked: SS
Date: 12/6/2018

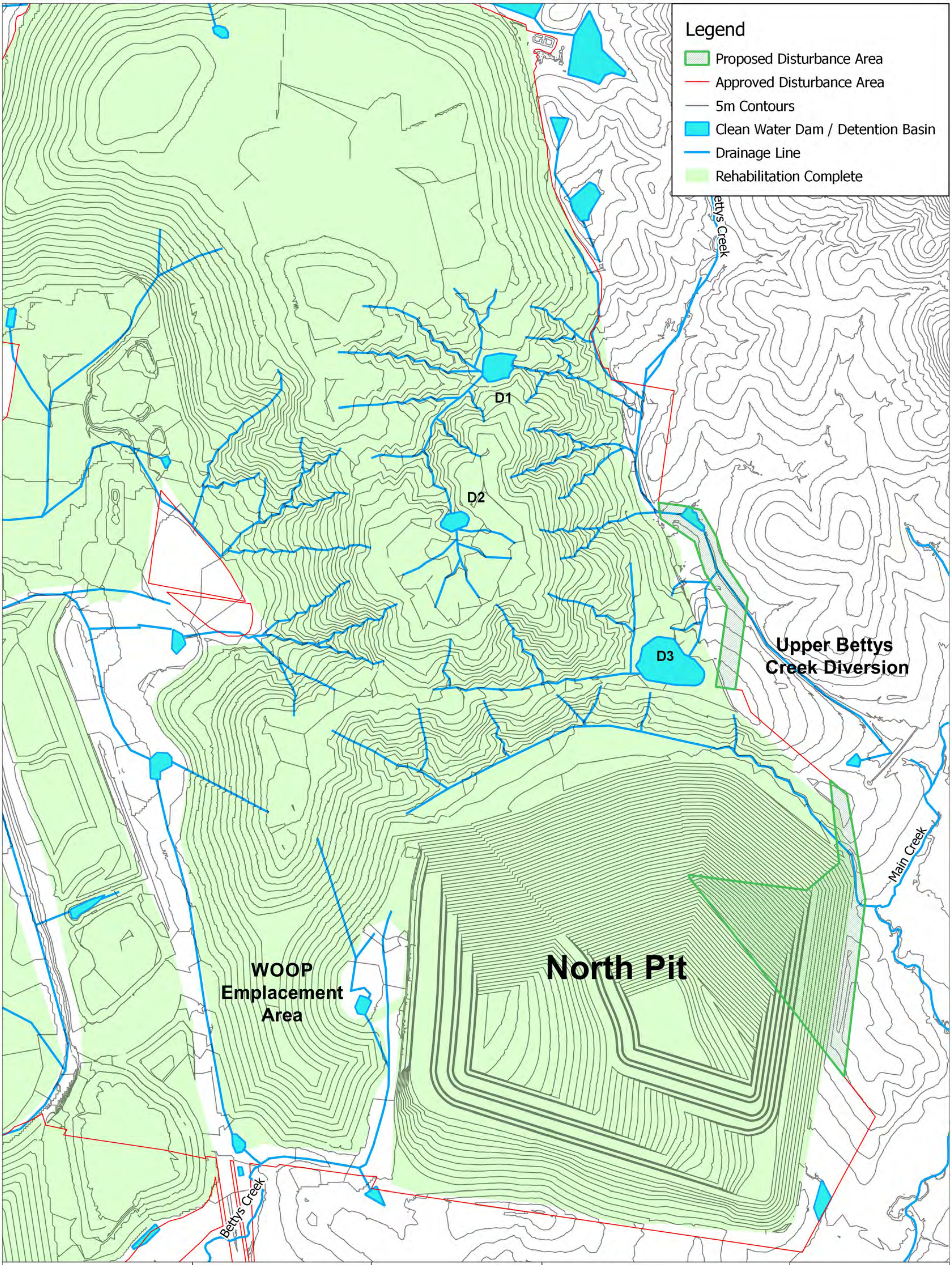

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Figure 3.4
Proposed Conceptual Final Landform Drainage Systems

Job Number: N1600_005
Revision: 6
Drawn: MB
Checked: SS
Date: 12/6/2018

4. WATER BALANCE

The assessment of the potential impacts of the Proposed Modification on the predicted water balance is based on the outcomes of a GoldSim model. The model is a daily time step model and includes water volume and salinity. The model uses the SILO climate data for 139 years. The potential impacts of the Proposed Modification were assessed using 121 possible climatic sequences and as such assesses the water balance for a large number of rainfall possibilities.

4.1 Operational Water Balance

4.1.1 Overview of Water Balance Model

The GoldSim site water balance model was updated to simulate the Proposed Modification mining and coal handling characteristics. The model considers existing and future operations and is used to predict the likely water surplus/deficits and requirements into the future. The model allows detailed analysis and calibration of the Mount Owen Complex water balance and considers:

- Direct rainfall onto dam/water storage surfaces.
- Water loss due to evaporation from water storages and pits.
- Runoff from natural, rehabilitated and disturbed catchment areas.
- Groundwater inflow to open cut pits.
- Water lost to product coal through the CHPP and ROM coal through the crusher.
- Water used for on-site dust suppression (haul roads and stockpiles).
- Transfers to and from other sites via the GRAWTS.
- Extraction from Glennies Creek.

The site model forms part of a water and salt balance model for the GRAWTS. The predicted water balance for the Approved Operations is presented in the Mount Owen Complex Water Management Plan and is reproduced in Table 4.1.

Table 4.1 Summary of Average Water Balance – Approved Operations

Water Management Element	Year 2 (2020) (ML/yr)	Year 8 (2025) (ML/yr)
INPUTS		
Direct rainfall and catchment runoff	2,225	2,275
Groundwater inflows into open cut pits	1,154	494
Imports from GRAWTS	3,292	3,276
Extractions from Glennies Creek	175	146
Bleed water recovered from tailings	6,102	1,057
Total inputs	12,949	7,248
OUTPUTS		
Evaporation from storages	528	629
CHPP usage	5,829	2,872
Dust suppression usage	1,071	647
Exports to GRAWTS	5,064	2,782
Overflows from Sediment Dams	71	80
Total Outputs	12,563	7,010
CHANGE IN STORAGE	385	238

Source: Mount Owen Complex Water Management Plan

4.2 Potential Impacts with Proposed Modification

Table 4.2 presents a summary of the water balance results for Years 2, 8 and 15 of the Proposed Modification. The predicted water inventory at the Mount Owen Complex is also shown on Figure 4.1.

The water balance modelling indicates that the Mount Owen Complex will make water during Year 2. This is primarily a result of increased bleed water recovered from tailings with tailings from Liddell being disposed into West Pit via the GRAWTS.

During Years 8 and 15 the modelling indicates a net water loss with a reduction of total water storage on site during an average year. This is also a result of tailings from the Mount Owen CHPP being disposed of at Liddell (i.e. 50% during Year 8 and 100% during Year 15) via the GRAWTS, in addition to Mount Owen no longer receiving tailings from Ravensworth or Liddell mines.

Table 4.2 Summary of Average Water Balance – Proposed Modification

Water Management Element	Year 2 (2020) (ML/yr)	Year 8 (2026) (ML/yr)	Year 15 (2033) (ML/yr)
INPUTS			
Direct rainfall and catchment runoff	2,566	2,552	2,179
Groundwater inflows into open cut pits	543	449	424
Imports from GRAWTS	2,281	2,875	2,534
Extractions from Glennies Creek	135	120	117
Bleed water recovered from tailings	7,719	1,120	0
Total inputs	13,244	7,115	5,254
OUTPUTS			
Evaporation from storages/pits	1,306	1,700	1,017
CHPP usage	5,871	3,231	1,446
Dust suppression usage	983	561	572
Exports to GRAWTS	3,832	3,459	3,037
Overflows from sediment dams	35	41	4
Total Outputs	12,027	8,992	6,075
CHANGE IN STORAGE	1,217	-1,877	-821

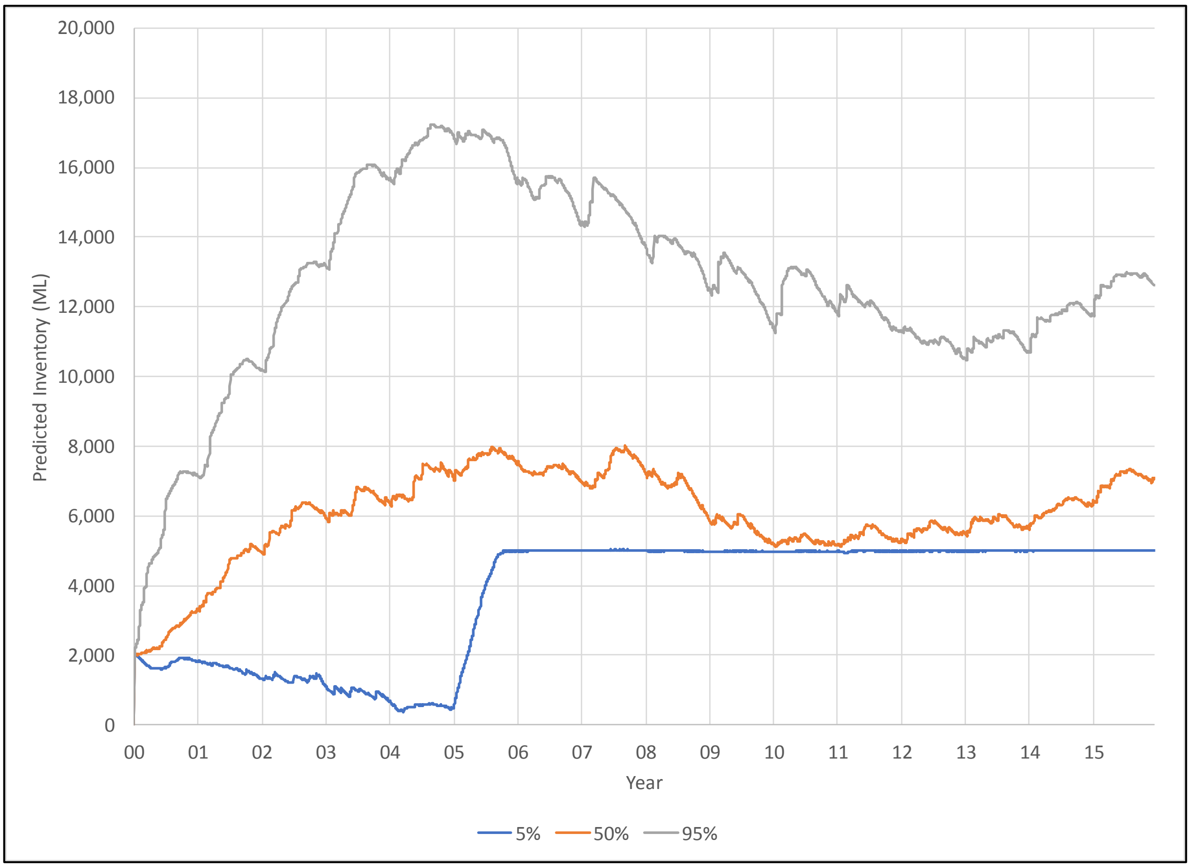

Figure 4.1 Predicted Water Storage Inventory – Mount Owen Complex

Figure 4.1 shows the predicted water storage inventory at the Mount Owen Complex for a range of statistical probabilities (i.e. 5%, 50% and 95%). The change in total water stored on site during the 5% scenario between years 5 and 6 is due to the Bayswater North Pit becoming available as a water storage during these years.

As indicated in Section 3, export of surplus water at the Mount Owen Complex is possible via transfers to the GRAWTS. Mount Owen proposes to continue to share water within the GRAWTS, including the use of existing water storages and, where necessary, utilise existing approved discharge points under the HRSTS at Ravensworth Operations. The GRAWTS includes a number of large water storages used to manage water from the various operations. Surplus water transferred from Mount Owen to the GRAWTS will be stored in these water storages and reused within the GRAWTS in preference to being discharged.

The water balance modelling indicates that the Proposed Modification will have negligible influence on the ability of the GRAWTS to operate and manage potential water discharges via the HRSTS.

The modelling also indicates that the Proposed Modification will not result in the need to purchase any additional WALs for extraction of water from the Hunter Regulated Water Source. The existing WALs are sufficient to meet the demands of the Proposed Modification.

The modelling indicates that the Proposed Modification will not require any alteration to the existing regulatory arrangements at other sites and will not result in any increase in discharges over what is already permitted to occur at Ravensworth Operations.

4.3 Final Void Water Recovery Analysis

4.3.1 Modelling Methodology

A final void recovery model was developed within the GoldSim modelling platform with the following key assumptions/input parameters used:

- Catchments
  - Final void surface runoff catchment area derived from the conceptual final landform design: 390 ha.
  - Final void spoil seepage catchment area derived from historical pit shell data, with 527 ha of catchment area contributing seepage to the final void (in addition to seepage sourced from the surface runoff catchment of 390 ha).
- Hydrology
  - Rainfall data sourced from long term data series for Jerrys Plains Post Office Bureau of Meteorology (BoM) Station 061086.
  - Evaporation data sourced from long term data series for Scone SCS BoM Station 061069.
  - Evaporation pan factors of 0.8 for lake pan factor and 0.85 for EvapT pan factor.
  - Rainfall runoff derived using Australian Water Balance Model (AWBM), with parameters sourced from the Mount Owen Complex Water Management Plan (2017) for pit and rehabilitated catchment types. The model was set up to consider both the surface runoff catchment and spoil seepage catchments to the final void. The final void spoil seepage catchment area is approximately 527 ha.
- Groundwater
  - Groundwater inflow rates provided by AGE (2018) with the net groundwater inflow/outflow to the final void considering final voids at Integra Underground Mine and possible connectivity.
- Storage

- Final void stage-storage-area relationships based on final landform for the open void space and final spoil landform for void storage space. Void spoil storage space was adopted as 20% based on advice from Glencore (internal studies for other Glencore mine sites).
- Modelling assumes fully mixed conditions in the final void lake and the water stored in the adjacent spoil (i.e. stratification effects are not modelled).

▪ Water Quality

- Runoff and spoil seepage TDS concentrations commencing at 2,680 mg/L (80th percentile TDS for dirty water systems in the WMS water quality records), improving to 520 mg/L over 10 years (based on EGI geochemical leachate tests (EGI, 2018)).
- Rainfall TDS concentrations assumed 10 mg/L.
- Groundwater TDS concentrations assumed 7,700 mg/L based on average historical water quality data for Permian water quality.

▪ Initial Conditions

- Assumed that the base of the spoil in the pit is full – i.e. water level at modelling commencement is at -180 mAHD.
- Water quality in void spoil is 2,680 mg/L (based on the 80th percentile TDS for dirty water systems in the WMS water quality records).

4.3.2 Results

The results of the final void recovery model are presented in Table 4.3 and shown on Figure 4.2.

Table 4.3 North Pit Final Void – Water Recovery Modelling Results

Parameter	Proposed Modification Final Landform	Approved Operations Final Landform
Water level equilibrium (mAHD)	-65	19
Time to equilibrium water level (years)	320	500
TDS (mg/L)	5,200 at equilibrium	5,500 at equilibrium
Spill risk	155 m freeboard to spill level @ 90 mAHD	65 m freeboard to spill level @ 84 mAHD

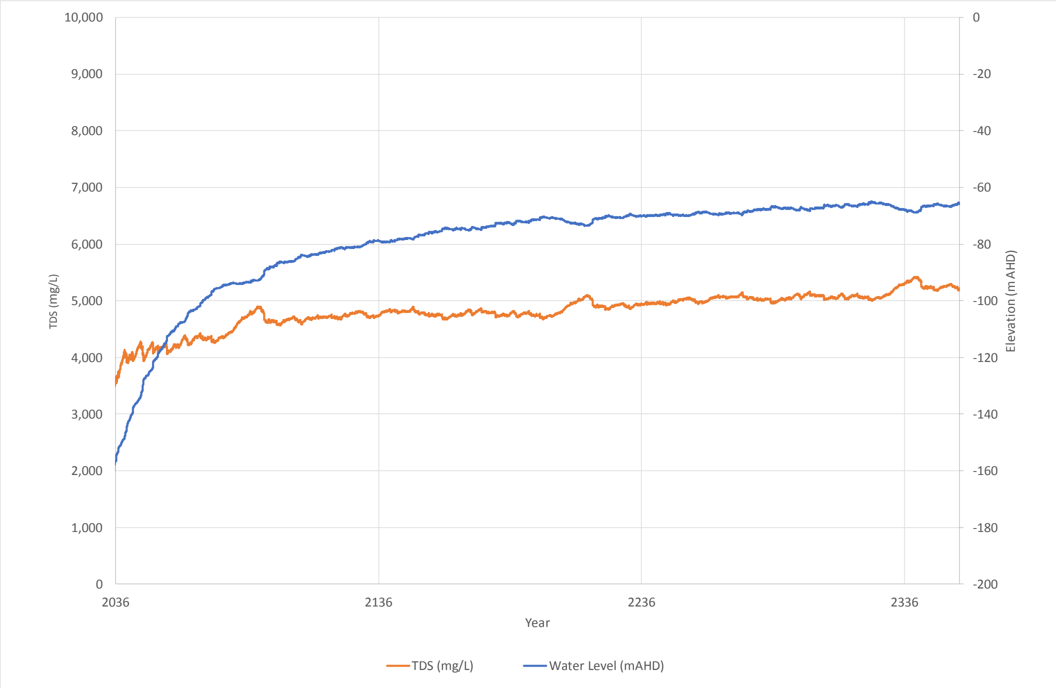

Figure 4.2 North Pit Final Void – Water Recovery Modelling Results

The final void recovery analysis indicates that the void will likely reach it's equilibrium water level within 320 years at approximately -65 mAHD. At this level the void would have a freeboard (i.e. vertical elevation to spill point) of approximately 155 m making the risk of potential spill to the environment negligible. The modelling indicates an increase in freeboard for the Proposed Modification final landform to 155 m from the Approved Operations Final Landform freeboard of 65 m.

The analysis also indicates that the void will have TDS concentrations of approximately 5,200 mg/L when the equilibrium water level is reached at approximately 320 years post mining.

5. SURFACE WATER IMPACTS AND MITIGATION MEASURES

As discussed in Section 2.2, the additional disturbance associated with the Proposed Modification is located in the catchment area of Main Creek. Main Creek is a tributary of Glennies Creek. A detailed assessment of the potential surface water impacts in Main Creek and Glennies Creek are discussed in Sections 5.1 to 5.9.

5.1 Catchment Areas

The predicted impacts on the catchment area of Main Creek and Glennies Creek are included in Table 5.1 for the following scenarios:

- Prior to any mining.
- Approved Operations 2020 landform.
- Proposed Modification Year 2 landform (corresponds to Approved Operations 2020 landform).
- Approved Operations final landform.
- Proposed Modification final landform.

Table 5.1 Predicted Catchment Area Changes (ha)

Catchment	Pre-Mining	Approved Operations 2020	Proposed Modification Year 2	Approved Operations Final Landform	Proposed Modification Final Landform	% Change Approved Operations Final Landform to Proposed Modification Final Landform
Bowmans Creek	25,055	21,590	21,570	20,510	20,500	0%
Stringybark Creek	1,290	1,300	1,300	1,300	1,300	0%
Yorks Creek	1,230	1,800	1,800	1,910	1,910	0%
Swamp Creek	2,380	390	390	1,160	1,160	0%

Catchment	Pre-Mining	Approved Operations 2020	Proposed Modification Year 2	Approved Operations Final Landform	Proposed Modification Final Landform	% Change Approved Operations Final Landform to Proposed Modification Final Landform
Bettys Creek	1,810	700	680	850	840	-1%
Glennies Creek[1]	51,580	52,010	51,970	52,110	52,140	0%
Main Creek	2,000	2,430	2,530	2,390	2,560	7%

1. *Glennies Creek pre-mining catchment area sourced from CLWD catchment boundaries used for water licensing*

The Proposed Modification will have no impact on the catchment areas of Stringybark Creek, Swamp Creek or Yorks Creek.

The Proposed Modification has a minor impact on the catchment area of Bettys Creek. There is a decrease in catchment area of approximately 8 ha (i.e. ~1%) with the Proposed Modification final landform compared to the Approved Operations final landform.

The Proposed Modification final landform will increase the catchment area of Main Creek, compared to the Approved Operations final landform. The predicted total catchment area in Main Creek however remains less than the total predicted catchment area of Main Creek associated with the 2004 Mount Owen Approval of 2,620 ha.

The increase in catchment area is associated with the return of additional catchment as part of rehabilitation of the overburden emplacement areas. The majority of the rehabilitated landform runoff that flows into Main Creek will enter via the existing Upper Bettys Creek Diversion and as such flows will be managed by the existing detention systems in place along this diversion. Local catchment areas in the middle reaches of Main Creek (i.e. downstream of the Upper Bettys Creek Diversion) will be reduced as a result of the associated increased area of the North Pit final void catchment associated with the Proposed Modification.

The predicted changes to flow durations, flooding and watercourse stability associated with the Proposed Modification are discussed in the following sections.

5.2 Flow Regimes

Mining operations have the potential to impact on flow regimes in watercourses by impacts on surface water runoff and baseflow contributions.

The predicted changes in catchment area for Main Creek (refer to Table 5.1) indicates that the Proposed Modification has the potential to impact on flow regimes in Main Creek. In addition, the Groundwater Impact Assessment (AGE, 2018) indicates that mining operations have the potential to impact on baseflows in Main Creek and as such also impact flow regimes.

The analysis of catchment areas and baseflow impacts (AGE, 2018) indicate that there will be negligible changes to previously approved impacts in the catchments of Stringybark Creek, Yorks Creek, Swamp Creek and Bettys Creek.

The potential impacts on flow regimes in Main Creek and Glennies Creek have been assessed using a combination of historical flow gauging data and modelled baseflow impacts (refer to the Groundwater Impact Assessment) (AGE, 2018).

5.2.1 Historical Flow Gauging Data

Flow gauging data is collected in NSW by CLWD. There is limited flow gauging data for ephemeral creek systems with flow gauging on these systems typically discontinued many years ago. No flow gauging is undertaken by Mount Owen, however, there is a current CLWD flow gauge on Glennies Creek, and records for two discontinued CLWD flow gauges in Swamp Creek and Yorks Creek.

There is one operating CLWD flow gauge located on Glennies Creek at “Middle Falbrook” (Gauging Station 210044, refer to Figure 2.1) with data available from 1956 to date. An analysis of annual and seasonal flows from 1956 to 2014 was presented to support the Continued Operations Project EIS (Umwelt, 2016a) and has been reproduced in Figure 5.1.

Historical flow gauging data is also available for two discontinued sites located on Swamp Creek (Station 210050) and Yorks Creek (Station 210049) (refer to Figure 2.1). Flow gauging records for these tributaries are available for the period from 1958 to 1968 (refer to Figure 5.2).

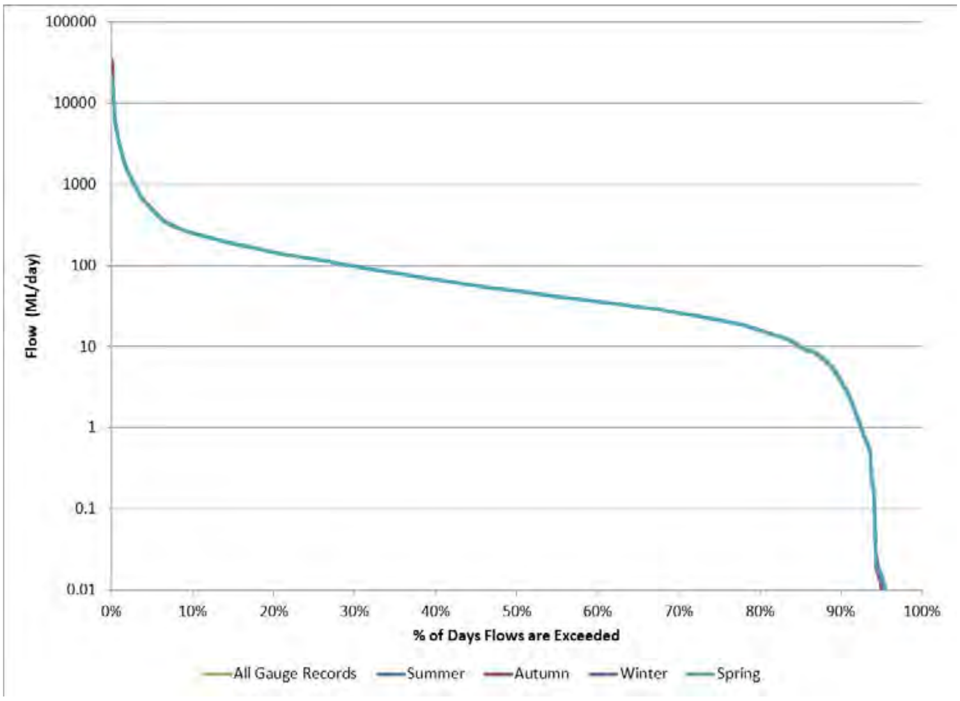

Figure 5.1 Flow Duration Curve – Glennies Creek (210044)

The flow duration curve shows no seasonality, a result of the highly regulated nature of Glennies Creek. The regulation of Glennies Creek creates an artificial baseflow due to the releases from the dam.

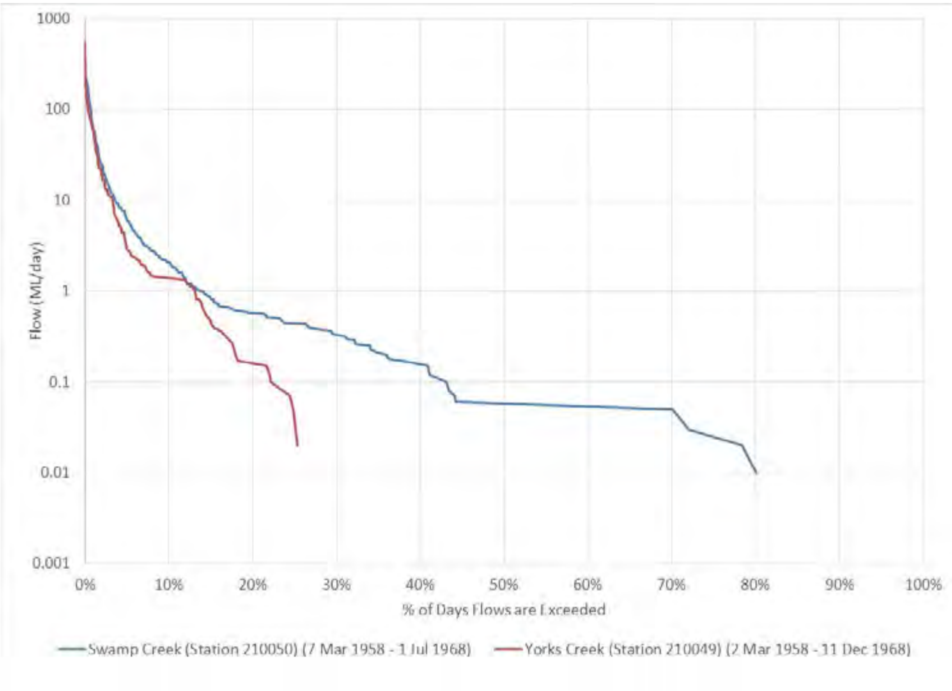

Figure 5.2 Flow Duration Curve – Swamp Creek (210050) and Yorks Creek (210049)

The analysis presented in Figure 5.2 indicates similar flow frequencies in Swamp Creek and Yorks Creek for flows greater than 10 ML/day. However, the analysis also indicates considerable variability in records between the two creek systems during low flow periods with <0.1 ML/day (i.e. approximately 1 L/s) of flow recorded in Swamp Creek 57% of the time and Yorks Creek 78% of the time. This is possibly due to mining in the Yorks Creek catchment area associated with the original Ravensworth East open cut mine (previously known as Swamp Creek Mine) which dates back to the early 1960s.

The historical data analysis (refer to Table 5.2) indicates total average annual flow rates ranging between approximately 670 to 900 ML/yr. This equates to 0.5 to 0.6 ML/ha/yr which is lower than the published average annual runoff rate of 0.7 ML/ha/yr (online Farm Dams Calculator, CLWD). The site summary reports for the flow gauges indicate that the Swamp Creek Gauge (210050) was located on sand, and the Yorks Creek Gauge (210049) on sand and gravel. There is potential that that the flow gauging data underestimates the total flow volume within each creek system as there would also be baseflows occurring through the sands and gravels below the limit of flow recording. The above data will therefore underestimate the likely flow volumes generated within the ephemeral catchment systems surrounding the Mount Owen Complex.

Table 5.2 Average Annual Flow Volumes Analysis (during flow gauging period)

Watercourse	Catchment Area at Gauge (ha)	Period of Record (days)	Recorded Rainfall (mm)	Average Annual Rainfall (mm)	Flow Volume (ML)	Average Annual Flow Volume (ML)	Average Flow Rate (ML/ha/yr)
Swamp Creek	1,900	3,770	7,001	678	9,260	897	0.47
Yorks Creek	1,200	3,960	7,263	670	7,229	666	0.56

The data analysis of historical flow data for Swamp Creek and Yorks Creek indicates that the average flow rates in the creek systems (for the period of record) ranged between approximately 0.5 to 0.6 ML/ha/yr.

5.2.2 Assessment – Main Creek

A hydrologic model using the AWBM was prepared to model the potential flow sequencing impacts of the Proposed Modification on stream flows in Main Creek.

AWBM relates daily rainfall and evapotranspiration to runoff using five functional stores; three surface stores to simulate partial areas of runoff, a base flow store and a surface runoff routing store.

The hydrological model was calibrated to the historical flow gauging data available for Swamp Creek due to the completeness of the data. The calibration fit is presented in Figure 5.3 with the calibration parameters provided in Table 5.3, where:

- C1 to C3 = surface storage capacities.
- A1 to A3 = partial areas represented by surface storages.
- BFI = baseflow index.
- K = daily baseflow recession constant.
- Ks = daily surface flow recession constant.
- Kb = daily baseflow recession constant.

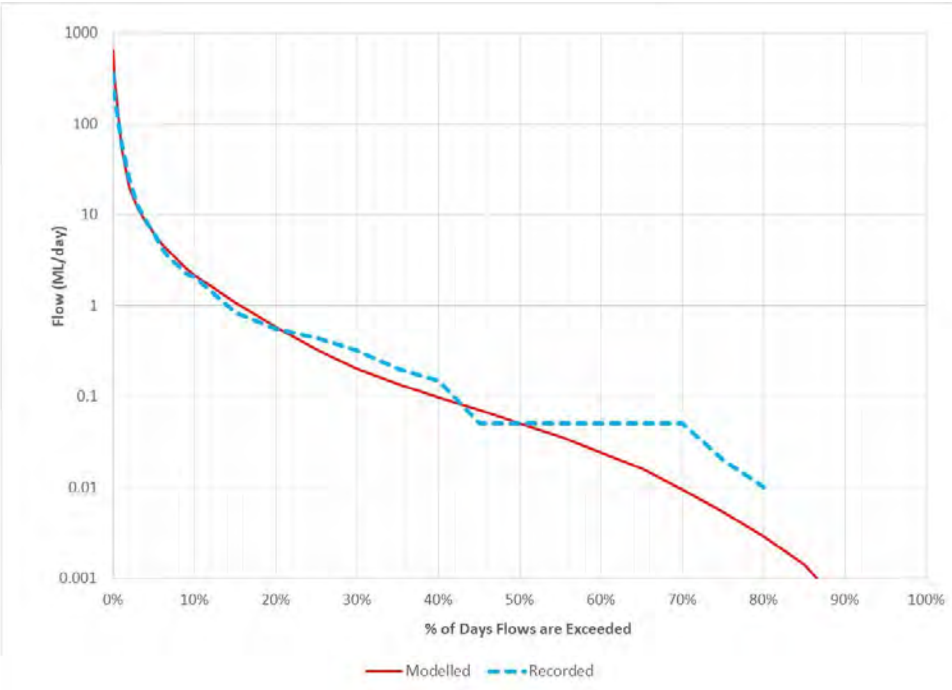

Figure 5.3 Calibration – AWBM Catchment Model – Flow Duration Curve

Table 5.3 AWBM Parameters

Parameter	C1	C2	C3	A1	A2	A3	BFI	KS	KB
Value	20	60	80	0.10	0.45	0.45	0.15	0.95	0.5

The calibrated AWBM model was used to simulate pre-mining streamflow conditions, Approved Operations stream flow conditions and streamflow conditions resulting from the Proposed Modification. The modelling was undertaken using the same SILO data drill data that is used for the water balance modelling (refer to Section 4) (i.e. 139 years). Inputs to the post mining streamflow AWBM models include both predicted catchment changes as well as baseflow impacts sourced from the Groundwater Impact Assessment (AGE, 2018). The scenarios listed in Table 5.4 were modelled for Main Creek.

Table 5.4 Flow Duration Model Scenarios

Scenario	Catchment Area (ha)	Mining Induced Baseflow Losses (ML/yr)
Pre-Mining	2,000	0
Approved Operations – 2020 Landform	2,430	1
Approved Operations – Final Landform	2,530	4

Scenario	Catchment Area (ha)	Mining Induced Baseflow Losses (ML/yr)
Proposed Modification – Year 2 Landform	2,390	1
Proposed Modification – Final Landform	2,570	9

The hydrological modelling results for Main Creek are presented in Figure 5.4.

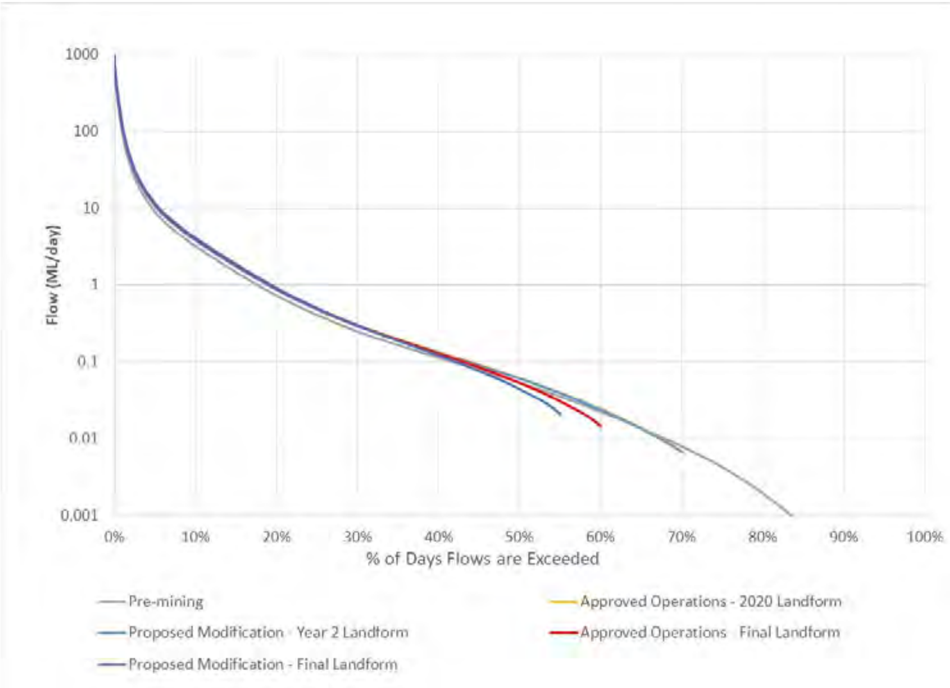

Figure 5.4 Flow Duration Modelled Results

The modelling indicates no perceptible change between the Approved Operations at 2020 compared to the Proposed Modification at Year 2.

For the Proposed Modification final landform, the modelling indicates a decrease in the period that Main Creek will potentially have no flows compared to the Approved Operations final landform. For the Approved Operations final landform, the modelling indicates Main Creek would be dry approximately 43% of the time. That is, a flow of 0.1 ML/day (approximately 1 L/s) would be exceeded 57% of the time). For the Proposed Modification final landform, the period on average predicted to be dry decreases to 42% of the time. That is, Main Creek will potentially be dry on average 4 days less per year (moving from 157 days per year to 153 days per year). The predicted change is associated with the net impact on catchment area and baseflow impacts associated with the Proposed Modification final landform. The assessment of baseflow changes is discussed in the Groundwater Impact Assessment (AGE, 2018), with the approach to licensing of this water take discussed in Section 7.2.

The average annual flow volumes for Main Creek, sourced from the AWBM model outputs are summarised in Table 5.5.

Table 5.5 Average Annual Flow Volumes

Scenario	Average Annual Flow Volume (ML/yr)
Pre-Mining	1,420
Approved Operations – 2020 Landform	1,720
Approved Operations – Final Landform	1,790
Proposed Modification – Year 2 Landform	1,690
Proposed Modification – Final Landform	1,810

The analysis indicates that average annual flow volumes in Main Creek will remain similar to the Approved Operations in Year 2 and increase with the Proposed Modification final landform.

5.2.3 Assessment – Glennies Creek

As described in Table 5.1 the Proposed Modification will influence less than approximately 0.01% of the current approved catchment area of Glennies Creek. As described above (refer to Section 5.2.1), Glennies Creek is a highly modified system and as such the hydrological, geomorphological and ecological conditions are driven by the regulation of the river system. The effects of regulation of Glennies Creek are apparent on the flow duration curves presented for gauging station 210044 - Glennies Creek at Middle Falbrook located downstream of the Glennies Creek Dam (refer to Figure 5.1). As such the potential impacts on Glennies Creek are negligible.

5.3 Flooding and Watercourse Stability

5.3.1 Yorks Creek

As part of the Approved Operations, Mount Owen committed to providing additional off-line detention capacity at the Ravensworth East MIA and the implementation of additional flow conveyance at Hebden Road, in order to address potential flooding issues in Yorks Creek in the vicinity of Hebden Road. To satisfy this commitment, Mount Owen proposed to modify the existing Industrial Dam at the Ravensworth East MIA to provide off-line detention storage for flood events associated with Yorks Creek above the 10% Annual

Exceedance Probability (AEP) event (refer to Section 2.2.1). An alternate method to the currently approved measures is included as part of the Proposed Modification. Mount Owen proposes to augment Dams 5 and 6 (refer to Appendix B) on the northern side of the North Pit emplacement area to provide flood attenuation and mitigation as opposed to modifications to the Industrial Dam and flow conveyance upgrades at Hebden Road. This additional detention capacity will be achieved through the modification of the existing outlet structures at these dams. Accordingly, the works previously proposed at the Ravensworth East MIA and the additional flow conveyance at Hebden Road are no longer required.

The proposed flood mitigation works consist of:

- Dam 5 Spillway Culvert - Conversion of the top 63 ML of dam storage into detention attenuation volume through modification of the existing outlet structure.
- Dam 6 Spillway Culvert - Conversion of the top 84.5 ML of dam storage into detention attenuation volume through modification of the existing outlet structure.

The Proposed Modification will not alter any of the existing approved mining operations in the Yorks Creek catchment area.

Methodology

The potential impacts of flooding and watercourse stability with the proposed changes to flood mitigation works were assessed by WSP Parsons Brinckernoff (2018) using a hydrologic model (XP-RAFTS) and a hydraulic model (HEC-RAS) to represent the catchment areas and creek system. The assessment approach for the modelling, Australia Rainfall and Runoff (AR&R) 1987, is consistent with the methodology used to assess flood impacts for the Approved Operations (Umwelt, 2016c). OEH confirmed this approach was reasonable for the Proposed Modification.

To allow comparison to the assessment for the Approved Operations, the 1%, 5% and 10% AEP events were modelled.

The results from two scenarios were used to determine if the proposed changes to flood mitigation are consistent with the Approved Operations (Umwelt, 2016c): Pre-Approved Operations final landform; and Approved Operations final landform.

Hydrology Parameters used in XP-RAFTS Analysis

The model parameters used in the modelling process are consistent with those used in previous hydraulic modelling undertaken for the Approved Operations Surface Water Impact Assessment (Umwelt, 2016).

The key hydrology parameters used in the XP-RAFTS model analysis were:

- Laurenson Equation S = BQn+1

  where n = -0.285

- Mannings Roughness n = 0.04 to 0.07 (long unkempt grass to medium-heavy brush and tree cover)

- Initial and Continuing Infiltration Losses

  IL = 10 mm
  CL = 2.5 mm/hr

- Channel Routing Travel time calculated based on channel length and velocity derived from average slope

Design Rainfall Depths

Australian Rainfall and Runoff (AR&R) is a national guideline document, accompanied by data and software, that can be used for the estimation of design flood characteristics in Australia. The most recent updates to the AR&R guidelines were published in 2016 (version 4). Historically, the AR&R 1987 guidelines (version 3) and terminology have been used to estimate the design rainfall depths and temporal patterns for the Approved Operations (Umwelt, 2016c). To maintain consistency with the previous assessment and approval and enable comparison to previous models the terminology and design flood estimation methodology as used in the 1987 version of the AR&R guideline has been used in this assessment. The critical design storm event for the Yorks Creek catchment area is 6 hours.

Results

- Dams
  - The modelling indicates that the proposed flood mitigation measures result in minor increases in peak dam levels during the modelled storm events, as well as, limiting peak dam outflows to only have minor increases compared to the pre Approved Operations final landform scenario.
  - In addition, the modelling indicates that the proposed flood mitigation measures delay the peak flows from the dams relative to the upstream catchment flows, helping to mitigate peak flow convergence downstream.
  - Modelled peak dam levels and outflows are provided in Table 5.6 and Table 5.7.

Table 5.6 Peak Flood Model Results for Dams 5 and 6 – Peak Flood Levels (mAHD)

Dam	Landform	Flood Event (AEP)		
		10%	5%	1%
Dam 5	Pre-Approved Operations Final Landform	167.18	167.28	167.48
	Approved Operations Final Landform	167.12	167.27	167.56
Dam 6	Pre-Approved Operations Final Landform	164.94	165.01	165.16
	Approved Operations Final Landform	164.84	164.97	165.21

Table 5.7 Peak Flood Model Results for Dams 5 and 6 – Peak Outflows (m^3/s)

Dam	Landform	Flood Event (AEP)		
		10%	5%	1%
Dam 5	Pre-Approved Operations Final Landform	6.82	9.11	14.16
	Approved Operations Final Landform	7.40	10.78	18.61
Dam 6	Pre-Approved Operations Final Landform	8.26	11.18	17.64
	Approved Operations Final Landform	7.06	11.72	22.75

The potential impacts of changes to peak outflows from Dams 5 and 6 on watercourse stability is discussed below in the section labelled watercourse stability.

- Hebden Road
  - Hebden Road crosses Yorks Creek upstream of the confluence of Yorks Creek and Bowmans Creek.
  - The modelling indicates negligible increases in peak flows, depths, velocity and time of high hazard conditions for vehicles over Hebden Road for the proposed flood mitigation measures when compared to the Approved Operations final landform scenarios.
  - The duration of vehicle high hazard conditions does not increase during the 10% and 5% AEP events, with an increase of 10 minutes predicted during the 1% AEP event (i.e. 3% longer inundation).
  - As presented as part of the Approved Operations EIS (Umwelt, 2016c), Hebden Road is currently impassable to vehicles during the 5% AEP event. Hebden Road is a rural road with no footpath provided and pedestrian traffic along the road in this

area is highly unlikely given the distance to the nearest residence (approximately 8 km by road).

- Mount Owen proposes to, as agreed as part of the Approved Operations (Umwelt, 2016) install flood warning signs along Hebden Road near the Yorks Creek crossing as part of the implementation of the future flood mitigation works. The warning signs will be NSW Roads and Maritime Service (RMS) standard warning signs to advise drivers that the road ahead may be covered in floodwaters and flood depth signs to show the depth of floodwaters across the road.

- Government Property (Lot 4 DP 232149)

  - A land parcel, Lot 4 DP 232149, is located adjacent to Yorks Creek downstream of the Hebden Road crossing. This lot is registered as being owned by the State of New South Wales and is Crown Land. There is no built infrastructure on this land parcel.
  - The modelling indicates increases in peak depths flood depths and velocities at this land parcel.
  - The modelled increases in peak flood depths are 40 mm, 30 mm and 20 mm for the 10%, 5% and 1% AEP events respectively compared to the approved impacts in for the Approved Operations of 8 mm, 0 mm and 370 mm for the same events.
  - As discussed in the Approved Operations EIS (Umwelt, 2016c) the duration of flooding will increase by a negligible amount with increases in flooding durations of up to approximately 5 minutes. Modelling also indicated that the durations of flooding would range between approximately 10 hours for the 10% AEP storm event to approximately 14 hours for the 1% AEP storm event at this land parcel.
  - It is considered that the proposed flood mitigation measures will have negligible impact on flood impacts on this land parcel compared to the currently approved flood mitigation measures.

- Watercourse Stability

  - The modelling indicates minor changes in peak flow velocities within Yorks Creek with the proposed flood mitigation measures (refer to Figure 5.5). The minor changes in peak velocities indicate that there will be negligible potential to impact on watercourse stability with the proposed flood mitigation measures.

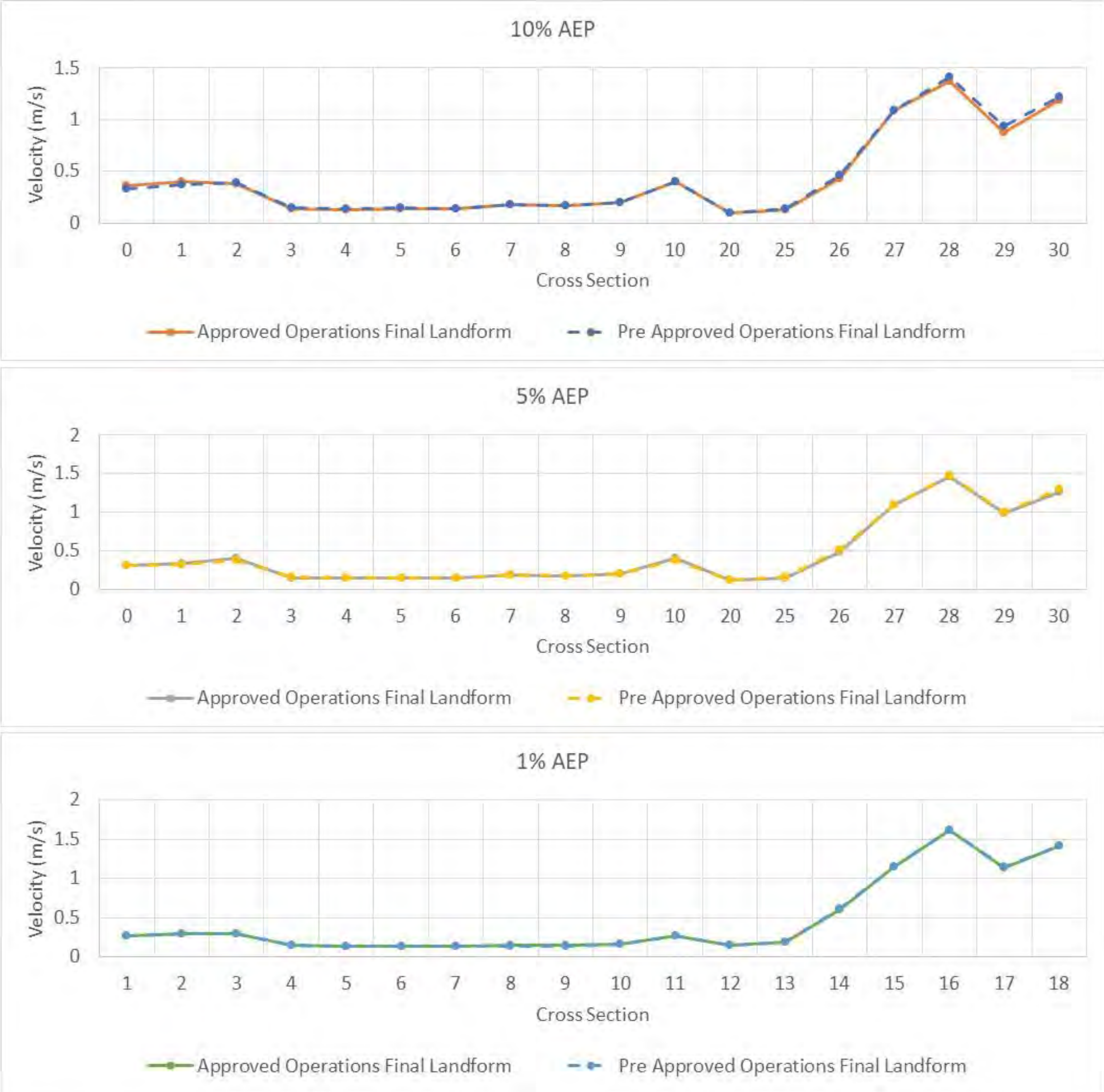

Figure 5.5 Yorks Creek Proposed Flood Mitigation Measures – Modelled Peak Velocities

5.3.2 Main Creek

The Proposed Modification has the potential to influence flooding and watercourse stability in Main Creek as a result of catchment changes associated with the mining operations and overburden emplacement areas.

Methodology

The potential impacts on flooding and watercourse stability were assessed using a one dimensional (1D) hydrodynamic model of Main Creek (refer to Figure 5.6). The model used for the assessment had been previously developed and was used to assess flood impacts for the Approved Operations (Umwelt, 2016c). The model utilises the XP-Storm modelling platform. OEH confirmed that using an approach that is consistent with the previous flood modelling assessments was reasonable for the Proposed Modification.

The following events were modelled:

- 39% AEP storm event to assess potential impacts on watercourse stability (previously known as the 2-year Average Recurrence Interval (ARI) storm event).
- 2% and 1% AEP storm events to assess any potential flooding impacts.
- 0.5% and 0.2% AEP storm events as proxies for climate change as per OEH Standard Environmental Assessment Requirements (SEARs) (2015).
- 0.1% AEP storm event to determine any required flood protection works in accordance with the Glencore flood protection requirements.
- Probable Maximum Flood (PMF) to map flood prone land as per the OEH Standard SEARs. The results from the 1% AEP plus 500 mm were also used to map the flood planning area in accordance with the OEH Standard SEARs.

Two scenarios were modelled for the assessment:

- Existing conditions based on the current topographical data.
- Developed conditions, based on the catchment areas of the proposed final landform with consideration of landform changes associated with potential overburden emplacement and water management structures, including a small height flood levee to the east of the pit. The modelling scenario has been selected to represent the potential "worst case" for flooding impacts with the combined maximum catchment areas and maximum development extents modelled simultaneously (refer to Figure 5.4).

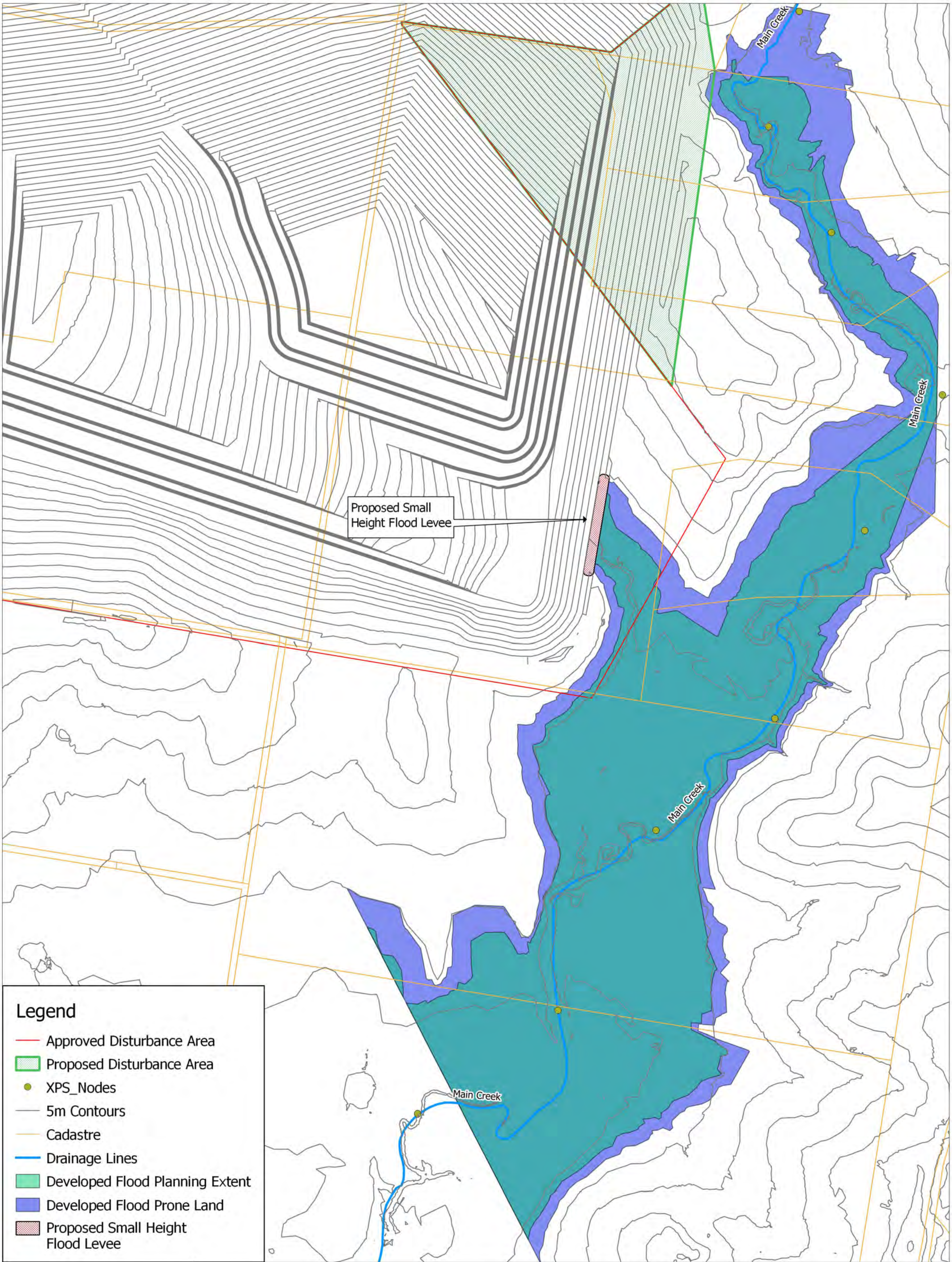

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Figure 5.6
Main Creek
Flood Planning Context

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Drawn: MB
Checked: SS
Date: 22/5/2018

Hydrology Parameters used in XP-Storm Analysis

The model parameters used in the modelling process were consistent with those used in previous hydraulic modelling undertaken for the Approved Operations Surface Water Impact Assessment (Umwelt, 2016).

The key hydrology parameters used in the XP-Storm model analysis were:

- Laurenson Equation S = BQn+1

  where n = -0.285

- Mannings Roughness n = 0.035 to 0.050

  n* = 0.25

- Horton Infiltration where Fp = Fc + (Fo + Fc).e-kt

  Fp = Horton Infiltration (mm/hr)
  Fo = 25 mm/hr
  Fc = 1.27 mm/hr
  k = 0.0015 1/sec
  t = time (sec)

The Mannings roughness for the catchment area (n*) is 0.25. This is consistent with the catchment being generally grazing land. The Mannings roughness (n) for the creek bed ranged from 0.035 to 0.060. The infiltration parameters used in the modelling are consistent with soils being typically clay.

Design Rainfall Depths

To maintain consistency with the previous assessment and approval and enable comparison to previous models the terminology and design flood estimation methodology as used in the 1987 version of the AR&R guideline has been used in this assessment. The critical design storm event for the Main Creek catchment area is 36 hours.

The AR&R 1987 guidelines have been used in this assessment for modelling of the design rainfall events using IFD data sourced from the BoM 1987 Rainfall IFD Data System. The design rainfall depths for each event modelled are listed in Table 5.8.

Table 5.8 Design Rainfall Depths

Annual Exceedance Probability (AEP)	Rainfall Depth (mm)
39%	90.180
2%	186.480
1%	210.420
0.5%	228.540
0.2%	256.316
0.1%	277.324

The PMF event was modelled using the Probable Maximum Precipitation (PMP). The PMP can be estimated for any catchment in Australia using three generalised methods:

1. Generalised Short Duration Method (GSDM) – for durations up to 6 hours and areas up to 1,000 km^2.
2. Revised Generalised Tropical Storm Method (GTSMR) – for durations up to 120 hours and areas up to 150,000 km^2 in the regions of Australia where tropical storms are the source of the greatest depths of rainfall.
3. Generalised Southeast Australia Method (GSAM) – for durations up to 96 hours and areas up to 100,000 km^2 in the region of Australia where tropical storms are not the source of the greatest depths of rainfall.

The GSDM methods applies to Main Creek due to the location of the catchment area and having a catchment area less than 1,000 km^2. The resulting rainfall depth was 670 mm over 6 hours for GSDM.

Watercourse Stability Indicators

Velocity and tractive stress thresholds were sourced from Fischenich (2001) for the bed and bank materials typical of those observed in Main Creek. Potential changes to watercourse stability may occur in those reaches of the watercourse where the hydraulic modelling indicates a change in the stability threshold for either the velocity or tractive stress. This method identifies potential changes to watercourse stability using both the magnitude of the modelled changes to velocity and tractive stress as well as the bed and bank materials.

The reference velocity and tractive stress thresholds used in the analysis are summarised in Table 5.9.

Table 5.9 Selected Watercourse Stability Thresholds

Bed and Bank Material	Velocity Threshold (m/s)	Tractive Stress Threshold (N/m^2)
Fine Gravel	0.8	3.6
25 mm Cobble	1.5	15.8
Hardpan	1.8	32.1

Source: Fischenich (2001)

Assessment of Impacts

The results of the flood modelling for Main Creek, including peak flows, flood depths and velocities are presented in Table 5.10. The modelling indicates some minor increases in flood depths in the mid-stream reaches of Main Creek immediately downstream of the confluence with the Upper Bettys Creek Diversion with the Proposed Modification final landform (i.e. maximum catchment contributing to flood flows). However, the modelling also indicates that the peak flows, velocities and depths will be equal to or less than those for the Approved Operations final landform in the middle to lower reaches of Main Creek. The modelling results presented in Table 5.9 indicates an increase in peak velocity from 1.14 m/s to 1.15 m/s for the 39% event (i.e. 2-year ARI), this is likely a result of rounding in the model calculations. Therefore, no change in peak flow velocities is predicted.

The potential impacts associated with the increases in peak flows in the upstream reaches are assessed further below. Potential impacts on flood depths on private properties is discussed further below.

Table 5.10 Peak Flood Model Results for Main Creek

Flood Event (AEP)	Scenario	Parameter		
		Flow (m^3/s)	Velocity (m/s)	Depth (m)
39%	Approved Operations Final Landform	26.66	1.14	1.07
	Proposed Modification Final Landform	26.12	1.15	1.07
	Predicted Change	-0.54	0.01	-0.01
2%	Approved Operations Final Landform	67.47	1.15	1.40
	Proposed Modification Final Landform	66.43	1.15	1.39
	Predicted Change	-1.04	0.00	-0.01
1%	Approved Operations Final Landform	77.99	1.15	1.51
	Proposed Modification Final Landform	76.45	1.15	1.49
	Predicted Change	-1.54	0.00	-0.01

Flood Event (AEP)	Scenario	Parameter		
		Flow (m^3/s)	Velocity (m/s)	Depth (m)
0.5%	Approved Operations Final Landform	86.19	1.15	1.59
	Proposed Modification Final Landform	84.76	1.15	1.57
	Predicted Change	-1.43	0.00	-0.01
0.2%	Approved Operations Final Landform	99.82	1.15	1.71
	Proposed Modification Final Landform	98.72	1.15	1.70
	Predicted Change	-1.10	0.00	-0.01
0.1%	Approved Operations Final Landform	109.79	1.15	1.80
	Proposed Modification Final Landform	108.63	1.15	1.79
	Predicted Change	-1.17	0.00	-0.01
PMF	Approved Operations Final Landform	654.31	1.92	3.65
	Proposed Modification Final Landform	633.99	1.88	3.63
	Predicted Change	-20.32	-0.04	-0.02

Private Properties

In the lower reaches of Main Creek (i.e. downstream of the Proposed Disturbance Area but upstream of the Glennies Creek Road crossing) the creek passes through one private property with existing acquisition rights (refer to Figure 5.7). The modelling results at the private property are presented in Table 5.11 and indicate no increase in peak flows, velocities or flood depths with the Proposed Modification final landform compared to the Approved Operations final landform.

Table 5.11 Peak Flood Model Results at Private Property

Flood Event (AEP)	Scenario	Parameter		
		Flow (m^3/s)	Velocity (m/s)	Depth (m)
39%	Approved Operations Final Landform	26.66	1.11	1.68
	Proposed Modification Final Landform	26.12	1.10	1.66
	Predicted Change	-0.54	-0.01	-0.01
2%	Approved Operations Final Landform	67.47	1.68	2.53
	Proposed Modification Final Landform	67.47	1.68	2.53

Flood Event (AEP)	Scenario	Parameter		
		Flow (m^3/s)	Velocity (m/s)	Depth (m)
	Predicted Change	-1.20	-0.01	-0.02
1%	Approved Operations Final Landform	77.98	1.81	2.73
	Proposed Modification Final Landform	76.43	1.79	2.70
	Predicted Change	-1.55	-0.02	-0.03
0.5%	Approved Operations Final Landform	86.24	1.89	2.87
	Proposed Modification Final Landform	84.76	1.88	2.85
	Predicted Change	-1.48	-0.01	-0.07
0.2%	Approved Operations Final Landform	99.89	2.02	3.08
	Proposed Modification Final Landform	98.81	2.01	3.06
	Predicted Change	-1.08	-0.01	-0.02
0.1%	Approved Operations Final Landform	109.87	2.11	3.22
	Proposed Modification Final Landform	108.71	2.10	3.20
	Predicted Change	-1.16	-0.01	-0.02
PMF	Approved Operations Final Landform	654.42	4.75	7.82
	Proposed Modification Final Landform	634.16	4.68	7.70
	Predicted Change	-20.27	-0.07	-0.12

With the low predicted velocities for flows (as the flows are out of bank), combined with the overall modelled decrease in maximum flood depth and duration in relation to the Approved Operations final landform, the Proposed Modification final landform is not considered to have a significant impact on the Main Creek floodplain, and will not adversely impact any private landholders in the catchment.

Flood Protection for the Operations

Glencore's required flood immunity for open cut mining pits is the 0.1% AEP event. Flood modelling indicates that the flood levels adjacent to the North Pit with the Proposed Modification will require a small height levee to ensure flood protection to the Glencore standard (refer to Figure 5.6).

The 0.1% AEP flood level adjacent to the pit is 91.55 mAHD. This indicates that a 1.55 m high flood levee (including 0.5 m freeboard) will be required on the south-western edge of the North Pit. The levee will be approximately 250 m long. The conceptual location of the small height levee is shown on Figure 5.4. The final design of the levee will be confirmed during preparation of the Mining Operations Plan and detailed Mine Closure Plan.

Watercourse Stability

The results for maximum modelled tractive stress for the Approved Operations final landform and the Proposed Modification final landform are presented in Figure 5.7 for the 39% AEP event (i.e. 2 year ARI event) and in Figure 5.8 for the 2% AEP event. The respective chainages presented are shown in Figure 5.9.

The results indicate that the bank full flows (i.e. 39% AEP event) in Main Creek have velocities that lie within the erosive thresholds of 25 mm cobbles and tractive stresses that lie within the erosive thresholds of 25 mm cobbles and hardpan. This is consistent with visual observations of the bed of the creek (refer to Section 2.2.2). The modelling also indicates that there will be minor increases in tractive stresses and stream power in the upper reaches of Main Creek with the Proposed Modification. The maximum modelled increases in tractive stress are approximately 1 to 2 N/m^2 which occur for approximately 1,200 m downstream of the confluence with the Upper Bettys Creek Diversion in the 39% AEP event. The predicted increase in tractive stress will not change the erosive potential within any of these reaches into a different erosive bed threshold category and are minor in the context of the existing Approved Operations erosive potential.

The predicted increases in stream power for the 39% AEP event also occur in the first 1,200 m downstream of the confluence with the Upper Bettys Creek Diversion and range between 1.8 to 4.1 W/m^2.

The modelling results for the 2% AEP event are consistent with the 39% AEP event with increases in both tractive stresses and stream power in the upper reaches immediately downstream of the confluence with the Upper Bettys Creek Diversion.

Figure 5.7 Stability Indicators – Main Creek – 39% AEP Flood Event

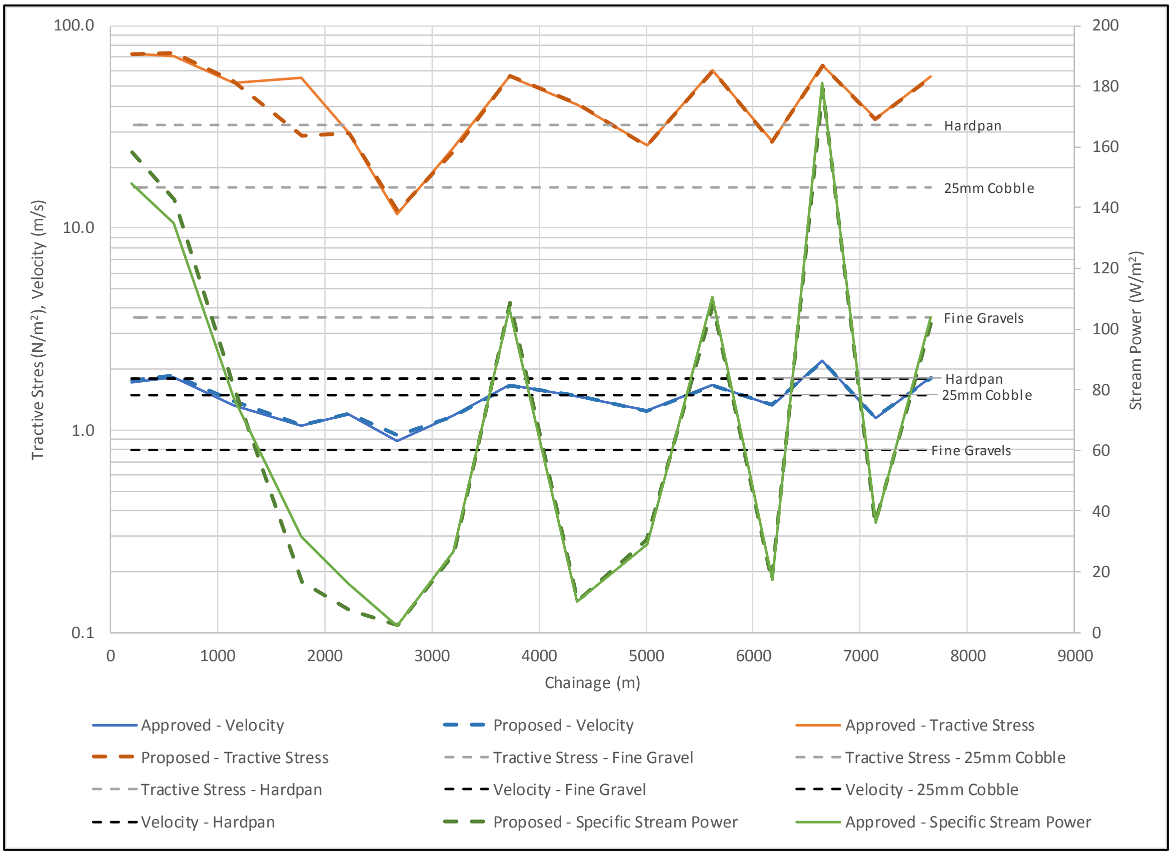

Figure 5.8 Stability Indicators – Main Creek – 2% AEP Flood Event

Even though changes in velocity and tractive stresses have the potential to result in local changes to erosion and scouring, the analysis indicates that it is unlikely that the Proposed Modification will result in an overall increase in erosion or scouring of Main Creek. Mount Owen proposes to continue to monitor Main Creek for potential impacts associated with the mining operations, including watercourse stability, as per the existing Surface Water Management and Monitoring Plan (refer to Section 7.1).

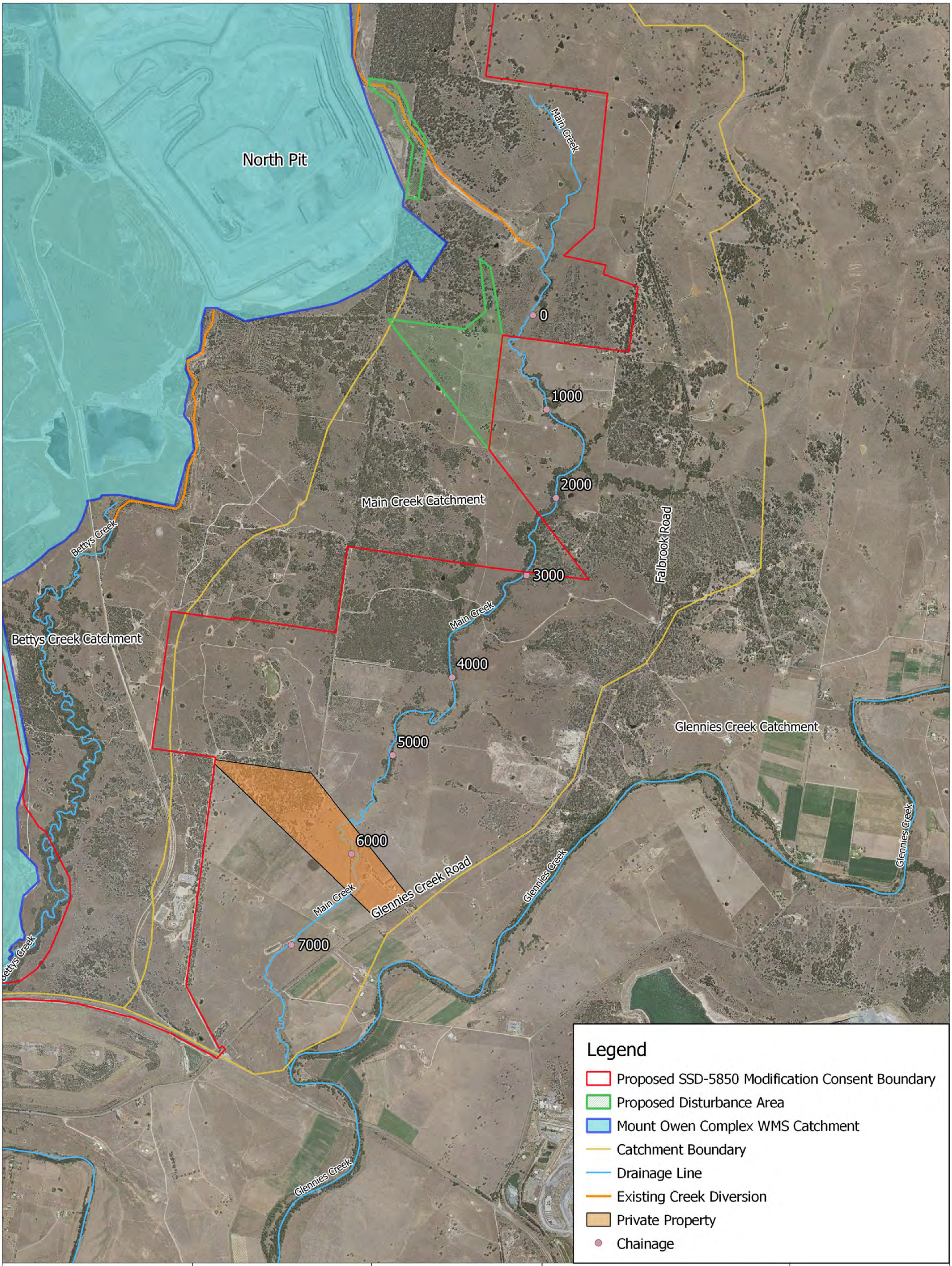

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Figure 5.9
Main Creek Model Layout

Job Number: N1600_005
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Drawn: MB
Checked: SS
Date: 22/5/2018

Climate Sensitivity Analysis

The modelling indicates that the flood depths in Main Creek increase in the order of 150 mm between the 0.5% and 0.2% AEP flood events (refer to Table 5.12). These events were modelled to act as proxies for assessing sensitivity to climate change. Similarly, the modelling shows that the maximum flow velocities within Main Creek remain low (i.e. typically less than 1.15 m/s) and do not change due to the flow conveyance capacity of the floodplain.

Table 5.12 Peak Flood Model Results for Main Creek – 0.5% and 0.2% AEP

Scenario	Flood Event (AEP)	Parameter		
		Flow (m^3/s)	Velocity (m/s)	Depth (m)
Approved Operations Final Landform	0.5%	86.19	1.15	1.585
	0.2%	99.82	1.15	1.711
	Predicted Change	13.63	0.00	0.126
Proposed Modification Final Landform	0.5%	84.76	1.15	1.572
	0.2%	98.72	1.15	1.700
	Predicted Change	13.96	0.00	0.128

The analysis indicates the impacts of climate change, that is, affecting rainfall intensities, in Main Creek will have minimal impacts on the assessment of flood/flow behaviour in the creek and as such no further assessment is required.

Flood Planning Information

Specific flood planning information associated with flood planning areas and flood prone land were included in the flooding assessment. Each of the specific planning tools are listed below along with their definitions (in italics) as included in the NSW Floodplain Development Manual (2005) (the Manual).

The Flood Planning Area and Flood Prone Land for Main Creek adjacent to the Proposed Disturbance Area are presented on Figure 5.6.

Flood Planning Area

The area of land below the flood planning level (FPL) and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 manual.

The assessment indicates that the Flood Planning Area for Main Creek intercepts the Proposed Disturbance Area (refer to Figure 5.6). The assessment also indicates that the

Proposed Modification will have minimal impact on flood extents during the 1% AEP and as such will not impact on the land subject to flood related development controls (i.e. flood planning areas) in the Main Creek catchment area.

Flood Prone Land

Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.

The assessment indicates that there are regions within the Proposed Disturbance Area on the edge of the area defined as flood prone land in Main Creek (refer to Figure 5.6). The assessment also indicates that the Proposed Modification will have negligible impact on flood flows or extents during the PMF and as such will not impact on the extent of flood prone land in the Main Creek catchment area.

5.4 Water Quality

The existing WMS as outlined in Section 3.1, includes mine dewatering systems, water storages, sedimentation and retention basins, settling and tailings ponds, diversion drains, levee banks and earth bunding around the main stockpile, laydown hardstand areas and fuelling areas. The extensions to the WMS associated with the Proposed Modification have been designed to continue to divert clean water around mining operations and segregate, store and reuse mine impacted water to minimise adverse effects on water quality from mining operations to downstream waterways.

As set out in Section 3.2, it is proposed to integrate the WMS associated with the Proposed Modification into the existing WMS to limit the potential impacts on downstream water quality by managing water that has the potential to cause environmental harm. In conjunction with the proposed WMS, a series of erosion and sediment control measures will be utilised during operational and rehabilitation phases of the Proposed Modification to manage water quality (refer to Section 5.8.1).

Background water quality data indicate (refer to Section 2.3) that Main Creek (a tributary of Glennies Creek) occasionally displays elevated TDS and TSS concentrations.

The Approved Operations WMS is designed to enable Mount Owen to manage and operate the WMS to meet licence conditions within the requirements of the POEO Act, taking account of both historical and current water qualities in the surrounding watercourses, and current and future downstream water users. The risk of overflows during events that exceed the approved design criteria and potential impacts associated with overflows is currently managed by the Mount Owen Complex WMP. The WMP allows for the ongoing assessment of risk as mining operations progress, and the implementation of improvements and changes where required. The design strategy for the WMS (refer to Section 3) includes:

- Management (capture and storage) of mine water exposed to coal and/or coal processing for events up to and including the 1% AEP 24-hour storm event.
- Management of runoff from disturbed areas, including overburden emplacement areas, based on the Blue Book requirements (Landcom, 2004 and DECC, 2008).
- Ongoing evaluation of the WMS adequacy based on the design criteria validated through water quality sampling.

If the Proposed Modification is approved, Mount Owen will update the existing WMP to reflect the changes to water management associated with the Proposed Modification.

The changes to the WMP will incorporate the water quality monitoring provisions, recommended by EGI (2018), to monitor for ARD effects.

Consistent with the Approved Operations, no discharges will occur from the Mount Owen Complex with the Proposed Modification. Surplus water on site will be transferred via the GRAWTS to the other Glencore mines (refer to Section 4).

The Proposed Modification final landform has been designed to minimise the catchment contributing to the North Pit final void. The water balance for the final void indicates that, at the predicted recovery rates, the equilibrium water levels with the North Pit final void occur within 320 years at approximately -65 mAHD with a TDS concentration of 5,200 mg/L at 320 years. As such it is predicted that the final void will remain a self-contained system with a predicted freeboard of 155 m with no surface spills predicted to downstream watercourses.

As such it is considered, that with the measures proposed above, the Proposed Modification will have minimal impact on water quality in downstream watercourses.

5.5 Geomorphological and Hydrological Values

The Proposed Modification is not expected to have a significant impact on the geomorphological and hydrological values of local surface water systems. Potential impacts on geomorphological stability and changes to potential erodibility and scour as a result of the Proposed Modification have been assessed and indicate that there is negligible risk of increased erosion or scour.

The proposed flood mitigation measures in the Yorks Creek catchment have been assessed to be consistent with the currently approved flood mitigation works. The proposed flood mitigation measures will continue to maintain peak velocities to be non-scouring (i.e. maximum modelled velocities of 1.7 m/s). It is considered that scour potential along Yorks Creek will not be increased from the Approved Operations final landform due to the proposed flood mitigation measures associated with the Proposed Modification.

The mid-section of Main Creek typically has a well-defined channel and wide floodplain. The lower section of Main Creek, upstream of the confluence with Glennies Creek has been modified for agricultural purposes and is open grassland. Main Creek has a low channel gradient, is ephemeral and the channel is frequently dry with some ponded water. In the mid-section of Main Creek, the riparian zone of the creek banks has some vegetation and existing erosion is minimal. The downstream portion of Main Creek is open grassland with no riparian vegetation along creek banks, and some erosion is apparent.

The Proposed Modification will result in lower peak flows with reduced flood levels and reduced flood duration in the lower reaches of Main Creek compared to the current Approved Operations final landform. Peak velocities of flow during flood events will remain the same with the Proposed Modification as the Approved Operations final landform. It is considered that scour potential along Main Creek will not be increased from the Approved Operations final landform due to the Proposed Modification.

5.6 Riparian and Ecological Values

The predicted changes to flow regimes both during and following the mining operations associated with the Proposed Modification are predicted to be negligible in the context of ephemeral streams. The changes to flow regimes are also considered to be negligible on a regional scale, i.e. Main Creek flows into a regulated river system with a catchment area twenty to twenty-five times the size of the Main Creek catchment area. The Proposed Modification is consequently considered likely to have negligible impact on ecosystems and downstream users as the predicted impact is within the natural variation of the existing creek systems.

It is considered that there will be negligible changes to flow regimes with the proposed changes to the flood mitigation works on Yorks Creek.

5.7 Water Users

There are no licensed water users on Main Creek downstream of the Proposed Disturbance Area. There is one private landholder downstream of the Proposed Disturbance Area on Main Creek that retains basic landholder rights for domestic and stock use.

The Proposed Modification will not reduce annual flow volumes in Main Creek compared to the currently Approved Operations landform conditions during operations and will result in a minor reduction with the final landform (refer to Table 5.5). As such basic landholder rights on Main Creek and Glennies Creek will not be affected during operations with the Proposed Modification.

The proposed changes to the flood mitigation works on Yorks Creek will have negligible impact on downstream water users.

5.8 Summary of Proposed Mitigation Measures

In addition to extending the existing approved WMS (refer to Section 3.2) and a small height flood levee to protect the open cut pit from inundation during extreme flood events, measures are proposed to minimise water quality impacts associated within disturbance areas.

5.8.1 Erosion and Sediment Control Measures

Erosion and sediment control will continue to be undertaken in accordance with the Mount Owen Complex Erosion and Sediment Control Plan (ESCP), which will be updated if the Proposed Modification is approved. The ESCP provides a framework for the management of erosion and sedimentation at the Mount Owen Complex.

During operations, additional WMS components will be constructed as work progresses. The operational phase will involve the ongoing management of the WMS.

The objective of the ESCP is to ensure that appropriate structures and programs of work are in place to:

- Identify activities that could cause erosion and generate sediment.
- Describe the location, function and capacity of erosion and sediment control structures required to minimise soil erosion and the potential for transport of sediment downstream.
- Ensure erosion and sediment control structures are appropriately maintained.
- Fulfil the statutory conditions of the project approval.
- Meet industry standards and best practice, specially:
    - Landcom 2004. Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.
    - Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.
    - Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields (DIPNR undated)

5.9 Cumulative Impacts

No other mining operations have surface operations in the Main Creek catchment. Further downstream, in the Glennies Creek catchment, Rix's Creek North open cut, Ashton open cut operate and Glencore's Integra Underground Mine operate. Recent assessment work undertaken by Hansen Bailey (2017) indicated that the Integra

Underground Mine could result in some temporary changes to geomorphology and condition of the creeks to be undermined. However, Hansen Bailey (2017) concluded that the Integra Underground Mine was unlikely to generate additional cumulative impacts due to the minor influence of subsidence on surface drainage at a catchment scale.

The proposed changes to flood mitigation works in Yorks Creek are considered to have negligible impacts relative to the currently approved flood mitigation works. As such it is considered that there will be no changes to cumulative impacts on Yorks Creek that were previously assessed in the Approved Operations EIS (Umwelt, 2016).

5.9.1 Flows

The Proposed Modification will result in changes to the catchment area of Main Creek compared to the catchment areas of the Approved Operations final landform. This is primarily due to the proposed final landform shaping and drainage systems.

The modelled average dry days in Main Creek from the Approved Operations final landform to the Proposed Modification final landform are negligible within the context of ephemeral streams. The Groundwater Impact Assessment for the Integra Underground Mine Modification 8 (AGE, 2017) indicates that the approved operations at Integra Underground currently take baseflows of 1 ML/yr from Main Creek and that this will not increase with Modification 8 at Integra Underground. The cumulative impact of the Integra Underground baseflow take on the predicted impacts for the Proposed Modification is considered to be minor with average annual flow volumes in Main Creek in the order of 1,700 to 1,800 ML/yr.

The analysis of watercourse stability indicates minor changes to tractive stress and stress power with typically increases in the upper reaches and decreases in the lower reaches (downstream of the Proposed Modification) of Main Creek. The Proposed Modification is consequently considered likely to have limited impact on waterway stability and scour potential, ecosystems and downstream users. There are no other mining operations that have the potential to influence flood flows in Main Creek.

5.9.2 Water Quality

Management of potential water quality impacts throughout the life of the Approved Operations is undertaken using the WMS. It is proposed to integrate water management for the Proposed Disturbance Area with the existing WMS (as set out in Section 3). In conjunction with the proposed Mount Owen Complex WMS, a series of erosion and sediment control measures will be utilised during operation and rehabilitation phases of the operations to manage water quality (refer to Section 5.8.1).

The WMS and associated erosion and sediment control systems are required to meet specific design criteria based around industry standards to contain mine affected water and protect downstream environments from contamination.

Through management of dirty water and mine water within the integrated WMS over the life of the operations, reduction of peak flood flows and similar scour potential in Main Creek with consideration of proposed mitigation measures, it is not anticipated that water quality in downstream waterways will be adversely impacted as a result of the Proposed Modification.

As such the cumulative potential impacts on water quality in downstream watercourses is negligible.

5.9.3 Water Users

Main Creek flows into Glennies Creek which has a catchment area twenty to twenty-five times the size of Main Creek and forms part of the Hunter Regulated River System. Water quantity is not anticipated to be adversely impacted by the Proposed Modification.

As the Proposed Modification and adjacent mining operations operate in a highly regulated water system (refer to Section 2.1.3) any water take associated with the Proposed Modification or existing approved operations will need to meet the requirements of the WM Act in regard to licensing of water take. As such the Proposed Modification is considered to have negligible cumulative impacts on downstream water users.

6. SUMMARY OF ASSESSMENT AGAINST COMMONWEALTH SIGNIFICANT IMPACT GUIDELINES

As discussed in Section 2.1.1, in December 2017 the Proposed Modification was determine not to be a controlled action and therefore the Proposed Modification does not require approval under the EPBC Act.

Detailed environmental studies have been undertaken to inform the proposed conceptual design for the Proposed Modification. The consideration of the outcomes of these studies in the design of the Proposed Modification and integration with the Approved Operations minimise the potential for the impacts on surface water resources. These factors include:

- The extent of existing and approved open cut and underground mining within and surrounding approved operations, with mining already significantly altering the water environment.
- The management of impacts within the regime established by NSW water and pollution control legislation, which provides for sustainable water take from water sources, management of water quality by imposition of discharge quality criteria and management of salt loads within sustainable targets by managing water discharges to the environment.
- By maintaining buffer distances to Main Creek (approximately 50 m from the top of bank to the Proposed Modification Pit Shell).
- Water management system designed to meet legislative requirements and relevant guidelines (e.g. guidelines for treatment of runoff from disturbed areas).
- Minimisation of works within the flood prone areas of Main Creek to minimise the potential to impact on flood behaviour.
- Maximised water recycling and sharing across the GRAWTS.
- No requirement to discharge water (regarding water quality and quantity) from the operations to the surrounding surface water environment.

These factors reduce the potential for significant impacts on existing surface water resources. A summary of the potential surface water impacts against the Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resources (DoE 2013) is included in Table 6.1.

Table 6.1 Assessment Against Significant Impact Guidelines: Coal Seam Gas and Large Coal Mining Developments – Impacts on Water Resources

Aspect	Impact
Flow Regimes	The footprint of mining operations will increase with the Proposed Modification and water from this increased area will be captured, treated and reused within the WMS. The Proposed Modification includes placement of a small height (1.5 m) flood levee adjacent to the open cut pit to provide protection from flooding associated with flood flows in Main Creek during events >1% AEP flood event. The assessment indicates that the Proposed Modification will have minor to negligible impacts on flow regimes including flood flow velocities and depths and associated potential impacts on downstream landholders and watercourse stability in Main Creek when compared to the existing Approved Operations. The proposed changes to flood mitigation measures on Yorks Creek are considered to have negligible impacts on flow regimes compared to the currently approved flood mitigation measures. The detailed assessment of potential impacts on flow regimes includes assessment of impacts on catchment areas and flow durations (refer to Section 5) including flow duration impacts as a result of changes to catchment areas and baseflow contributions on Main Creek. The proposed changes to the approved flood mitigation works on Yorks Creek have also been assessed with consideration of changes to flooding and watercourse stability as well as access along public roads. The assessment of potential impacts of flow regimes on riparian and ecological values is included in Section 5.6.
Recharge Rates; Aquifer pressure or pressure relationships between aquifers; Groundwater table levels	Refer to Groundwater Impact Assessment (AGE, 2018)
Groundwater/surface water interactions	Groundwater interactions are discussed and assessed in the Groundwater Impact Assessment (AGE, 2018). The surface water assessment indicates that the final landform baseflow impacts will result in Main Creek being dry for a similarly same period per year as for the Approved Operations final landform (i.e. moving from 157 dry days per year to 153 dry days per year on average. In addition, the assessment of the North Pit final void indicates that the void continues to be a self-contained system with a predicted freeboard of 155 m, with no surface spills predicted to downstream watercourses.
River/floodplain connectivity	The Proposed Modification is not expected to have an impact on river / floodplain connectivity as no mining is proposed in floodplain areas. One small section of the Proposed Disturbance Area is located within the edge of the flood prone land associated with Main Creek. The assessment indicates that the Proposed Modification will have negligible influences on flood behavior in Main Creek and as such it is considered that the Proposed Modification will not influence river/floodplain connectivity. The detailed assessment of flood behavior and potential impacts on flooding regimes, including impacts on river/floodplain connectivity is included in Section 5.3.

Aspect	Impact
Inter-aquifer connectivity	Refer to Groundwater Impact Assessment (AGE, 2018)
Coastal Processes	No impacts on coastal process are predicted as a result of the Proposed Modification which is located well inland, being approximately 80 km from the coast.
Impact on water users	The assessment of impacts on water users indicates that there will be negligible impact on surface water users. All water take associated with the Proposed Modification will be licensed in accordance with the WM Act. Mount Owen is currently sourcing water licenses in the Jerrys Water Source and Glennies Water Source to meet requirements for licensing in these water sources. The detailed assessment of impacts on surface water users is included in Section 5.7. Further details on licensing provisions are included in Section 7.2.2).
State Water Resource Plans	The surface water and alluvial water sources within and adjacent to the Proposed Disturbance Area are managed under the Hunter Unregulated and Alluvial Water Sources WSP. In addition, water extraction from the Hunter River is managed under the Hunter Regulated River Water Source WSP. Both WSPs are State Water Resource Plans and are governed under the WM Act. The NSW Government WSPs provide a regional water balance for these water sources and consider cumulative water use. Water take for the Mount Owen Complex will continue to comply with the above listed WSPs and WM Act which are designed to provide for the sustainable use of NSW's water resources.
Water Quality	Mount Owen has a comprehensive WMS in place at the Mount Owen Complex to manage the potential impacts of the existing mining operations on water resources. The WMS for the Proposed Modification will be designed in accordance with relevant government standards to limit potential impacts on downstream water qualities by managing water that has the potential to cause environmental harm. To manage water quality during operational and rehabilitation phases of the Proposed Modification, erosion and sediment control measures and other water quality control measures in accordance with the relevant government standards will be implemented to minimise any potential impact on water quality. Monitoring results will be assessed against the relevant trigger values. The risks to downstream environments associated with sediment laden water are mitigated by the design of the Mount Owen Complex WMS in accordance with design criteria established by the NSW Government specifically for sediment control at mining and quarry operations. These controls will effectively manage this risk. Through management of sediment laden (dirty) water and mine water within the WMS over the life of the operations and based on flood assessment findings that indicate no changes to velocities and associated scour potential in Main Creek, it is not anticipated that water quality in Main Creek or Glennies Creek will be adversely impacted by the Proposed Modification.

7. MANAGEMENT, MONITORING, LICENSING AND REPORTING

7.1 Water Management Plan and Monitoring

The existing Mount Owen Complex WMP (approved October 2017) includes the sub plans (all approved October 2017):

- Erosion and Sediment Control Plan.
- Surface Water Management and Monitoring Plan.
- Groundwater Management and Monitoring Plan.
- Surface Water and Groundwater Response Plan.
- Creek Diversion Plan.

Copies of these plans are available on the Mount Owen Complex website http://www.mtowencomplex.com.au/en/environment/Pages/plans-programs.aspx.

The above management plans were updated to include the requirements of the Approved Operations. The management plans include specific monitoring for:

- Erosion and sediment control measures.
- Water balance monitoring.
- Watercourse stability monitoring and management.
- Surface water quality monitoring.
- Flow monitoring.
- Contingency measures.
- Decommissioning of the WMS.

If the Proposed Modification is approved, the Mount Owen Complex WMP and associated sub plans will be updated to include the WMS and water balance associated with the Proposed Modification,

There are three water quality monitoring locations on Main Creek, with one location upstream of the operations, one mid-stream and the third downstream of both the current

Approved Operations and the Proposed Modification. Water quality will continue to be monitored at these locations.

Currently watercourse monitoring includes monitoring of the Upper Bettys Creek Diversion and Main Creek on an annual basis for watercourse stability and stream health. This will continue with the Proposed Modification.

7.2 Licensing Requirements

7.2.1 Protection of the Environment Operations Act 1997

Licensing requirements for the operations under the POEO Act remain unchanged with the Proposed Modification.

7.2.2 Water Act 1912 and Water Management Act 2000 - Overview

The Hunter Unregulated and Alluvial Water Sources WSP applies to water take from watercourses and alluvial groundwater in the vicinity of the Mount Owen Complex. The operation of the Hunter Unregulated and Alluvial Water Sources WSP is governed by the WM Act.

The Proposed Modification will not increase the capture of runoff take from clean catchment areas. Runoff from dirty and mine water catchments will be contained within the WMS to meet the requirements of the EPL. There are also no harvesting dams proposed as part of the Proposed Modification. As such the licensing regime for the Approved Operations during the operational stages in regard to surface water is not predicted to change as a result of the Proposed Modification.

This review demonstrates that licensing for both during operations and the conceptual final landform for the Proposed Modification can be appropriately accommodated in the current water licence regime.

7.2.3 Hunter Unregulated and Alluvial Water Sources WSP - During Operations

One of the key objectives of the Mount Owen Complex WMS is the diversion of clean water around mining operations to minimise capture of upslope runoff and separate clean water runoff from mining activities. The Proposed Modification will not increase the clean water runoff capture from natural landform areas within the WMS compared to the Approved Operations.

Based on 100 per cent capture of runoff at the regional runoff rates (refer to www.farmdamscalculator.dnr.nsw.gov.au) of 0.7 ML/ha/yr, the clean water areas captured in the WMS total a maximum of 72 ha (as per the Approved Operations EIS (Umwelt, 2016)) which equates to the capture of approximately 50 ML/yr. Based on Mount Owen landholdings of approximately 5,670 ha, Mount Owen has a harvestable Rights provision of approximately 397 ML/yr (i.e. 5,670 ha x 0.7 ML/ha/yr x 10% harvestable rights provision). As such, the capture of clean water runoff will not be modified by the Proposed Modification and is within the Harvestable Rights provisions of Mount Owen.

Approximately 192.5 ML of the 200 ML unit licence (refer to Table 3.2) in the Jerrys Water Source is associated with evaporative losses from the existing diversion dams located to the north of the Mount Owen Complex. As part of this Proposed Modification the existing outlet structure to Dam 5 and 6 will be modified to provide suitable detention for flood flows. This change of use is expected to have negligible impact on the licensed water take (as these are on 3rd order or above watercourses) associated with evaporation losses in these dams.

7.2.4 Hunter Unregulated and Alluvial Water Sources WSP - Final Landform

Dams may be required in the final landform for a number of reasons with the three primary purposes being:

- Long term management of drainage in the final landform (for example, their ongoing use as dryland attenuation basins / detention areas to reduce flow velocities downslope and continue the operation of the established clean water management systems whilst maintaining drainage and creek line stability).
- Use to support final land uses (e.g. farm dams for stock watering or water storages for other uses).
- Environmental purposes (for example, the retention of dams with developed ecosystems will have biodiversity value in the final landform).

The number of dams in the final landform will depend on the detailed design of the final landform and land use which will be progressively developed and refined over the life of the operation.

All dams to be retained in the final landform will be fully licensed in accordance with licensing requirements in force at the time. Dams which cannot be licensed due to limitations on available water allocations or other reasons will be removed prior to closure.

The details of the licensing assessment are discussed further in the following sections.

Estimated Catchment Changes Relevant to Final Landform Licensing

Table 7.1 outlines the catchment changes and estimated water take relevant to the Approved Operations and the Proposed Modification conceptual final landforms.

Table 7.1 Estimated Water Take – Approved Operations and Proposed Modification

Aspect	Licenses Held (units)	Surface Water (ML/yr)	Baseflow[1] (ML/yr)	Alluvial[1] (ML/yr)	>=3rd Order Watercourse[2] (ML/yr)	Maximum Licensable Water Take (ML/yr)	Net (ML/yr)
Jerrys Water Source							
Approved Operations	200	100	-	7	192.5	299.5	-99.5
Proposed Modification	200	89.1	1	4	192.5	286.6	-86.6
Glennies Water Source							
Approved Operations	0	64	-	15	0	79.0	-79.0
Proposed Modification	17	18.9	8	27	0	53.9	-36.9

Note 1. Source - AGE (2018)
Note 2: Source – Umwelt (2016)
Note: Surface Water take refers to the net of catchment diversion and final void

Based on the catchment and associated water take changes outlined above and information on baseflow and alluvial losses, licence summaries for Jerrys Water Source and Glennies Water Source are summarised below.

Summary of Licensing – Jerrys Water Source

The key outcome in regard to take in Jerrys Water Source is a maximum licensable water take of approximately 286.6 ML/yr (89.1 ML/yr surface water, 1 ML/yr baseflows, 4 ML/yr alluvial water take and 192.5 ML/yr associated with evaporative losses from dams on >=3rd order watercourses (refer to Table 7.1). Mount Owen currently holds 200 ML in Jerrys Water Source (based on 100% of available water determinations under the Hunter Unregulated and Alluvial Water Sources WSP).

Summary of Licensing – Glennies Water Source

The key outcome in regards to take in Glennies Water Source is a maximum licensable water take of approximately 53.9 ML/yr (18.9 ML/yr surface water, 8 ML/yr baseflows, 27 ML/yr alluvial water take (refer to Table 7.1). Mount Owen currently holds 17 ML in Glennies Water Source (based on 100% of available water determinations under the Hunter Unregulated and Alluvial Water Sources WSP).

Final Landform Licensing Assessment

This section outlines the potential licensing scenario for the Proposed Modification conceptual final landform, based on current licensing requirements. The outcomes of the licensing assessment are as follows:

- Estimated shortfall of 86.6 ML/yr water take from the Jerrys Water Source for the Proposed Modification conceptual final landform.
- Estimated shortfall of 36.9 ML/yr water take from the Glennies Water Source for the Proposed Modification conceptual final landform. A decrease in water take compared to the Approved Operational final landform estimated net water take of 64.1 ML/yr.

As previous discussed with CLWD (formerly DPI Water) during the Continued Operations Project submissions the Jerrys Water Source allocation is likely to be readily sourced given the volume of entitlement available and nature of land use in this water source. That is, there are 2,097 unregulated river and 1,246 aquifer units in the Jerrys Water Source. With the additional licenced take in the Jerrys Water Source of 86.6 ML equating to approximately 2.6% of the total water entitlement.

The Glennies Water Source is more constrained with 446 unregulated river and 10 aquifer units available. A similar approach to potential licensing for the Proposed Modification is proposed as was discussed with CLWD for the Continued Operations Project. The licensing shortfall in the Glennies Water Source could be met by a combination of purchasing additional WALs and/or changes to the drainage pathways associated with the final landform to drain additional catchment to the Glennies Water Source.

On this basis, and consistent with the discussions held with CLWD for the Continued Operations Project, a potential final landform alternative has been investigated to demonstrate that the water licensing requirements can be met if sufficient allocation is not available in the Glennies Water Source in the future.

An analysis of the Proposed Modification conceptual final landform indicates that the runoff from areas of rehabilitated mine catchment that are currently proposed to drain to the west (i.e. the Jerrys Water Source) could be directed to drain to the east (i.e. Glennies Water Source). Approximately 53 ha of the Proposed Modification conceptual final landform that is currently draining to the west would need to drain to the east to offset the net predicted take of 36.9 ML/yr (i.e. 53 ha x 0.7 ML/ha/yr average regional runoff rate). This reshaping could increase the estimated net water take from the Jerrys Water Source from 86.6 ML/yr by 36.9 ML/yr to 123.5 ML/yr. That is, under this scenario additional WALs would need to be sourced in the Jerrys Water Source to provide a total of 123.5 ML/yr, to generate a net neutral estimated water take for the Glennies Water Source. As demonstrated above the additional Jerrys Water Source allocation is likely to be readily sourced given the volume of entitlement available.

This scenario demonstrates that in terms of net take there would be a neutral water take from the Glennies Water Source (i.e. based on using the 17 units of WALs currently held) and no additional water allocation would need to be sourced in the Glennies Water Source.

7.2.5 Hunter Regulated River Water Sharing Plan

The water balance assessment (refer to Section 4) indicates that the existing licence allocations are sufficient to meet the water requirements of the Mount Owen Complex with the Proposed Modification during operations. That is, the assessment indicates that no additional WALs will need to be purchased in the Hunter Regulated River WSP as a result of the Proposed Modification.

The key outcome in regards to take in the Glennies Creek Management Zone 3A post mining is a maximum licensable water take of approximately 13 ML/yr of surface water (AGE, 2018). Mount Owen holds sufficient WALs to license this predicted take.

7.3 Reporting

A summary of surface water monitoring results will continue to be provided in the Annual Review. As a minimum, the following information will be reported in the Annual Review:

- A summary of monitoring results;
- An analysis of monitoring results against impact assessment criteria, historical monitoring results;
- Annual site water balance and comparison against predictions in the SEE;
- An identification of any trends in the monitoring results;
- Any non-compliances reported during the year; and
- Actions taken to address any non-compliances.

In addition, any significant findings regarding the implementation of the WMP will be reported in the Annual Review, including:

- The effectiveness of the erosion and sediment controls;
- Changes to the site water balance; and
- Any identified issues or exceedances of trigger values.

The Annual Review will also document reviews and feedback relating to the maintenance and performance of the WMS.

8. QUALIFICATIONS

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

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

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

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

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

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

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

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

g. This report does not provide legal advice.

9. REFERENCES

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APPENDIX A

Water Quality Data Analysis

Analysis of Routine Monitoring Parameters (data range from August 2009 to September 2017)

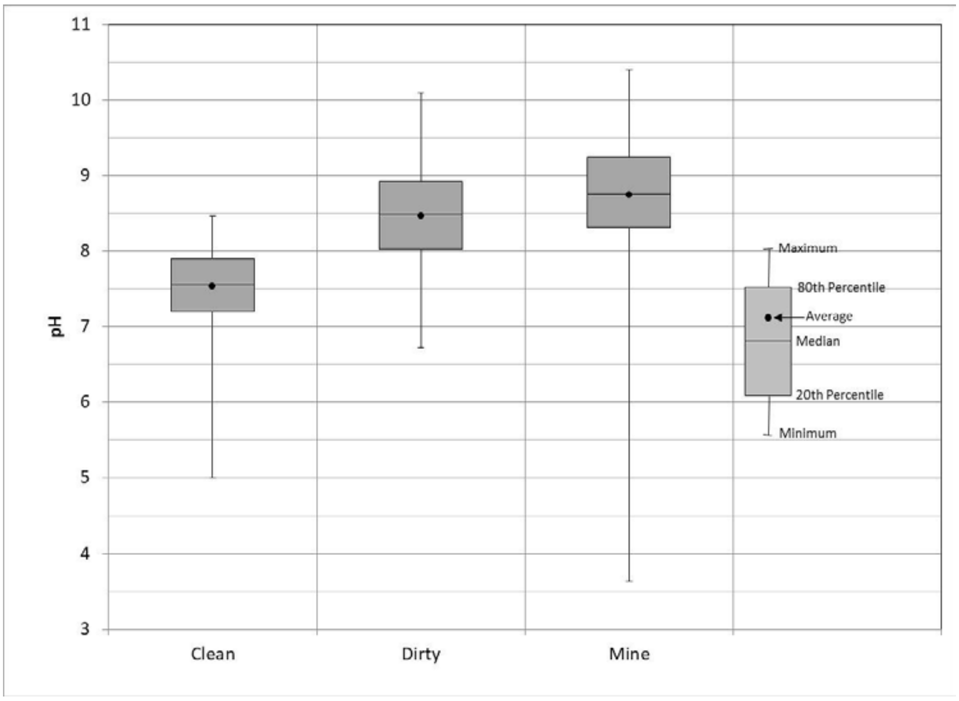


Figure A - pH

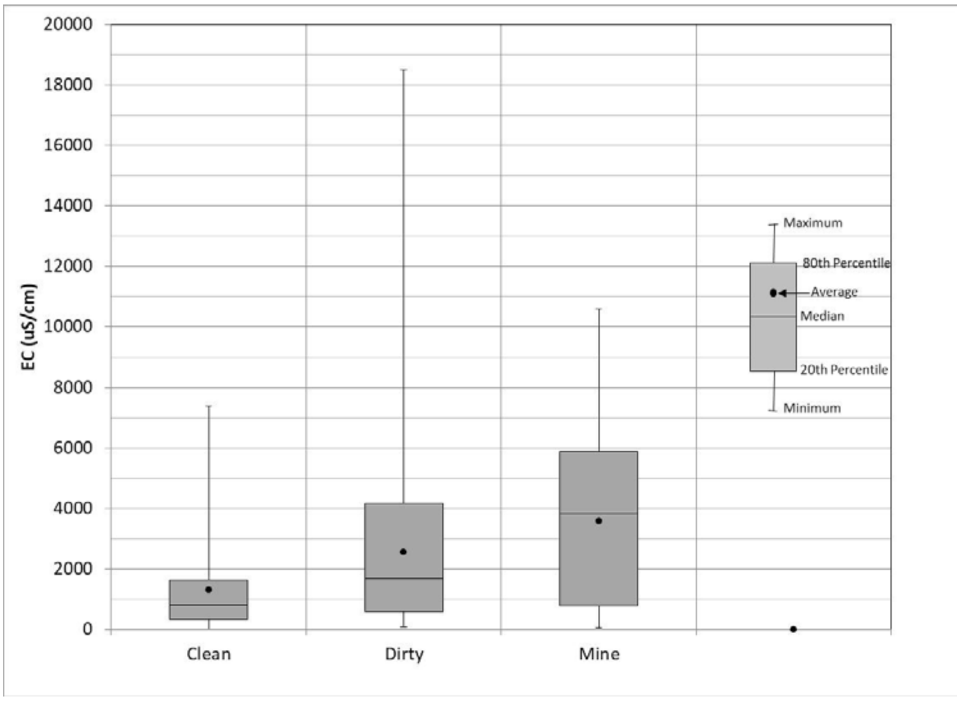


Figure B - EC

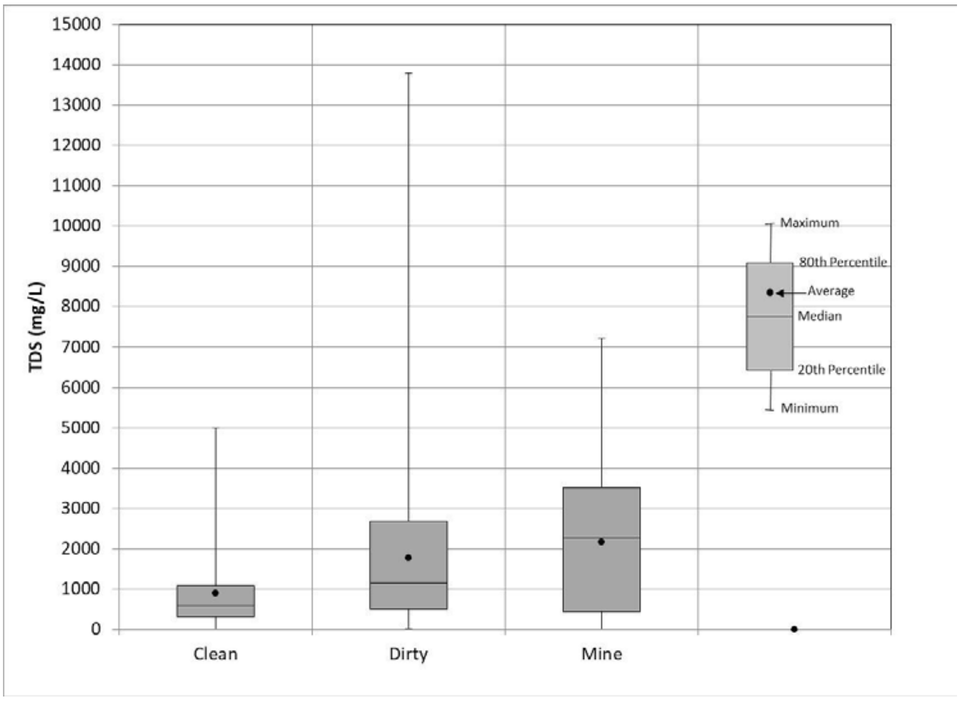


Figure C - TDS

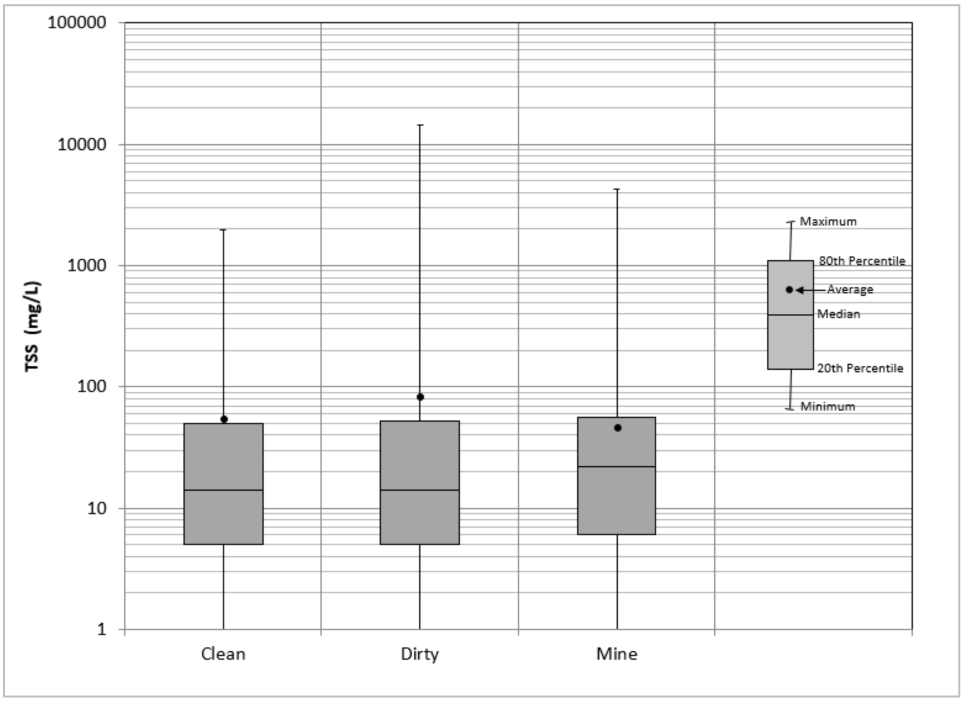


Figure D - TSS

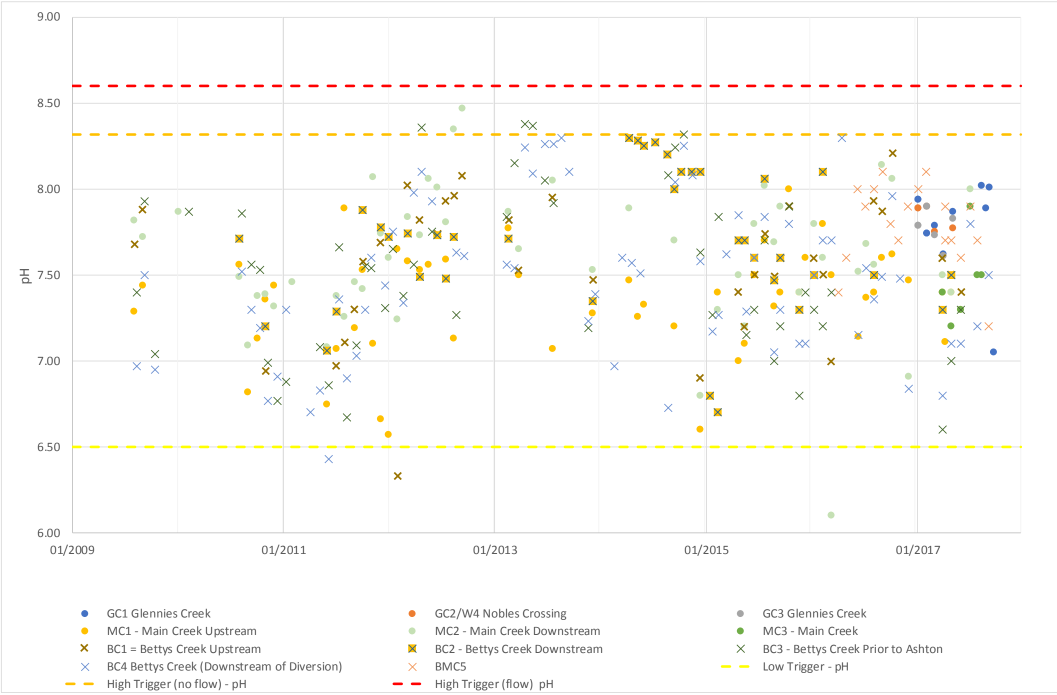


Figure E - Clean water system – pH

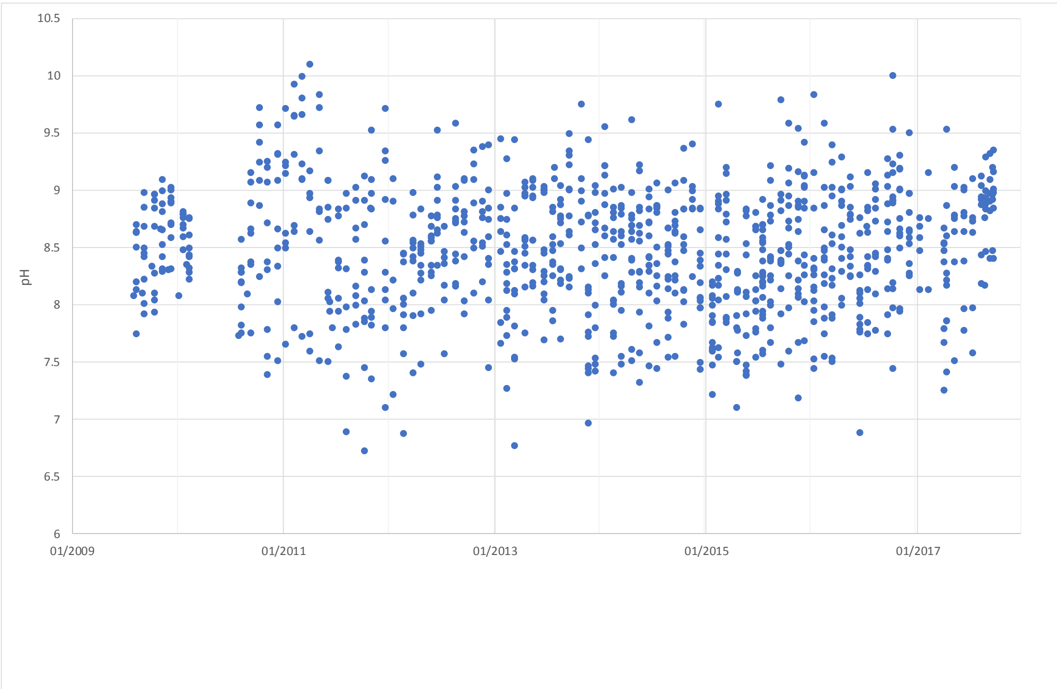


Figure F - Dirty water system – pH

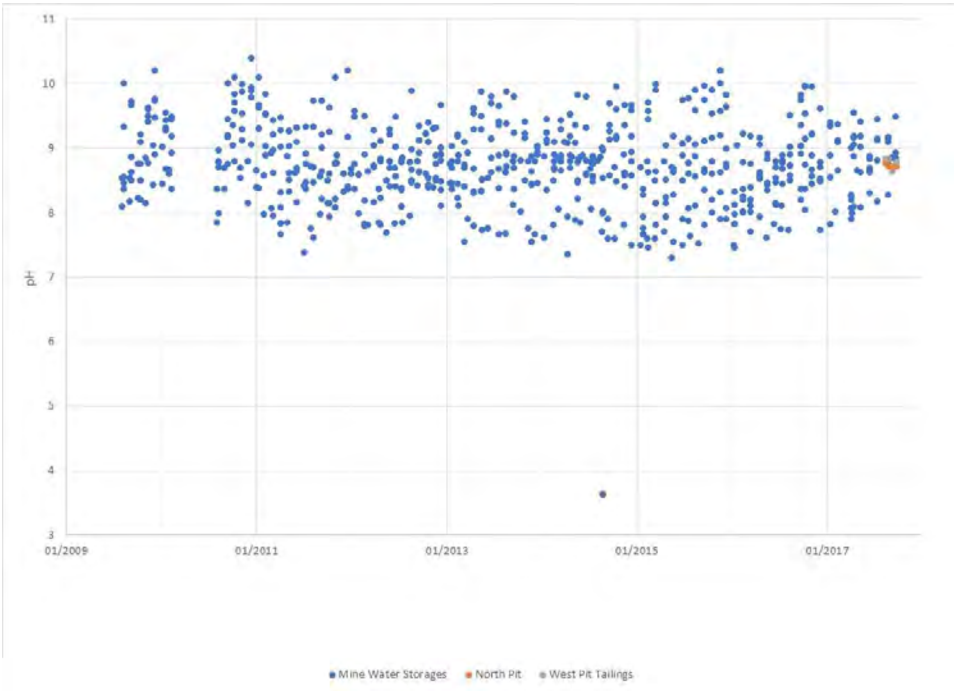


Figure G - Mine water system – pH

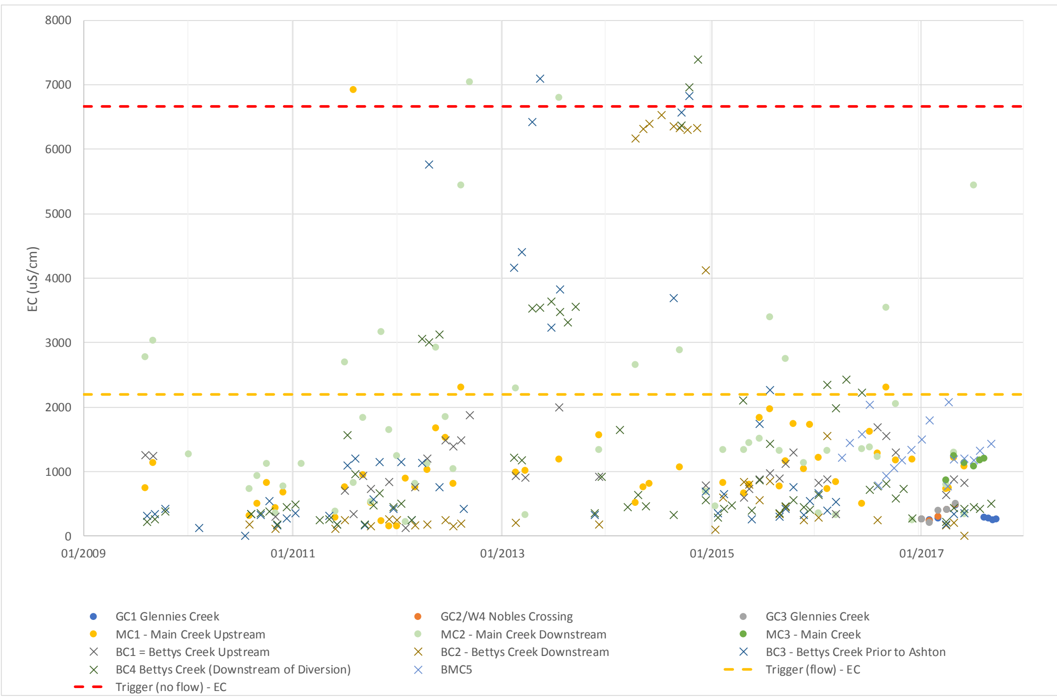


Figure H - Clean water system – EC

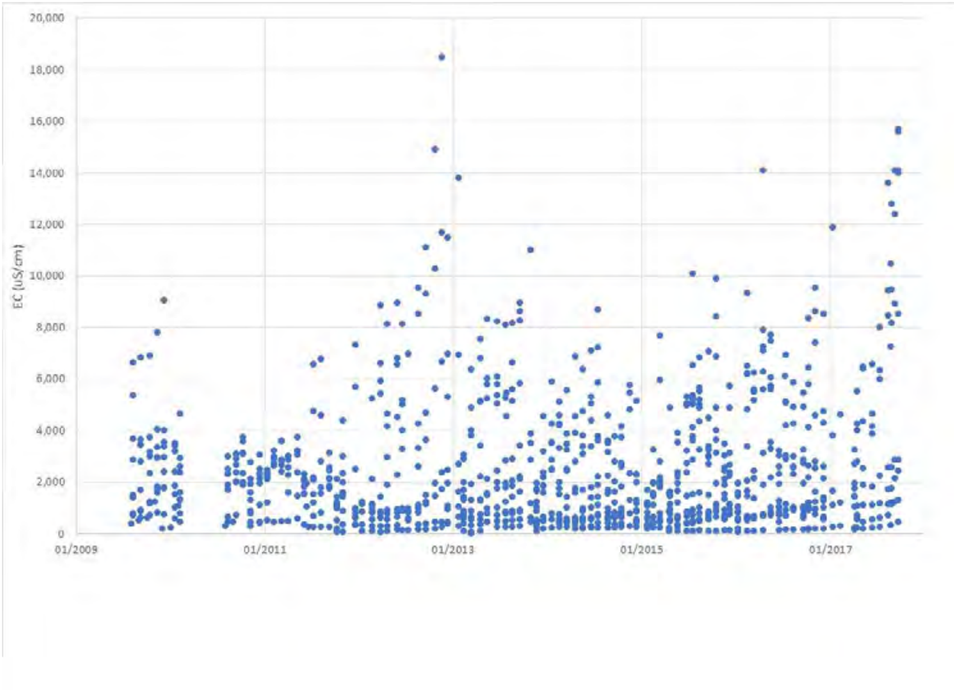


Figure I - Dirty water system – EC

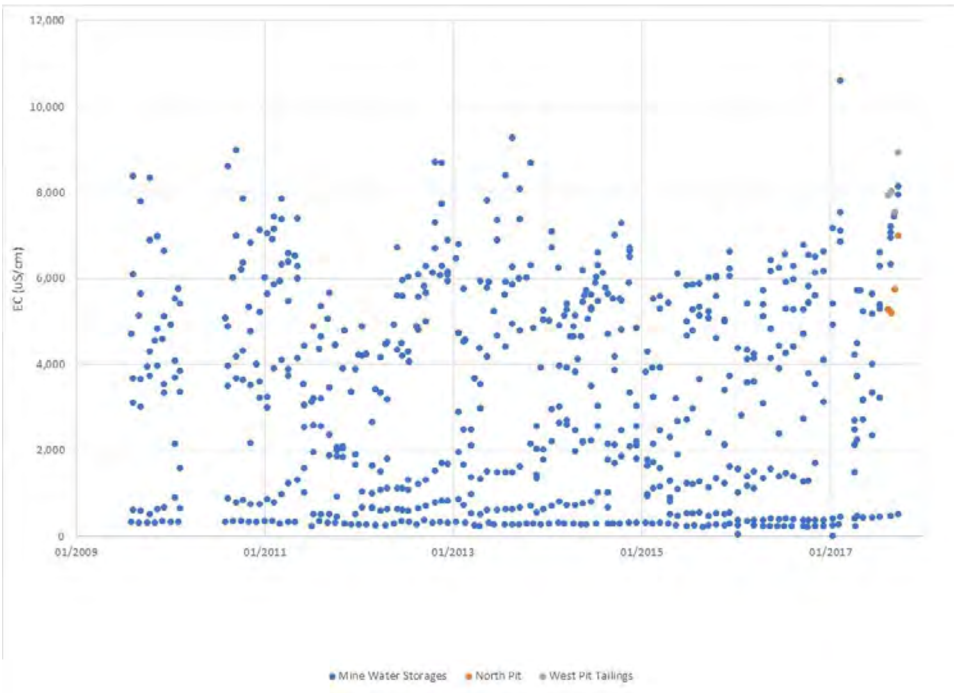


Figure J - Mine water system – EC

Figure K - Clean water system – TDS

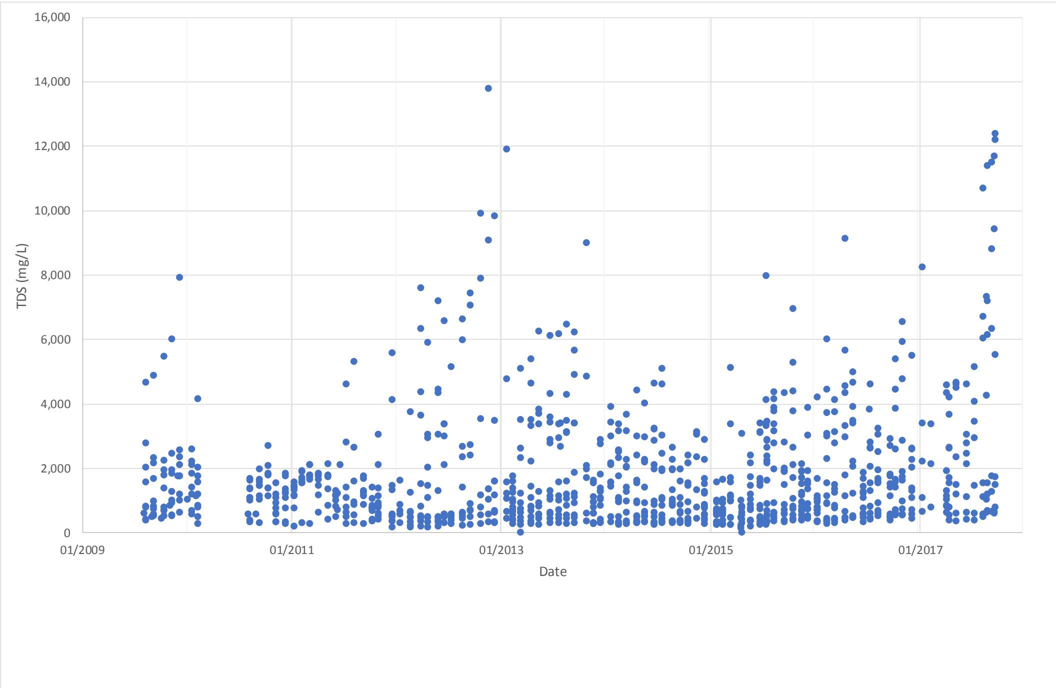


Figure L - Dirty water system – TDS

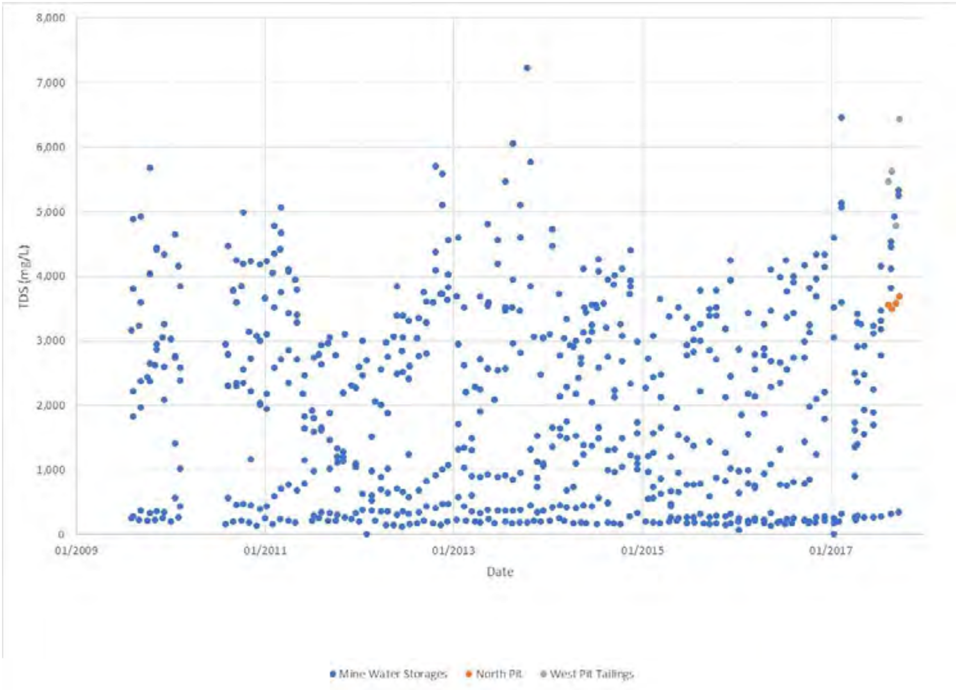


Figure M - Mine water system – TDS

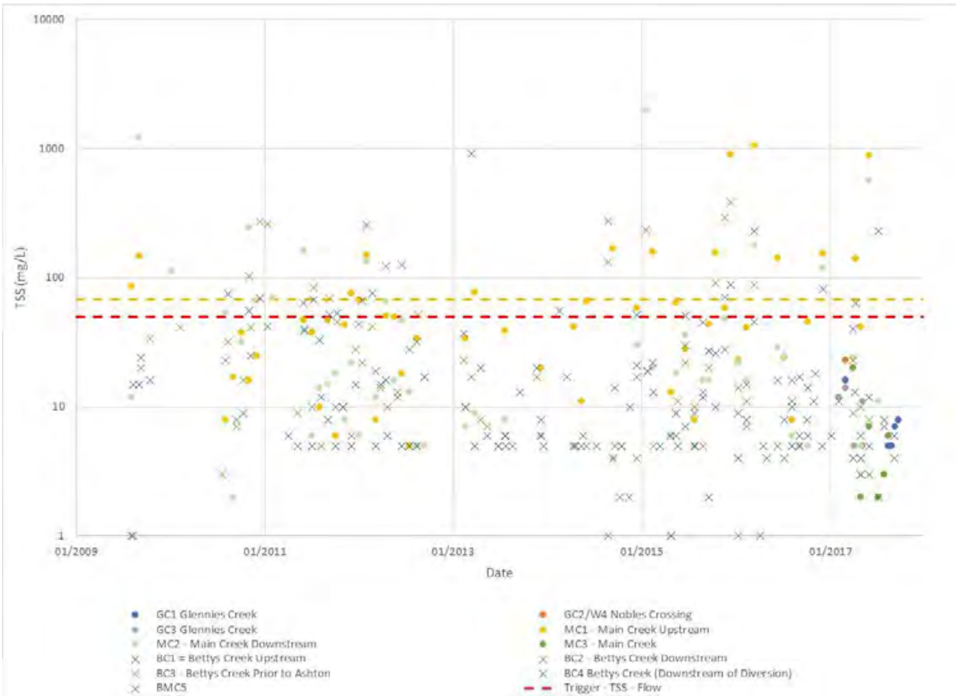


Figure N - Clean water system – TSS

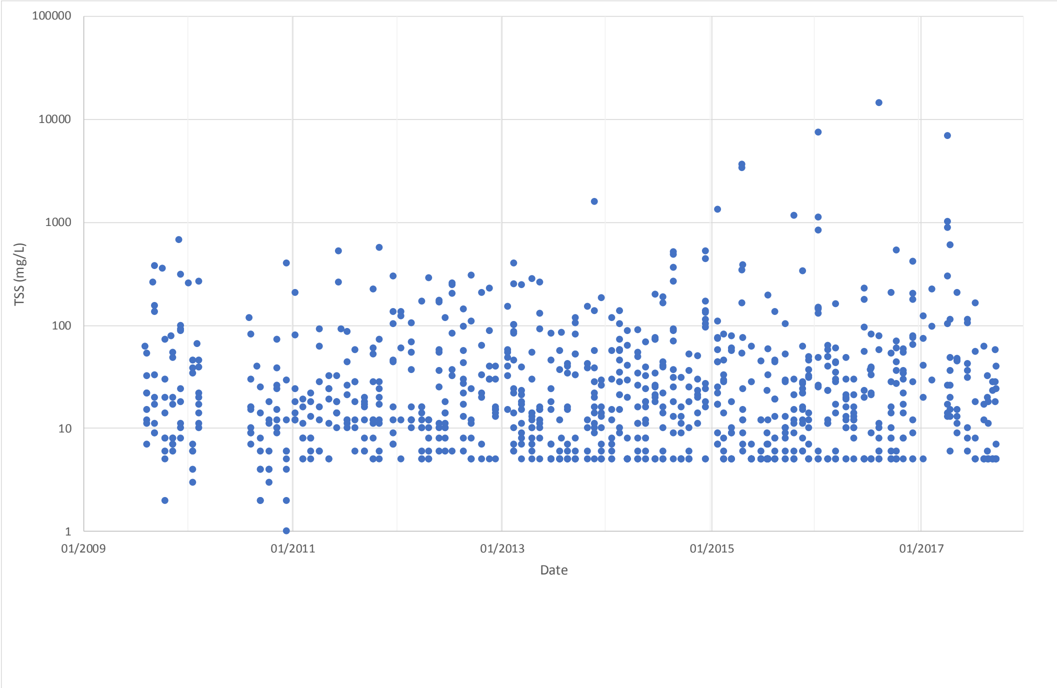


Figure O - Dirty water system – TSS

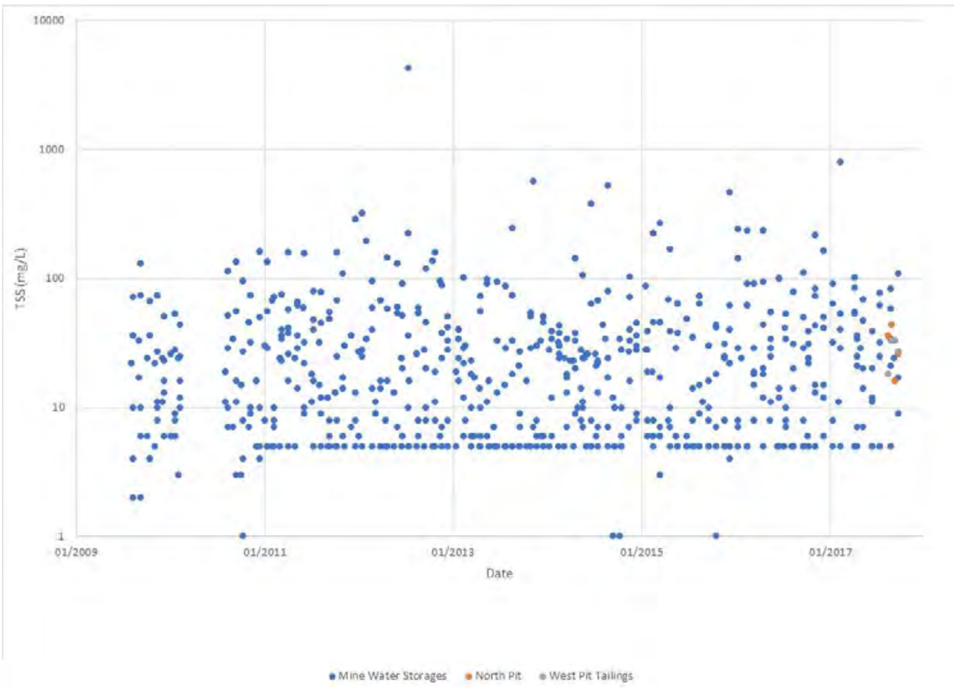


Figure P - Mine water system – TSS

Nutrients and Organics Analysis (data range from August 2009 to September 2017)

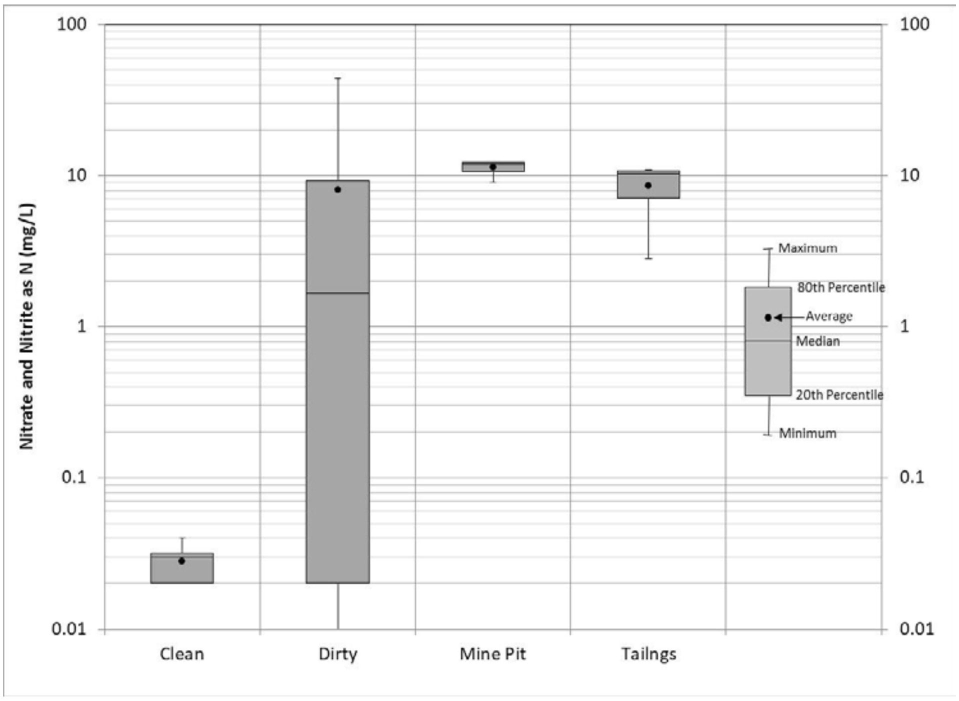


Figure Q - Nitrate and Nitrite as N Water Quality Monitoring Analysis

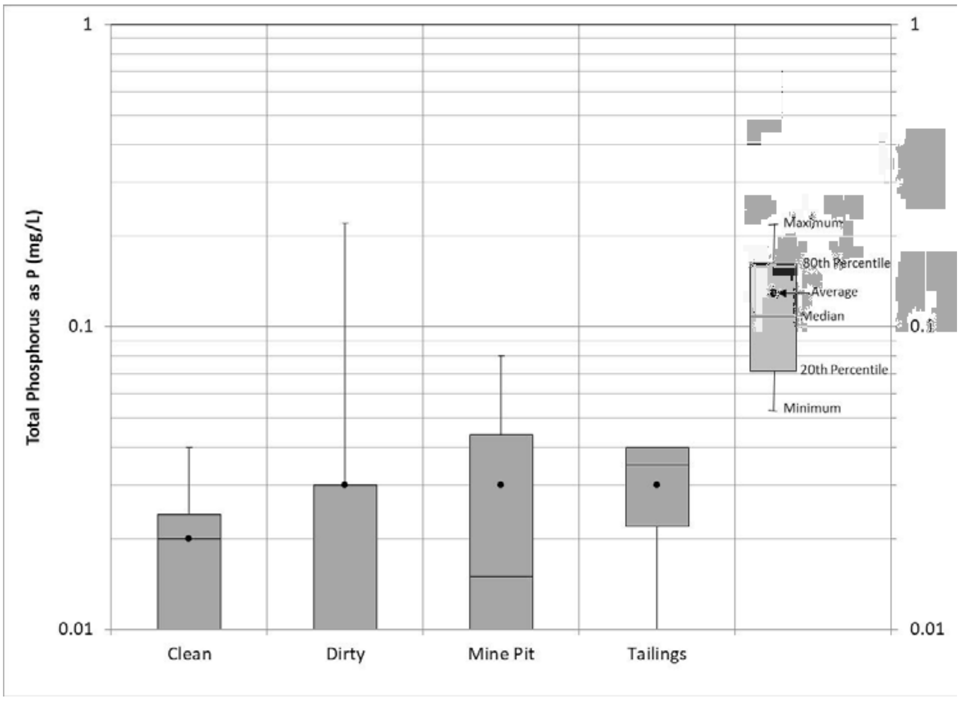


Figure R - Total Phosphorus as P Water Quality Monitoring Analysis

Total Metals Analysis (data range from August 2009 to September 2017)

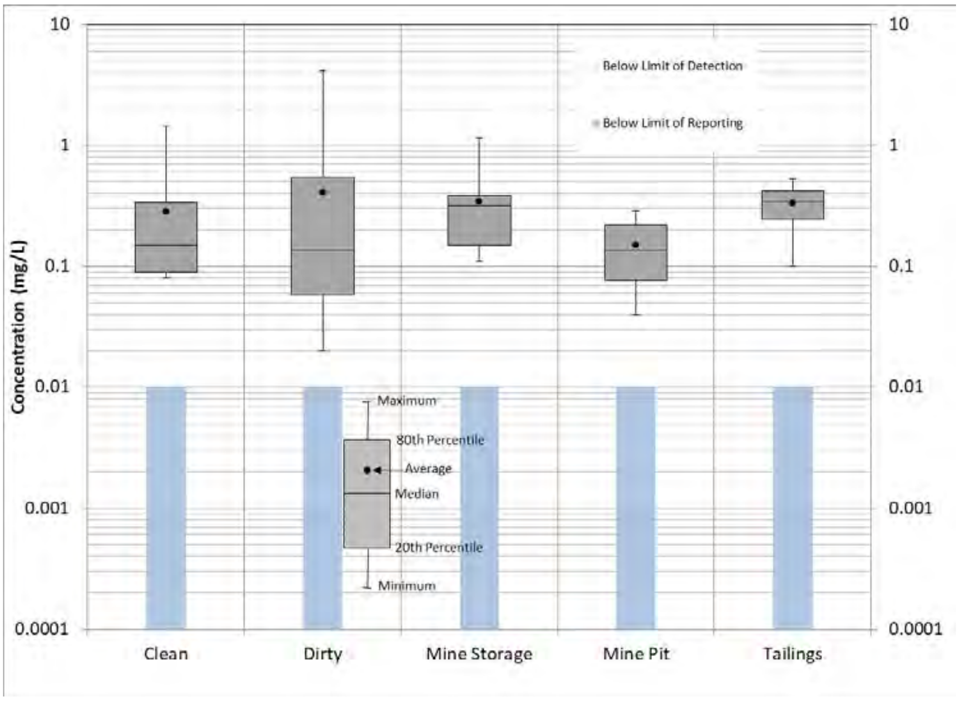


Figure S - Aluminium Water Quality Monitoring Analysis

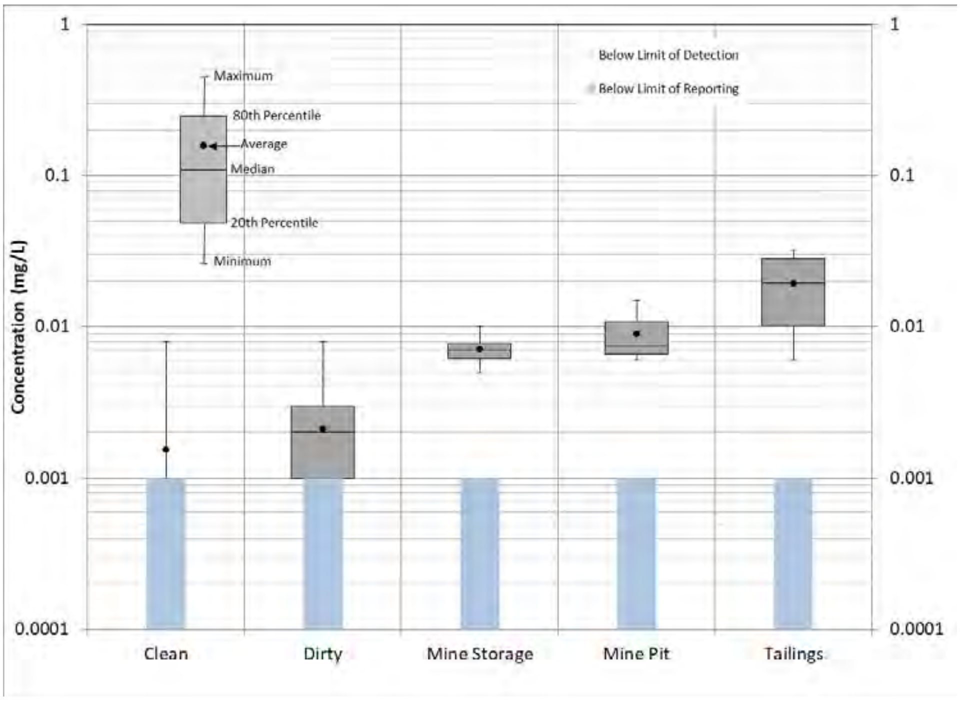


Figure T - Arsenic Water Quality Monitoring Analysis

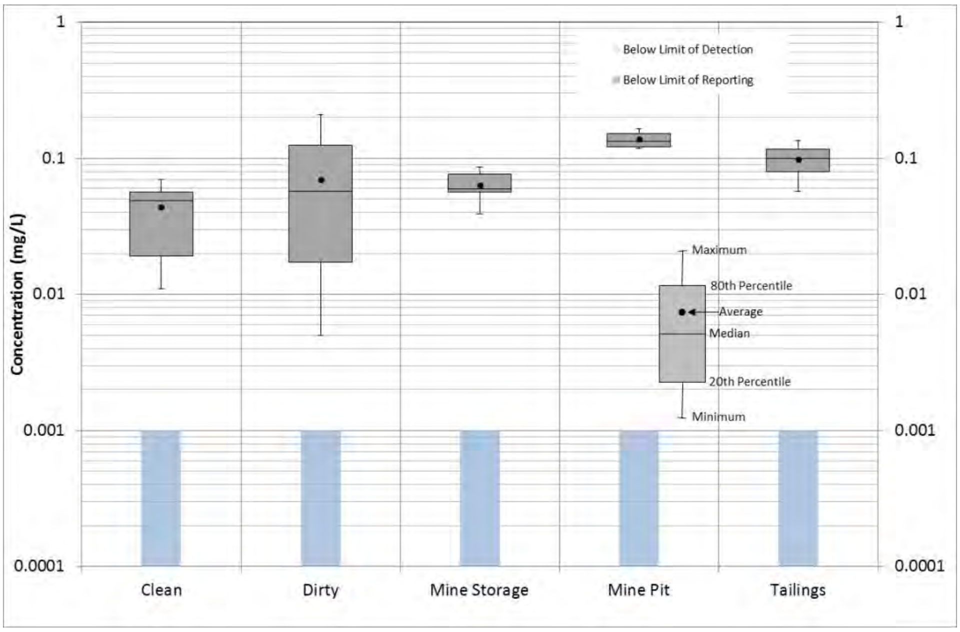


Figure U - Barium Water Quality Monitoring Analysis

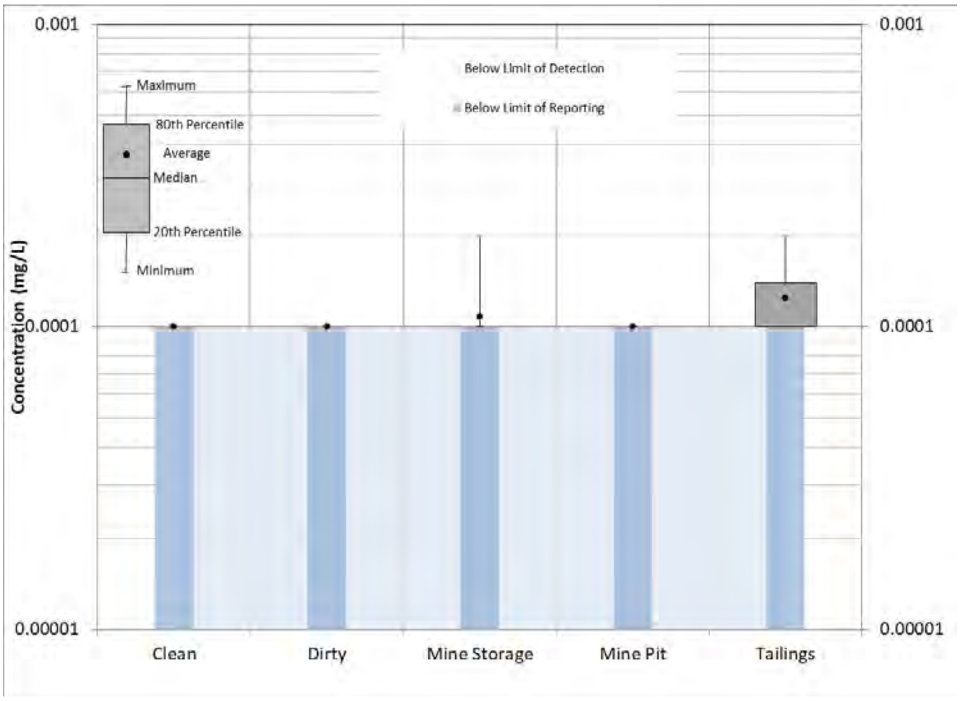


Figure V - Cadmium Water Quality Monitoring Analysis

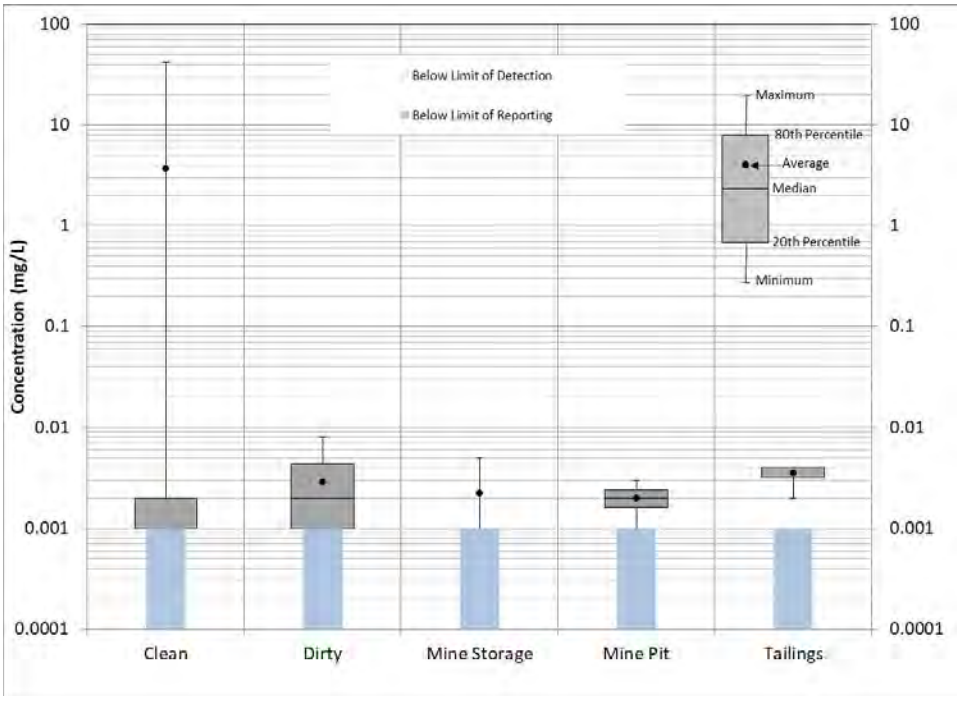


Figure W - Copper Water Quality Monitoring Analysis

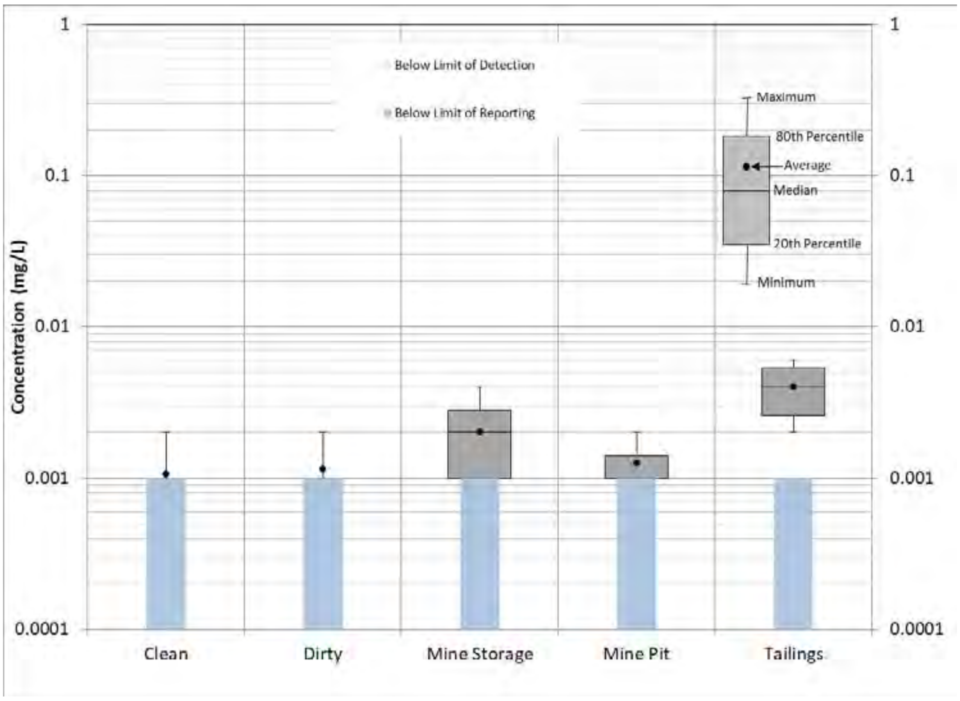


Figure X - Cobalt Water Quality Monitoring Analysis

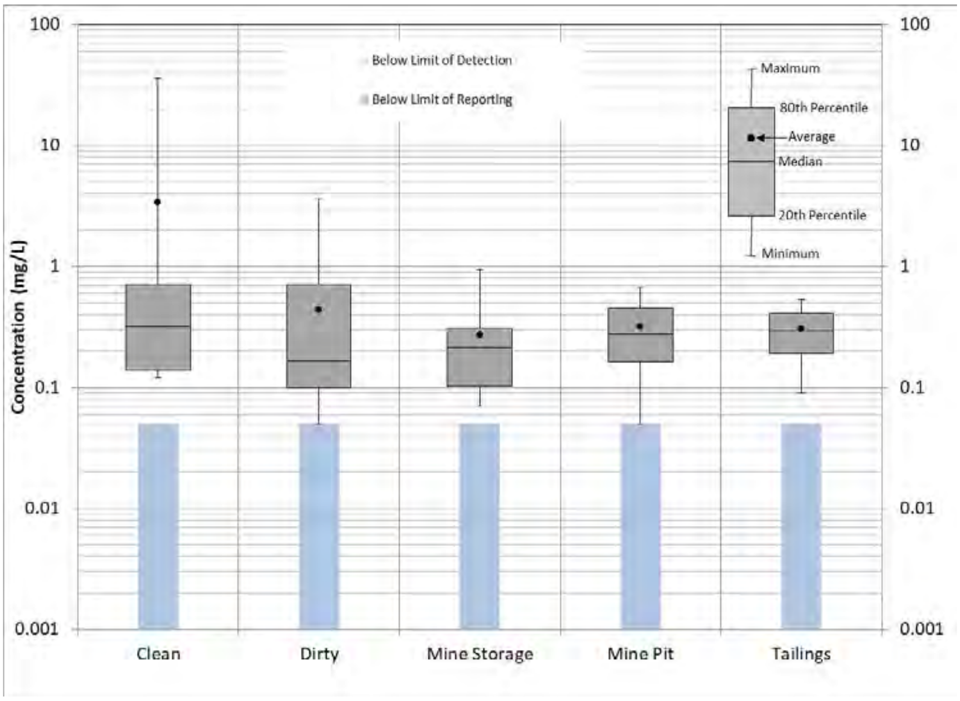


Figure Y - Iron Water Quality Monitoring Analysis

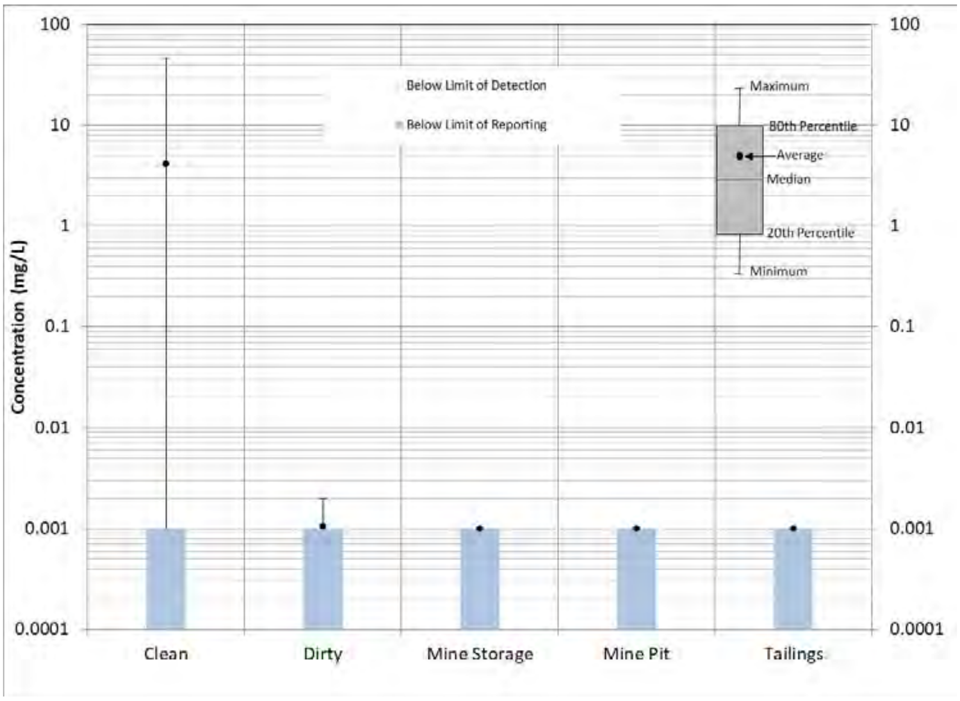


Figure Z - Lead Water Quality Monitoring Analysis

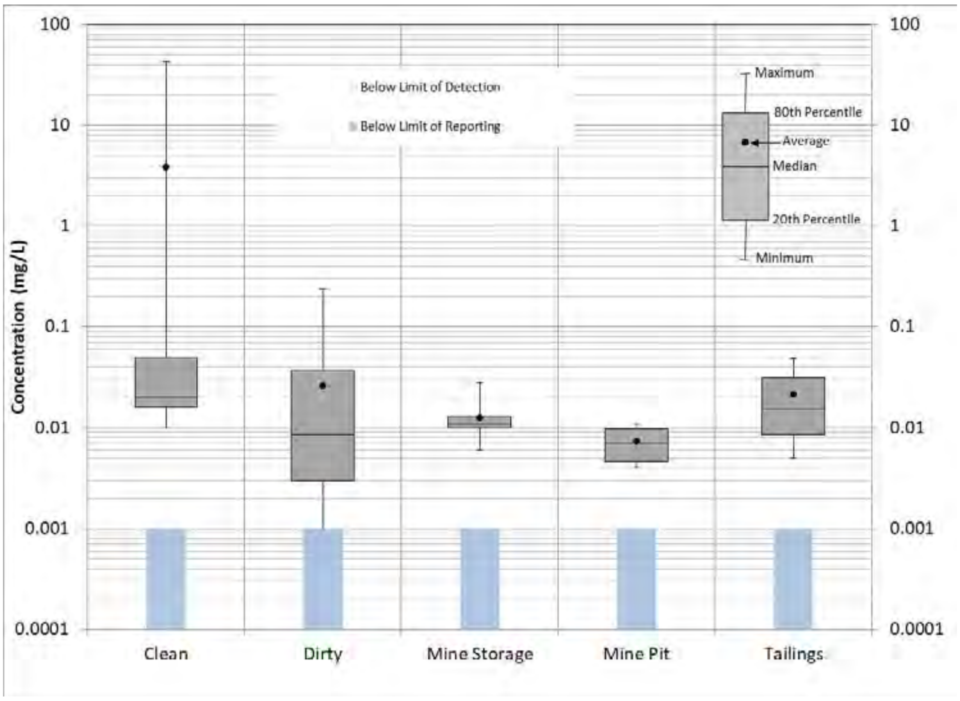


Figure AA - Manganese Water Quality Monitoring Analysis

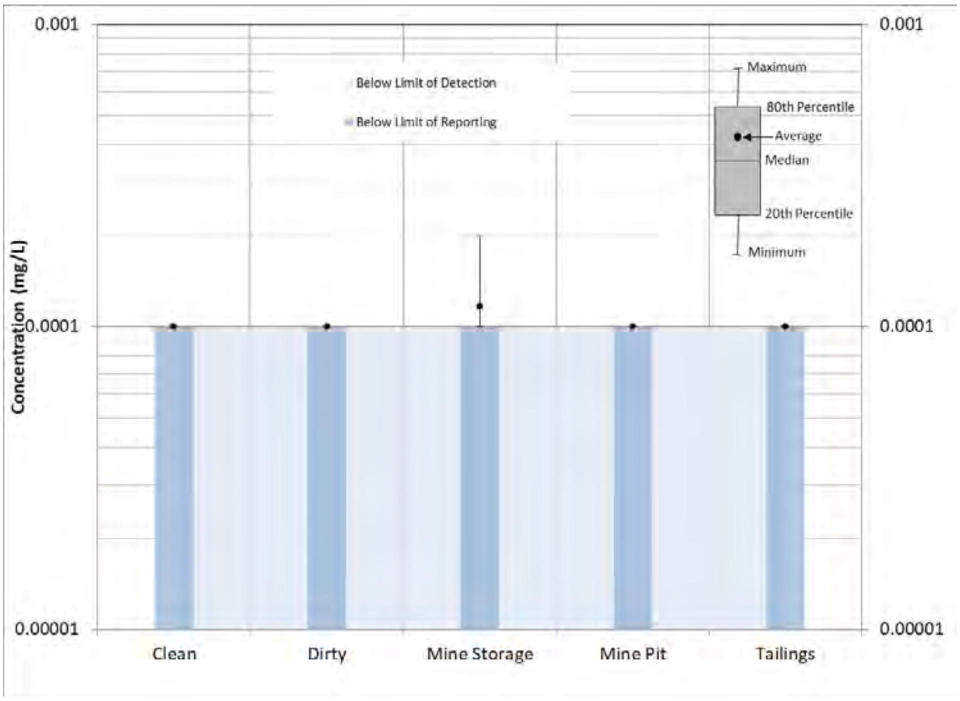


Figure AB - Mercury Water Quality Monitoring Analysis

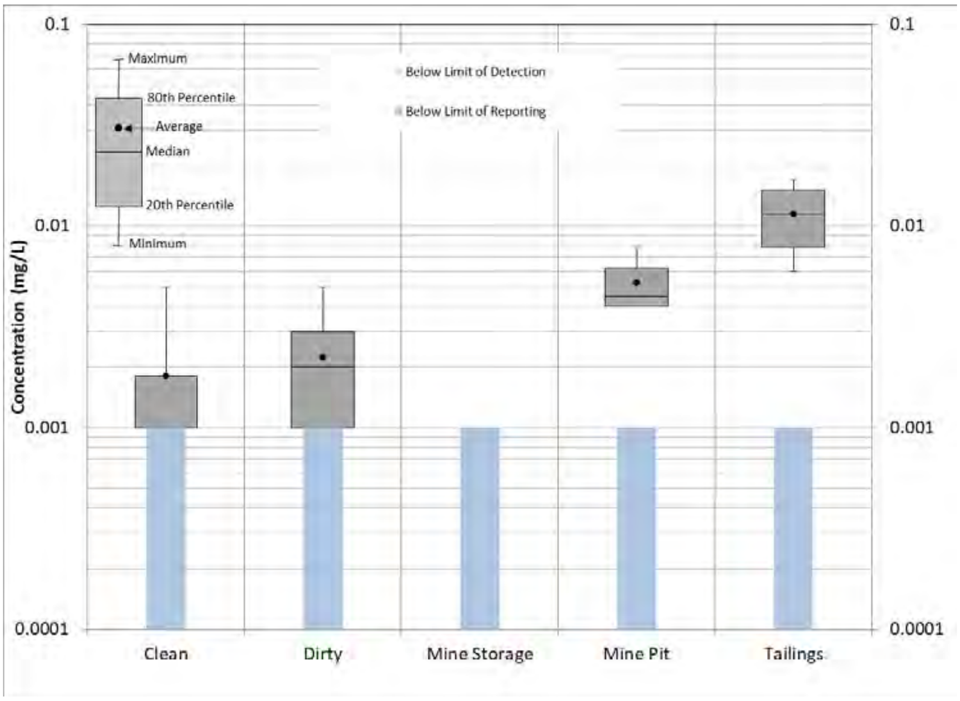


Figure AC - Nickel Water Quality Monitoring Analysis

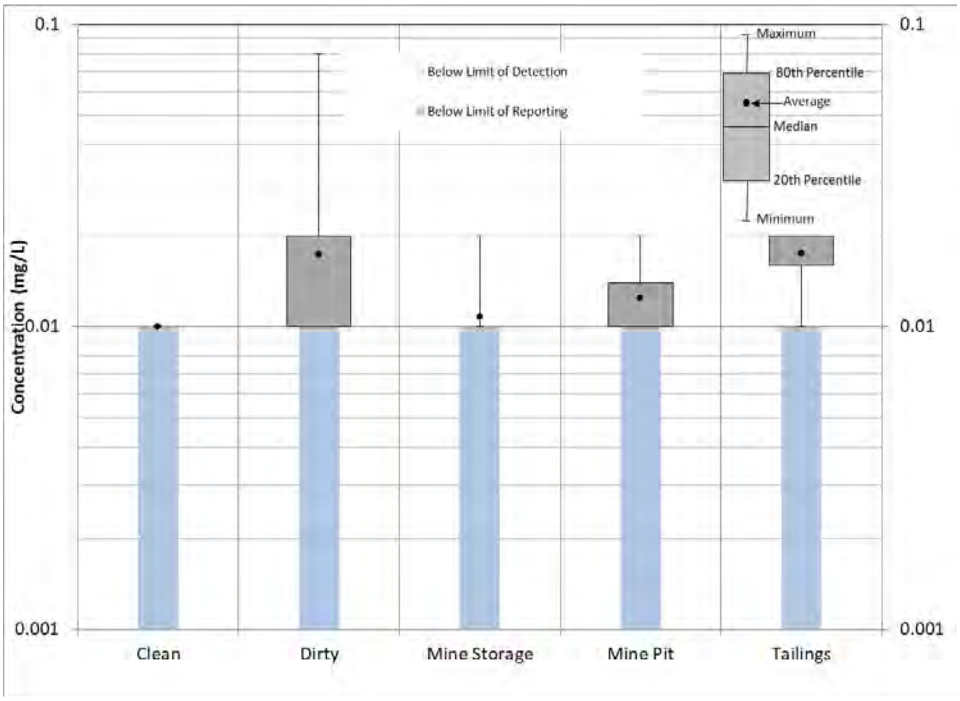


Figure AD - Selenium Water Quality Monitoring Analysis

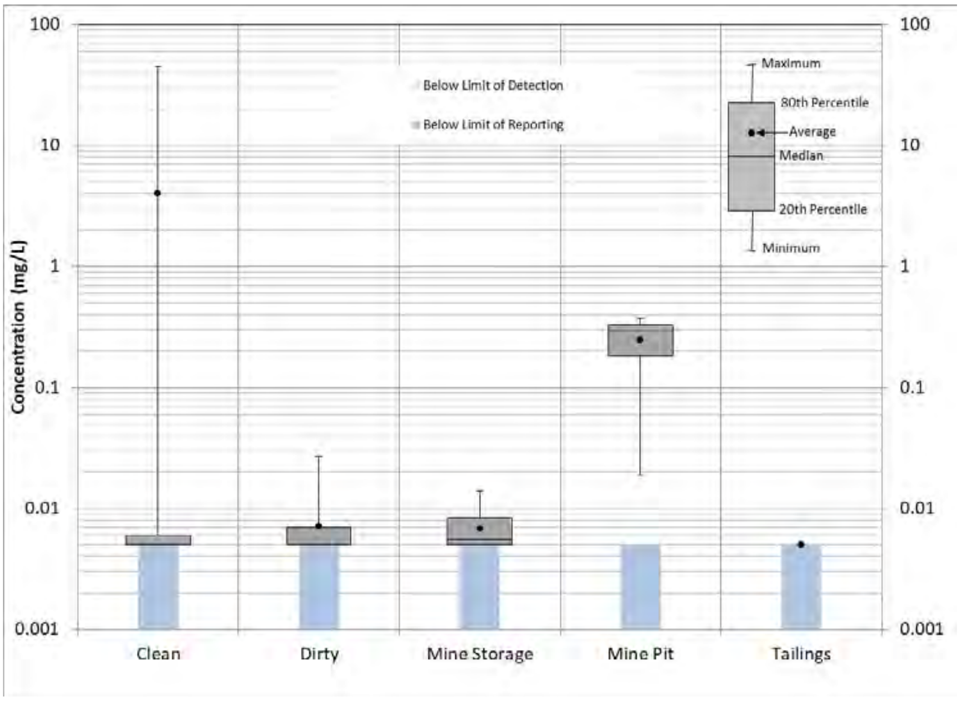
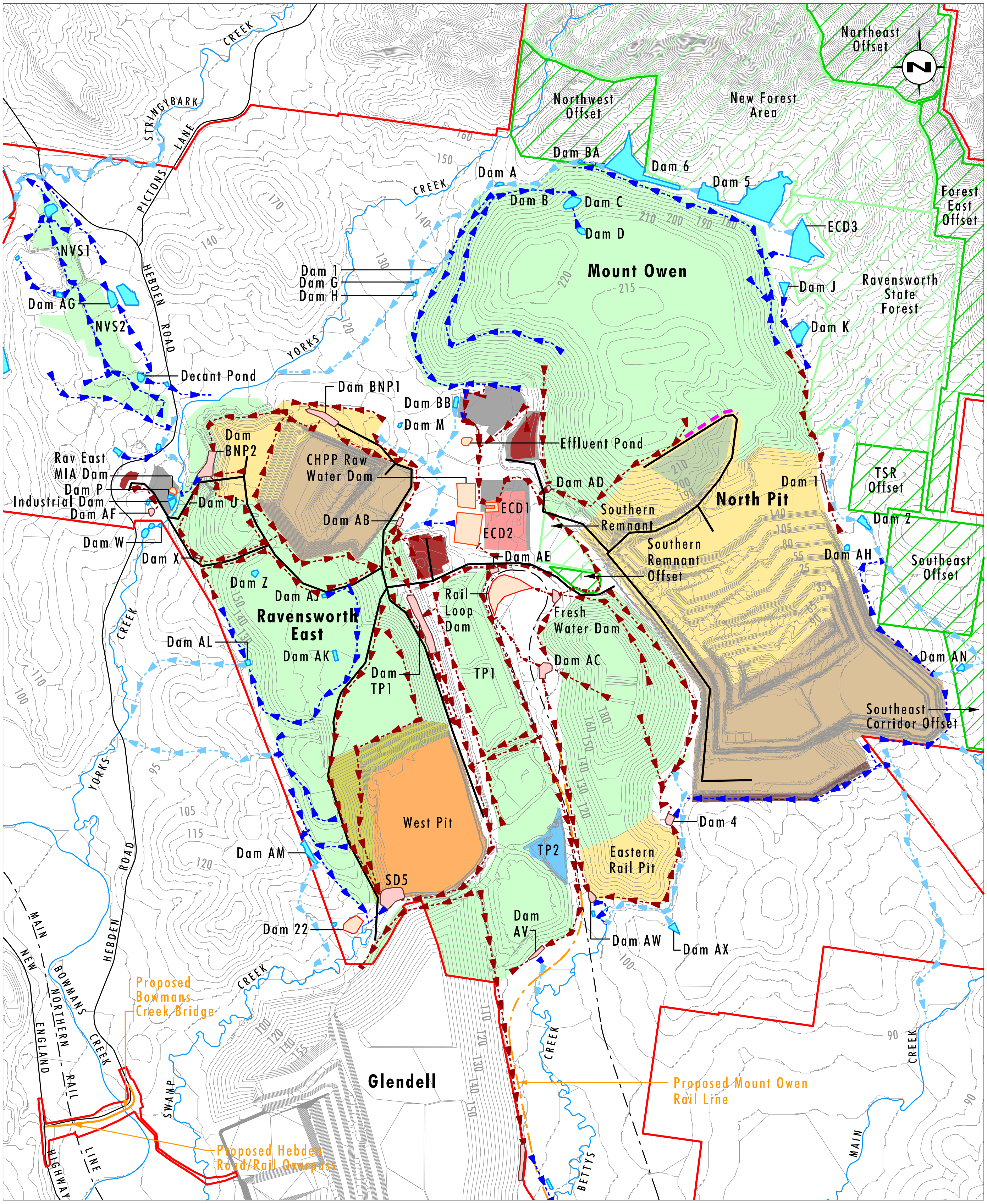


Figure AE - Zinc Water Quality Monitoring Analysis

APPENDIX B

Approved Conceptual Water Management System



Data Source: Mount Owen (2014)

Note: Contour Interval 5m(AHD). Subject to refinement as part of WMP process

0 0.5 1.0 2.0km

1:40 000

Legend

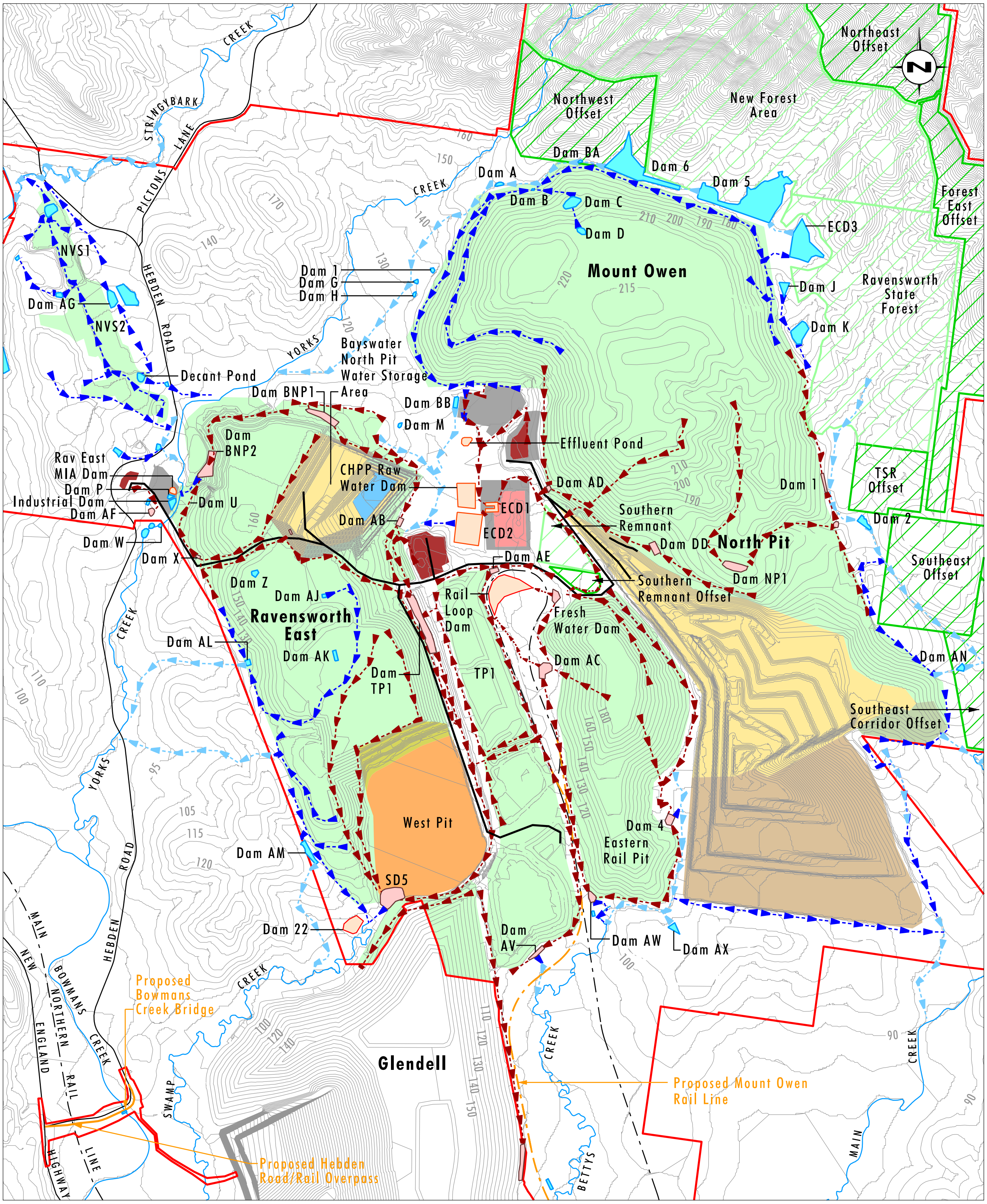
- Project Area
- Existing Biodiversity Offset Areas
- Ravensworth State Forest
- Existing Railway
- Proposed Rail Upgrade Works
- Proposed Hebden Road Upgrade Works
- Clean Water Dam
- Sediment Dam
- Mine Water Dam
- Existing Flow Path
- Clean Water Diversion Drain
- Dirty Water Drain
- Windrow
- Drainage Line
- Haul Road
- Active Mining Area
- Active Overburden Emplacement Area
- Topsoil Removal
- Coal Stockpile - Product
- Coal Stockpile - ROM
- Infrastructure
- Rehabilitation - Complete
- Rehabilitation - Temporary
- Shaped Not Seeded
- Tailings Placement
- Water Storage Area

FIGURE 2.3

Conceptual Surface Water Management Year 5

File Name (A4): R21/3109_1131.dgn
20160513 8.32

umwelt



Data Source: Mount Owen (2014)

Note: Contour Interval 5m(AHD). Subject to refinement as part of WMP process

0 0.5 1.0 2.0km

1:40 000

Legend

- Project Area
- Existing Biodiversity Offset Areas
- Ravensworth State Forest
- Existing Railway
- Proposed Rail Upgrade Works
- Proposed Hebden Road Upgrade Works
- Clean Water Dam
- Sediment Dam
- Mine Water Dam
- Existing Flow Path
- Clean Water Diversion Drain
- Dirty Water Drain
- Drainage Line
- Haul Road
- Active Mining Area
- Active Overburden Emplacement Area
- Coal Stockpile - Product
- Coal Stockpile - ROM
- Infrastructure
- Rehabilitation - Complete
- Rehabilitation - Temporary
- Shaped Not Seeded
- Tailings Placement
- Water Storage Area

FIGURE 2.4

Conceptual Surface Water Management Year 10

File Name (A4): R21/3109_1132.dgn
20160513 8.33