APPENDIX 9

Surface Water Assessment

Inspired people | Dedicated team
Quality outcomes

SURFACE WATER ASSESSMENT

Mount Owen Continued Operations Project

FINAL

October 2014

GLENCORE

SURFACE WATER ASSESSMENT

Mount Owen Continued Operations Project

FINAL

October 2014

Prepared by
Umwelt (Australia) Pty Limited

on behalf of
Mount Owen Pty Limited

Project Director:	**Barbara Crossley**
Project Manager:	**Tim Browne**
Technical Director:	**Susan Shield**
Report No.	**3109/R05/V6**
Date:	**October 2014**

umwelt

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 Introduction

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres north-west of Singleton, 24 kilometres south-east of Muswellbrook and to the north of Camberwell village (refer to **Figure 1.1**).

Mount Owen Pty Limited (Mount Owen), a subsidiary of Glencore Coal Pty Limited (formerly Xstrata Coal Pty Limited (Xstrata)), currently owns and operates the three existing open cut operations in the Mount Owen Complex; Mount Owen (North Pit), Ravensworth East (West Pit and Glendell (Barrett Pit). Mount Owen anticipate that mining will commence in the northern portion of the Ravensworth East in an area known as the Bayswater North Pit (BNP) in 2015. The mining operations at the Mount Owen Complex include the integrated use of the Mount Owen coal handling and preparation plant (CHPP), coal stockpiles and the rail load out facility (refer to **Figure 1.2**).

Mount Owen (North Pit) has an approved production rate of 10 million tonnes per annum (Mtpa) of run of mine (ROM) coal, and blended with Ravensworth East (approved 4 Mtpa) and Glendell (approved 4.5 Mtpa) ROM coal, feed the Mount Owen CHPP and associated infrastructure, which has a total approved processing capacity of 17 Mtpa of ROM coal. Processed coal, both semi soft and thermal, are transported via the Main Northern Rail Line to the Port of Newcastle for export, or by conveyor for domestic use as required.

Mount Owen expects, subject to market conditions, that mining will be completed within the currently approved area of the North Pit and the West Pit by 2018 and late 2014 respectively; and Glendell by 2022. Mount Owen has undertaken extensive exploration of its mining tenements and identified substantial additional mineable coal tonnes to the south of the currently approved North Pit. Further exploration verified economically viable reserves within an area located in the northern portion of the existing approved Ravensworth East Mine, referred to as the BNP. The proposed Ravensworth East Resource Recovery (RERR) Mining Area, is located immediately east of the West Pit and is proposed to be mined sequentially after mining has been completed in the BNP.

Mount Owen is seeking development consent for the Mount Owen Continued Operations Project (the Project) to extract these additional mineable coal tonnes through continued open cut mining methods. The Project proposes to continue the existing mining operations within the North Pit to the south beyond the current approved North Pit mining limit (the North Pit Continuation) in addition to undertaking mining operations within the BNP area, sequentially followed by the proposed RERR Mining Area (refer to **Figure 1.2**).

The Project seeks to maintain the current approved North Pit extraction rate of 10 Mtpa of ROM coal, extracting approximately 74 million tonnes (Mt) of ROM coal from the North Pit Continuation. The extraction of these additional mineable coal tonnes would continue the North Pit life to approximately 2030 (an additional 12 years). Additionally, the Project seeks to maintain the current approved Ravensworth East extraction rate of 4 Mtpa of ROM coal, and to extract approximately 12 Mt of ROM coal from the BNP. Subject to market conditions, mining within the BNP area would be undertaken from approximately 2015 to 2022, with the mining in the proposed RERR Mining Area to follow sequentially from approximately 2022 to 2027 and extract approximately 6 Mt of ROM coal.

Project will enable the consolidation of the Mount Owen and Ravensworth East Operations to provide for further operational efficiency by providing a single development consent for continued operations. The Project does not include any aspect of the ongoing operations at Glendell Mine and will continue to operate in accordance with its current development consent.

FIGURE 1.1

Locality Plan

umwelt

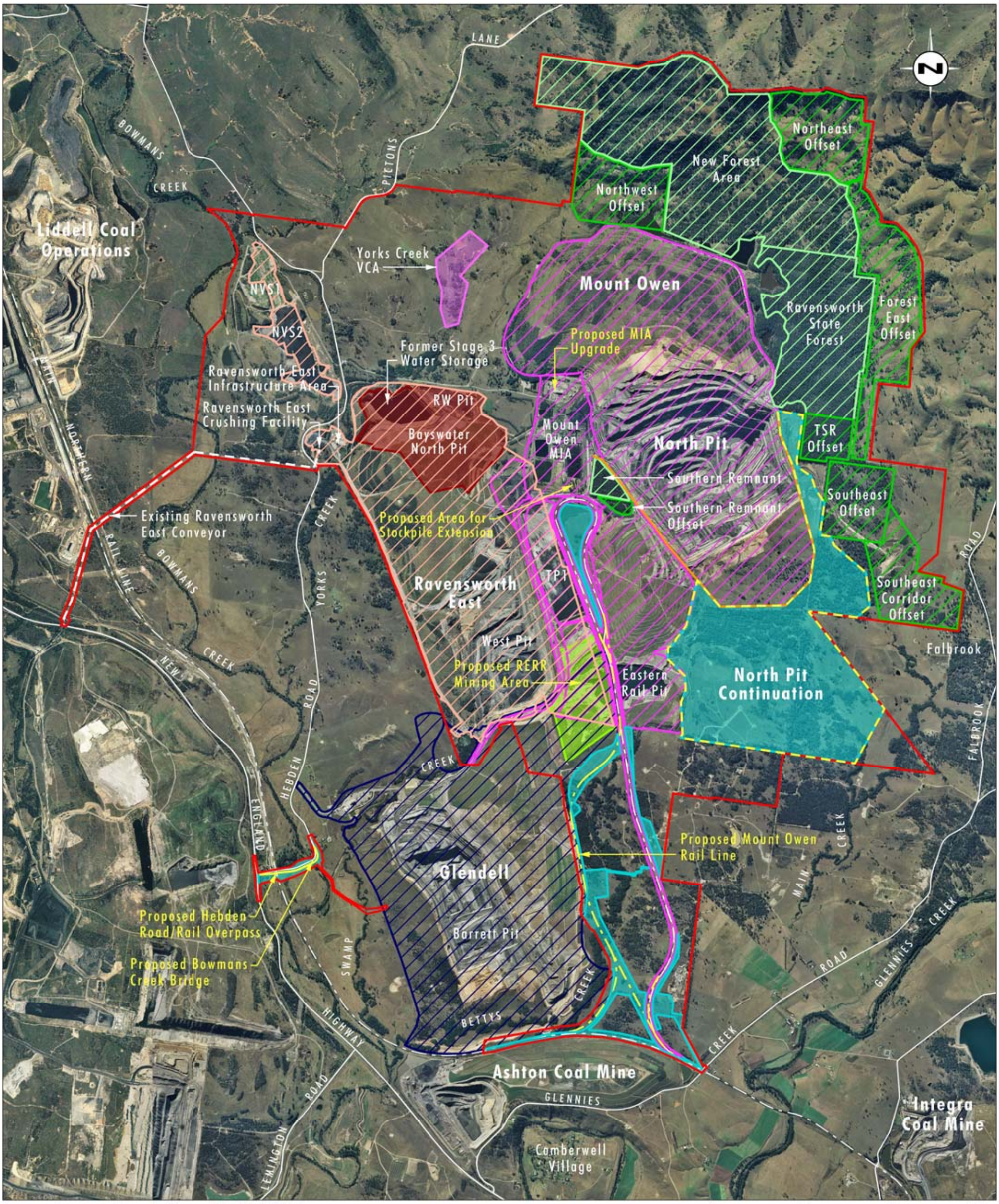


Image Source: Mount Owen (2012-2013)
Data Source: Mount Owen (2014)

0 1 2 3km
1:60 000

Legend

- Project Area
- Approved North Pit Mining Extent
- Proposed North Pit Continuation
- Proposed Rail Upgrade Works
- Proposed Hebden Road Upgrade Works
- Proposed Disturbance Area
- Proposed RERR Mining Area
- Yorks Creek VCA
- Bayswater North Pit
- Mount Owen Operational Area
- Glendell Operational Area
- Ravensworth East Operational Area
- Existing Biodiversity Offset Area
- Ravensworth State Forest

FIGURE 1.2

Proposed Mount Owen Continued Operations Project

File Name (A4): R05/3109_625.dgn
20141008 16.28

The Mount Owen Complex has an extensive existing water management system (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 (refer to **Section 3.0**).

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 Greater Ravensworth Water Sharing System (GRWSS) with the Cumnock, Ravensworth Surface Operations, Narama, Ravensworth Underground and Liddell mining operations. The GRWSS then allows greater flexibility in the mine water management by the Mount Owen Complex.

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

The Project is State Significant Development as defined by the provisions of the State Environmental Planning Policy (State and Regional Development) 2011 and requires development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Minister for Planning is the consent authority for the Project.

An Environmental Impact Statement (EIS) has been prepared for the Project to accompany a Project Application following Department of Planning and Environment (DP&E) issuing Director-General's Requirements (DGRs) for the Project (refer to **Section 1.2**). This Surface Water Assessment forms a component of the EIS.

1.1 Proposed Project

The Project aims to maintain the utilisation of the existing Mount Owen and Ravensworth East infrastructure and to maximise the recovery of mineable coal tonnes from within the existing Glencore mining tenements.

A key Project design consideration has been to maximise the efficient use of the existing infrastructure and areas previously approved for disturbance and as a result, minimise the overall surface disturbance area required for the Project as far as practicable.

The key features of the Project are outlined in **Table 1.1**. **Figure 1.2** shows the general layout of the Project. For a detailed description of the existing approved operations and the Project, refer to **Section 2.0** of the EIS.

Table 1.1 – Key Proposed Features of the Project

Key Feature	Proposed Operations
Mine Life	• Consent will be sought for 21 years (from date of Project Approval) to provide for mining until approximately 2030 and contingency for other activities such as rehabilitation and capping of tailings emplacement areas.
Limits on Extraction	No change in approved extraction rates. • North Pit – up to 10 Mtpa ROM. • Ravensworth East – up to 4 Mtpa ROM.

Table 1.1 – Key Proposed Features of the Project – cont.

Key Feature	Proposed Operations
Mine Extent	• Continuation of the North Pit footprint to the south of current approved North Pit mining limit. • Mining within the approved BNP, followed sequentially by mining within the proposed RERR Mining Area within the Ravensworth East Mine. • Mining depths to approximately 300 m (North Pit). • Total additional mineable coal tonnes of approximately 92 Mt ROM (comprising 74 Mt ROM (North Pit Continuation), 12 Mt ROM (BNP) and 6 Mt ROM (proposed RERR Mining Area). • Changes to mine water management system.
Operating Hours	• No change proposed - 24 hours per day, 7 days per week.
Workforce Numbers	• No significant change to workforce numbers is required. Current workforce required to operate North Pit and CHPP fluctuates and peaks at about 660 and the Ravensworth East development consent allows for a workforce of up to 260 to operate Ravensworth East operations. • Addition of approximately 330 personnel for construction phase for proposed infrastructure works (approximately 18 months).
Mining Methods	• No change to mining methods proposed.
Mount Owen CHPP and MIA	• No change to existing approved CHPP capacity of 17 Mtpa ROM. • product stockpile extension; • CHPP improvements (including operational efficiencies) to increase processing capacity and tailings management; • MIA extensions and improvements;
Existing Mine Infrastructure	• Continued utilisation of all existing mining infrastructure, including the existing crushing plant for the crushing of overburden.
Infrastructure Construction Activities	• Infrastructure upgrades including: ▪ provision for a northern rail line turn-out and additional Mount Owen rail line; Hebden Road overpass over Main Northern Rail Line; and ▪ New Hebden Road bridge crossing over Bowmans Creek.
Tailings and Coarse Reject Emplacement	• Continued use of the Ravensworth East voids for tailings emplacement and co-disposal of coarse reject and overburden within the North Pit Continuation, the West Pit / BNP and the proposed RERR Mining Area as mining progresses. • Tailings cells may be constructed and filled within the North Pit Continuation area as required to allow time for consolidation and drying of tailings in the West Pit and the proposed RERR Mining Area. • Allowance for the receipt of tailings from other mines.
Coal Transportation	• No change to current export coal transportation with the exception of the use of the proposed additional rail line. • No change to capacity of 17 Mtpa ROM coal. • Use of existing rail line for Glencore train park up. • Transportation of up to 2 Mtpa ROM coal and crushed gravel on an as required basis via the existing overland conveyor to Liddell Coal Operations and the RCT in addition to maintaining the current approval to transport ROM coal to Bayswater and Liddell power stations.

1.1.1 Avoidance of Potential Surface Water Impacts

As discussed in the EIS for the Project, Mount Owen has completed detailed iterative environmental studies to inform the proposed conceptual design for the Project.

Specifically in relation to minimising the impact on water sources this has included:

- the extent of the North Pit Continuation has been designed with a minimum standoff of 200 metres from the high bank of Main Creek in accordance with the minimal harm criteria of the NSW Aquifer Interference Policy (2012);
- the proposed Bowmans Creek Bridge has been designed so that the bridge piers will not be located within the low flow channel of Bowmans Creek; and
- the proposed rail bridge over Bettys Creek has been designed to minimise disturbance within the Bettys Creek channel.

1.2 Director-General's Requirements

The Director-General of the DP&E has provided requirements for the Project (DGRs) that identify key issues for consideration in the EIS.

The requirements of the DGRs relating to surface water and the sections where these requirements are addressed in this report are set out in **Table 1.2**.

Table 1.2 – Director-General's Requirements

Surface Water Assessment Requirements	Section of Report
Detailed assessment of potential impacts on the quality and quantity of existing surface and groundwater resources, including:	
• detailed modelling of potential groundwater impacts;	Refer to Groundwater Assessment - EIS Appendix 10
• impacts on affected licensed water users and basic landholder rights; and	**Section 6.6**
• impacts on riparian, ecological, geomorphological and hydrological values of watercourses, including environmental flows.	**Sections 6.4** and **6.5**
A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume, salinity and frequency of any water discharges), water supply infrastructure and water storage structures.	**Sections 4.0** and **5.0** and **Appendix B**
An assessment of proposed water discharge quantities and quality/ies against receiving water quality and flow objectives.	**Sections 2.0**, **5.0** and **6.0**
Assessment of impacts of salinity from mining operations, including disposal and management of coal rejects and modified hydrogeology, a salinity budget and the evaluation of salt migration to surface and groundwater sources.	**Section 5.0** and Groundwater Assessment (EIS Appendix 10).
Identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*.	**Section 8.3**
Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP).	**Sections 5.0** and **8.3**

Table 1.2 – Director-General's Requirements – cont.

A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo.	**Sections 2.0** and **8.3**
A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.	**Sections 3.0**, **6.0** and **8.1**
Compliance with the Hunter River Salinity Trading Scheme.	**Sections 3.0**, **5.0** and **7.0**

1.3 Potential Surface Water Impacts

The following are the key aspects of the Project that have the potential to impact on the surface water resources:

- landform changes as a result of the North Pit Continuation and continued mining operations within the Ravensworth East mining area, including:
  - continued mining using open cut methods;
  - ROM coal and product coal stockpiles;
  - overburden emplacement areas;
  - clean water diversions;
  - the emplacement of tailings within the West Pit and proposed RERR Mining Area at Ravensworth East Mine, and in-pit tailings cells in the North Pit Continuation;
- infrastructure upgrades including:
  - product coal stockpile extension;
  - CHPP improvements (including operational efficiencies) to increase processing capacity and tailings management;
  - MIA upgrades;
  - Hebden Road upgrades;
  - Mount Owen Complex rail line upgrades;
- changes to the Mount Owen Complex water balance associated with the Project; and
- ongoing rehabilitation of mine areas.

Some minor potential impacts may also result from proposed mining support infrastructure and associated services.

The location of these proposed changes and the associated conceptual surface water management system are shown in **Figures 1.2**, and **4.2** to **4.5,** and are discussed in **Section 4.0**. The potential impacts of the Project and proposed surface water management strategies are discussed in **Section 6.0**.

1.4 Structure of this Report

The key components of the Surface Water Assessment Report for the Project are included in the following sections:

- Director-General's Requirements relevant to surface water assessment (refer to **Table 1.2**);
- Surface water context, including existing watercourses, catchment context and water quality; **Section 2.0**, **Appendix A**.
- Existing Water Management System; **Section 3.0**.
- Proposed Water Management System; **Section 4.0**.
- Water balance; **Section 5.0**.
- Potential impacts of the Project and proposed surface water management strategies; **Sections 6.0** and **7.0**.
- Monitoring, Licensing and Reporting; **Section 8.0**.

2.0 Surface Water Context

The Project involves continued operations within portions of catchments that are currently subject to extensive mining or impacts associated with mining, and have well established and robust existing water management systems in place to minimise surface water impacts. The following sections describe the nature of these catchment areas and associated watercourses, existing water quality and licensing provisions. There is limited downstream water use in the associated watercourses, as described in **Section 2.3**.

2.1 Catchment Areas and Watercourses

The Project Area is located within the catchments of Bowmans Creek and Glennies Creek. Both Bowmans Creek and Glennies Creek flow into the Hunter River to the south of the Project Area. Bowmans Creek catchment is located to the north and west of the Project Area, while Glennies Creek is located to the east and south (refer to **Figure 2.1**). In the vicinity of the Project Area, the Bowmans Creek catchment includes the sub catchments of Stringybark Creek, Yorks Creek, Swamp Creek and Bettys Creek and Glennies Creek catchment includes the sub catchment of Main Creek (refer to **Figure 2.2**). The existing Mount Owen Complex WMS is located within the Project Area. The extent of the Mount Owen Complex WMS is shown on **Figure 2.2**.

Land uses within and immediately surrounding the Project Area include other mining operations, State Forest, biodiversity offset areas and rural residential land holdings. Downstream water users are discussed further in **Section 2.3**.

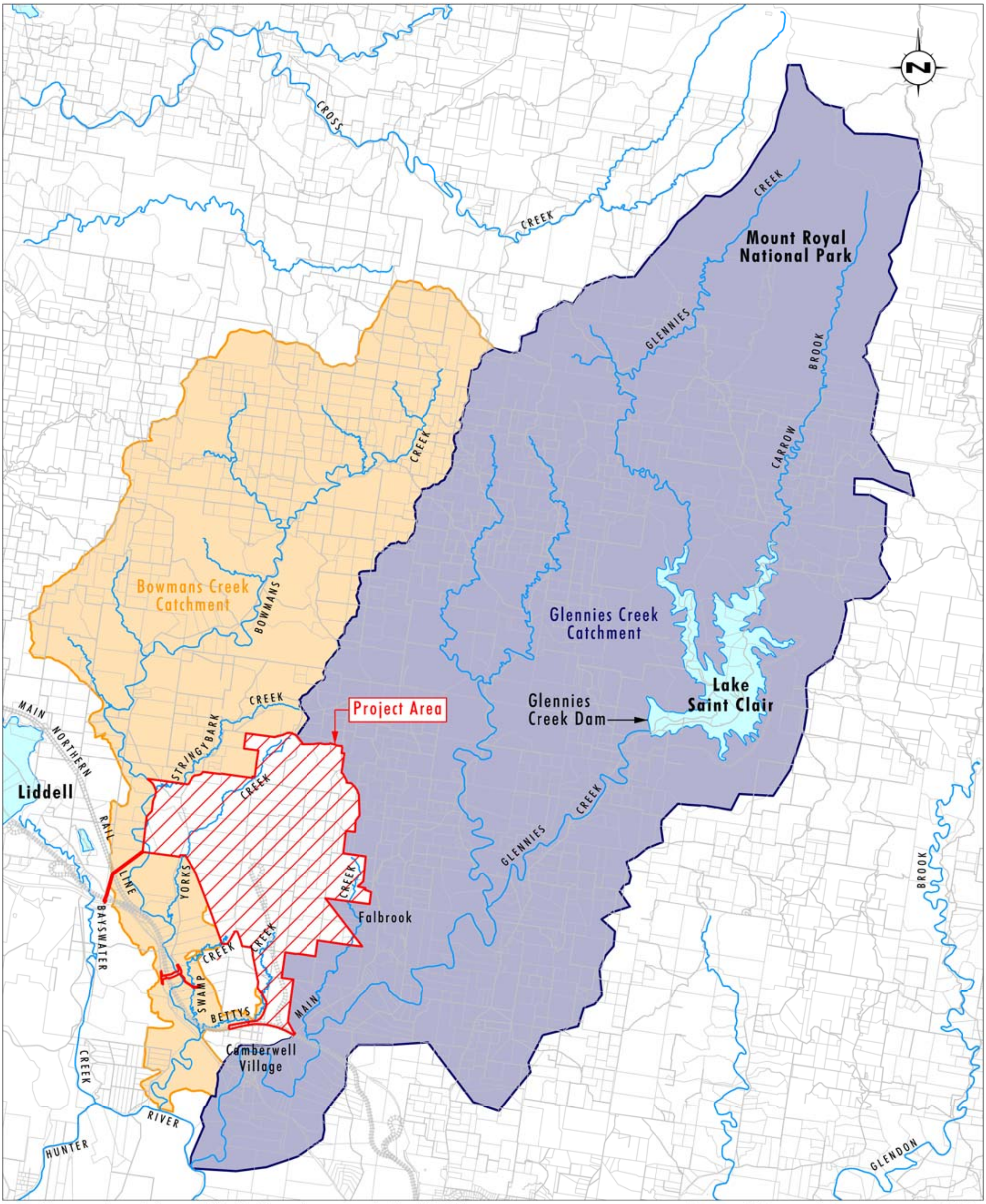
The catchment boundaries for watercourses within and surrounding the Project Area are shown in **Figure 2.2**. Previous mining operations within the Project Area have modified local catchments through the capture of runoff from mining areas within the WMS and diversion of upslope runoff around the mining operations.

For each watercourse within the Project Area, the stream order, pre-mining catchment area, current catchment area and current approved final landform catchment area are included in **Table 2.1**.

Table 2.1 – Project Area Catchments

Watercourse		**Catchment Areas**		
Name	**Schedule (order)[1]**	**Pre-mining[2] (ha)**	**Current [3,4] (ha)**	**Final Approved Landform[3,4] (ha)**
Bowmans Creek	**3 (6th order)**	**25,055**	**22,010**	**20,390**
Stringybark Creek	2 (3rd order)	1,290	1,220	1,300
Yorks Creek	2 (3rd order)	1,230	1,580	1,660
Swamp Creek	2 (4th order)	2,380	410	1,440
Bettys Creek	2 (4th order)	1,810	660	960
Glennies Creek	**3 (6th order)**	**52,335**	**50,265**	**50,405**
Main Creek	2 (4th order)	2,000	2,480	2,620

Notes 1) Strahler watercourse ordering classification.
2) Based on 1:25,000 LPI topographical map series.
3) Does not include water management system 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 diversions.



Data Source: Mount Owen (2014), Geoscience Australia (2006), Department of Lands (2009)

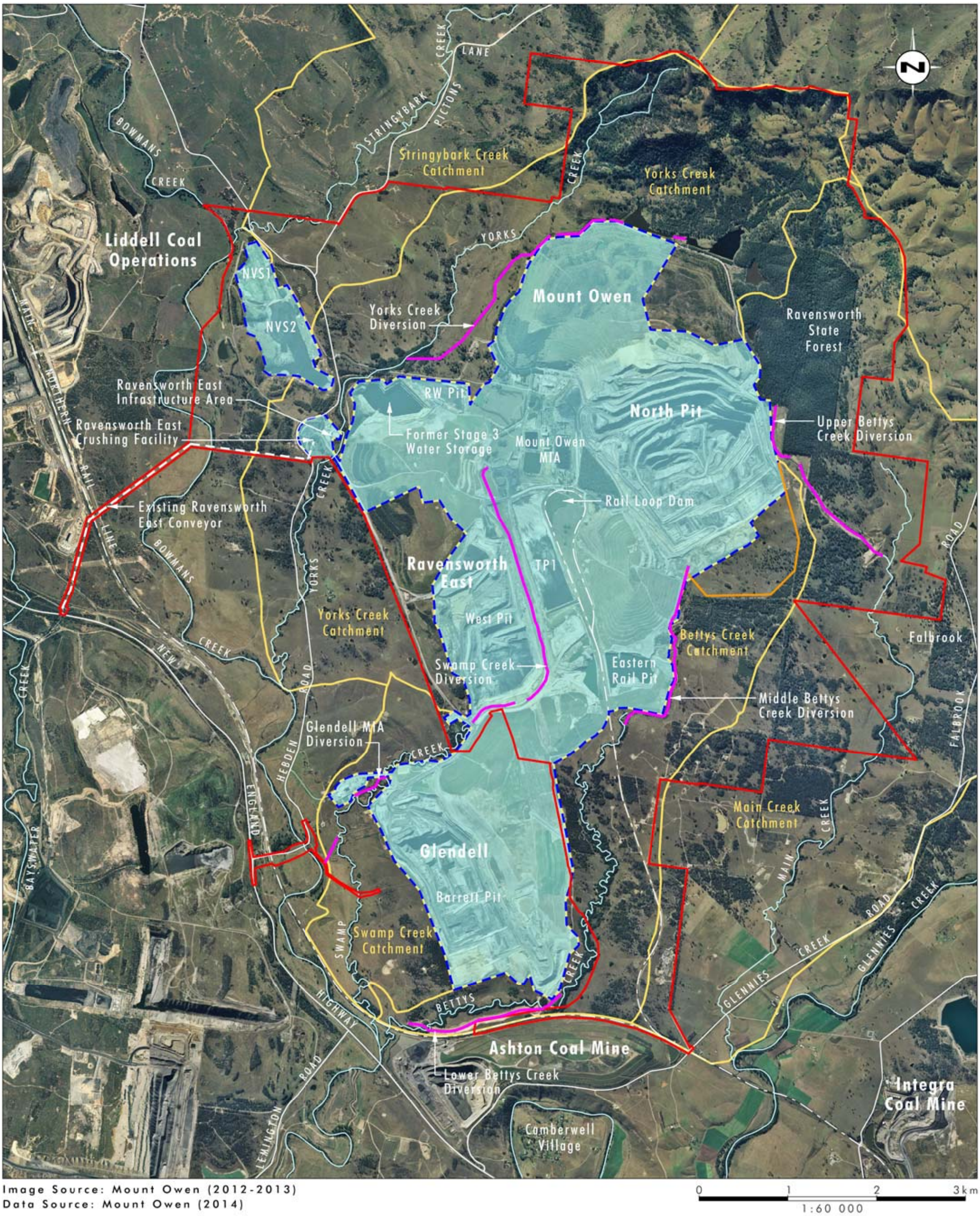
0 2.5 5.0 10.0km
1:200 000

Legend
Project Area
Glennies Creek Catchment Area
Bowmans Creek Catchment Area
Cadastre
Railway
Drainage Line

FIGURE 2.1

Catchment Context

File Name (A4): R05/3109_624.dgn
20140901 9.59



Legend

- Project Area
- Approved North Pit Mining Extent
- Mount Owen Complex Water Management System Catchment
- Catchment Boundary
- Existing Diversion Channel

FIGURE 2.2

Project Area Surface Water Catchment Context

File Name (A4): R05/3109_503.dgn
20140915 16.54

2.1.1 Bowmans Creek

The headwaters of Bowmans Creek are located 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 kilometre wide.

Bowmans Creek has four major tributaries in the vicinity of the Project Area, namely Stringybark Creek, Yorks Creek, Swamp Creek, and Bettys Creek. The catchment area of Bowmans Creek within the Project Area has been reduced by the existing mining operations. 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 soil landscape within the lower catchment is predominantly the Liddell (ld) soil landscape with very low relief, gentle slopes, low fertility and slightly acidic topsoil. The soil landscape within the upper catchment is predominantly the Rosevale (rv) soil landscape with low relief, slopes of 15 per cent to 20 per cent, low to moderate fertility and slightly acidic topsoil. Liddell soils in these areas are imperfectly drained and have a high to very high erosion potential (Kovac and Lawrie 1991). Rosevale soils in these areas are imperfectly to well drained and have low to high erosion potential (Kovac and Lawrie 1991). The other soil landscapes in the catchment (typically Hunter (hu) and Bayswater (bz)) also tend to be moderately susceptible to erosion (further details on soil landscapes are provided in Section 5.1 and Appendix 12 of the EIS).

The Project 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 proposed over Bowmans Creek on Hebden Road to allow for two-way traffic movements. There is no proposed mining associated with the Project within the direct catchment area of Bowmans Creek.

2.1.2 Stringybark Creek

Stringybark Creek is a tributary of Bowmans Creek and is located upstream of the Project Area. Stringybark Creek is an ephemeral waterway with a well defined channel, varying from confined areas with a relatively narrow width to wider open sections. The wider sections have floodplain widths of typically up to 70 metres in extent and tend to be characterised by wooded vegetation.

Stringybark Creek is largely unaffected by the Project. The only part of Stringybark Creek catchment that is currently part of the Mount Owen Complex WMS (refer to **Figure 2.2**) is the existing tailings emplacement areas North Void Stage 1 (NVS1) and North Void Stage 2 (NVS2), located in the northern part of the Project Area to the north-east of Ravensworth East Mine. NVS1 has already been capped and by Year 1 of the Project, NVS1 and NVS2 will be capped and revegetated. In Year 1 of the Project, NVS1 vegetation will be fully established and runoff will be returned to Stringybark Creek. NVS2 will be in the final stages of rehabilitation in year one, and runoff from the NVS2 area will be classed as dirty for up to 2 years after rehabilitation is complete until vegetation is fully established, upon which runoff will be returned to Stringybark Creek (refer to **Section 4.2.1**).

2.1.3 Yorks Creek

Yorks Creek is a tributary of Bowmans Creek. Yorks Creek typically has a defined channel several metres in width and approximately 1 metre to 1.2 metres 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. Yorks Creek is ephemeral and is frequently dry and is considered typical of the Schedule 2 (3^{rd} to 4^{th} order) watercourses in the area.

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 hectares) to Yorks Creek. Approximately 120 hectares of the catchment is incorporated into the WMS for the Ravensworth East Mine. As part of this Project it is proposed to divert an additional 190 hectares of rehabilitated overburden emplacement from the Swamp Creek catchment into Yorks Creek (refer to **Section 4.2.1**).

The Project components located within the Yorks Creek catchment include the BNP which will be an active pit in Year 1 and Year 5. A portion of the BNP final void is located within the pre-mining catchment area of Yorks Creek. The BNP final void will be investigated for use as an operational water storage after cessation of mining in 2022. The western portion of Ravensworth East within the Yorks Creek catchment will be fully rehabilitated by Year 1 of the Project. Any runoff from the haul road to access the Ravensworth East ROM coal stockpile and the ‘M’ series conveyor will be contained as part of the Project’s WMS while operational (refer to **Figure 1.2**).

2.1.4 Swamp Creek

Swamp Creek is a tributary of Bowmans Creek. Swamp Creek is typical of 2^{nd} order watercourses in the Hunter Valley area and is an ephemeral creek. Water quality sampling on the creek has noted that the creek is frequently dry with isolated pools of water, which tend to become saline through evapo-concentration during dry periods.

The soils of the upper slopes of the catchment area of Swamp Creek are classified as Bayswater Soil Landscape, while soils of the lower slopes are classified as Hunter Soil Landscape. The Bayswater Soil Landscapes are susceptible to moderate sheet and gully erosion, particularly on steeper creek line slopes, while Hunter Soil Landscapes are The Hunter Soil Landscape is susceptible to minor stream bank erosion on watercourses and minor sheet and gully erosion (Kovac and Lawrie 1991). The creek channel is narrow and well defined with wooded vegetation. Gullies of up to 3 metres within Swamp Creek are associated with the characteristically high erodibility of the soils.

Prior to mining, the land use within the Swamp Creek catchment was typically farming and grazing.

The Swamp Creek catchment has been highly modified due to mining. These modifications include approximately 1,000 hectares of the catchment being incorporated into the WMS for the Ravensworth East and Mount Owen Mines, and two diversions. The upper Swamp Creek catchment has an approved diversion of approximately 500 hectares of Swamp Creek (Upper Swamp Creek Diversion) headwaters to Yorks Creek in addition to an approved diversion of 30 hectares to Main Creek (via the Upper Bettys Creek Diversion) to divert clean catchment flows around Mount Owen Mine. The lower catchment of Swamp Creek includes a diversion of approximately 60 hectares to Yorks Creek at Ravensworth East Mine. In addition, the middle reaches of Swamp Creek have been diverted through the mining operations (Swamp Creek Diversion) (refer to **Figure 2.2**).

The Glendell Mine is located downstream of the Project Area within the Swamp Creek catchment area. As part of the Glendell Mine, disturbed areas will be progressively rehabilitated and returned to Swamp Creek catchment over the life of the current approved Glendell development. A portion of the Glendell Mine final void is located within the pre-mining catchment area of Swamp Creek. A portion of the BNP final void is also located within the pre-mining catchment area of Swamp Creek. Further discussion on the proposed final voids is provided in **Section 4.2.4**.

As part of this Project, clean water runoff from the northern portion of the rehabilitated North Pit emplacement area will be diverted to Yorks Creek (refer to **Section 4.2.1**).

2.1.5 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.

Soils present in the Bettys Creek catchment are similar to those encountered in the Swamp Creek catchment and include Bayswater Soil Landscape in the upper slopes and Hunter Soils Landscape in the lower sections of the catchment (Kovac and Lawrie 1991). The Bayswater Soil Landscapes are susceptible to moderate sheet and gully erosion, particularly on steeper creek line slopes. The Hunter Soil Landscape is susceptible to minor stream bank erosion on watercourses and minor sheet and gully erosion.

Erosion is not a concern in the lower reaches of Bettys Creek, downstream of the Eastern Rail Pit (ERP) as in these reaches riparian vegetation is well established and dominated by casuarinas.

Before mining was undertaken in this catchment, the land use within the Bettys Creek catchment was typically farming and grazing. Currently, land use within the catchment is predominantly mining in the mid reaches and open woodland for conservation in the downstream reaches. Sections of the catchment are being revegetated and conserved as part of the existing Bettys Creek Habitat Management Area associated with Glendell Mine.

The catchment of Bettys Creek is highly modified and a large proportion of Bettys Creek catchment is currently incorporated into the Mount Owen Complex water management system. Approximately 490 hectares of the upper catchment of Bettys Creek has been diverted to the east of 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 ERP (refer to **Figure 2.2**).

The current approved North Pit extends through the mid reaches of Bettys Creek catchment, resulting in a currently approved final void of approximately 230 hectares within the pre-mining Bettys Creek catchment. Further discussion on the proposed final void as result of the Project is provided in **Section 4.2.4**. Downstream of the North Pit, Bettys Creek has also been diverted around the Glendell Mine. In addition, a portion of the Glendell Mine final void and the proposed RERR Mining Area final void is located within the pre-mining catchment area of Bettys Creek. The proposed RERR Mining Area final void will be investigated to be used as a tailings emplacement area as part of closure planning five years prior to cessation of the Project.

2.1.6 Glennies Creek

Glennies Creek flows from headwaters in the Mt Royal Range to the Hunter River approximately 3 kilometres downstream of the Hunter River's confluence point with Bowmans Creek. Glennies Creek has a catchment area approximately twice the size of Bowmans Creek and has sufficient contributing catchment to maintain flows under most climatic conditions. Glennies Creek Dam captures runoff from the upper half of the catchment.

As part of existing licence conditions, Mount Owen can extract water from Glennies Creek as a raw water supply to the Mount Owen Complex (refer to **Section 5.0**).

Glennies Creek has one tributary in the vicinity of the Project Area, namely Main Creek (refer to **Section 2.1.7**). The Project Area is approximately 4.5 kilometres upstream of the confluence of Main Creek and Glennies Creek with proposed mining operations in the Main Creek catchment, upstream of the confluence with Glennies Creek.

2.1.7 Main Creek

Main Creek is a 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 kilometres upstream of the Glennies Creek confluence with the Hunter River. The majority of the catchment is open grasslands, and the riparian zone is mostly well vegetated along the mid portion with a well defined creekline. The lower portion of the catchment is used for grazing and the creek line is poorly defined.

The upper catchment of Bettys Creek, upslope of Mount Owen Mine has been diverted 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 hectares. In the currently approved final landform, approximately 130 hectares of the upper Swamp Creek catchment is also be diverted to Main Creek via the Upper Bettys Creek diversion.

A portion of the North Pit final void is located within the pre-mining catchment area of Main Creek.

2.2 Existing Water Quality

2.2.1 Routine Surface Water Monitoring

The surface water monitoring program at the Mount Owen Complex is documented in the *Mount Owen Complex Surface Water Monitoring Program* (SWMP) (Xstrata Coal, 2012). The WMS at the Mount Owen Complex (Mount Owen, Ravensworth East and Glendell Mines) is an integrated system. Existing surface water quality monitoring locations for the Mount Owen Complex and points that are shared with Ashton and Liddell Operations are shown on **Figure 2.3**.

As described in the SWMP, Mount Owen undertakes monthly water quality monitoring for key indicator parameters such as pH, electrical conductivity (EC), total suspended solids (TSS) and Total Dissolved Solids (TDS). Water quality monitoring is undertaken by Mount Owen at 15 locations surrounding the WMS. Water quality monitoring in local watercourses is also undertaken by other Glencore mining operations in the surrounding area (refer to **Figure 2.3**).

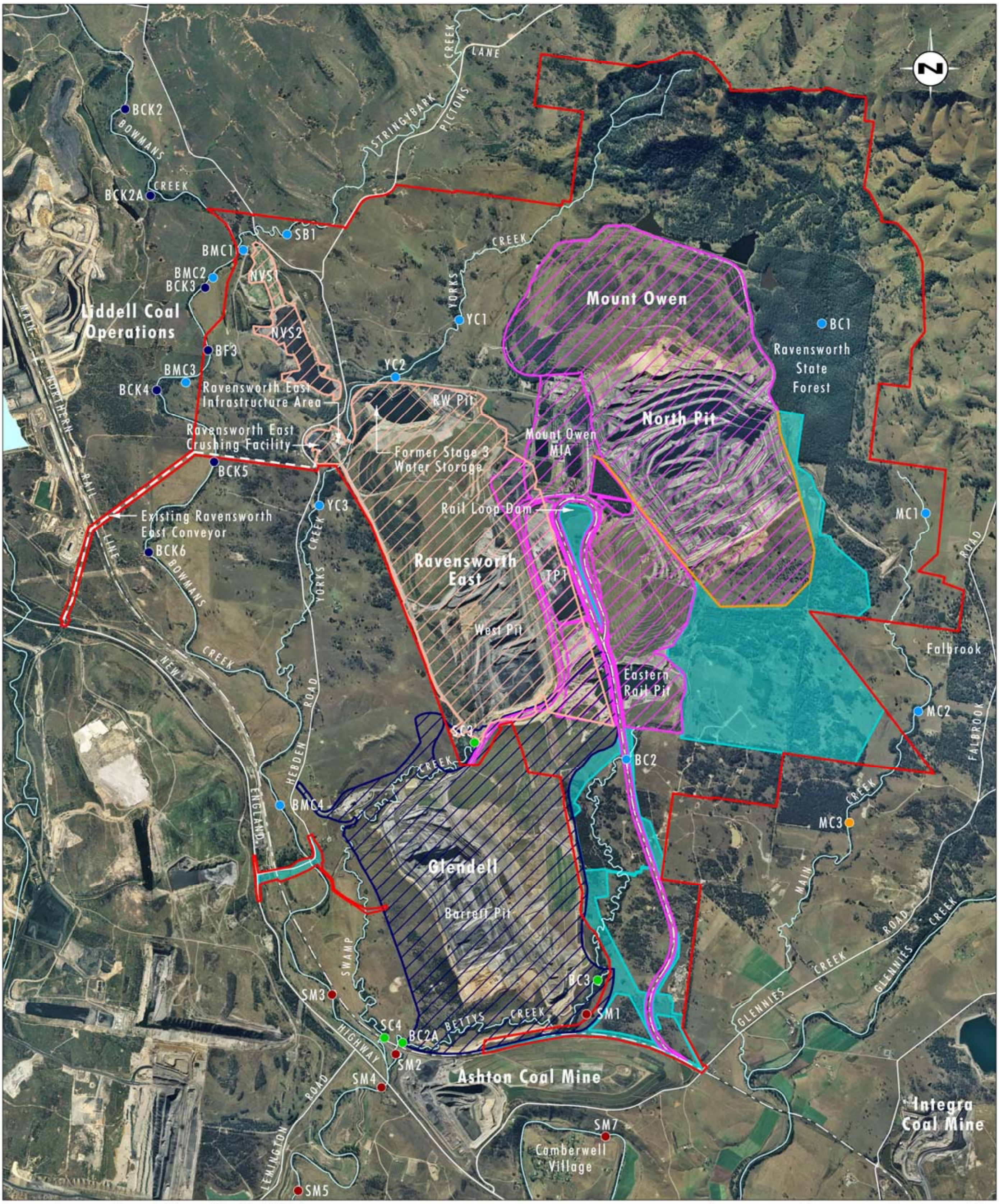


Image Source: Mount Owen (2012-2013)
Data Source: Mount Owen (2014), Department of Lands (2006)

0 1 2 3km
1:60 000

Legend

- Project Area
- Proposed Disturbance Area
- Approved North Pit Mining Extent
- Mount Owen Surface Water Monitoring Location
- Ashton Surface Water Monitoring Location
- Liddell Surface Water Monitoring Location
- Glendell Surface Water Monitoring Location
- Proposed Future Water Monitoring Location
- Mount Owen Operational Area
- Glendell Operational Area
- Ravensworth East Operational Area

FIGURE 2.3

Surface Water Quality Monitoring Locations

File Name (A4): R05/3109_504.dgn
20141008 16.29

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's 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. The SWMP presents site specific trigger values for the key water quality parameters of pH, EC, TSS and TDS for Bowmans Creek and for the ephemeral creek systems for both flow and no flow conditions.

The relevant default ANZECC trigger values and site specific trigger values for the key water quality indicators monitored by Mount Owen are shown in **Table 2.2**. The site specific trigger values for Bowmans Creek and for flow conditions in the ephemeral creeks are the same as the ANZECC default trigger values for pH, EC and TSS. The trigger value for TDS for Bowmans Creek and for flow conditions in the ephemeral creeks is based on historic data and is lower than the default ANZECC trigger values.

Table 2.2 - Water Quality Parameters and Trigger Levels

Parameter Monitored	ANZECC default trigger	Site Specific Trigger Values[1]		
		Bowmans Creek	Ephemeral Creek Systems	
			Flow Conditions	No Flow Conditions
pH	6.5 to 8.0	6.5 to 8.0	6.5 to 8.0	6.5 to 8.6
EC (µs/cm)	2,200	2,200	2,200	5,400
TSS (mg/L)	50	50	50	50
TDS (mg/L)	4,000 to 5,000[2]	1,480	1,480	4,700

1. Source: Mount Owen Complex Surface Water Monitoring Program (2012)
2. Source: ANZECC guidelines (2000) - recommended concentration of TDS in drinking water for beef cattle as no default trigger value is provided by the ANZECC guidelines (2000) for ecosystem protection.

Water quality monitoring data as reported in the Mount Owen Annual Environmental Management Reports (AEMRs) for 2012 and 2013 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.

A summary of historical water quality monitoring results is presented in **Table 2.3** which compares recorded water quality to site specific triggers (refer to **Table 2.2**) to provide context for baseline water quality. The full record of available water quality results from August 2008 to March 2014 for pH, EC, TSS and TDS are graphed against the site specific trigger levels and are included in **Appendix A**.

Table 2.3 - Key Water Quality Monitoring Results for Watercourses

Waterway	Overview of Historical Water Quality
Bowmans Creek	There are five monitoring locations along Bowmans Creek. BMC1, BMC2, BMC3 and BMC4 are located to the west of the Mount Owen Complex WMS. BMC5 (referred to as SM4 in Ashton water quality records) is located downstream of the WMS and Ashton Coal Mine. Water quality in Bowmans Creek is typically consistent across all monitoring locations and is typically within the site specific trigger values for EC and TDS. pH in Bowmans Creek is typically elevated at monitoring locations both upstream and downstream of the WMS. Average pH across the Bowmans Creek monitoring locations is 7.9, with a maximum recorded pH of 8.3 at BMC3 in December 2009. EC and TDS levels in Bowmans Creek are typically below their respective site specific trigger values, with all results measured downstream of the WMS within site specific trigger values. On average, concentrations of TSS in Bowmans Creek are below the site specific trigger value of 50 mg/L, however spikes in TSS above the site specific trigger value have historically been recorded at all monitoring locations.
Yorks Creek	There are three monitoring points along Yorks Creek, YC1, YC2, and YC3. YC1 and YC2 are upstream of the WMS and YC3 is downstream of the WMS. Water quality in Yorks Creek has historically varied across all of the monitoring sites. The variability in water quality readings both upstream and downstream of the WMS, is considered primarily to be due to the ephemeral nature of Yorks Creek. pH levels along Yorks Creek are typically within the site specific trigger values at all monitoring locations. Historically, EC levels within Yorks Creek have exceeded the site specific trigger values at all monitoring locations. Typically, the highest concentrations of EC have been recorded during periods of no flow at YC3 downstream of Ravensworth East Mine. TSS levels in Yorks creek are generally within the site specific trigger value, with some higher readings at YC1 and YC3. TDS levels for YC1 and YC2 are typically within the site specific trigger values. High concentrations of TDS during periods of no flow have been recorded at YC3 downstream of Ravensworth East Mine. Where high EC and TDS values have historically been recorded in Yorks Creek, typically in the fortnight prior to sampling there is very low or no rainfall recorded, resulting in reduced flows when the water quality samples were taken. Monitoring data demonstrates that the drier conditions potentially contribute to higher EC and TDS levels at these locations.

Table 2.3 - Key Water Quality Monitoring Results for Watercourses (cont.)

Swamp Creek	There are two monitoring locations along Swamp Creek, SC3 and SC4. Both of these locations are downstream of the WMS, with SC4 is located downstream of Glendell Mine. Water quality in Swamp Creek has historically varied at both of the monitoring locations. The variability in water quality readings in Swamp Creek is considered primarily to be due to the ephemeral nature of Swamp Creek. Swamp Creek pH, EC, TSS and TDS levels are typically higher at the upstream monitoring location (SC3) in comparison to the downstream monitoring location (SC4). pH, EC and TDS levels typically exceed the site specific trigger values at SC3 with water quality at this location having maximum recorded levels of 8.9 for pH, 10,200 µs/cm for EC and 6,570 mg/L for TDS. TSS levels along Swamp Creek are strongly linked to rainfall events, with exceedance of the site specific trigger value of 50 mg/L typically occurring after rainfall.
Bettys Creek	There are four water quality monitoring locations along Bettys Creek, BC1, BC2, BC2A and BC3. BC1 is located upstream of the WMS and BC2, BC2A and BC3 are located downstream of the WMS with BC2A being located downstream of Glendell Mine. Water quality in Bettys Creek has historically varied across all of the monitoring sites. The variability in water quality readings in Bettys Creek, which have been recorded in samples both upstream and downstream of the WMS, is considered primarily to be due to the ephemeral nature of Bettys Creek. Bettys Creek pH is highly variable across all monitoring locations, however the results are typically within the site specific trigger values. Bettys Creek EC, and TDS levels have been consistently within site specific trigger values with the exception of early 2012, where EC exceeded the ‘no flow’ trigger value with a maximum recorded level of 5,800 µs/cm. TSS levels along Bettys Creek are highly variable, with elevated recorded concentrations linked to rainfall events in the historical TSS records.
Main Creek	There are two monitoring locations along Main Creek, MC1 and MC2. MC1 is located upstream of the WMS and MC2 is located downstream of the WMS. Regular monitoring has occurred at both locations since mid 2011. Water quality in Main Creek has historically varied across the two monitoring sites. The variability in water quality readings in Main Creek, is considered primarily to be due to the ephemeral nature of Main Creek. pH levels for Main Creek are typically within the site specific trigger values. Recorded levels of EC occasionally exceed the ‘flow’ site specific trigger value, with a maximum recordings for EC of 7,000 µs/cm. TDS levels for Main Creek have been consistently below the ‘no flow’ site specific trigger value and typically fall below the ‘flow’ site specific trigger value. TSS levels along Main Creek are highly variable, with elevated concentrations typically linked to rainfall events in the historical TSS records. Elevated TSS concentrations recorded from June 2009 to September 2009 at MC1 (three elevated samples upstream of the WMS) and MC2 (one elevated sample downstream of the WMS) do not correlate with rainfall events, but can likely be attributed to upstream influences as these monitoring locations are upstream of the WMS.

The review of historical water quality monitoring data indicates that the water quality for Bowmans Creek and the ephemeral creek systems (refer to **Table 5.2**) typically lies within the site specific trigger values. The exceedances recorded (refer to **Table 5.2**) are consistent with expectations considering the ephemeral nature of Yorks Creek, Swamp Creek, Bettys Creek and Main Creek, where water quality monitoring results are dependant on rainfall and periods of no flow. Exceedances above the site specific trigger values are also influenced by the method used to select trigger values for periods of no flow (refer to **Table 2.2**) which are based on consideration of the 80th percentile value of historical records and ANZECC guidelines default trigger values.

Mount Owen also monitors water quality within the water management system for operational purposes on an as needs basis to assist the mine in its day to day management. The frequency of monitoring and the parameters monitored for operational purposes is undertaken at the discretion of Mount Owen.

Water quality results within the WMS for mine dams, along with 6 month rolling averages for pH and electrical conductivity (EC) are included in **Appendix A**. The water quality monitoring indicates that the pH within the Mount Owen mine water dams typically has a rolling 6 month average of approximately 8.6, with minimum and maximum readings of 6.0 and 10.4 respectively. EC results in the Mount Owen mine water dams show a wide variance with a rolling 6 month average of approximately 3,000 µs/cm.

2.2.2 Licensed Water Monitoring

Surface water monitoring in the Project Area is also undertaken in accordance with Mount Owen's Environment Protection Licence (EPL) 4460 and Ravensworth East Mine's EPL 10860. It is anticipated that should the Project be approved, Mount Owen and Ravensworth East Mines would operate under a single development consent and a consolidated EPL would also be sought.

The existing Mount Owen and Ravensworth East EPL surface water licensed monitoring locations (including the EPA identification number, type of monitoring point and location description from the EPL) are listed in **Table 2.4** and shown on **Figure 2.3**.

Table 2.4 – EPL Surface Water Licensed Monitoring Points

EPL No.	EPA Identification No.	Type of Monitoring Point	Description of Location in EPL
4460 Mount Owen	1	HRSTS monitoring point Discharge to waters Discharge quality Monitoring Volume monitoring	Discharge pipe to clean water diversion (Swamp Creek)
10860 Ravensworth East	4	Ambient Water Quality	At locations where water being sampled is representative of sites potentially impacted by mining.

Discharges from the WMS are released from a single location for EPL 4460 under the Hunter River Salinity Trading Scheme (HRSTS). EPL 4460 requires that water be discharged in accordance with the HRSTS, that is:

- a pH between 6.5 and 9.5;
- TSS below 120 mg/L; and
- a maximum volume of 66 ML per day.

No discharges have occurred under the HRSTS from WMS since the issuing of EPL 4460 to Mount Owen in 2005.

2.3 Downstream Users

The *Water Management Act 2000* defines water access and water sharing strategies. As part of this Act, Water Sharing Plans (WSPs) 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.

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* applies to watercourses in the vicinity of the Project Area and alluvial groundwaters. The catchment of Bowmans Creek is located within the Jerrys Water Source and the catchment of Main Creek is located within the Glennies Water Source. As both Bowmans Creek, its sub catchments, and Main Creek are covered by water sharing plans, water use in the Project Area is governed by the *Water Management Act 2000*. The groundwater associated with the hard rock aquifers (i.e. coal seams) is not covered by a water sharing plan but is governed under the *Water Act 1912*.

Water is extracted from Glennies Creek and the Hunter River downstream of the Project Area by Ashton Coal. Ashton also hold irrigation licences for Bowmans Creek and domestic and stock licences.

The majority of land adjacent to Yorks Creek, Bettys Creek and Swamp Creek downstream of the WMS to the New England Highway is owned by Glencore. There is one lot on Yorks Creek owned by a government authority and one lot on Bettys Creek owned by the Crown. As such there are no private landholders located immediately downstream of the Project Area on Yorks Creek, Swamp Creek or Bettys Creek. There are two private landholders with access to Main Creek located downstream of the Project Area.

There are no known licensed water users on waterways directly downstream of the Project Area along Yorks Creek, Swamp Creek, Bettys Creek or Main Creek. Potential impacts on downstream water users from the Project are discussed in **Section 6.6**.

3.0 Existing Water Management

As described previously, 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 GRWSS with the Cumnock, Ravensworth Surface Operations, Narama, Ravensworth Underground and Liddell mining operations. The GRWSS allows greater flexibility in the mine water management by the Mount Owen Complex.

The approach to water management at the Mount Owen Complex is set out in the existing *Mount Owen Complex Water Management Plan* (WMP), (Xstrata Coal, November 2012), which details measures to convey clean water away from the mining and associated infrastructure areas, and manage water affected by mining.

The existing WMS will need to be modified to include the proposed Project. The existing WMS is discussed below, with the proposed changes detailed in **Section 4.0**.

3.1 Overview

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.

As discussed in **Section 2.1**, diversions of the upper catchments for Yorks Creek, Swamp Creek and Bettys Creek have been undertaken as part of previous approved operations to reduce the volume of clean water entering and requiring management within the water management system.

Key objectives and functions of the Mount Owen Complex WMS include:

- 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 GRWSS to reduce reliance on raw/clean water (e.g. extraction from Glennies Creek);
- minimising adverse effects on downstream waterways (i.e. hydraulic and water quality impacts);
- reducing the discharge of pollutants from the mine to the environment; and
- managing approved water discharges to meet licence conditions.

Water is supplied to the Mount Owen Complex from both the GRWSS and Glennies Creek. Mount Owen currently holds 1,056 ML per year of High Security Entitlement and 861 ML per year of General Security Entitlement Water Access Licences for extraction of raw water from Glennies Creek. Raw water extracted from Glennies Creek is treated for use as potable water at the administration building and bath houses. Raw water is also used at the workshop and as the water supply for the fire fighting systems.

Wastewater from on-site facilities, including sewage, is collected and treated on site by a number of aerated wastewater treatment plants, which are licensed by Singleton Council. The effluent from the wastewater treatment plants at Mount Owen and Ravensworth East Mines is used to irrigate tree-lots.

3.2 Existing Water Management

The layout of the existing WMS is shown in **Figure 3.1**, indicating key dams and water handling infrastructure.

3.2.1 Clean Water Management

Existing clean water management includes diversion drains, catch drains, and clean water catch dams around the perimeter of the operational areas in order to capture and divert upslope runoff away from active mining areas.

The main clean water diversions for the Mount Owen and Ravensworth East Mines are shown in **Figure 2.2** and include:

- **Swamp Creek Diversions:** A series of diversion drains and clean water dams diverts the clean upstream catchment of Swamp Creek around the Mount Owen North Pit overburden emplacement area, to either Yorks Creek or in a southerly direction adjacent to Ravensworth East Mine to Swamp Creek.
- **Upper Bettys Creek Diversion:** A series of diversion drains and clean water dams diverts a small portion of the Swamp Creek catchment area and the Bettys Creek catchment area upstream of Mount Owen Mine to Main Creek.
- **Middle Bettys Creek Diversion:** A diversion drain diverts a portion of the Bettys Creek catchment area around the extent of the ERP.
- **Lower Bettys Creek Diversion**: Downstream of the Mount Owen and Ravensworth East Mines, Bettys Creek is also diverted around Glendell Mine (Lower Bettys Creek Diversion) (refer to **Figure 2.2**).

3.2.2 Dirty Water Management

Existing dirty water management includes the collection, management and distribution of water pumped from the active mining areas, runoff and seepage from overburden emplacement areas, and management of water affected by coal handling and processing activities. The water in these areas is classed as dirty water and mine water.

Dirty water includes runoff from disturbed areas and those areas currently being rehabilitated. The dirty water management system includes a series of catch drains and sediment dams located to capture and manage runoff from disturbed areas.

Mine water consists of water that has had the potential to be in contact with coal or carbonaceous material, and therefore has the potential to be saline and includes water associated with groundwater inflows to the open cut pits, and management of water at the Mount Owen CHPP area and tailings dams.

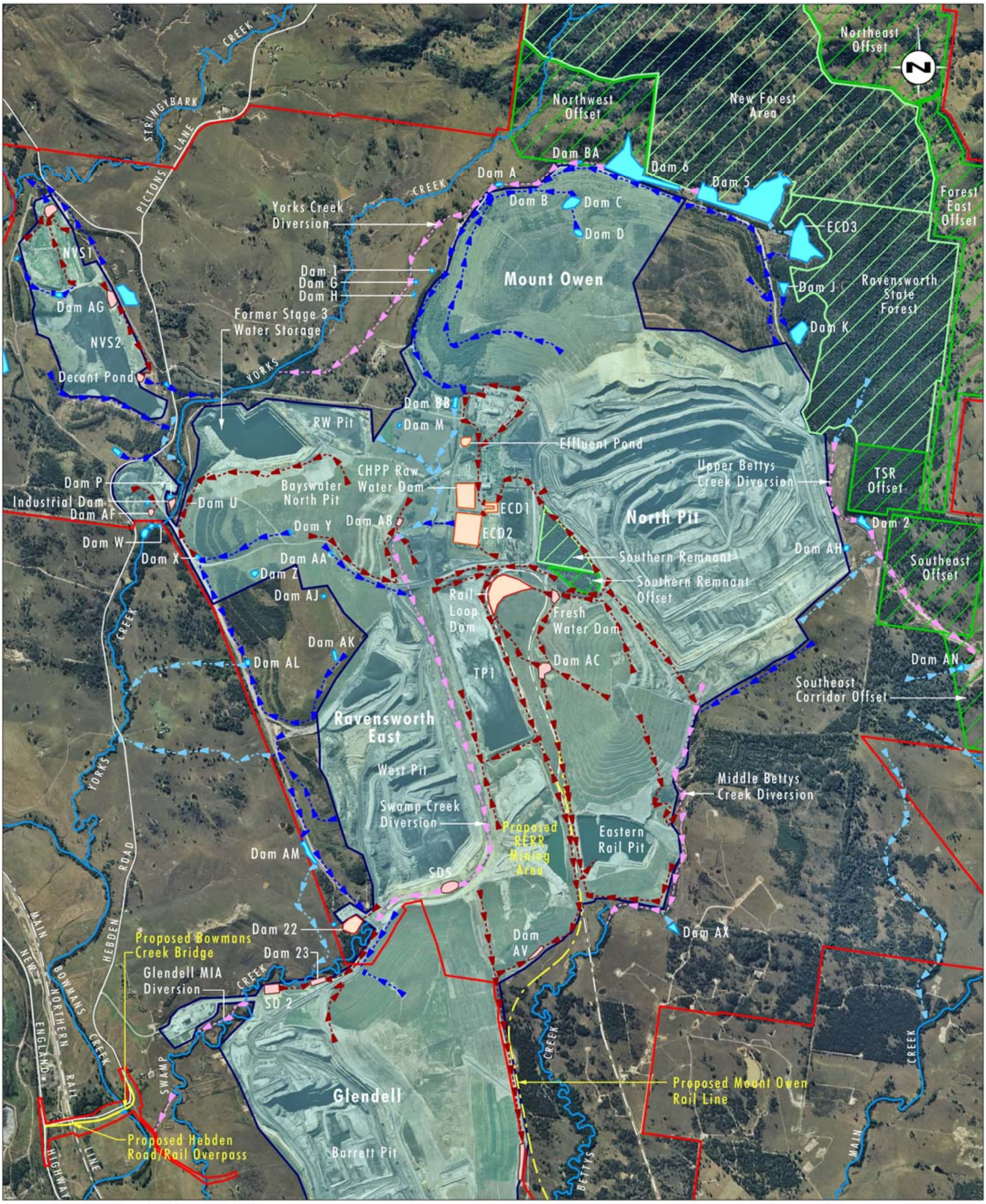


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)

0 0.5 1.0 2.0km
1:40 000

Legend

- Project Area
- Existing Biodiversity Offset Areas
- Ravensworth State Forest
- 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
- Existing Diversion Channel
- Drainage Line
- Existing Railway
- Mount Owen Complex Water Management System Catchment

FIGURE 3.1

Existing Surface Water Management

File Name (A4): R05/3109_706.dgn
20141024 10.21

The key water management components at the Mount Owen CHPP include the following:

- The CHPP Raw Water Dam located to the west of the Mount Owen CHPP area, which is the primary supply dam for the Mount Owen CHPP.
- A series of dirty water diversion drains have been constructed around the Mount Owen CHPP area to ensure dirty runoff from the Mount Owen CHPP area is captured within the WMS and does not enter the clean water system. Runoff from the Mount Owen CHPP area is directed to ECD1 which flows to ECD2. Water captured in ECD2 from the Mount Owen MIA, which includes the administration area, storage, washdown area, heavy vehicle workshop, fuel farm, Mount Owen CHPP, Product Stockpile and ROM areas, is managed and reused within the WMS.

The Mount Owen CHPP produces fine (tailings) and coarse reject being:

- Tailings disposed of as slurry which is pumped to the ERP, RW Pit and the southern area of West Pit.
- Coarse reject is co-disposed in the Mount Owen and Ravensworth East emplacement areas.

Runoff from the MIAs is classed as mine water, being largely water exposed to coal or used in coal processing. In certain areas within the MIAs, such as workshops, oils and hydrocarbons are stored and used. Water exposed to oils and greases within the MIAs are treated in an oil/water separator.

3.2.3 Water Management Dams

Water is managed and stored on site in a series of dams and tailings emplacement areas. Dam water storages include fresh, dirty and mine water dams. The key dams and storage areas that are currently part of the WMS together with their approximate design capacity and function are shown in **Table 3.1** and **Figure 3.1**.

Dirty water and mine water is shared between mines as part of the GRWSS to assist in minimising the demand for raw/clean water across the GRWSS. Discharges also occur from the GRWSS in accordance with Ravensworth Operations and Liddell Coal Mines EPLs. Excess water that cannot be shared to the GRWSS will be discharged in accordance with the HRSTS (refer to **Section 2.2.2**). Since 2005 no discharges have occurred from the WMS to the HRSTS (refer to **Section 2.2.2** for licensing details) with surplus water transferred to and utilised by the GRWSS, in preference to being discharged.

Table 3.1 - Key Water Management System Dams

Dam Name	Capacity (ML)	Function
Fresh Water Dams		
Fresh Water Dam	8	Used for fresh water storage of water pumped under licence from Glennies Creek. Water from this dam is transferred to the MIA raw water tanks and treated for use as potable water.
Mine Water Dams		
Dam 22	48	Used for mine water storage from operations at Ravensworth East and Glendell Mines, including water pumped from the Barrett Pit at Glendell Mine. Also the transfer dam to the GRWSS.

Table 3.1 - Key Water Management System Dams (cont.)

Dam Name	Capacity (ML)	Function
Former Stage 3 Water Storage	5,200	Currently undergoing dewatering to allow for commencement of mining in the BNP area of West Pit.
Rail Loop Dam	100	Captures runoff from the Rail Loop.
Dirty Water Dams		
ECD1	2	Settling dam to enable fines to settle out of dirty water captured from the Mount Owen MIA. Spills to ECD2.
ECD2	310	Mine water dam capturing runoff from the Mount Owen MIA, and water pumped from the North Pit. Water from this dam is managed and reused within the WMS. Water pumped to CHPP Raw Water Dam.
CHPP Raw Water Dam	96	Supply dam for water at the Mount Owen CHPP.
Dam AE	6.5	Captures runoff from the haul road
Dam AB	24	Captures runoff from the West Pit overburden emplacement area at Ravensworth East Mine that has been rehabilitated, and haul road to Ravensworth East Mine.
SD5	14	Currently captures runoff from the Ravensworth East Mine southern haul road.
Dam AV	18	Captures dirty runoff from the active pit operations at the proposed RERR Mining Area.
NVS2 Tailings Decant	32	Captures runoff from the NVS2 emplacement area and ongoing rehabilitation.
Dam X	22	Captures runoff from the West Pit overburden emplacement area at Ravensworth East Mine that has been rehabilitated, and access track over Ravensworth East Mine.
Dam U	31	Captures runoff from the Ravensworth East Mine northern haul road
Dam AF	2	Captures runoff from the Ravensworth East MIA and haul road.
Tailings Emplacement		
ERP	1,400	The ERP is currently being used for tailings emplacement.
RW Pit	300	The RW Pit is currently being used for tailings emplacement.
West Pit	40,000	West Pit is currently being used for tailings emplacement.

4.0 Proposed Water Management

4.1 Water Management Strategy

The water management strategy for the Project has been designed to integrate management of the Project with the existing water management system for the Mount Owen and Ravensworth East Mines. The strategy includes the separation of clean and dirty water, preventing the contamination of clean water by mining activities and managing compliance with statutory obligations.

Under Section 120 of the *Protection of the Environment Operations Act 1997* (POEO Act), it is an offence to pollute waters or cause harm unless licensed to do so. Inherent in the concept of not causing harm is the need to manage the risk of spilling from water management dams or related infrastructure, and also understanding the background water qualities in the local creek systems (refer to **Section 2.0**).

For the Project, three categories of water have been identified to be managed, each with different potential to cause environmental harm, namely:

- Clean water - Runoff from undisturbed or rehabilitated areas where vegetation is fully established, and where the water quality is suitable for release/discharge, and raw water imported under licence.
- Dirty water - Runoff from disturbed areas, such as active overburden emplacement areas or overburden emplacement areas where vegetation is not fully established. These areas have the potential for elevated TSS.
- Mine water - Mine water, being water exposed to coal or used in coal processing and runoff within MIAs. This water quality is typically at a higher level of salinity.

The target design criteria for the three categories of water are summarised in **Table 4.1**.

Table 4.1 – Design Criteria for Components of the WMS

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	Managed in line with the Blue Book (*Managing Urban Stormwater: Soils and Construction Volumes 1* and *2E*).
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.

Dirty water and mine water will continue to be shared between Glencore's mining operations as part of the GRWSS to assist in minimising the demand for raw/clean water across the GRWSS. In addition, excess water that cannot be shared in the GRWSS will be discharged in accordance with the HRSTS (refer to **Section 2.2.2**).

Raw water supply and wastewater treatment and disposal for the Project will be the same as for the existing operations (refer to **Section 3.2**).

The WMS for the Project will make provision for ongoing evaluation of all existing and proposed components of the WMS using additional data obtained through ongoing water quality sampling together with risk assessments where required to ensure the objectives (refer to **Section 3.1**) of the WMS are achieved.

4.1.1 Clean Water Management

The existing clean water management system includes a series of diversion drains and catch drains, and clean water catch dams around the perimeter of the operational areas in order to capture and divert upstream catchment runoff away from active mining areas. As mining progresses, the clean water controls will be maintained by the construction of new drains and dams as needed.

Diversion drains will be sized to safely convey the 5 per cent AEP storm event flows and proposed pump flows from upstream clean water dams to each of the respective clean water catch dams or downstream receiving catchment area. All diversion drains will be constructed to enable design flow velocities to be non-scouring. Rock protection and energy dissipation structures will be installed at the downstream outlets, where required, to ensure that runoff does not cause scour or erosion in downstream drainage systems, including the natural tributaries and main channels.

4.1.2 Dirty Water Management

The existing dirty water management system includes a series of catch drains and sediment dams located to capture and manage runoff from disturbed areas. The dirty water management system is and 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, 95^{th} percentile rainfall event.

As mining progresses, runoff from disturbed areas will be managed within the water management system and reused, or if water quality meets required guidelines, will be released to downstream waterways. The sediment dams will be emptied using a pump and pipe or gravity systems after rainfall events.

Dirty water diversion drains will be sized to safely convey the 5 per cent AEP storm event. All diversion drains will be constructed to ensure that the design flow velocities are non-scouring. Rock protection and energy dissipation structures will be installed at the downstream outlets, where required, to ensure that runoff does not cause scour or erosion in downstream drainage systems.

Erosion and sediment controls will be implemented to mitigate the impacts of construction and mining operations on nearby watercourses and the surrounding environment. Standard erosion and sediment control techniques will be used in accordance with the requirements of *Managing Urban Stormwater: Soils and Construction* (the Blue Book) (Landcom 2004 and DECC 2008), and are detailed in **Section 6.3**.

4.1.3 Mine Water Management

Mine water consists of water that has the potential to be in contact with coal or carbonaceous material, and therefore has the potential to be saline. Mine water also includes runoff from the MIAs. Mine water consists of:

- groundwater inflows;
- rainfall/runoff into mine pits;
- tailings decant water;
- dirty water runoff from the Mount Owen CHPP, MIA, stockpiles and rail load out areas, including where there is the potential for oils and hydrocarbons; and
- process water used at the Mount CHPP.

The WMS for mine water management areas will be designed to convey and contain runoff from the 1 per cent AEP 24 hour storm event. The water management system within the mine water management areas has been designed to minimise the risk of discharges of mine water to downstream watercourses.

Runoff from the Mount Owen CHPP area will continue to be contained and diverted to the mine water dams, by a series of bunds, culverts, and diversion drains prior to reuse in the WMS. The controls that will be implemented to contain and manage water within the Mount Owen MIA, CHPP area and product coal stockpile extension are shown in **Figure 4.1**.

Runoff from the Ravensworth East MIA will be contained and diverted to the new Ravensworth East MIA Dam by a series of bunds, culverts, and diversion drains prior to reuse in the WMS. The Industrial Dam, which currently manages runoff from the Ravensworth East MIA, will be converted into a clean water dam, to be used to mitigate flood flows (refer to **Section 6.2.1**).

4.2 Overview of Proposed Water Management System

As discussed in **Section 4.1**, the water management system manages water of three distinct types: clean, dirty and mine water. Each type of water requires different management measures to minimise the risk of contamination of downstream drainage systems by construction and mining activities.

The layout of the key components of the WMS for the life of the Project in relation to surrounding watercourses is shown on **Figures 4.2** to **4.5** and detailed below.

It is important to note that the stage plans presented in **Figures 4.2** to **4.5** are conceptual, being determined by current 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 stage 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 in the Project.

Similarly, the conceptual storage capacities required for the various water management dams are provided to indicate the quantum of the proposed dams. Refinement of the design criteria and capacities will be undertaken during detailed design stages of the Project, as well as the ongoing operational stages.

Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)

0 100 200 400m
1:7 500

Legend

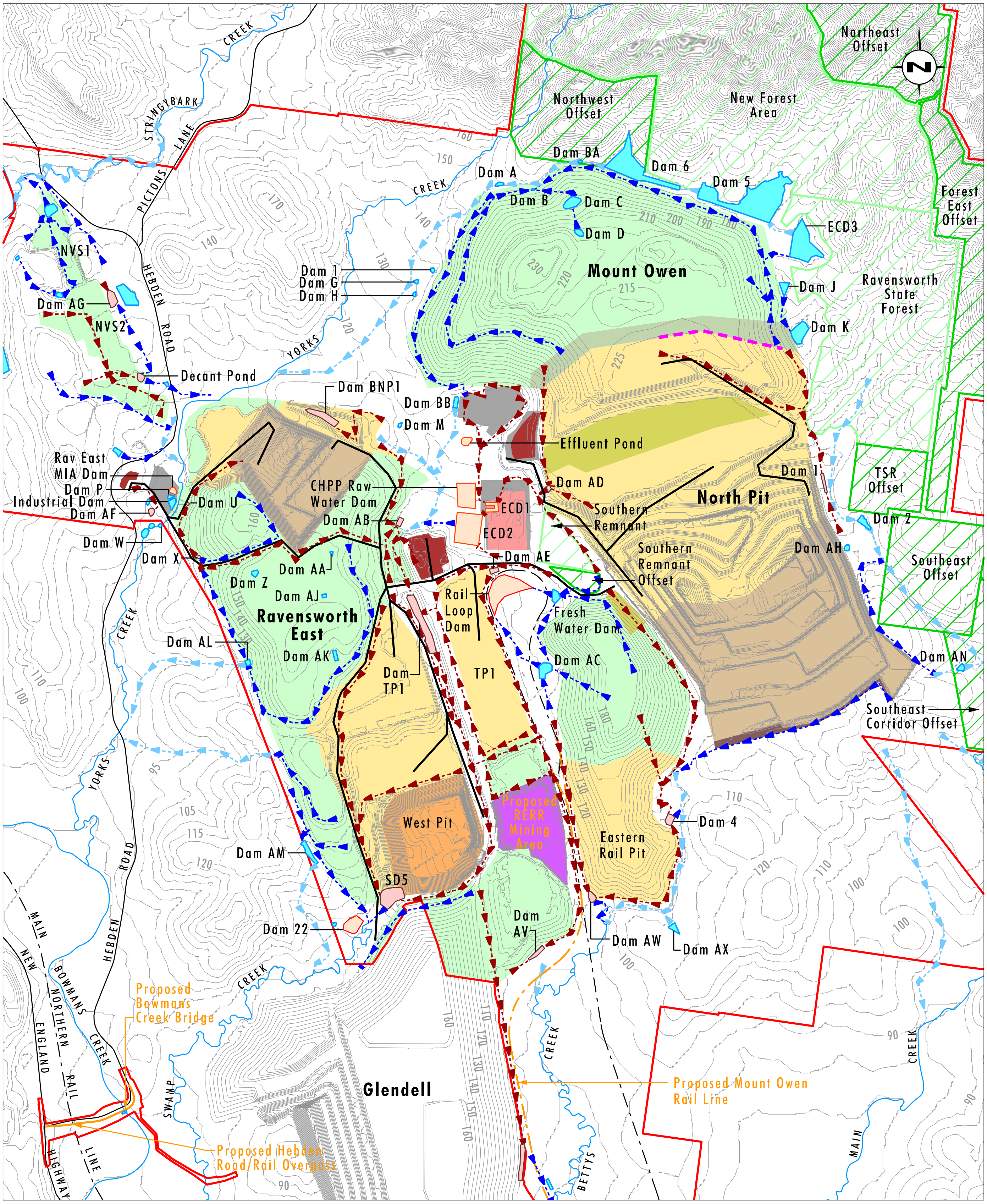
- Clean Water Dam
- Sediment Dam
- Mine Water Dam
- Existing Flow Path
- Clean Water Diversion Drain
- Dirty Water Drain

FIGURE 4.1

Conceptual Water Management System for the Mine Infrastructure Area and Product Stockpile Extension Area

File Name (A4): R05/3109_516.dgn
20140813 15.43

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

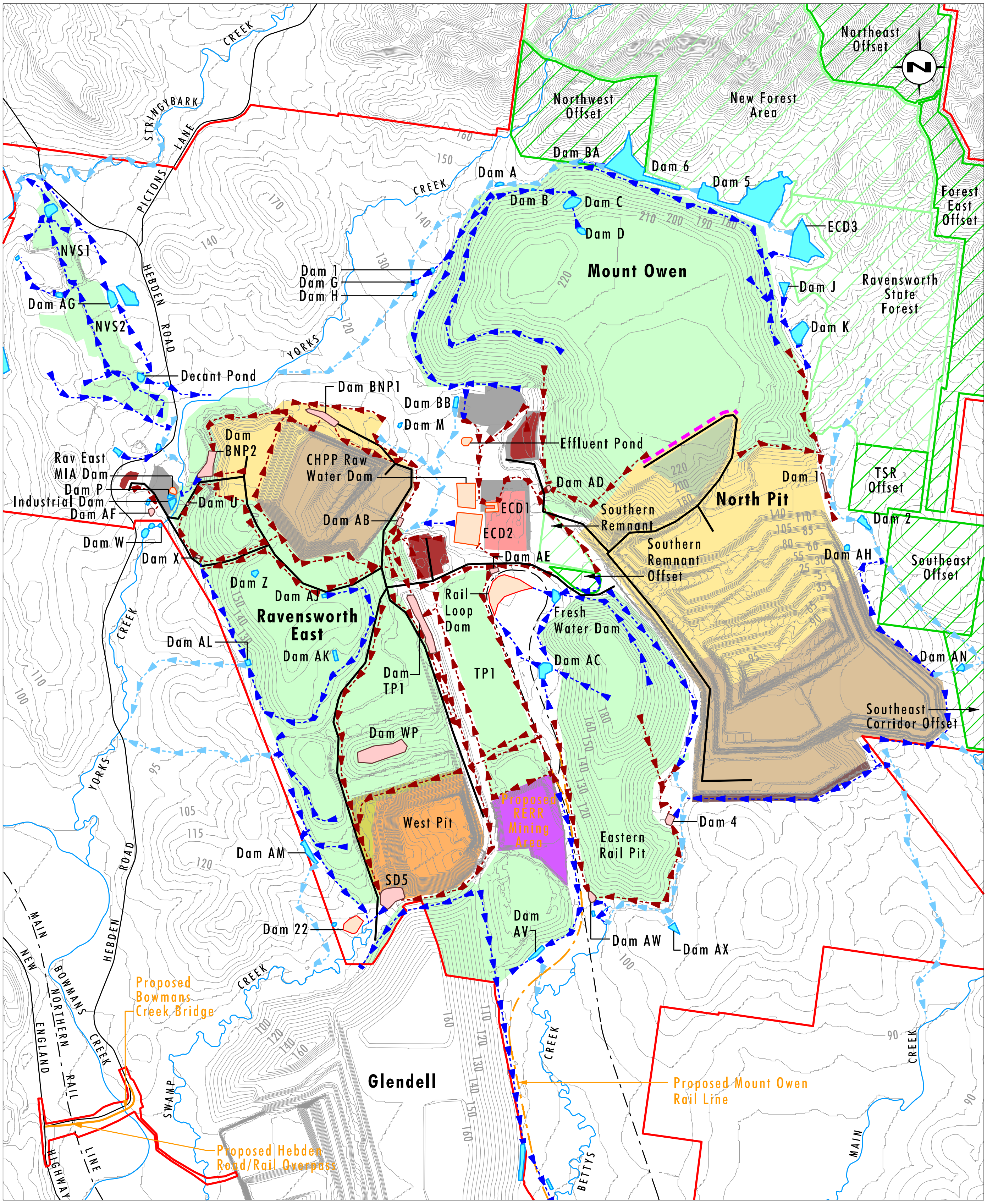
Legend

- 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
- Windrow
- Drainage Line
- Haul Road
- Active Mining Area
- Active Overburden Emplacement Area
- Topsoil Removal
- Coal Stockpile - Product
- Coal Stockpile - ROM
- Infrastructure
- Proposed RERR Mining Area
- Rehabilitation - Complete
- Rehabilitation - Temporary
- Shaped Not Seeded
- Tailings Placement

FIGURE 4.2

Conceptual Surface Water Management Year 1

File Name (A4): R05/3109_775.dgn
20140916 10.29



Data Source: Mount Owen (2014)

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

Legend

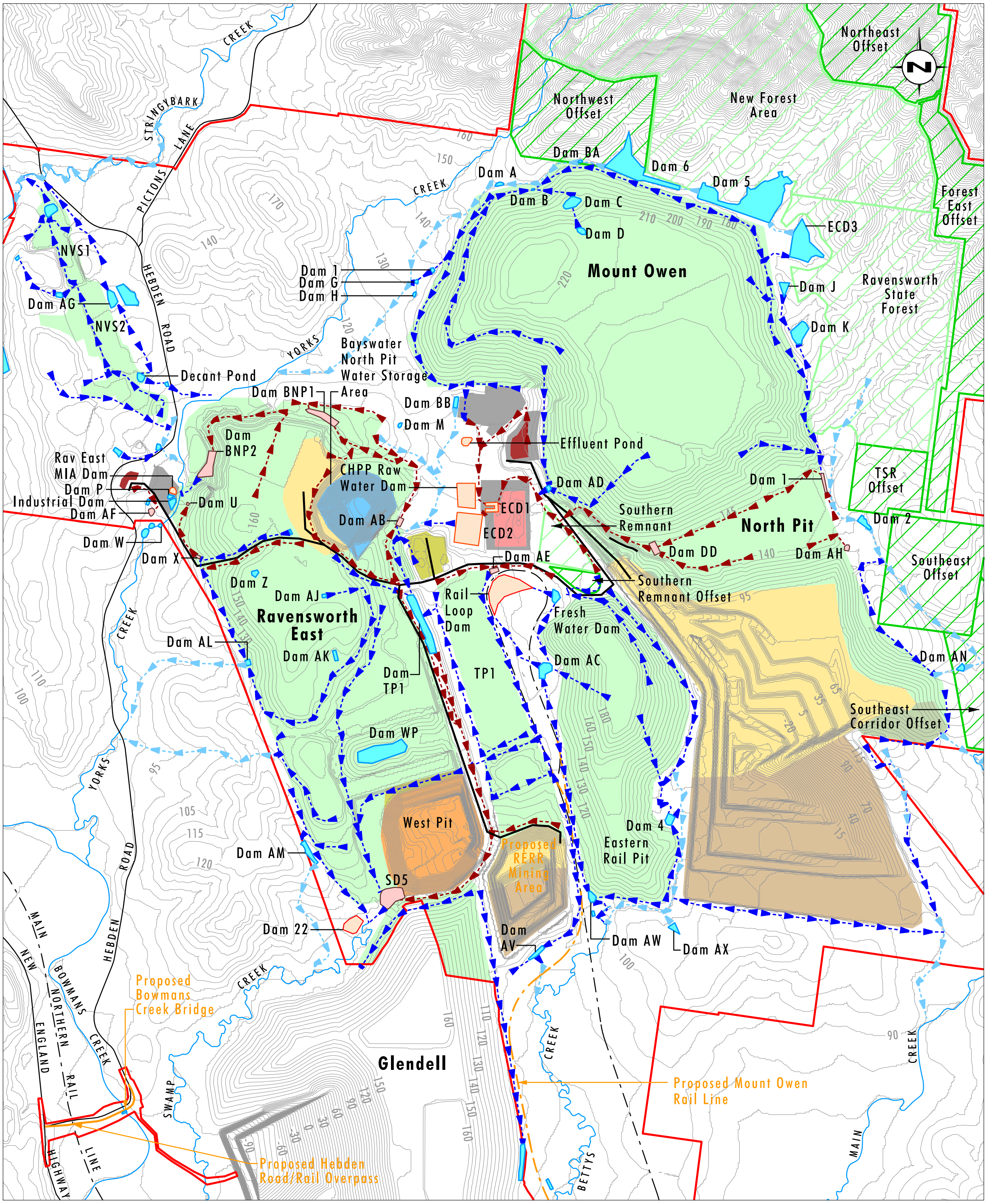
- Project Area
- Existing Biodiversity Offset Areas
- Ravensworth State Forest
- Existing Railway
- Proposed Rail Upgrade Works
- Proposed Hebden Road Upgrade Works
- Clean Water Dam
- Sediment Dam
- Mine Water Dam
- Existing Flow Path
- Clean Water Diversion Drain
- Dirty Water Drain
- Windrow
- Drainage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

FIGURE 4.3

Conceptual Surface Water Management Year 5

File Name (A4): R05/3109_776.dgn
20140916 10.36

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

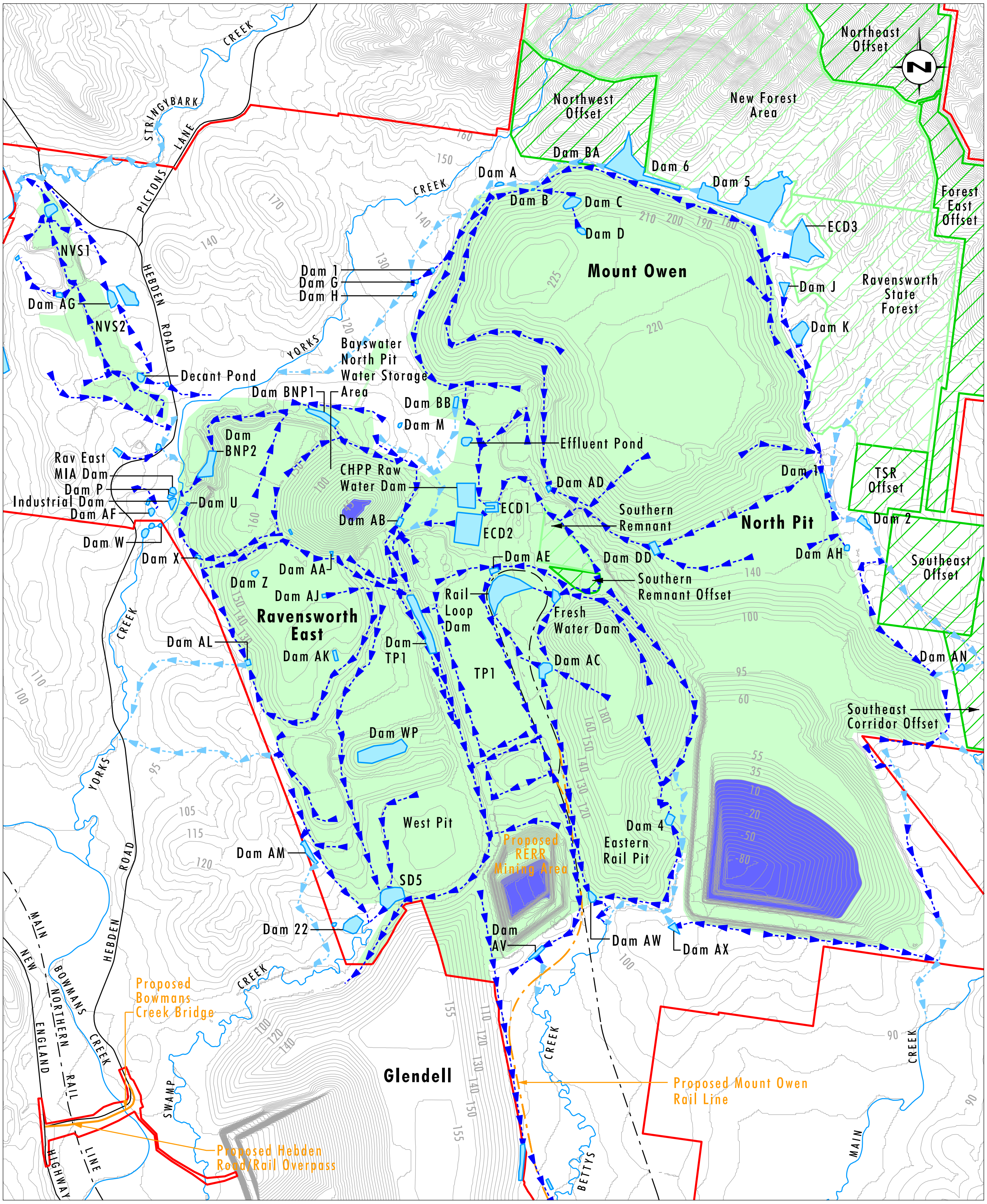
Legend

- 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 4.4

Conceptual Surface Water Management Year 10

File Name (A4): R05/3109_777.dgn
20140916 10.43



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
- Existing Flow Path
- Clean Water Diversion Drain
- Drainage Line
- Rehabilitation - Complete
- Final Void Water Level

FIGURE 4.5

Conceptual Surface Water Management Final Landform

File Name (A4): R05/3109_778.dgn
20141024 10.23

The existing WMS will continue to be used to manage runoff with all pit water and mine surface runoff directed to the WMS. Clean water diversions will continue to divert runoff from the upper catchments of Swamp Creek, Yorks Creek and Bettys Creek around the WMS.

4.2.1 Year 1

At Year 1 of the Project (refer to **Figure 4.2**), the North Pit and BNP will be active. The North Pit Continuation will progress to the south, and overburden material from the North Pit Continuation and the BNP will continue to be relocated to the southern portion of the North Pit, the ERP and West Pit emplacement areas respectively. Runoff from these locations will be contained within the WMS. The northern portion of the ERP will be rehabilitated and clean runoff will continue to be captured within the Rail Loop Dam. In addition, clean water diversion drains will be constructed upslope of the operational area in order to divert upstream catchment runoff away from active mining areas.

At Year 1, NVS1 will be rehabilitated and runoff released to Stringybark Creek. NVS2 will be in the final stages of rehabilitation and runoff from this area will be released to Stringybark Creek when vegetation is established.

At Year 1, the western portion of Ravensworth East Mine will be rehabilitated, with runoff released to Yorks Creek and Swamp Creek. TP1 and the southern portion of Ravensworth East Mine will be active overburden emplacement areas. The West Pit will be used for tailings emplacement. Runoff from these locations will be contained within the WMS.

4.2.2 Year 5

At Year 5 of the Project, (refer to **Figure 4.3**), the northern portion of the North Pit emplacement area will be rehabilitated and runoff will be redirected from the WMS to the Yorks Creek catchment. To manage potential impacts of the additional catchment area flowing to Yorks Creek on watercourse stability and flood access, additional flow conveyance and detention capacity will be constructed (refer to **Section 6.2.1**).

At Year 5 of the Project, the North Pit Continuation will continue to progress towards the south, with overburden emplacement also progressing south, with progressive rehabilitation occurring when final landform is achieved. The BNP will be an active pit, with overburden material to be placed to the north and west of the BNP. Runoff from the North Pit Continuation, BNP and proposed RERR Mining Area will be contained within the WMS. Clean water diversion drains will be constructed upslope of the operational area in order to divert upstream catchment runoff away from active mining areas. The West Pit will continue to be used for tailings emplacement.

At Year 5, the ERP, TP1 and the southern end of the Ravensworth East emplacement area will be in the final stages of rehabilitation, and runoff from these areas will be released to downstream watercourses where appropriate when vegetation is established.

4.2.3 Year 10

At Year 10 of the Project (refer to **Figure 4.4**), the North Pit Continuation will continue to progress towards the south, with overburden emplacement also progressing south, with progressive rehabilitation occurring when final landform is achieved. Overburden emplacement will be relocated to the southern portion of the North Pit emplacement area. The proposed RERR Mining Area will also be an active pit, with overburden material to be placed to the north of the proposed RERR Mining Area and within the BNP. These locations will be contained within the WMS. On completion of mining, the BNP will be investigated to potentially be used for ongoing operational water storage and allow for integration with the

GRWSS. Clean water diversion drains will be constructed upslope of the operational area in order to divert upstream catchment runoff away from active mining areas. The West Pit will continue to be used for tailings emplacement.

At Year 10, the BNP emplacement area will be in the final stages of rehabilitation, and runoff will be released to downstream watercourses where appropriate when rehabilitation is established.

4.2.4 Final Landform

When final landform is achieved (refer to **Figure 4.5**), all operations will be complete and the Project Area will be completely rehabilitated. A final void will remain within the North Pit Continuation, the BNP and the proposed RERR Mining Area. The BNP final void will be investigated to be potentially for ongoing operational water storage and allow for integration within the GRWSS, as required. Similarly the proposed RERR Mining Area final void will be investigated to be used as a tailings emplacement area as part of closure planning five years prior to cessation of the Project. Diversion drains will be constructed upslope of the final voids in order to divert upstream catchment runoff away from the final voids and to downstream watercourses.

4.2.5 Proposed Dams for the Project

The proposed clean water and dirty water dams required to manage dirty and clean runoff from disturbance areas and rehabilitated areas for the Project in addition to existing dams are listed in **Table 4.2**.

Table 4.2 – Additional Dams Related to the Project

Dam	Approximate Volume (ML)	Year 1 quality	Year 5 quality	Year 10 quality	Final Landform
Dam 1	70	Dirty Water	Dirty Water	Dirty Water	Clean Water
Dam 4	50	Dirty Water	Dirty Water	Clean Water	Clean Water
Dam AD	50	Dirty Water	Dirty Water	Clean Water	Clean Water
Dam DD	45	-	-	Dirty Water	Clean Water
Dam AE	5	Dirty Water	Dirty Water	Dirty Water	Clean Water
Dam AW	35	Dirty Water	Dirty Water	Clean Water	Clean Water
Dam AH	10	Clean Water	Clean Water	Dirty Water	Clean Water
Dam WP	22	Dirty Water	Dirty Water	Clean Water	Clean Water
Dam TP1	57	Dirty Water	Dirty Water	Clean Water	Clean Water
BNP1	13	Dirty Water	Dirty Water	Dirty Water	Clean Water
BNP2	35	-	Dirty Water	Dirty Water	Clean Water
Ravensworth East MIA Dam	4	Mine Water	Mine Water	Mine Water	Clean Water

Tailings emplacement areas will be managed as part of the Project. This includes the filling, capping and revegetation of ERP, TP1, the proposed RERR Mining Area (if no other beneficial reuse option is identified), and the West Pit void. Overburden emplacement areas that will be revegetated as part of the Project include Ravensworth East overburden emplacement areas and the North Pit Continuation.

Rehabilitation of the mining area will be undertaken as mining progresses. The ongoing rehabilitation is shown in **Figures 4.2** to **4.5**. Runoff from final, stable rehabilitated areas will be conveyed to the downstream catchment areas once the required runoff water quality criteria are achieved. In the final landform, clean and dirty WMS controls will be removed where possible. Components of the WMS may remain in place following the completion of mining and on decommissioning.

5.0 Water Balance

As discussed in **Section 3.0**, 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 an integrated WMS. In addition, the Mount Owen Complex is an integral part of the GRWSS with the Cumnock, Ravensworth Surface Operations, Narama, Ravensworth Underground and Liddell mining operations. The GRWSS allows greater flexibility in the mine water management by the Mount Owen Complex.

The use and management of water within the Glendell Mine does not form part of the Project and will continue to be managed pursuant to the existing Development Consent. However, due to the integrated nature of the WMS, the overall water balance of the Mount Owen Complex (which includes water make and use at the Glendell Mine) and the changes to the water balance associated with the Project are detailed in this document.

Inflows to the water balance include site rainfall runoff, tailings decant water, groundwater inflows to open cut pits, transfers from other mines within the GRWSS and water extracted under licence from Glennies Creek.

A detailed Site Water Balance Report has been completed for the Project and is included as **Appendix B**. A summary of the water balance findings are included in the remainder of this section.

5.1 Overview of Models

The water balance models are based in Microsoft Excel and utilise Palisade @Risk software to undertake a Monte Carlo analysis to calculate the probability of different water balance outcomes based on the variability of the model input data.

Daily timestep water balance models have been used to assess the gross water balance for the existing operations and the Project, the frequency and volume of water transfers to and from the Mount Owen Complex, the frequency and volume of spills, and final void water levels for the Project.

Water is supplied to the Mount Owen Complex from both the GRWSS and Glennies Creek. Mount Owen currently holds 1,056 ML per year of High Security Entitlement and 861 ML per year of General Security Entitlement Water Access Licences for extraction of water from Glennies Creek.

Surplus water at the Mount Owen Complex is able to be managed by either transfers to the GRWSS or discharged via the HRSTS via either Ravensworth Operations and Liddell Coal Mines or from the Mount Owen Complex.

5.2 Potential Impacts with the Project

Table 5.1 presents a summary of the gross water balance results for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project in isolation from the GRWSS.

Table 5.1 - Project Gross Water Balance (ML)

Scenario	10th Percentile	50th Percentile	90th Percentile
Year 1 (2016)	-2,325	-810	1,660
Year 5 (2020)	-2,200	-665	1,810
Year 10 (2025)	-800	340	2,310

The 50th percentile gross water balance results show that the Project is estimated to be in water deficit in Year 1 (2016) and Year 5 (2020). At Year 10 the Project, in isolation from the GRWSS, is predicted to operate at a surplus (i.e. water exporter to the GRWSS) as a result of lower ROM production and therefore lower CHPP demands and losses to tailings.

While the gross water balance model assesses the gross site water surplus or deficit for a given year without importing or exporting water to site, the likely import and export volumes to meet daily operational requirements also needs to be understood. As there is limited water storage capacity at the complex, water is transferred to the complex to meet water demands during dry periods and transferred from the complex to manage water surplus during wet periods. For example, over the course of a single year, during periods of high or prolonged rainfall, the complex may have a surplus of water at one time during the year while a prolonged dry period may result in a water deficit at another time. This is likely to result in water transfers to and from the complex that will be greater than the stated gross water balance.

Imports to the Mount Owen Complex include water pumped from the GRWSS and water sourced from Glennies Creek under water access licences. **Table 5.2** presents the modelled annual mine complex import volumes for Project stage plans Year 1 (2016), Year 5 (2021) and Year 10 (2025).

Table 5.2 - Annual Import Volumes (ML)

Scenario	10th Percentile	50th Percentile	90th Percentile
Year 1 (2016)	2,325	1,450	1,840
Year 5 (2020)	2,210	1,320	1,745
Year 10 (2025)	670	280	505

Exports from the Mount Owen Complex include water transfers to the GRWSS, licensed discharges and spills. **Table 5.3** presents the modelled annual export volumes for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.

Table 5.3 - Annual Export Volumes (ML)

Scenario	10th Percentile	50th Percentile	90th Percentile
Year 1 (2016)	190	640	3,790
Year 5 (2020)	195	650	3,840
Year 10 (2025)	105	530	2,950

Glencore presently has a project underway to construct a new water storage, to be known as Reservoir North, at Liddell. Reservoir North will form an integral component of the GRWSS and be the primary off-site water storage for the Mount Owen Complex with a proposed storage capacity of 2 GL. The pipeline connecting the Mount Owen Complex with Reservoir North, which is subject to a separate approvals process. In addition, the BNP will be investigated for use as an operational water storage after the completion of mining in 2022.

Mount Owen proposes to, within 3 years of Project Approval, review the Mount Owen Complex water balance and interactions with the GRWSS including options for storage and transfer of surplus water.

As indicated in **Section 5.1**, export of surplus water at the Mount Owen Complex are possible via transfers to the GRWSS and discharges under the HRSTS. Mount Owen proposes to continue to share water within the GRWSS and utilise discharges under the HRSTS for the Project either via the Ravensworth Operations and Liddell Coal Mines or from the Mount Owen Complex.

The dirty water management system has been designed and will be constructed in accordance with the Blue Book (Landcom 2004 and DECC 2008) and as such the risk of spill from the dirty water management system is consistent with Blue Book design criteria. By designing this system in accordance with Blue Book criteria, the risk of adverse environmental impacts associated with design spills from the dirty water management system is minimised.
Contingency measures associated with impacts of extended dry periods or drought are discussed further in **Section 8.1.6**.

The proposed final landform has been designed to minimise the catchment contributing to the proposed final voids. In addition, Mount Owen propose to investigate the potential options to use the BNP void for water storage and the proposed RERR Mining Area for tailings emplacement. These options could provide benefits for other mines within the Greater Ravensworth area.

Groundwater flows into and out of the final voids were estimated using relationships provided by Jacobs (2014). If the final voids remain as water bodies in the final landform, the water balance indicates the final voids are not likely to spill and will reach an equilibrium level below the spill level. The predicted equilibrium water levels with the North Pit final void, BNP final void and proposed RERR Mining Area final void are 19 mAHD, 47.5 mAHD and -8 mAHD respectively.

6.0 Surface Water Impacts and Mitigation Measures

The Project and associated WMS (refer to **Section 4.0**) has the potential to impact on surface water systems. This includes the potential to impact on:

- catchment areas and flow volumes in local watercourses (refer to **Section 6.1**);
- flooding, including flow rates, velocities and depths (refer to **Section 6.2**);
- water quality in local watercourses (refer to **Section 6.3**);
- geomorphological and hydrological values of watercourses, including environmental flows (refer to **Sections 6.4**);
- riparian and ecological values of watercourses (refer to **Section 6.5**); and
- water users, both in the vicinity and downstream of the Project (refer to **Section 6.6**).

A detailed assessment of these potential impacts has been undertaken for the Project with the assessment findings outlined in **Sections 6.1** to **6.6**. The impact assessment has been undertaken by comparing the approved final landform, as a base case, with the potential impacts of the Project to determine the incremental impacts.

The proposed mitigation measures for the impacts assessed in **Sections 6.1** to **6.6** are summarised in **Section 6.7**.

6.1 Catchment Areas and Annual Flow Volumes

The Project will result in the need to divert runoff upslope of the operational areas and manage runoff from disturbed areas during the operational and rehabilitation phases of the Project. In the absence of local stream gauging data, catchment areas provide an indicator of the potential relative changes in flow volumes that might occur. As such, changes in catchment areas have been used to predict the potential impacts on annual flow volumes.

The existing approved mining operations include a number of measures to mitigate the impacts on catchment areas. These measures will be continued throughout the life of the Project, including diversion of clean water around mine areas and drainage of rehabilitated areas back to downstream catchments where the water quality is suitable for release. The overburden emplacement areas will be rehabilitated as soon as practicable when final landform is achieved. By implication, some areas will be rehabilitated concurrently with overburden placement in others. The strategy of concurrent rehabilitation will minimise the duration for which catchment is lost during the operational phase. Where practical, once rehabilitation is established, areas will be designed to externally drain to return water to the surrounding environment.

Table 6.1 summarises the predicted impacts on the catchment areas for each of the watercourses for the following scenarios:

- prior to any mining;
- currently approved final landform;
- Project Year 5 (the predicted Project year with the largest area of catchment contained in the WMS); and
- proposed final landform.

Table 6.1 – Predicted Impacts on Catchment Areas

Catchment	Pre-Mining (ha)	Current Area (2012) (ha)[1]	Current Approved Final Landform (ha)	Project		
				Year 5[1] (ha)	Proposed Final Landform[2]	
					Area (ha)	%[4]
Bowmans Creek[3]	**25,055**	**22,010**	**20,390**	**21,590**	**20,520**	**99.4%**
- Stringybark Creek	1,290	1,220	1,300	1,300	1,300	100%
- Yorks Creek	1,230	1,580	1,660	1,800	1,920	116%
- Swamp Creek	2,380	410	1,440	390	1,230	85%
- Bettys Creek	1,810	660	960	700	780	81%
Glennies Creek[3]	**52,335**	**50,265**	**50,405**	**50,215**	**50,255**	**99.7%**
- Main Creek	2,000	2,480	2,620[5]	2,430	2,470	94%

Notes: 1) Excluding WMS
2) Final Landform is when both the decommissioning of infrastructure and the rehabilitation of the post mining landform are completed.
3) Catchment areas modified to reflect changes due to the Project and approved and proposed Liddell Operations. This does not include impacts from other modifications (such as other mining operations) downstream of the Project Area.
4) Project final landform catchment area as a percentage of the current approved final landform.
5) Catchment area updated and larger than identified in Mount Owen Operations EIS, 2003 (previously 1,750 ha), as more accurate terrain data is now available (LiDAR) over entire catchment

The Project results in a larger final void extent than the currently approved final landform within the catchment areas of Swamp Creek, Bettys Creek and Main Creek.

As shown in **Table 6.1**, substantial changes have occurred to the catchment areas (i.e. when comparing pre-mining to the current area) as a result of the approved diversions of the upper catchments of Swamp Creek and Bettys Creek, and the catchment area of the WMS. The catchment areas of Bettys Creek and Swamp Creek are also reduced by the Glendell Mine located downstream of the Mount Owen and Ravensworth East Mines.

For the assessment, the proposed final landform has been compared to the currently approved final landform (refer to **Table 6.1**). In addition, changes during the life of the Project have been considered, where required, by comparing the current catchment areas to the Project Year 5 catchment areas (i.e. when the WMS has the largest influence on downstream catchment areas).

In summary, the Project will result in the following changes to the local catchments, and consequent annual flow volumes, from the currently approved final landform to the proposed final landform catchment areas:

- Stringybark Creek - No changes to the currently approved final landform catchment area.

- Yorks Creek - The Project will increase the catchment area of Yorks Creek by approximately 260 hectares (16 per cent increase from the currently approved final landform catchment area) primarily as a result of the location of the BNP Void and the proposed diversion of the rehabilitated northern Mount Owen emplacement area to Yorks Creek in Year 5 of the Project.

- Swamp Creek - Over the life of the Project, the Swamp Creek catchment will initially be reduced compared to the current catchment area. The proposed final landform will reduce the Swamp Creek catchment by approximately by 210 hectares (15 per cent) compared to the approved final landform, primarily as a result of the proposed diversion of the rehabilitated northern Mount Owen emplacement area to Yorks Creek in Year 5 of the Project, and the BNP final void. The diversion of the rehabilitated northern Mount Owen emplacement area is proposed to prevent runoff from the emplacement area flowing into the WMS, requiring it to be managed as part of the dirty water system. The diversion of runoff from the emplacement area will return flows to downstream watercourses over the life of the Project.

- Bettys Creek - The Project will initially reduce the Bettys Creek catchment compared to the current catchment area, primarily due to the North Pit Continuation final void. The proposed final landform will result in a reduction of Bettys Creek catchment compared to the approved final landform, by approximately 180 hectares (19 per cent), primarily as a result of the increase in area of the North Pit Continuation final void.

- Main Creek - The Project will reduce the catchment area of Main Creek, compared to the approved final landform, by approximately 150 hectares (6 per cent) primarily as a result of the North Pit Continuation final void. This reduction of Main Creek catchment due to the Project will return the Main Creek catchment area closer to its pre-mining catchment area, compared to the currently approved final landform.

The Project will result in no changes to the approved final landform, associated catchment areas or annual flow volumes for Stringybark Creek. The Project will result in an increase in catchment contributing to Yorks Creek. As such annual flow volumes for Stringybark Creek and Yorks Creek are not expected to decrease as a result of the Project.

It is important to note that the changes in annual flow volumes associated with reductions in catchment areas for Swamp Creek and Bettys Creek from the approved final landform to the proposed final landform are considered to be small within the context of ephemeral streams. That is, the change in flows is less than the seasonal and annual variations in flow volumes. Inferring potential variations in flow volumes from historical rainfall data (as no local stream gauges are present) supports this consideration. As analysis indicates that during the historical rainfall period for Jerrys Plains (1884 to 2012) extreme wet and dry periods occur where the rainfall ranges between 200 per cent to 50 per cent of average rainfall conditions.

The proposed reduction of the Main Creek catchment area compared to the currently approved final landform will also return the annual flow volumes with the Project closer to those of the pre-mining catchment than would have been achieved by the current approved final landform.

Due to the limited localised impact, it is anticipated that the Project will have negligible impact on major downstream watercourses including Bowmans Creek, Glennies Creek and the Hunter River. The change in total catchment contributing to the downstream watercourses of Bowmans Creek and Glennies Creek when the Project is compared to the current approved final landform is minimal, where the reduction in total contributing catchment is less than 0.6 per cent for both Bowmans Creek and Glennies Creek.

6.2 Flooding

6.2.1 Methodology

Dynamic flood modelling of the waterways and catchments surrounding the Mount Owen Complex was undertaken using XPStorm®. Flood modelling was undertaken for the current landform, approved final landform, the Project Year 5 landform (i.e. when the catchment of the WMS is largest during the Project) and the proposed final landform. Flood events that were simulated included the 10 per cent, 5 per cent and 1 per cent AEP events (also referred to as the 10 year, 20 year and 100 year average recurrence interval (ARI) events).

For the assessment, flood modelling results for the proposed final landform have been compared to the approved final landform. In addition, changes during the life of the Project have been considered, where required, by comparing the current catchment areas to the Project Year 5 catchment areas (i.e. when the WMS has the largest influence on downstream catchment areas) for the 10 per cent and 5 per cent AEP events.

The approved final landform model includes the currently approved extent of the North Pit, final rehabilitated landforms for NVS1 and NVS2, Glendell Mine, Ravensworth East Mine, approved and proposed Liddell Continued Operations and the existing Bowmans Creek Bridge on Hebden Road.

The flood modelling for all events and landforms is based on the assumption that all sediment dams are full within the operational WMS so as to obtain a conservative estimate of flood peaks.

6.2.2 Overview of Results

The results of the flood modelling for Yorks Creek, Swamp Creek, Bettys Creek and Main Creek, including the peak watercourse flow, flood depth and velocity are shown in **Tables 6.2** to **6.8**. The modelling results for the proposed Bowmans Creek Bridge on Hebden Road are detailed in **Table 6.9**, and the modelling results for the proposed rail bridge over Bettys Creek is detailed in **Table 6.10**.

In accordance with the NSW Floodplain Development Manual (2005), the 1 per cent AEP flood event is used as a floodplain management tool in assessing impacts of development on flooding and has also been used as the design event for proposed crossings. The flood modelling indicates that the Project is generally located outside of the 1 per cent AEP event flood extent as shown in **Figure 6.1**, with the exception of the proposed rail bridge over Bettys Creek, the proposed Bowmans Creek Bridge on Hebden Road and areas of flow conveyance within Bowmans Creek and Yorks Creek. There is no proposed mining or overburden emplacement proposed within the 1 per cent AEP flood extent.

At Ravensworth East Mine, the western boundary of the Project Area extends over Bowmans Creek, and as such encompasses the 1 per cent AEP flood extent. East of Glendell Mine, the Project Area boundary extends over Bettys Creek, and as such encompasses the 1 per cent AEP flood extent. Over the life of the Project, no operations or disturbance of land is proposed occur within the 1 per cent AEP flood extent in either of these locations.

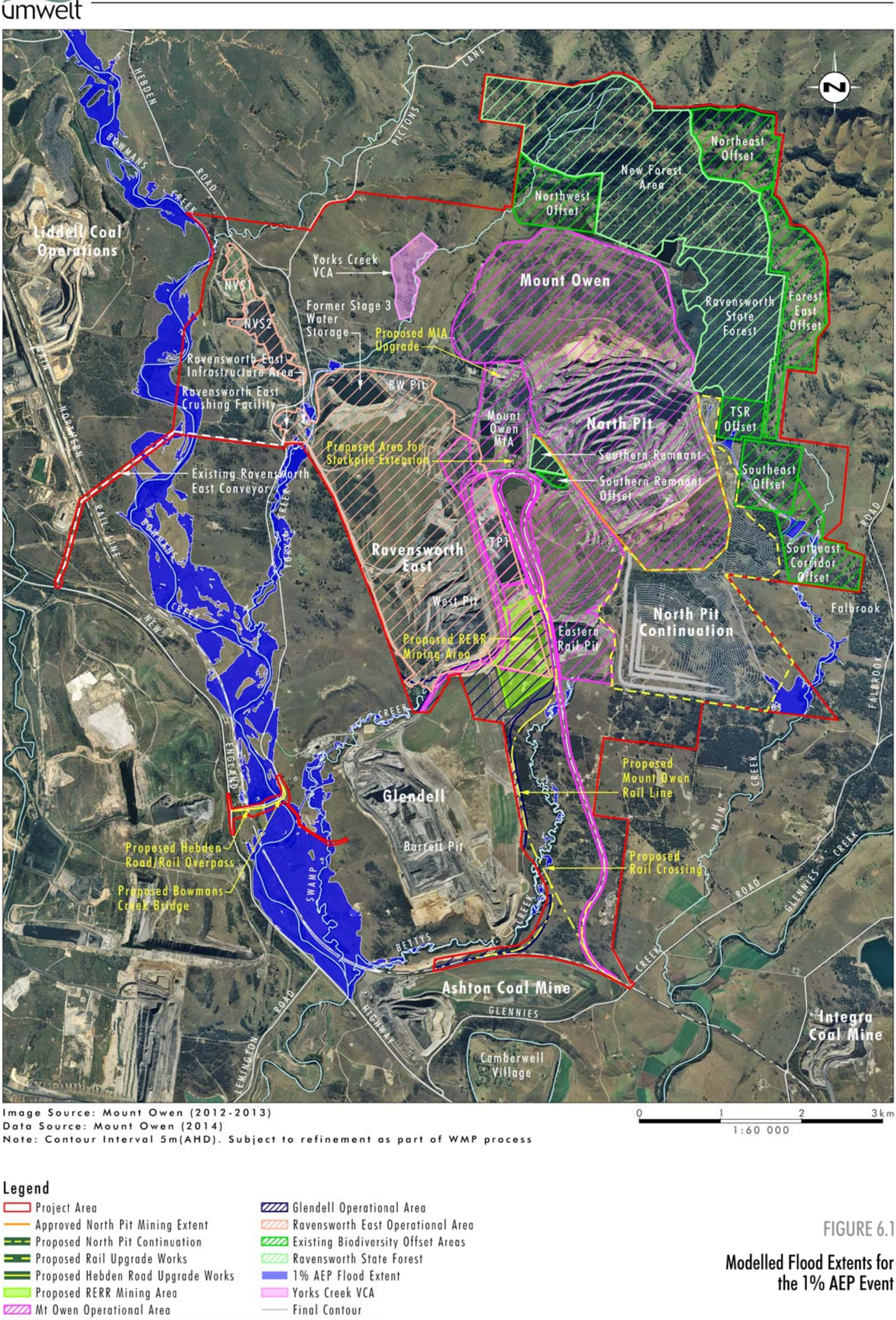


FIGURE 6.1

Modelled Flood Extents for the 1% AEP Event

File Name (A4): R05/3109_822.dgn
20141008 16.30

The eastern extent of the Project Area boundary extends over Main Creek. The majority of Main Creek and associated 1 per cent AEP flood extent occurs within the Southeast Corridor Offset area and a small area within the Project Area near the North Pit Continuation as shown in **Figure 6.1**. Flood modelling indicates that the flood extent for the 1 per cent AEP flood event is located along a minor drainage line, associated with backwater flows from Main Creek and will extend to within 50 metres of the edge of the North Pit Continuation final void with less than 1 metre freeboard. As part of highwall access and safety works Mount Owen construct road safety berms which will be at least 1 metre high around the crest of high walls and steep slopes. The road safety berm around the North Pit Continuation will provide additional freeboard for the 1 per cent AEP flood event. The details of the road safety berm and flooding interactions will be included in the updated Water Management Plan.

Further detail on flooding impacts for relevant catchments is provided in the following sections.

6.2.2.1 Yorks Creek

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 at Hebden Road will be provided.

The purpose of the abovementioned flow controls is to maintain existing channel stability by managing potential velocity increases in Yorks Creek associated with increases in peak flow rates and to manage potential impacts on access during flooding at the Hebden Road crossing of Yorks Creek.

The proposed off line detention capacity will be provided by modifying the existing Industrial Dam (refer to **Figures 3.1** and **4.2**) to provide off line detention storage for flood events above the 10% AEP event. The modifications to the Industrial Dam will include construction of an overflow spillway from Yorks Creek to the Industrial Dam and a low flow outlet pipe from the Industrial Dam to Yorks Creek.

The additional flow conveyance will be provided at the Hebden Road crossing of Yorks Creek and will consist of an additional box culvert under the road.

The modelling results for Yorks Creek for the approved final landform, the proposed final landform, current landform and the Project Year 5 landform (i.e. when the catchment of the WMS is largest during the Project) are compared in **Table 6.2** for the 10 per cent, 5 per cent and 1 per cent AEP events. The modelling results for the proposed final landform and the Project Year 5 landform include the abovementioned additional detention capacity and flow conveyance.

Table 6.2 - Peak Flood Model Results for Yorks Creek

Scenario	10% AEP event			5% AEP event			1% AEP event		
	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)
Approved Final Landform	2.73	1.19	36.5	2.91	1.16	44.6	3.29	1.12	67.8
Proposed Final landform	2.88	1.29	42.9	3.02	1.26	50.7	3.31	1.21	69.1
Current Landform	2.11	1.62	23.6	2.33	1.64	29.0	-	-	-
Project Year 5	2.87	1.29	42.4	3.01	1.27	50.1	3.31	1.21	69.2

Results are presented for flows immediately upstream of the confluence of Yorks Creek with Bowmans Creek.

Flood modelling indicates that the peak flows in Yorks Creek downstream of the WMS are anticipated to increase over the life of the Project compared to the modelled peak flows for the current landform and approved final landform (refer to **Table 6.2**). This increase in flows is due to the proposed diversion of the North Pit emplacement area (approximately 190 hectares) that will be diverted from Swamp Creek catchment to Yorks Creek catchment in Year 5. This modelled increase would occur along the clean water channel from the North Pit emplacement area (refer to **Figure 4.2**) to the downstream reaches of Yorks Creek immediately upstream of the confluence with Bowmans Creek. The upstream reaches of Yorks Creek, including where the Voluntary Conservation Area (VCA) is located, will not be impacted (refer to **Figure 6.1**).

The potential increases in flood depths associated with the increases in peak flow rates are expected to have minimal impact as there are no private landholders located adjacent to the creek or on the floodplain of Yorks Creek. The modelling indicates an increase in peak flood depths at the Hebden Road crossing over Yorks Creek. These impacts are discussed further below.

The modelling indicates an increase in peak velocities within Yorks Creek. The long term stability of the bed and banks of a watercourse is influenced by the flow energy within the watercourse. The flow energy is typically estimated using modelled flow velocities and tractive stresses (i.e. the force of the water on the bed and banks of a watercourse) throughout the modelled watercourse in response to a bank full flow event. The bank full flow event is classed as the design event that results in maximum flow depths that are approximately equal to the top of bank of the watercourse, typically the 50 per cent AEP event. Analysis of the modelling results indicates that the flows within bank (i.e. for the 50 per cent AEP event) are currently classed as unstable based on an analysis of tractive stresses and bed/bank conditions. Although the Project will increase the in channel tractive stresses by a small amount they will continue to be in the current range (i.e. unstable). As such it is considered that the Project will have minimal impact on watercourse stability of the channel of Yorks Creek.

The modelling indicates that the Project will not influence flood flows and levels within Bowmans Creek and that impacts of the Project on flood flows in the Yorks Creek catchment will be limited to Yorks Creek.

Flood Access at Hebden Road

Potential impacts on flood access at the Hebden Road crossing of Yorks Creek are summarised in **Tables 6.3** to **6.5**.

The modelling indicates no change in the maximum flood hazard category for the 1 per cent AEP and 10 per cent AEP events. The modelling indicates an increase in maximum flood hazard category for the 5 per cent AEP event (refer to **Table 6.3**). The change in maximum flood hazard category at the Hebden Road crossing over Yorks Creek for the 5 per cent AEP event is primarily driven by an increase in the maximum flood depth over the road (refer to **Table 6.4**).

Analysis of the modelling results also indicates an increase in the duration that the Hebden Road crossing over Yorks Creek would be impassable to vehicles (based on the flood hazard category analysis) for the 1 per cent AEP and 5 per cent AEP events of 50 minutes (12 per cent) and 70 minutes (38 per cent) respectively for the proposed final landform when compared to the final approved landform (refer to **Table 6.5**).

Table 6.3 - Flood Hazard Category @ Hebden Road crossing of Yorks Creek

Flood Event	Final Approved Landform	Proposed Final Landform	Year 5 Project Landform
1% AEP	Damage to light structures (4)	Damage to light structures (4)	Damage to light structures (4)
5% AEP	Vehicles unstable (2)	Wading unsafe (3)	Wading unsafe (3)
10% AEP	Walking and vehicle access (1)	Walking and vehicle access (1)	Walking and vehicle access (1)

Note 1: Flood Hazard Categories have been determined in accordance with methods outlined in the NSW Floodplain Development Manual (2005).

Note 2: Flood Hazard Categories increasing in order are: Walking and vehicle access (1), Vehicles unstable (2), Wading unsafe (3), Damage to light structures (4).

Table 6.4 - Maximum Flood Depth (metres) @ Hebden Road crossing of Yorks Creek

Flood Event	Final Approved Landform	Proposed Final Landform	Year 5 Project Landform
1% AEP	0.94	0.87	0.88
5% AEP	0.32	0.53	0.49
10% AEP	0.11	0.18	0.16

Table 6.5 - Duration of Vehicles Unstable Flood Hazard Category (hrs:mins) @ Hebden Road crossing of Yorks Creek

Flood Event	Final Approved Landform	Proposed Final Landform	Year 5 Project Landform
1% AEP	6:50	7:40	7:35
5% AEP	3:20	4:35	4:25
10% AEP	-	-	-

Hebden Road is a rural road and as such the main concerns associated with flood impacts at the Yorks Creek crossing are in regards to maintaining vehicle access over the crossing during flood events. The impacts as a result of the Project on vehicle access are related to an increase in the duration that Hebden Road is impassable for vehicles during the 1 per cent AEP and 5 per cent AEP events. No changes to the ability to drive over Yorks Creek at the Hebden Road crossing for the 10 per cent AEP event are expected. That is, more regular flood events are not impacted, with the impacts during major flood events relating to an increase in duration when the road is impassable to vehicles.

6.2.2.2 Swamp Creek

The modelling results for Swamp Creek for the approved final landform, the proposed final landform, current landform and the Project Year 5 landform are compared in **Table 6.6** for the 10 per cent, 5 per cent and 1 per cent AEP events.

Table 6.6 - Peak Flood Model Results for Swamp Creek

Scenario	10% AEP event			5% AEP event			1% AEP event		
	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)
Approved Final Landform	2.28	0.53	33.1	2.28	0.53	40.4	2.29	0.57	55.3
Proposed Final landform	2.27	0.55	25.6	2.27	0.53	31.9	2.28	0.54	44.0
Current Landform	1.39	0.62	5.4	1.52	0.64	6.6	-	-	-
Project Year 5	2.24	0.57	15.5	2.27	0.57	19.9		0.54	36.8

Results are presented for flows approximately 1.5 kilometres upstream of the confluence of Swamp Creek with Bowmans Creek which is located downstream of the extent of the WMS associated with the Project.

The modelling indicates that peak flows for the proposed final landform will reduce by approximately 20 per cent for the 1 per cent AEP event from the approved final landform due to the reduction in contributing catchment area (refer to **Table 6.1**), however the reduction in flow is anticipated to have negligible impacts on flood depths and velocities downstream of the Project.

Modelling indicates the peak flows in Swamp Creek for Year 5 will be increased from peak current operations (refer to **Table 6.6**). There are also corresponding increases in flood depths during modelled events for the Project Year 5 landform when compared to the current landform for the 10 per cent and 5 per cent AEP flood events.

6.2.2.3 Bettys Creek

The modelling results for Bettys Creek for the approved final landform, the proposed final landform, current landform and the Project Year 5 landform (are compared in **Table 6.7** for the 10 per cent, 5 per cent and 1 per cent AEP events.

Table 6.7 - Peak Flood Model Results for Bettys Creek

Scenario	10% AEP event			5% AEP event			1% AEP event		
	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)
Approved Final Landform	0.81	1.29	14.1	0.87	1.30	16.4	1.05	1.31	24.2
Proposed Final Landform	0.75	1.16	8.5	0.83	1.20	10.3	0.95	1.28	13.6
Current Landform	1.99	1.14	12.3	2.16	1.16	14.5	-	-	-
Project Year 5	0.79	1.30	14.4	0.86	1.30	16.9	1.03	1.30	24.4

Results are presented for flows approximately 2.2 kilometres upstream of the confluence of Bettys Creek with Bowmans Creek, upstream of the Lower Bettys Creek Diversion.

The modelling indicates that peak flows for the proposed final landform will reduce by approximately 44 per cent for the 1 per cent AEP event compared to the approved final landform due to the reduction in contributing catchment area (refer to **Table 6.1**). The reduction in flow in Bettys Creek for the proposed final landform will similarly decrease flood depths and velocities downstream of the Project Area.

Modelling indicates the peak flows in Bettys Creek for Year 5 will be increased from peak flows for current operations (refer to **Table 6.7**), with corresponding decreases in flood depths during modelled events for the Project Year 5 landform when compared to the current landform for the 10 per cent and 5 per cent AEP flood events.

6.2.2.4 Main Creek

The modelling results for Main Creek for the approved final landform, the proposed final landform, current landform and the Project Year 5 landform (i.e. when the catchment of the WMS is largest during the Project) are compared in **Table 6.8** for the 10 per cent, 5 per cent and 1 per cent AEP events.

Table 6.8 - Peak Flood Model Results for Main Creek

Scenario	10% AEP event			5% AEP event			1% AEP event		
	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)	Depth (m)	Velocity (m/s)	Flow (m^3/s)
Approved Final Landform	1.15	1.16	45.9	1.29	1.16	58.1	1.53	1.15	80.4
Proposed Final landform	1.12	1.16	42.5	1.28	1.16	56.1	1.48	1.16	74.5
Current Landform	1.08	1.12	45.1	1.19	1.12	54.6	-	-	-
Project Year 5	1.15	1.15	45.7	1.29	1.15	57.9	1.53	1.15	80.1

Results are presented for flows approximately 0.4 kilometres upstream of the confluence of Main Creek with Glennies Creek.

The modelling indicates that peak flows for the proposed final landform will reduce by approximately 7 per cent for the 1 per cent AEP event from the approved final landform due to the reduction in catchment as a result of the North Pit Continuation final void. The reduction in peak flows corresponds to a modelled decrease in flood depths and negligible impacts on velocities downstream of the Project.

Modelling indicates the peak flows in Main Creek for Year 5 of the Project will increase compared to peak flows for the current operations (refer to **Table 6.8**) with the return of clean water runoff from rehabilitated areas of the WMS to the Main Creek catchment. Associated with the reduction in peak flows from the current operations to Year 5 is an increase in peak velocity and flood depths. The increases in peak velocity and flood depth for Year 5 of the Project are a result of changes to the upper catchments of the Upper Bettys Creek Diversion (refer to **Figure 2.1**). The increases in peak velocity and flood depth are also approximately equal to or less than the approved final landform and as such are considered to have negligible impact on downstream landholders and watercourse stability.

In the mid and lower reaches of Main Creek (i.e. downstream of the Project Area), where the creek passes through two private properties, modelling indicates that the proposed final landform will result in a decrease to the duration of flooding (length of time the water level is out of bank) in comparison to the approved final landform. This flood duration decrease is estimated to be approximately 20 minutes (a reduction of less than 2 per cent) for the 10 per cent, 5 per cent, and 1 per cent AEP events. Due to the low associated velocities of the out of bank flow and decrease in maximum flood depth and duration in relation to the approved final landform, the Project is not considered to have a significant impact on the Main Creek floodplain, and will not adversely impact any private landholders in the catchment.

6.2.2.5 Proposed Infrastructure Crossings

Two waterway crossings are proposed as part of the Project and shown in **Figure 6.1**. These crossings are the proposed Bowmans Creek Bridge on Hebden Road and the proposed rail bridge over Bettys Creek.

Currently during the 1 per cent AEP flood event the approaches to the existing Bowmans Creek Bridge on Hebden Road are inundated. The proposed Bowmans Creek Bridge has been designed so that the bridge deck will not be inundated during the 1 per cent AEP flood event, however the approaches to the bridge will be. The proposed Bowmans Creek Bridge has been designed as a dual lane, 3 span bridge with twin reinforced concrete blade wall type piers and is located parallel to the existing Bowmans Creek Bridge on Hebden Road. No piers will be located in the low flow channel. The proposed Bowmans Creek Bridge will have a total span of 45 metres, consisting of a 20 metre main span and two 12.5 metre approach spans. The width of the proposed bridge will be 10 metres, and the bridge soffit will be elevated approximately 5 metres above the Bowmans Creek channel invert. Rock scour protection will be provided on the channel banks from the piers to the abutments, however the main channel between the piers will not have scour protection.

The proposed rail bridge crossing over Bettys Creek has been designed as a single span bridge. This proposed rail bridge will have a span of approximately 16 metres and width of approximately 17 metres that will be elevated approximately 4.5 metres above the Bettys Creek channel invert. Rock rip-rap or other suitable scour protection will be provided at bridge abutments to control erosion.

The modelling results for the proposed Bowmans Creek Bridge and the proposed Bettys Creek rail bridge for flood depth, velocity and flow for the 1 per cent AEP event are compared in **Tables 6.9** and **6.10** respectively.

Table 6.9 - Peak Flood Model Results for Proposed Bowmans Creek Bridge on Hebden Road

Location	Scenario	1% AEP		
		Depth (m)	Velocity (m/s)	Flow (m^3/s)
Upstream of Bridge	Existing Bridge	4.3	0.6	676.8
	Proposed Bridge	4.7	0.7	684.0
Downstream of Bridge	Existing Bridge	5.2	1.8	680.8
	Proposed Bridge	5.2	1.9	688.0

Note 1: Results are presented for the approved final landform model (i.e. with existing crossing) and proposed final landform model (i.e. with proposed duplication) approximately 100 metres upstream and 170 metres downstream of the proposed Bowmans Creek Bridge.

Note 2: Model with proposed bridge includes the Project final landform. As such the increase in peak flows at the Hebden Road crossing of Yorks Creek are a result the Project including the North Pit emplacement area diversion.

Modelling indicates that the proposed Bowmans Creek Bridge on Hebden Road (refer to **Table 6.9**) will have negligible impact on peak depth and velocity downstream of the bridge for the 1 per cent AEP event. The peak depth and velocity in Bowmans Creek upstream of the proposed Bowmans Creek Bridge is anticipated to increase slightly due to the raised road embankments for the proposed Bridge restricting floodplain flows. Modelling indicates an afflux of approximately 400 millimetres (i.e. increase in peak flood depths) associated with the proposed Bridge. This afflux extends approximately 480 metres upstream of the proposed Bridge. There are no private properties within the afflux zone with all land adjacent to Bowmans Creek in the afflux zone owned by Glencore, except one parcel owned by a government authority. Modelling indicates that peak flows for the 1 per cent AEP event, similar to the existing approaches, will overtop the proposed approaches to the Bowmans Creek Bridge across the Bowmans Creek floodplain, but the proposed bridge will not be overtopped.

Table 6.10 - Peak Flood Model Results for Proposed Rail Bridge on Bettys Creek

Location	Scenario	100 year ARI		
		Depth (m)	Velocity (m/s)	Flow (m3/s)
Upstream of Crossing	Existing Bettys Creek channel	2.05	1.06	24.6
	With proposed rail bridge	1.85	0.89	13.8
Crossing	With proposed rail bridge	2.14	1.37	13.8
Downstream of Crossing	Existing Bettys Creek channel	2.39	1.06	24.6
	With proposed rail bridge	2.11	0.72	13.7

Note 1: Results are presented for the approved final landform model (i.e. existing Bettys Creek channel) and Project final landform model (i.e. with proposed crossing) approximately 270m upstream and 115m downstream of crossings.

Note 2: Model with proposed crossing includes the Project final landform associated with the Project (such as the decrease in catchment area associated with the North Pit final void).

Modelling indicates that the proposed rail bridge across Bettys Creek, along with the proposed reduction in Betty Creek catchment (refer to **Table 6.1**), will result in reduced flows, depths and velocities in Bettys Creek upstream and downstream of the proposed rail bridge for the 1 per cent AEP event (refer to **Table 6.10**). There are modelled localised velocity increases at the proposed rail bridge. The channel at this location will be protected against potential erosion through the use of rock rip-rap or other suitable scour protection. The increase in flood depths at the crossing are localised and will not affect any private properties as the land adjacent to Bettys Creek is owned by Glencore. Modelling indicates that peak flows for the 1 per cent AEP event do not overtop the proposed rail bridge on Bettys Creek. As such it is considered that the proposed rail bridge on Bettys Creek will have negligible impact on flooding and watercourse stability.

6.3 Water Quality

The existing WMS as outlined in **Section 3.0**, 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 Project WMS has been designed to divert clean water around mining operations and segregate, store and reuse mine impacted water to minimise adverse affects on water quality from mining operations to downstream waterways.

As set out in **Section 4.0**, it is proposed to integrate water management for the Project within the existing WMS to limit the potential impacts of the Project 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 construction, operation and rehabilitation phases of the Project to manage water quality (refer to **Section 6.7**).

Background water quality data (refer to **Section 2.2**) indicates that Bowmans Creek historically does not have elevated pH, EC or TSS concentrations. Tributaries of Bowmans Creek including Yorks Creek and Swamp Creek historically have elevated concentrations of EC and TDS during periods of reduced flow, and elevated TSS concentrations during rainfall events. Swamp Creek occasionally shows elevated pH levels during periods of low flow. Bettys Creek typically has consistent EC and TDS, with elevated TSS concentrations during rainfall events.

The historic water quality in Main Creek (a tributary of Glennies Creek) occasionally displays elevated salinity and TSS concentrations.

The Project 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 spilling and potential impacts associated with spilling is currently managed by the 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 Project WMS (refer to **Section 4.1**) includes:

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

As part of the Project, Mount Owen proposes to update the existing WMP to reflect the changes to water management at the complex associated with the Project.

If required, controlled discharges to Swamp Creek will flow via Bowmans Creek to the Hunter River in accordance with EPL 4460 and the HRSTS. There are specific requirements for discharge under the HRSTS including certain parameters relating to flow volumes that must be followed to reduce potential impact during discharge events. Any discharges will be controlled so as to stay within the existing creek banks and at a rate to minimise erosion impacts. The Project does not propose to increase either the discharge volumes or water quality criteria from those specified in the currently approved EPL.

The proposed final landform has been designed to minimise the catchment contributing to the proposed final voids. In addition, Mount Owen will investigate to potentially use the BNP void for ongoing operational water storage and allow for integration within the GRWSS, as required, and the proposed RERR Mining Area for tailings emplacement. These options could provide benefits for other mines within the Greater Ravensworth area. If the final voids remain as water bodies in the final landform, the water balance for the final voids indicates that, at the predicted recovery rates, the equilibrium water levels with the North Pit final void will be approximately 19 mAHD, the BNP final void water level will be approximately 48 mAHD and proposed RERR Mining Area final void water level will be approximately -8 mAHD. As such it is predicted that the final voids will remain self contained systems with no surface spills predicted to downstream watercourses.

As discussed further in **Section 8.1**, Mount Owen will update the WMP and associated monitoring programs. The water quality criteria in the WMP are consistent with the NSW Water Quality and River Flow Objectives and associated ANZECC guidelines (refer to **Section 2.2.1**).

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

6.4 Geomorphological and Hydrological Values

The Project 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 Project are discussed below.

6.4.1 Yorks Creek

The mid and downstream portions of Yorks Creek typically have a well defined channel and wide floodplain. Yorks Creek is a Schedule 2 watercourse with a low channel gradient, ephemeral and frequently dry. In the downstream portion of Yorks Creek, the riparian zone of the creek banks has some vegetation and existing erosion is minimal.

The Project will result in increased peak flows with associated increases in flood levels and flow velocities along Yorks Creek due to diversion of clean water runoff from the North Pit emplacement area. Potential impacts on stability (i.e. scour potential along the lower reaches of Yorks Creek) are proposed to be managed by provision of additional flow conveyance and detention capacity (refer to **Section 6.2.2.1**). It is considered that with the proposed management and monitoring measures (refer to **Sections 6.7** and **8.1),** the potential impacts are acceptable.

6.4.2 Swamp Creek and Bettys Creek

Swamp Creek and Bettys Creek downstream of the Project Area typically have well defined channels and wide floodplains. These creeks are Schedule 2 watercourses with low channel gradients, are ephemeral and frequently dry. In Swamp Creek downstream of the Project Area, the riparian zone of the creek banks has some vegetation and existing erosion is minimal. In Bettys Creek downstream of the Project Area, the riparian zone of the creek banks is well vegetated and existing erosion is also minimal.

The Project will result in lower peak flows with similar or slightly reduced flood levels and velocities in the lower reaches of Swamp Creek and Bettys Creek downstream of the Project Area. Scour potential along the lower reaches of Swamp Creek and Bettys Creek downstream of the Project Area will not be increased from the approved final landform due to the Project.

6.4.3 Main Creek

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, downstream of the Project Area, 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 Project 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 final landform. Peak velocities of flow during flood events will remain the same for the Project as the current approved final landform. Scour potential along the lower reaches of Main Creek will not be increased from the current approved final landform due to the Project.

6.5 Riparian and Ecological Values

To retain the existing riparian and ecological conditions that support local ecosystems downstream of the Project Area, the proposed infrastructure involving creek crossings have been designed to meet fish passage requirements, and where required, impacts of flooding and flow volumes in local ephemeral waterways have been mitigated.

The proposed Bowmans Creek Bridge on Hebden Road and the proposed rail bridge over Bettys Creek have been designed to meet fish passage requirements, as outlined in *Why do fish need to cross the road? Fish Passage Requirements for Waterway Crossings* (Fairfull, S. & Witheridge, G, 2003).

Bowmans Creek is classified as a *Class 2 moderate fish habitat*, and these waterways require crossings to be designed as a bridge, arch structure, high flow culvert or ford. The proposed Bowmans Creek Bridge meets the recommended fish passage crossing requirements. Bettys Creek is classified as a *Class 3 minimal fish habitat*, and these waterways require crossings to be designed as a high flow culvert or ford. The proposed rail bridge over Bettys Creek meets the recommended fish passage crossing requirements.

The changes in annual flow volumes associated with changes to catchment areas for Yorks Creek, Swamp Creek, Bettys Creek and Main Creek from the current approved final landform to the proposed final landform are considered to be small within the context of ephemeral streams. The changes to annual flow volumes are also considered to be small on a regional scale. That is, the change in flows are less than the seasonal and annual variations in flow volumes comparing dry years to wet years. In addition, the Project is considered to have negligible impacts on baseflows (refer to Appendix 10 of the EIS). The Project 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.

6.6 Water Users

The majority of land adjacent to Yorks Creek, Bettys Creek and Swamp Creek downstream of the Project Area to the New England Highway is owned by Glencore. There is one lot on Yorks Creek owned by a government authority and one lot on Bettys Creek owned by the Crown. As such there are no private landholders located immediately downstream of the Project Area on Yorks Creek, Swamp Creek or Bettys Creek. There are two private landholders with access to Main Creek located downstream of the Project Area.

There are no known licensed water users on waterways directly downstream of the Project Area along Yorks Creek, Swamp Creek, Bettys Creek or Main Creek. There are known licensed water users on Bowmans Creek and Glennies Creek downstream of the Project Area. In addition, there are private landholders downstream of the Project Area on Main Creek, Glennies Creek and Bowmans Creek that retain basic landholder rights for domestic and stock use.

The Project will not reduce annual flow volumes in Main Creek compared to the currently approved landform conditions (refer to **Table 6.1**). As such basic landholder rights on Main Creek and Glennies Creek will not be affected by the Project.

The Project will result in a reduction to the catchment areas of Bowmans Creek and Glennies Creek (less than 0.6 per cent). As such, the Project is considered to have negligible impact on basic landholder rights downstream of the Project Area on Bowmans Creek or Glennies Creek.

6.7 Summary of Proposed Mitigation Measures

In addition to the Project WMS (refer to **Section 4.0**), mitigation measures are proposed to mitigate flooding impacts on Yorks Creek and water quality impacts associated with disturbance areas. The proposed mitigation measures are summarised in **Sections 6.7.1** and **6.7.2**.

6.7.1 Yorks Creek Flooding

As detailed in **Section 6.2.2.1,** 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 at Hebden Road are proposed.

The proposed off line detention capacity will be provided by modifying the existing Industrial Dam (refer to **Figures 3.1** and **4.2**) to provide off line detention storage for flood events above the 10% AEP event. The modifications to the Industrial Dam will include construction of an overflow spillway from Yorks Creek to the Industrial Dam and a low flow outlet pipe from the Industrial Dam to Yorks Creek.

The additional flow conveyance will be provided at the Hebden Road crossing of Yorks Creek and will consist of an additional box culvert under the road.

6.7.2 Erosion and Sediment Control Measures

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

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; and
- meet the requirements of the Blue Book (Landcom 2004 and DECC 2008) and the *Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields* (DIPNR undated).

6.7.2.1 Construction

Construction environmental management plans will detail the specific inspection, maintenance and revegetation requirements for each works area based on the construction program schedule. These control measures will be set out in a detailed Erosion and Sediment Control Plan for ground disturbance works and will be in accordance with relevant guidelines for erosion and sediment control, including the relevant volumes of the Blue Book, as follows:

- 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 2A – Installation of Services*.
- Department of Environment and Climate Change (DECC) 2008. *Managing Urban Stormwater – Soils and Construction, 2C – Unsealed Roads*.
- Department of Environment and Climate Change (DECC) 2008. *Managing Urban Stormwater – Soils and Construction, 2D – Main Road Construction*.
- Department of Environment and Climate Change (DECC) 2008. *Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries*.

When work is required within or adjacent to watercourses, work will be in accordance with guidelines from *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volumes 2A, 2C, 2D and 2E* (DECC 2008) (the Blue Book), including:

- works within the riparian zone will maximise, where possible the preservation of any existing vegetation and minimise disturbance;

- designs for works within or near water bodies will ensure the retention of natural functions and maintenance of fish passage in accordance with NSW Fisheries Guidelines (undated) *Fish Friendly Waterway Crossings* (refer to **Section 6.5**); and

- planned works will, where possible, be scheduled for forecasted dry weather periods.

6.7.2.2 Operations

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

- Landcom 2004. Managing Urban Stormwater – *Soils and Construction, Volume 1, 4th Edition*; and

- Department of Environment and Climate Change (DECC) 2008. *Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries*.

Specific erosion and sediment control measures proposed to be implemented for the Project will also include those measures outlined in **Section 4.2** and the Mine Closure and Rehabilitation Assessment Report (refer to Appendix 18 of the EIS).

7.0 Cumulative Impacts

Land use within the catchments of Bowmans Creek and Glennies Creek includes mining operations, quarrying, grazing and rural residential holdings. In addition, Glennies Creek Dam (Lake St Clair) located on Glennies Creek (refer to **Figure 2.1**) regulates flows in Glennies Creek dam for water abstraction purposes.

Established mining operations within the catchment areas of Bowmans Creek and Glennies Creek include Glendell Mine to the south-west; Liddell Coal Operations to the north-west; Ravensworth Operations to the south-west; Integra Mine to the south-east; and Ashton Mine to the south.

As discussed in **Section 6.0,** the impact assessment has been undertaken by comparing the approved final landform, as a base case, to the Project to determine the incremental potential impacts. The impact assessment also considers the proposed modifications to Liddell Coal Operations to the north-west and the Glendell mine to the south.

The surface water assessment indicates that the Project is expected to have negligible impacts on flows, water quality and water users relative to the existing approved impacts immediately downstream of the Project Area, on Bowmans Creek and Glennies Creek, and on the Hunter River.

It is considered that the Project will have negligible cumulative impacts on flows in downstream watercourses, water quality and downstream users when compared to the current approved final landform. This is discussed in more detail below.

7.1 Flows

The Project will result in changes to the catchment areas for Yorks Creek, Swamp Creek, Bettys Creek and Main Creek compared to the catchment areas of the currently approved final landform at Mount Owen Mine. This is due to proposed diversions from the North Pit emplacement area and the North Pit, BNP and proposed RERR Mining Area final voids. The Project will not change the currently approved final catchment of Stringybark Creek.

The modelled reductions in peak flows and changes to catchment areas for Yorks Creek, Swamp Creek, Bettys Creek and Main Creek from the approved final landform to the proposed final landform are considered to be small within the context of ephemeral streams. That is, the change in flows are less than the seasonal and annual variations in flow volumes comparing dry years to wet years. The Project is consequently considered likely to have limited impact on waterway stability and scour potential, ecosystems and downstream users.

The change in total catchment contributing to the downstream watercourses of Bowmans Creek and Glennies Creek when the Project is compared to the approved final landform is negligible, where the reduction in total contributing catchment is less than 0.6 per cent for both Bowmans Creek and Glennies Creek. As such the Project is considered to have negligible cumulative impacts to downstream watercourses.

7.2 Water Quality

To manage potential water quality impacts throughout the life of the Project, it is proposed to integrate water management for the Project with the existing WMS (as set out in **Section 4.0**). In conjunction with the proposed Mount Owen Complex WMS, a series of erosion and sediment control measures will be utilised during construction, operation and rehabilitation phases of the Project to manage water quality (refer to **Section 6.3.1**).

Mount Owen is required to undertake monthly water quality monitoring at locations surrounding the Mount Owen Complex for key indicator parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), and total suspended solids (TSS) under the *Mount Owen Surface Water Monitoring Program*.

As detailed in **Section 2.2**, the ANZECC guidelines provide both default trigger values and methods to determine site specific water quality triggers. Site specific triggers for the Mount Owen Complex water quality monitoring locations have been determined using the ANZECC guideline methods and are described in the WMP (refer to **Table 2.2**). The site specific water quality triggers can be used to characterise the water quality and ecological integrity of the water resource.

Background water quality data indicates that Bowmans Creek historically has elevated pH, and EC and TDS concentrations are typically within site specific trigger values. Tributaries of Bowmans Creek including Yorks Creek and Swamp Creek historically have elevated concentrations of EC and TDS during periods of reduced flow, and elevated TSS concentrations during rainfall events. Swamp Creek occasionally shows elevated pH levels during periods of low flow. Bettys Creek typically has consistent EC and TDS, with elevated TSS concentrations during rainfall events. The historic water quality in Main Creek (a tributary of Glennies Creek) occasionally displays elevated EC and elevated TSS concentrations during high rainfall events.

Through management of dirty water and mine water within the integrated WMS over the life of the Project, reduction of flows and a modelled reduction or similar scour potential in waterways downstream of the Project Area with consideration of proposed mitigation measures, it is not anticipated that water quality in downstream waterways will be adversely impacted by the Project. As such the Project is considered to have negligible cumulative impacts to water quality on downstream watercourses.

7.3 Downstream Users

Private landowners downstream of the Project Area along Main Creek and Bowmans Creek have the potential to be impacted by the Project. Private landowners along Main Creek will experience reduced flood peaks and flood durations due to the Project by comparison to the current approved final landform. Peak flood levels and velocities in Bowmans Creek downstream of the Project Area will not be impacted by the Project. Water quality is not anticipated to be adversely impacted by the Project.

As such the Project is considered to have negligible cumulative impacts on downstream water users.

8.0 Monitoring, Licensing and Reporting

Water systems are monitored within the Project Area and surrounds in accordance with the *Mount Owen Complex Water Management Plan* .

Water monitoring at Mount Owen Mine is undertaken to assess compliance against licence conditions and consent conditions, and for operational purposes. This includes monitoring of erosion and sediment controls, the site water balance and water quality.

If the Project is approved, the *Mount Owen Complex Water Management Plan* and associated sub plans will be updated to include monitoring and reporting aspects of the Project as discussed in **Sections 8.1** to **8.4**.

A substantial record of baseline data has been collected for Mount Owen Mine (refer to **Section 2.2**) and will be used to inform the ongoing review of monitoring data, allowing any potential impacts of the Project to be identified and management measures implemented where appropriate.

8.1 Monitoring

8.1.1 Erosion and Sediment Control Measures

Erosion and sediment controls will be monitored during construction and operation in accordance with the *Blue Book* (Landcom 2004 and DECC 2008). Monitoring of the performance of the water management systems and associated erosion and sediment control measures will be set out in the WMP, with monitoring typically undertaken monthly and after major storm events.

8.1.2 Water Balance Monitoring

As part of the water balance monitoring for the Mount Owen water management system, water imported to site, water used on site and water discharged from site will be monitored in accordance with *Water Reporting Requirements for Mines* (NOW undated).

8.1.3 Watercourse Stability Monitoring and Management

Mount Owen currently monitor the channel stability of Yorks Creek, Swamp Creek, Bettys Creek and Main Creek with results reported in the Annual Review. Monitoring points have been established along each of the creeks upstream and downstream of the Mount Owen Mine. Cross sections are also used to identify change in slope and depict creek bed profile. The creek bed profiles are compared with profiles in previous studies to determine if the creek banks have remained stable or declined in condition.

Mount Owen proposes to continue to monitor channel stability in watercourses as part of the Project.

Many local creek conditions are a result of historical farming and grazing practices which have contributed to the degradation of riparian areas (refer to **Section 2.1**). Erosion of watercourse bed and banks has been identified within local watercourses, including Swamp Creek and Bettys Creek (refer to **Sections 2.1** and **2.2**). Monitoring and remediation of erosion within watercourses outside of the active mining and emplacement areas will continue to be managed as set out in the *Mount Owen Complex Landscape Management Plan* (Mount Owen 2011).

8.1.4 Surface Water Quality Monitoring

Surface water quality monitoring is currently undertaken within the WMS and at various upstream and downstream locations on the creeks located near the Project Area. Water quality parameters monitored in watercourses upstream and downstream of the Project Area include monthly sampling of pH, electrical conductivity, total suspended solids and total dissolved solids. Surface water monitoring will be continued over the life of the Project. Mount Owen propose to:

- Continue to record and document the existing water quality upstream and downstream of the Project Area so as to highlight any areas of concern or impact. As part of the implementation of the Project, the WMP will be updated to reflect an additional surface water monitoring point on Main Creek (refer to **Figure 2.3**), downstream of the North Pit Continuation final extent. The water quality parameters and frequency of sampling for watercourses surrounding the Project will remain as for the existing approved operations.

- Continue to record and document water quality within the WMS as required for pH, electrical conductivity, total suspended solids, total dissolved solids, chlorine, nitrogen, sulphate, magnesium, calcium, phosphorous, oil and grease, chemical oxygen demand, biological oxygen demand, faecal coliform and nitrate.

- Monitor water quality during HRSTS discharge events as set out in the EPL.

- Review and monitor the performance of erosion and sediment controls.

- Continue the reporting of monitoring results in the Annual Review.

The existing and proposed surface water quality monitoring points are shown in **Figure 2.3**. A new monitoring point on Main Creek (MC3) is proposed to provide information on potential impacts from the North Pit Continuation. Monitoring at MC3 will commence upon Project approval. In addition, Mount Owen will continue to monitor water quality during HRSTS discharge events as set out in the EPL.

8.1.5 Flow Monitoring

Flow monitoring on Yorks Creek, Swamp Creek, Bettys Creek and Main Creek will continue to be undertaken by visual observation of the flows during water quality sampling (flow, no-flow). The flow observations will be used to inform the assessment of water quality data.

8.1.6 Contingency Measures

The process of detailed design, construction and monitoring/maintenance of the proposed WMS during the operational phase is intended to reduce the risks associated with unplanned spillages or other unforeseen circumstances with potential to result in unexpected environmental impacts. That is, the system has been designed considering the range of potentially relevant environmental factors and variables, reducing the risk of the implemented system not performing as planned.

In addition, Mount Owen has a *Pollution Incident Response Management Plan (*PIRMP) (2012), which sets out hazards to be managed, incident management, notification procedures, and other key information to address incidents.

As a further contingency measure, the following key components will be used as required during the Project, to address potential surface water impacts:

- Water shortages: The water balance modelling has indicated that the Mount Owen Complex will typically operate with a water deficit in Year 1 and Year 5 of the Project and in surplus in Year 10. Mount Owen expect that water will be available from the GRWSS and existing Hunter Regulated River WALs to accommodate the predicted water deficit years. However, if water shortages develop in the GRWSS, Mount Owen will either source additional water from external sources or reduce production. This could include purchasing additional water allocations and may include sourcing water from other operations (e.g. other mining operations). These additional water sources would be obtained in accordance with any relevant licences and approvals.

- Water surplus: The risk of spilling from the water management dams is discussed in **Section 5.2**. In the event of poorer water quality or if a greater risk of spilling than originally indicated is identified at any specific sediment dam, the contingency measures that will be implemented include:

  - increasing pumping rates to more quickly remove water from the dam where practical, or increasing the capacity of the dam if time constraints permit;
  - review and upgrading of rehabilitation of areas where runoff water quality is found to be poorer than expected post completion of rehabilitation works; and
  - if the water surplus relates to the overall water balance, transfer of water within the GRWSS and/or the number and use of HRSTS salt credits will be reviewed together with the overall water balance modelling.

- Unforeseen failure or catastrophic events: In the event of an unforeseen spillage associated with incidents such as accidental damage, operational failures or extreme catastrophic occurrences, the hazard notification protocols in the PIRMP will be followed.

- Possible impacts of climate change: Climate change is poses an increased risk of both water shortages and extreme flood events. Given the predicted water surplus in the latter years of the Project, it is considered likely that the possible reduced availability of water will not significantly impact the Project.

  Climate change may significantly impact on the final void water balances, particularly as the current prediction is that it will take several years for water levels to recover within the final voids. The impacts of climate change over such a long period are potentially significant, most likely decreasing the water level within the final voids and increasing the freeboard to spill levels.

  While the impact on rainfall and evaporation are the most obvious possible impacts of climate change on surface water management, the potential impacts of climate change on rehabilitation in terms of the long term sustainability of vegetation will be re-assessed at least 5 years prior to closure. Changes that result in a deterioration in vegetation cover could result in increased surface water impacts, particularly in terms of TSS. The vegetation currently being established on rehabilitated areas and proposed to be used for the Project will be tolerant of anticipated future climatic changes.

8.2 Decommissioning of the Water Management System

As part of decommissioning, the mine, water management dams will either remain in use for identified and approved future land uses or will be removed. If the dams are to be retained, the capacity of the dams will be reviewed and the size/volume modified as necessary. Some of the proposed diversion drains, catch drains and site bundings will remain in place as part of the final landform where considered to be stable in the long term and where required to minimise erosion. Areas disturbed by removal or modification of water management structures will be reshaped and revegetated. The measures required to effectively decommission the water management system and the water management controls required in the post mining landform will be considered in further detail as part of the detailed mine closure planning process. This closure planning process is discussed in further detail in the closure section of the main text of the EIS.

8.3 Licensing Requirements

8.3.1 Protection of the Environment Operations Act 1997

Surface water monitoring at the Mount Owen Complex is undertaken in accordance with Mount Owen's current EPL 4460. Operations at Ravensworth East Mine are currently operated in accordance with EPL10860 under the *Protection of the Environment Operations Act 1997*. It is anticipated that should the Project be approved, operations associated with the Mount Owen and Ravensworth East Mines will be consolidated into one development consent and a consolidated EPL would also be sought, as detailed in **Section 2.2.**

Mount Owen will continue to focus on managing discharge water quality to meet licence requirements.

8.3.2 Water Act 1912 and Water Management Act 2000

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* applies to watercourses in the vicinity of the Project Area and alluvial groundwaters. The catchment of Bowmans Creek is located within the Jerrys Water Source and the catchment of Main Creek is located within the Glennies Water Source. As both Bowmans Creek and Main Creek are covered by water sharing plans, water use in the Project Area is governed by the *Water Management Act 2000*. The groundwater associated with the hard rock aquifers (i.e. coal seams) is not covered by a water sharing plan but is governed under the *Water Act 1912* (refer to Appendix 10 of the EIS).

Under the Harvestable Rights regulations (*Water Management Act 2000*), landholders may harvest up to 10 per cent of the average regional runoff on a property. The existing and proposed WMS include a series of diversion drains and clean water dams around the perimeter of the mining areas in order to divert upslope catchment runoff away from the mining areas (refer to **Figures 4.2** to **4.5**). As such, the capture of upslope clean water runoff from undisturbed/natural areas is limited and the use of harvestable rights provisions for Mount Owen will be minimal for the Project.

Mount Owen proposes to operate the Project in accordance with the *Hunter Regulated River Water Sharing Plan 2003* for extractions from Glennies Creek.

8.4 Reporting

A summary of surface water monitoring results will 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 and the predictions in the EIS;
- annual site water balance and comparison against predictions in the EIS;
- 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 water management system.

9.0 References

ANZECC/ARMCANZ, 2000. *National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality*.

Department of Environment and Climate Change (DECC), 2008. *Managing Urban Stormwater – Soils and Construction*, *Volume 2A Installation of services*.

Department of Environment and Climate Change (DECC), 2008. *Managing Urban Stormwater – Soils and Construction*, *Volume 2C Unsealed Roads*.

Department of Environment and Climate Change (DECC), 2008. *Managing Urban Stormwater – Soils and Construction*, *Volume 2D Main Road Construction*.

Department of Environment and Climate Change (DECC), 2008. *Managing Urban Stormwater – Soils and Construction*, *Volume 2E – Mines and Quarries*.

Department of Primary Industries and Natural Resources (DIPNR), undated, *Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields*).

Fairfull, S. Witheridge, G, 2003. *Why do fish need to cross the road? Fish Passage Requirements for Waterway Crossings*

Kovac, M. & Lawrie, J.W., 1991. *Soil Landscapes of the Singleton 1:250 000 Map Sheet.* Department of Land and Water Conservation of NSW, Sydney.

Landcom, 2004. *Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.*

NSW Government, 2005. NSW Floodplain Development Manual

NSW Office of Water (NOW), undated. *Water Reporting Requirements for Mines.*

Xstrata Coal, 2012. *Mount Owen Complex Surface Water Monitoring Program*.

Xstrata Coal, 2012. *Mount Owen Complex Water Management Plan*.

Xstrata Coal, 2011. *Mount Owen Complex Erosion and Sediment Plan*.

APPENDIX A

Historical Water Quality Monitoring Results

Appendix A - Historical Water Quality

Monitoring Results

Water quality monitoring results for creeks traversing and surrounding the Mount Owen project area are shown below.

- Water Quality Results for all water quality monitoring points along Bowmans Creek from August 2008 to March 2014 for pH, electrical conductivity, total suspended solids and total dissolved solids are shown in **Figures A.1** to **A.4**.

- Water Quality Results for all water quality monitoring points along Yorks Creek from August 2008 to March 2014 for pH, electrical conductivity, total suspended solids and total dissolved solids are shown in **Figures A.5** to **A.8**.

- Water Quality Results for all water quality monitoring points along Swamp Creek from August 2008 to March 2014 for pH, electrical conductivity, total suspended solids and total dissolved solids are shown in **Figures A.9** to **A.12**.

- Water Quality Results for all water quality monitoring points along Bettys Creek from August 2008 to March 2014 for pH, electrical conductivity, total suspended solids and total dissolved solids are shown in **Figures A.13** to **A.16**.

- Water Quality Results for all water quality monitoring points along Main Creek from August 2008 to March 2014 for pH, electrical conductivity, total suspended solids and total dissolved solids are shown in **Figures A.17** to **A.20**.

All total suspended solids graphs have been capped at 300 mg/L. Some of the water quality samples have been taken during or just after rainfall events when turbidity readings are high, and well above the ANZECC maximum total suspended solid concentration levels (50 mg/L).

A water quality overview for pH and electrical conductivity for on site dam storages within the Mount Owen mine water management system are shown in **Figures A.21** and **A.22** respectively.

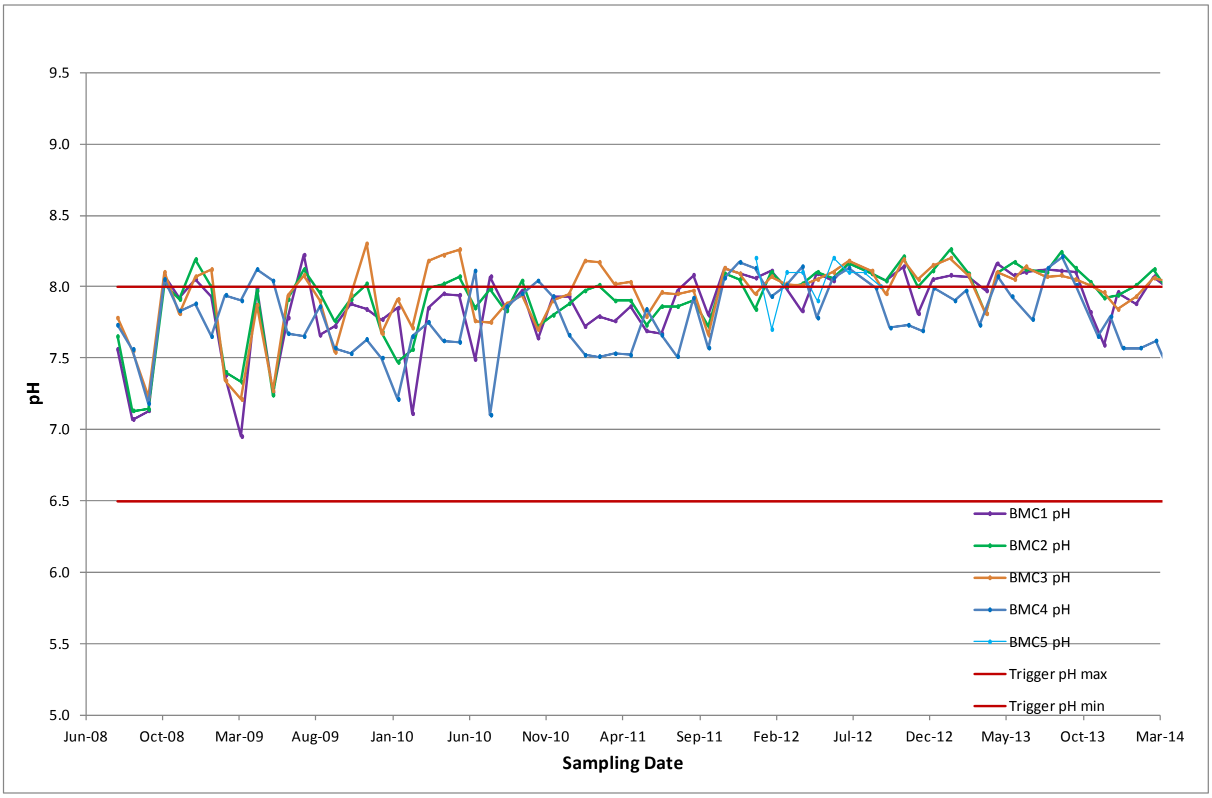


Figure A.1 - Bowmans Creek pH

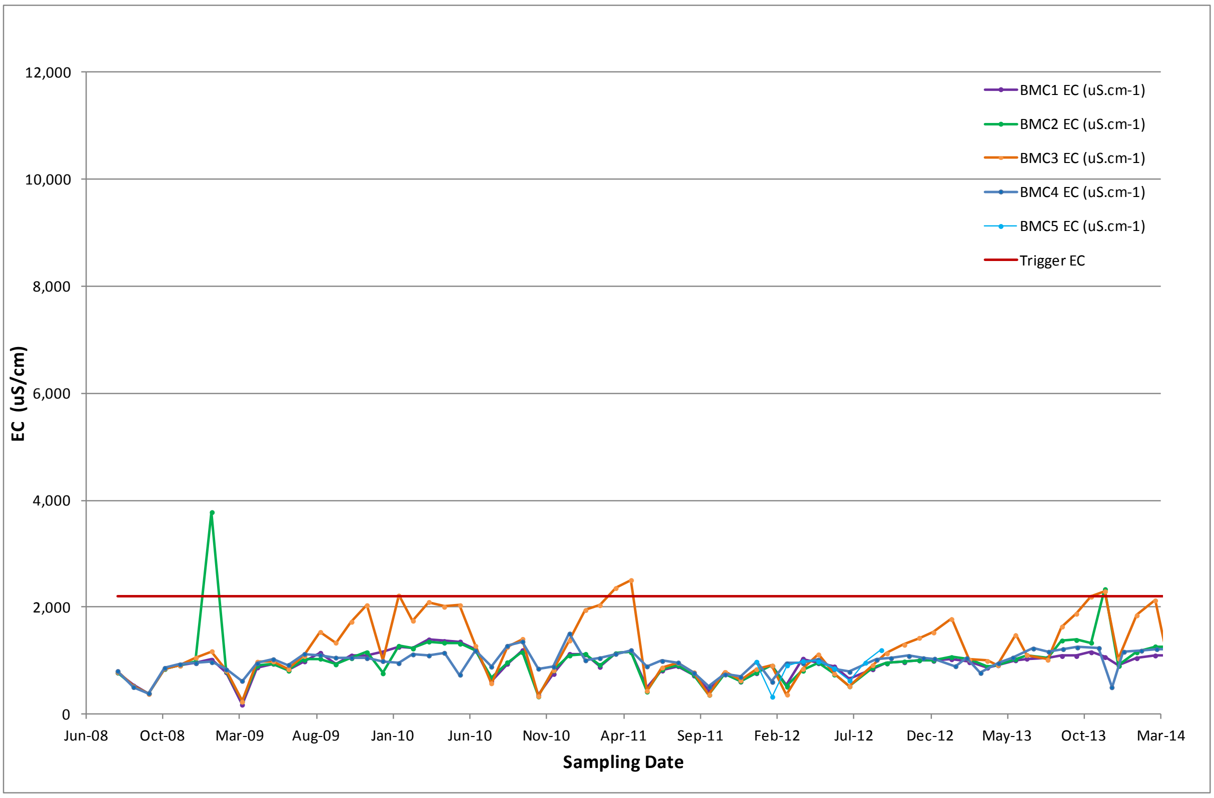


Figure A.2 - Bowmans Creek Electrical Conductivity

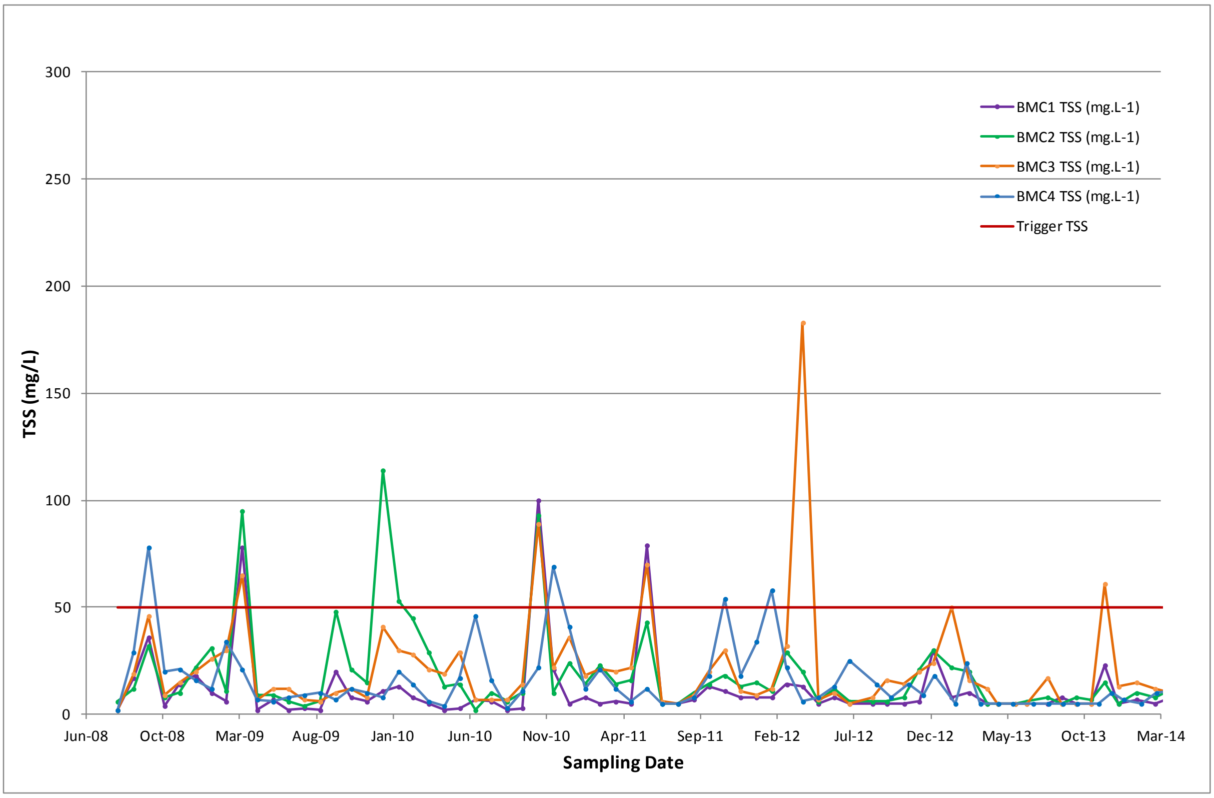


Figure A.3 - Bowmans Creek Total Suspended Solids

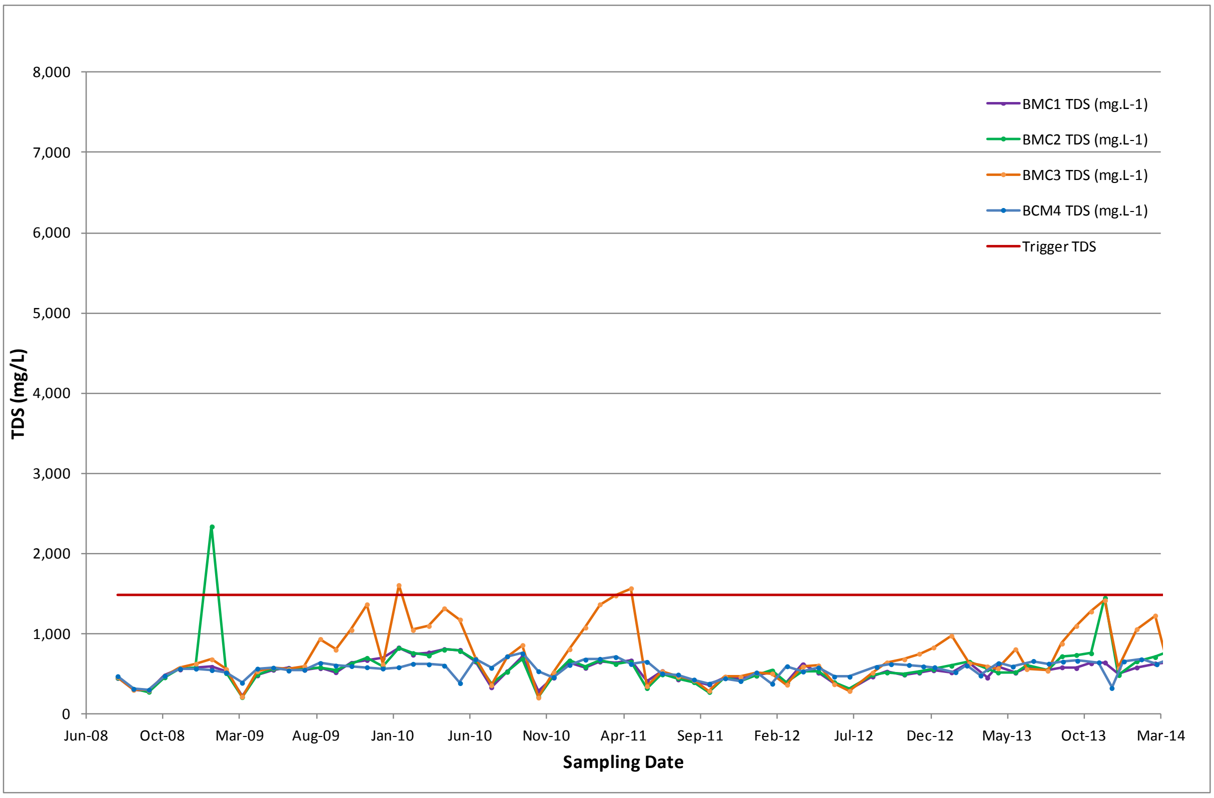


Figure A.4 - Bowmans Creek Total Dissolved Solids

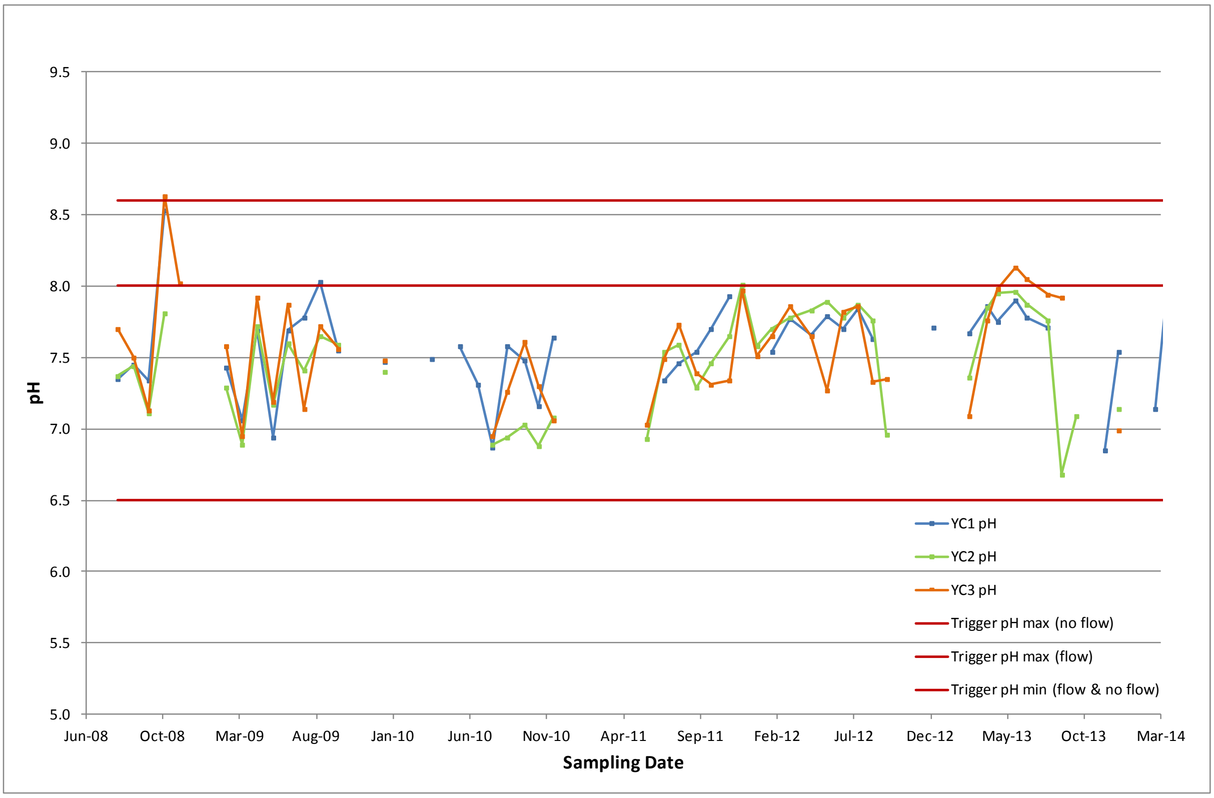


Figure A.5 - Yorks Creek pH

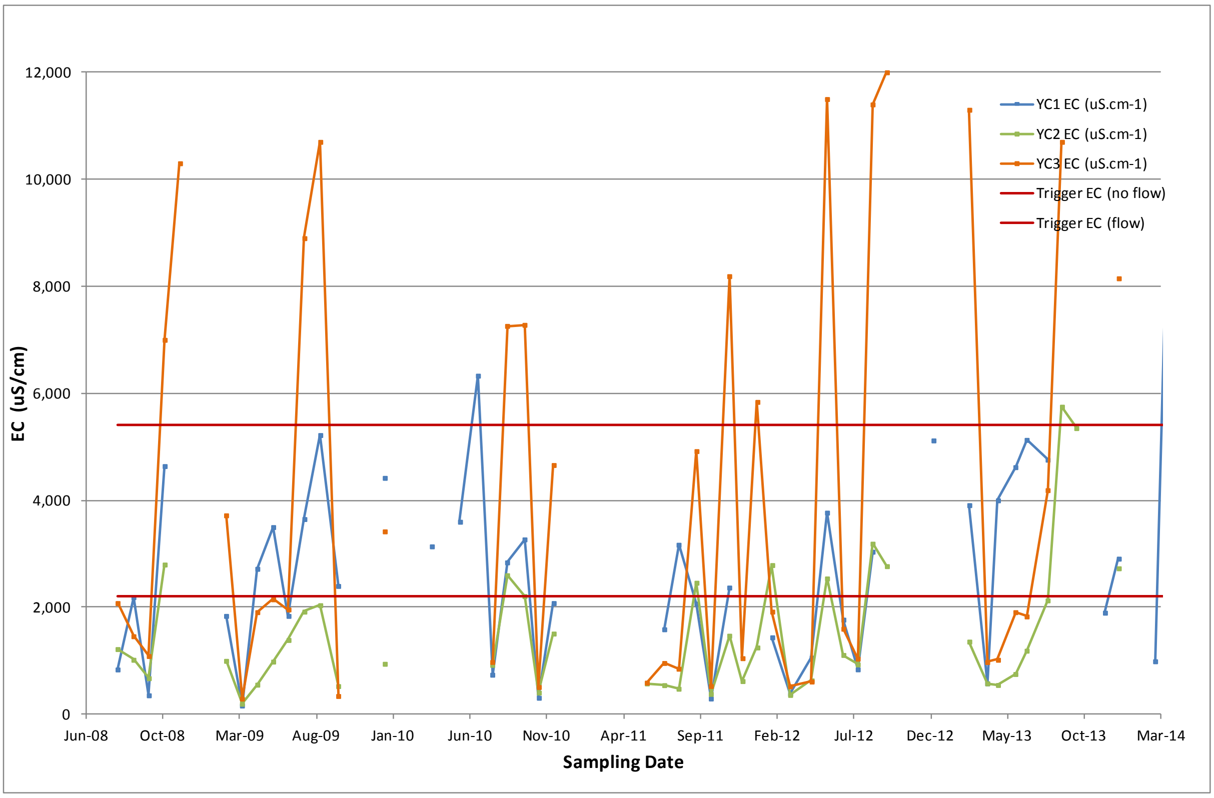


Figure A.6 - Yorks Creek Electrical Conductivity

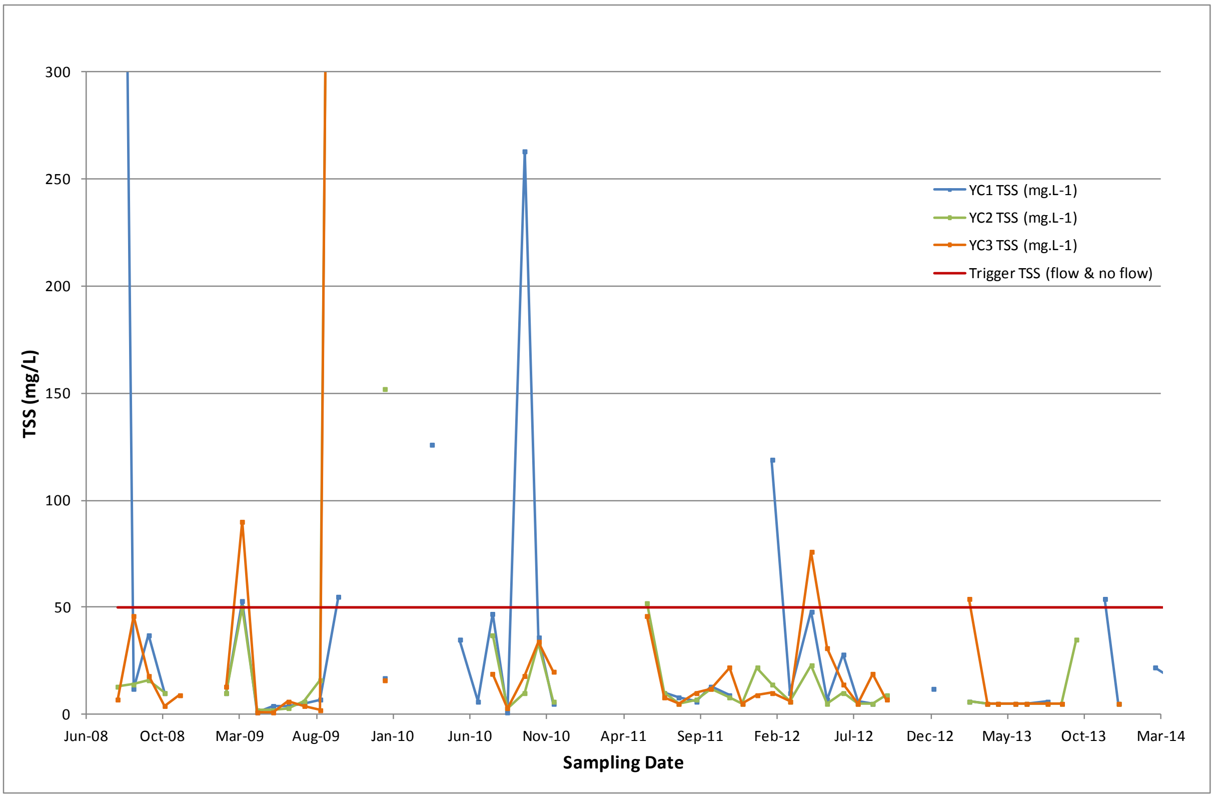


Figure A.7 - Yorks Creek Total Suspended Solids

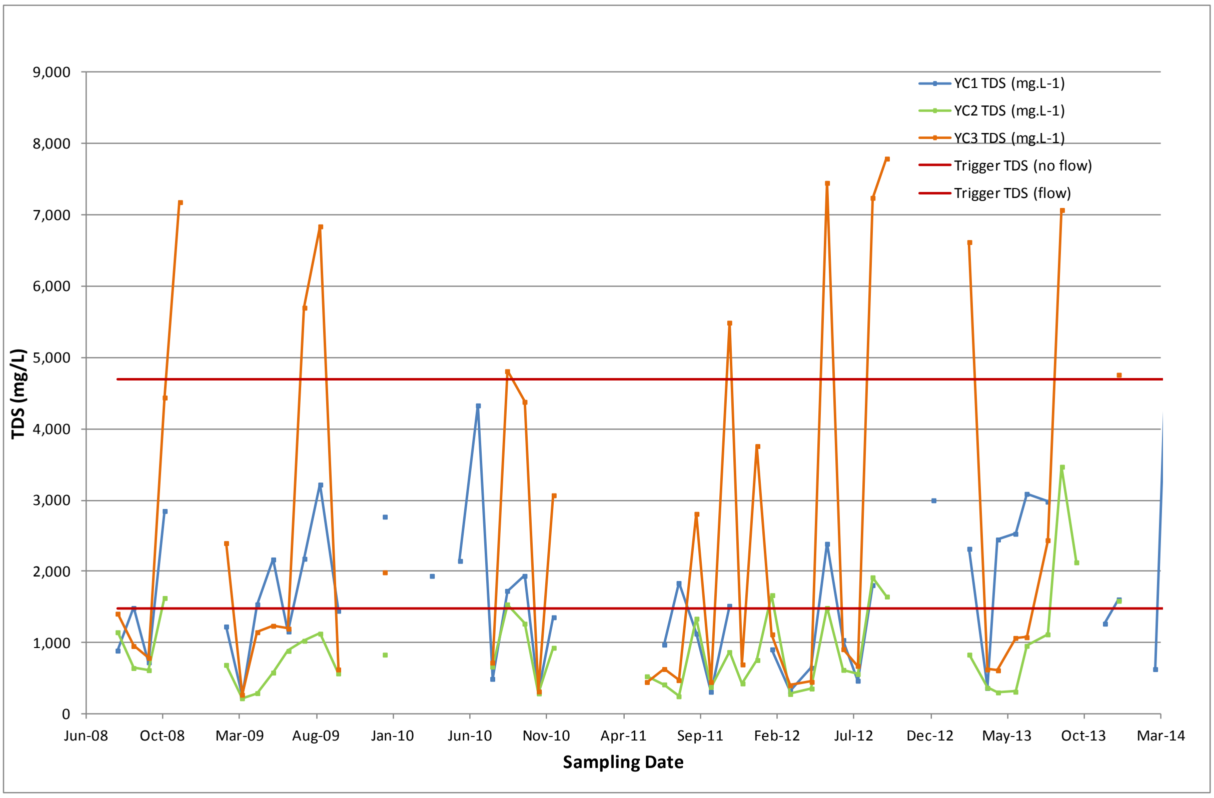


Figure A.8 - Yorks Creek Total Dissolved Solids

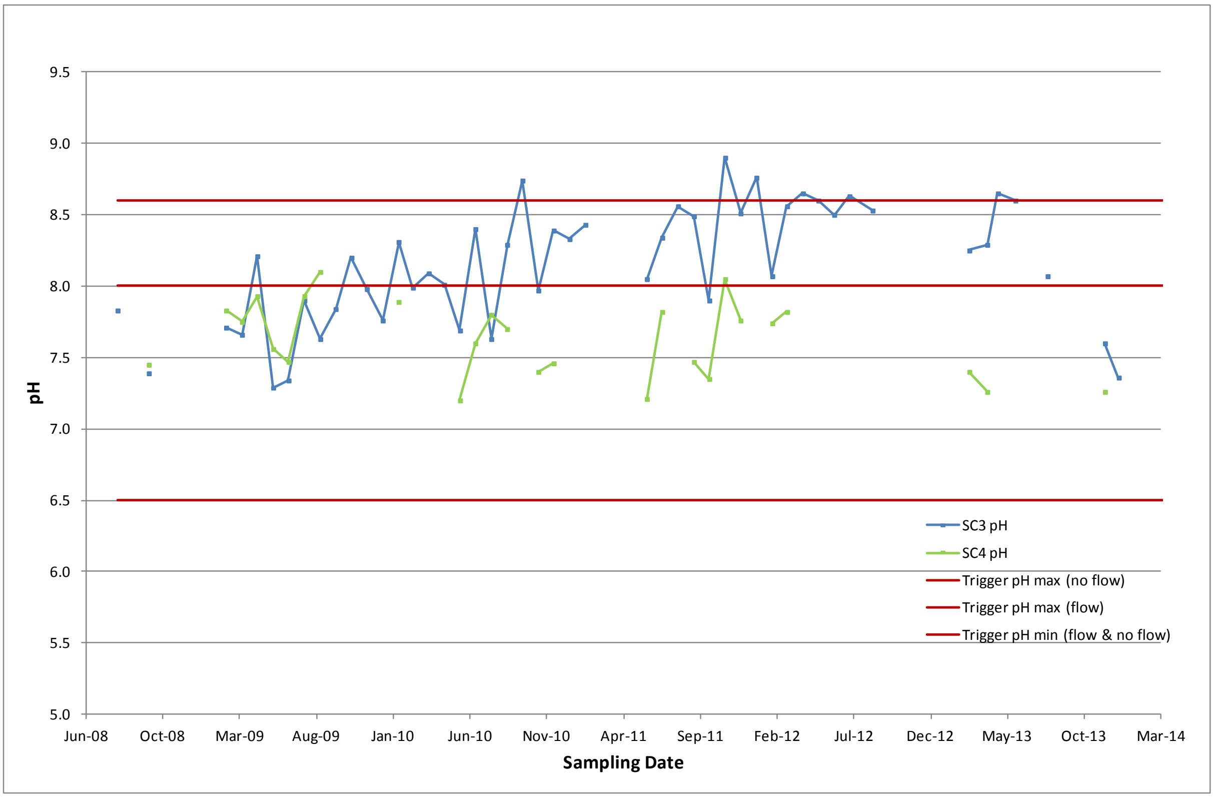


Figure A.9 - Swamp Creek pH

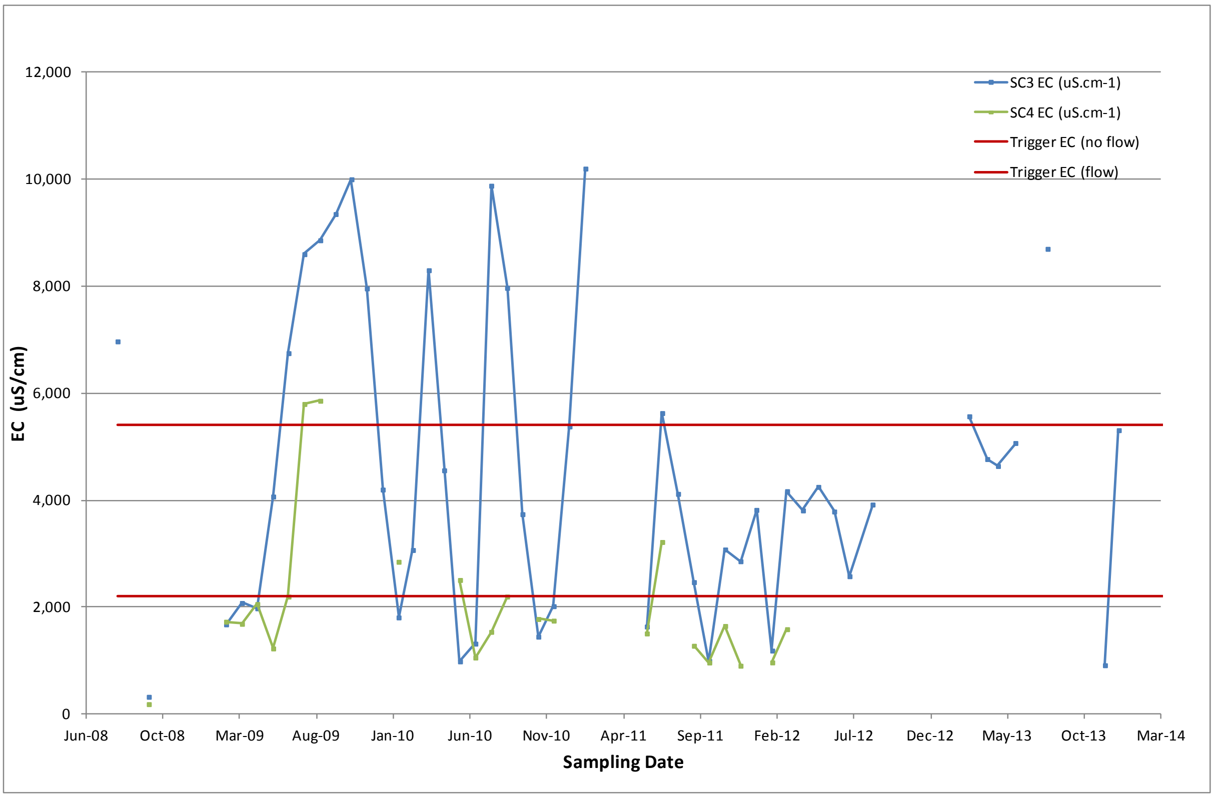


Figure A.10 - Swamp Creek Electrical Conductivity

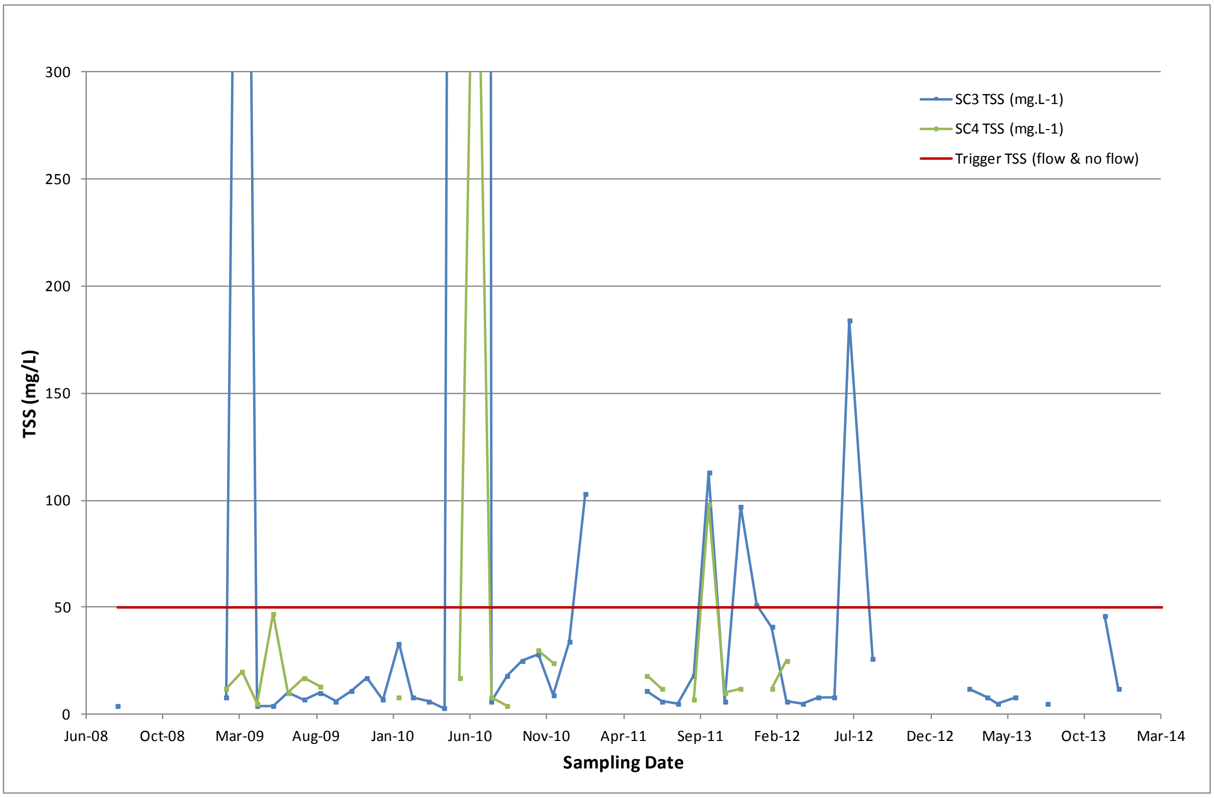


Figure A.11 - Swamp Creek Total Suspended Solids

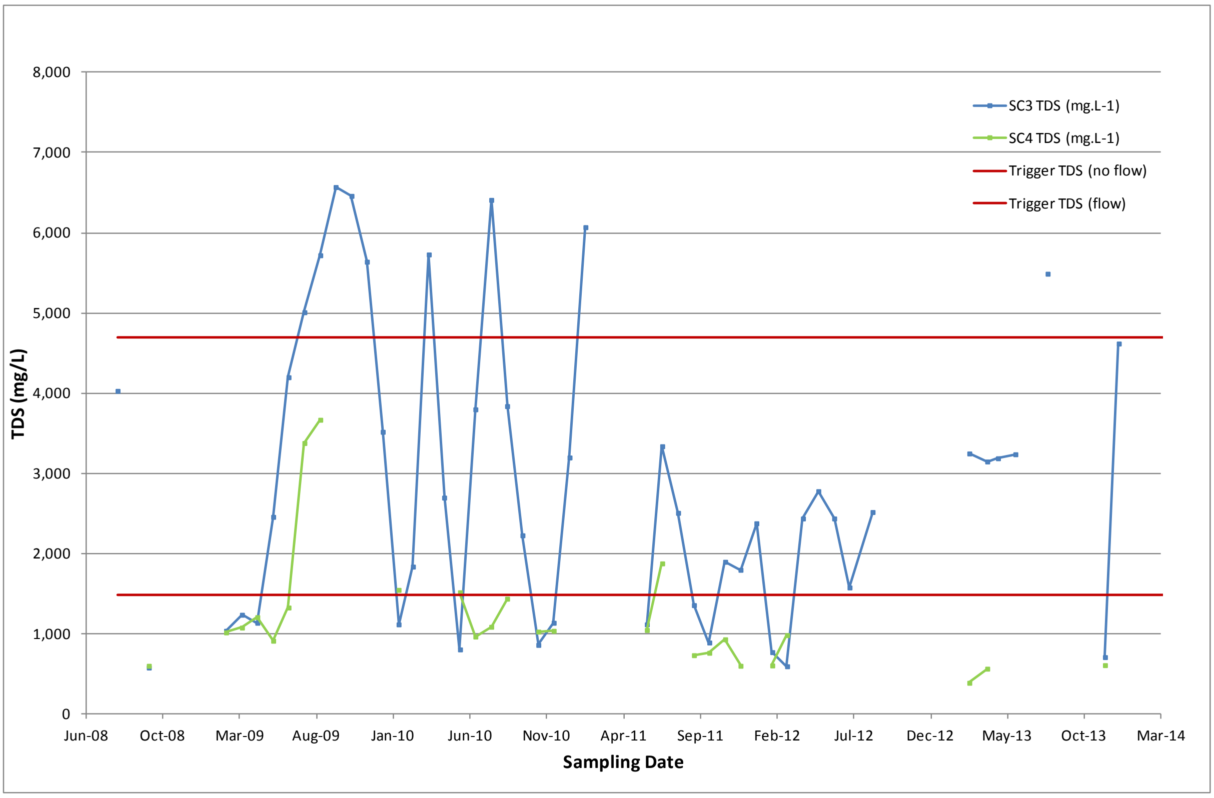


Figure A.12 - Swamp Creek Total Dissolved Solids

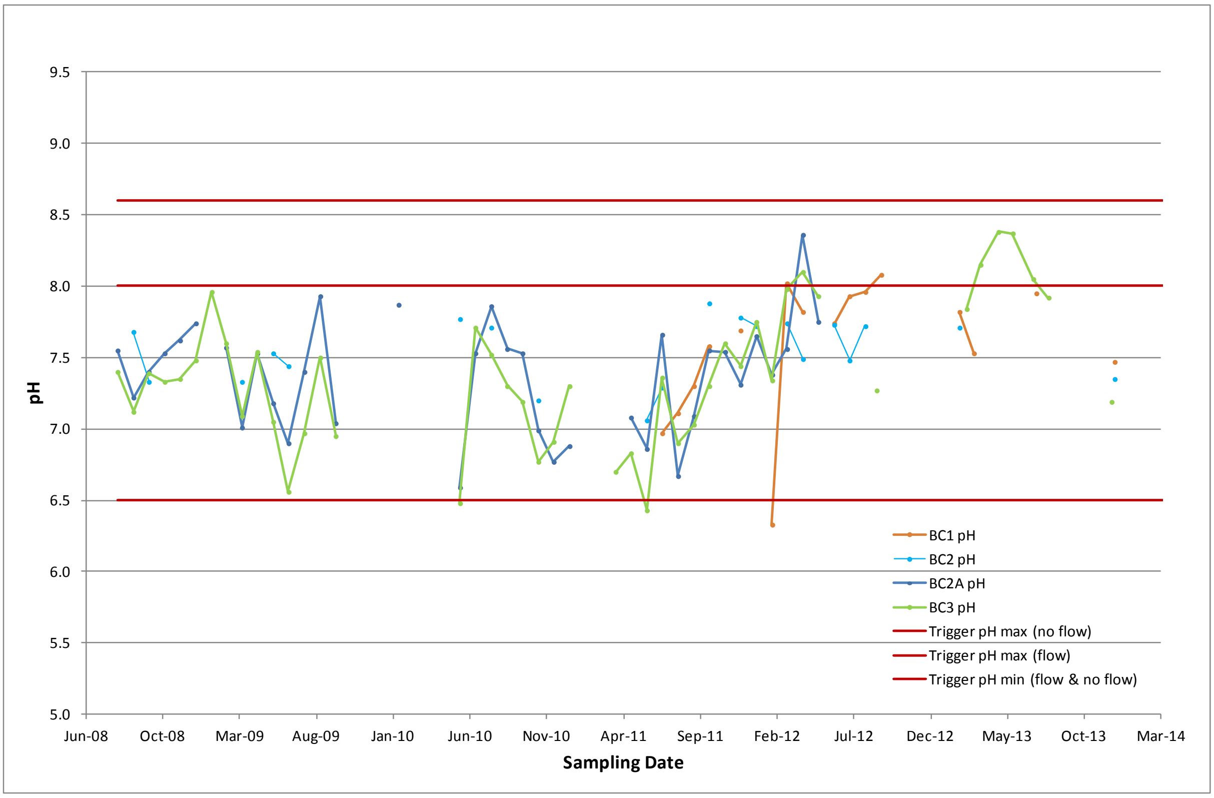


Figure A.13 - Bettys Creek pH

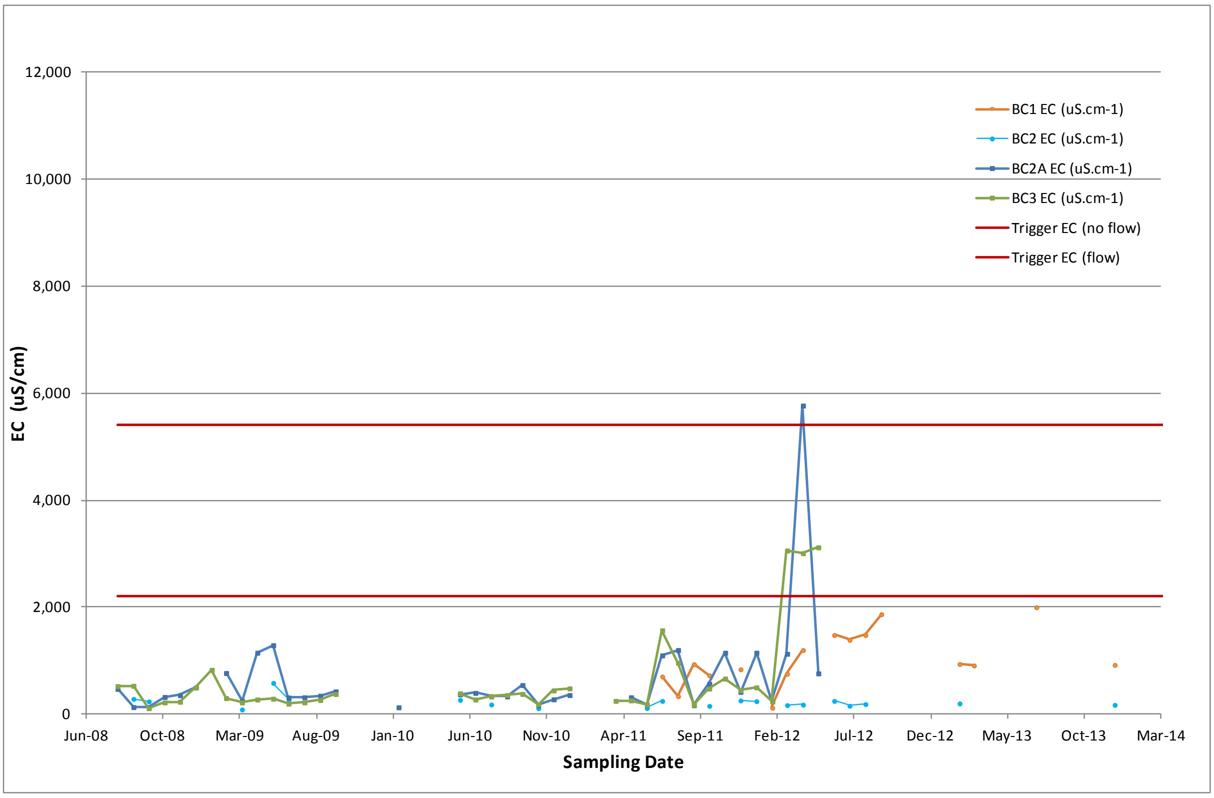


Figure A.14 - Bettys Creek Electrical Conductivity

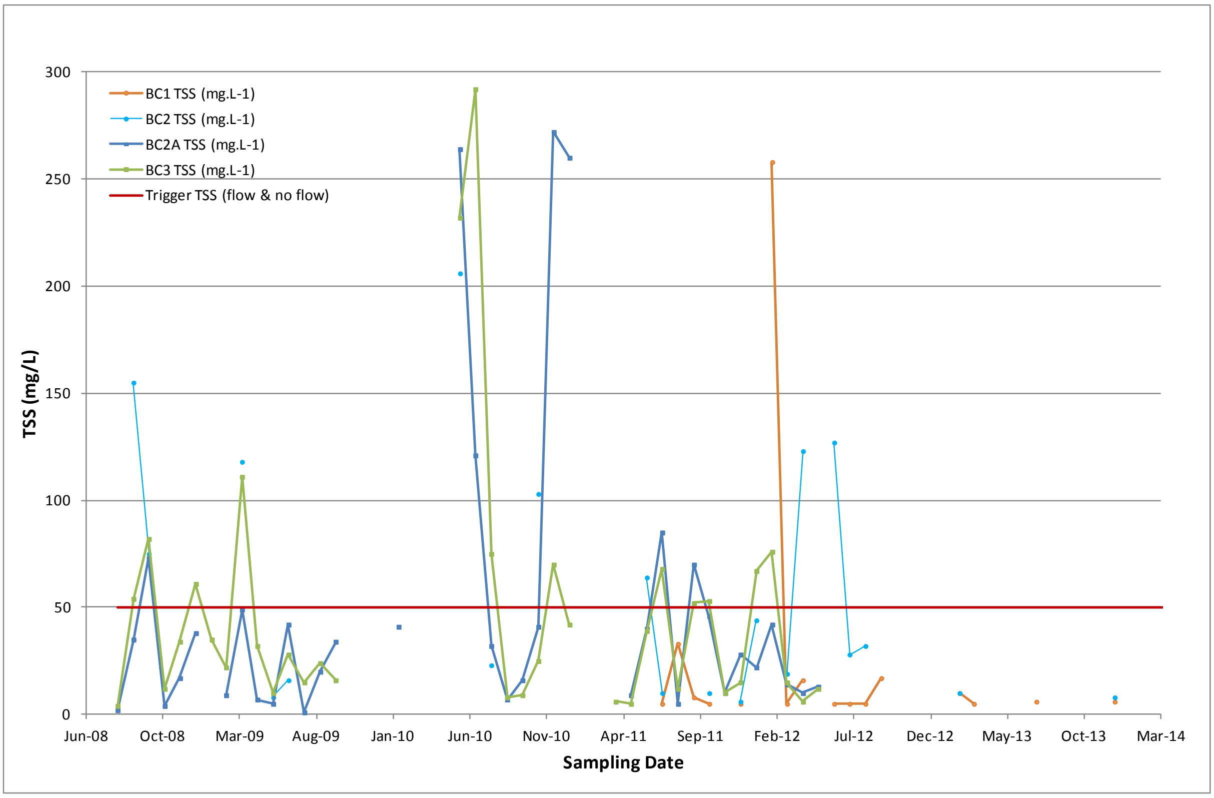


Figure A.15 - Bettys Creek Total Suspended Solids

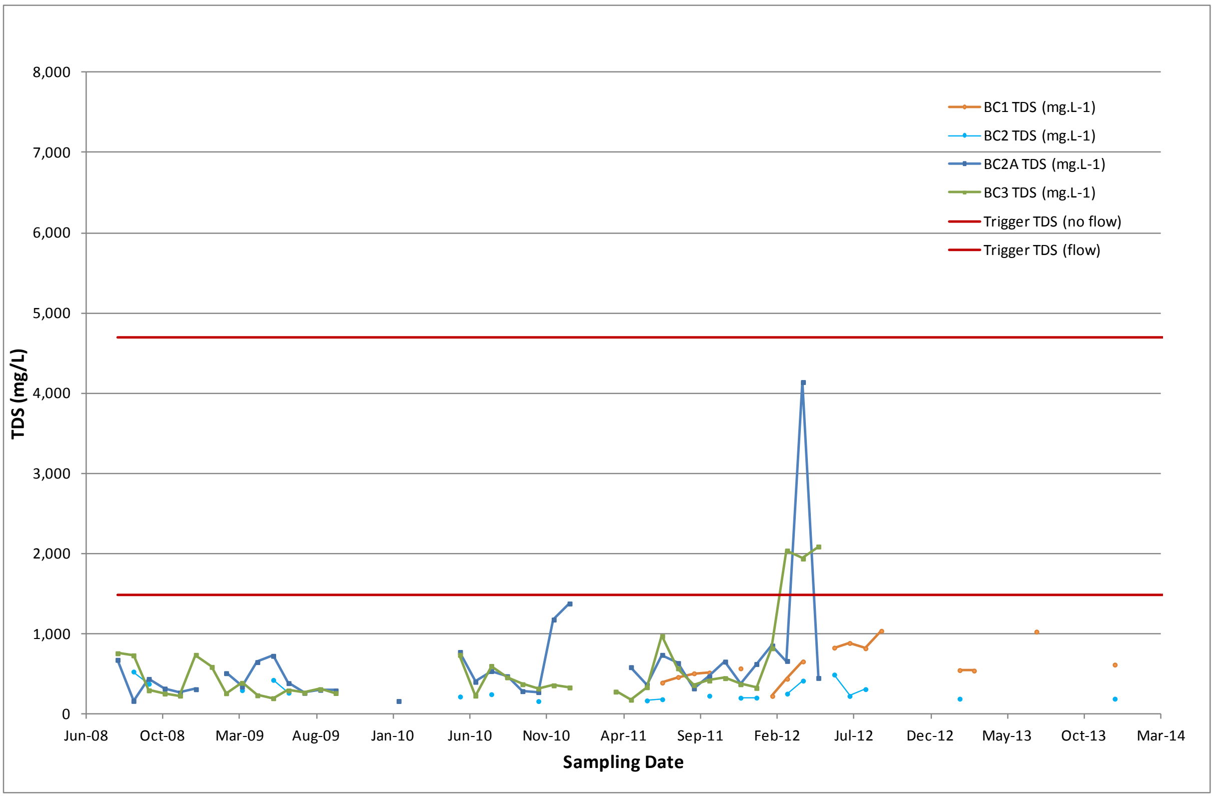


Figure A.16 - Bettys Creek Total Dissolved Solids

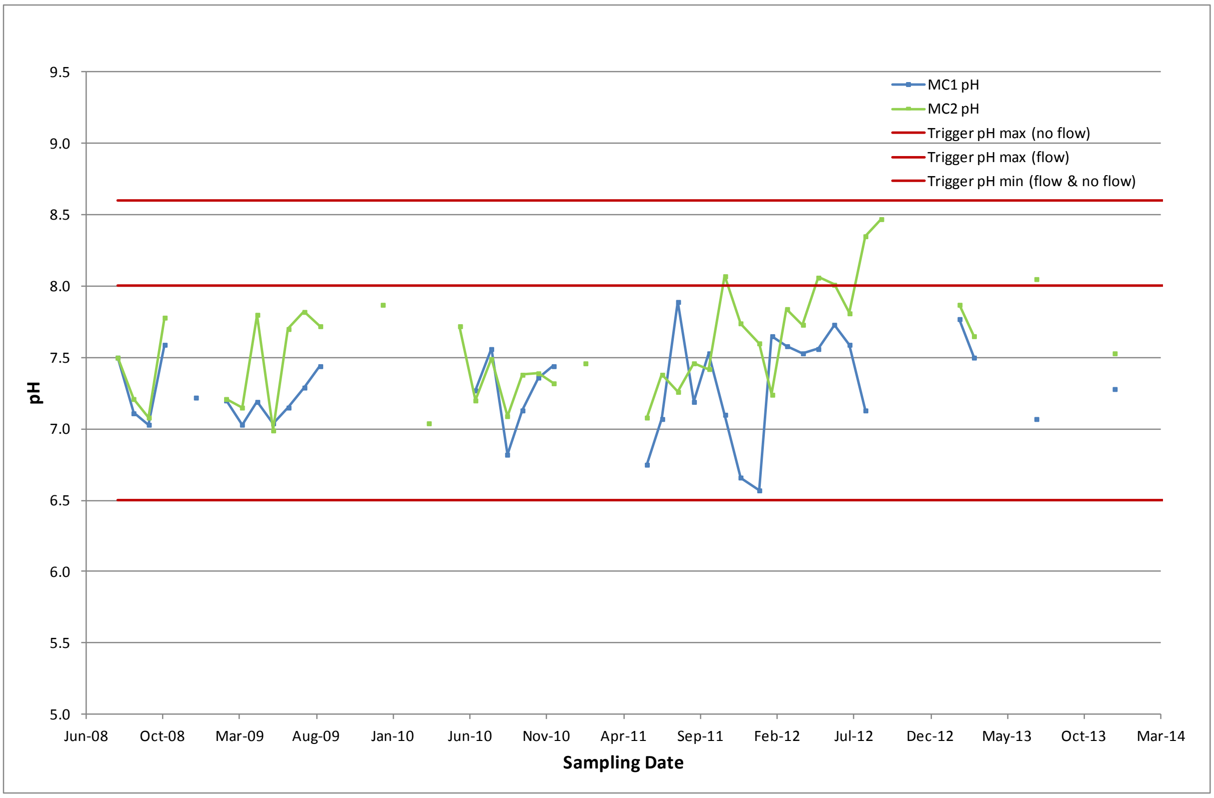


Figure A.17 - Main Creek pH

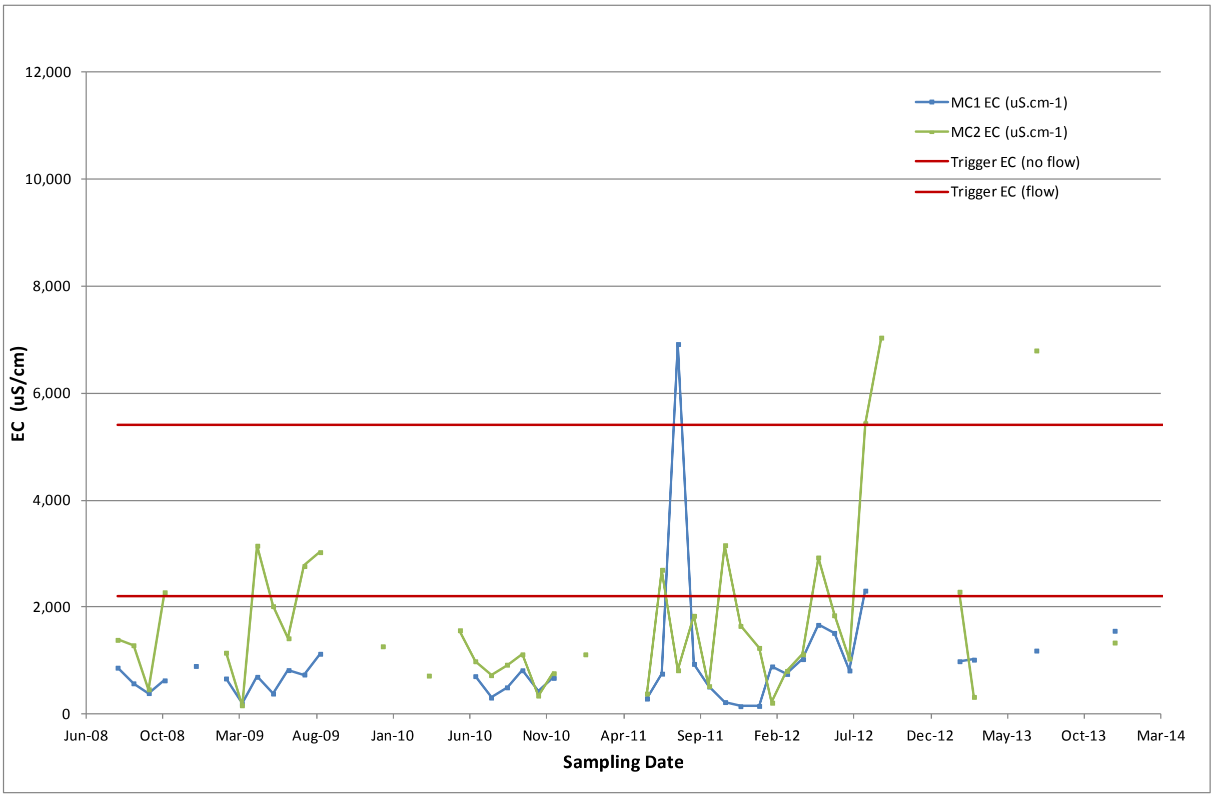


Figure A.18 - Main Creek Electrical Conductivity

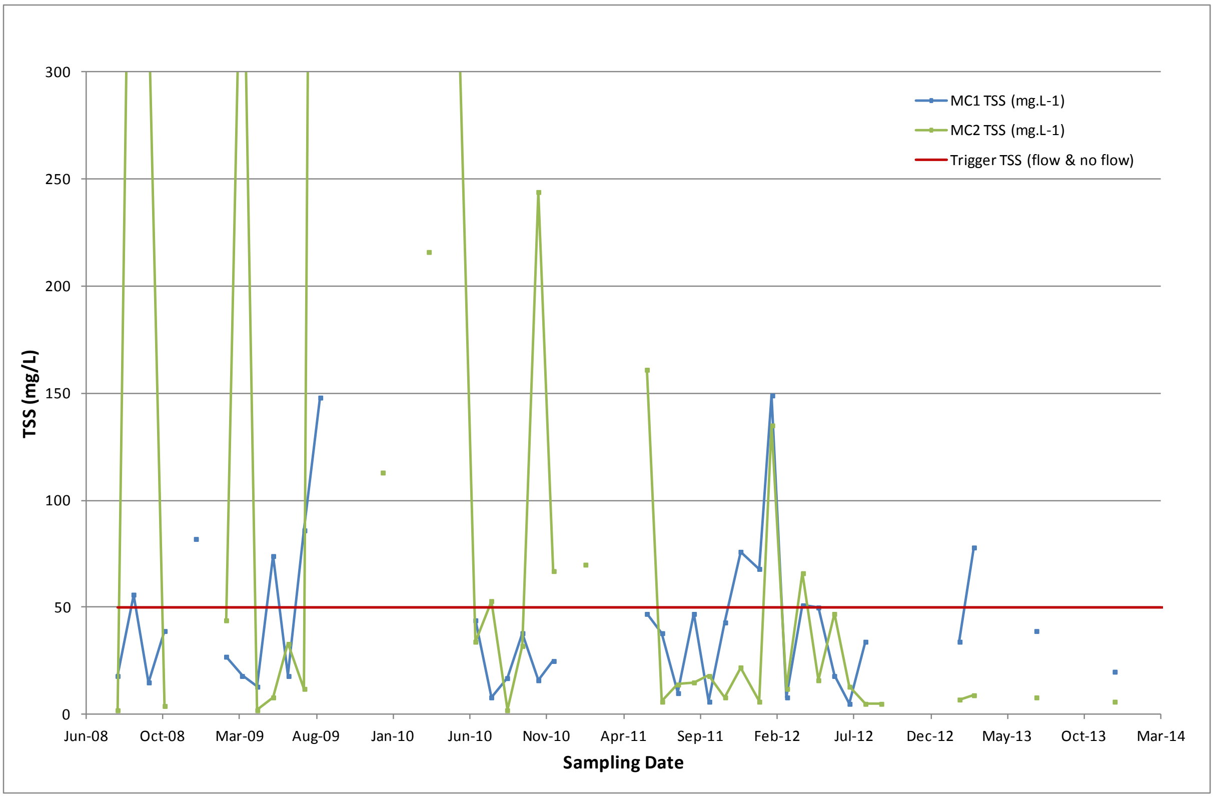


Figure A.19 - Main Creek Total Suspended Solids

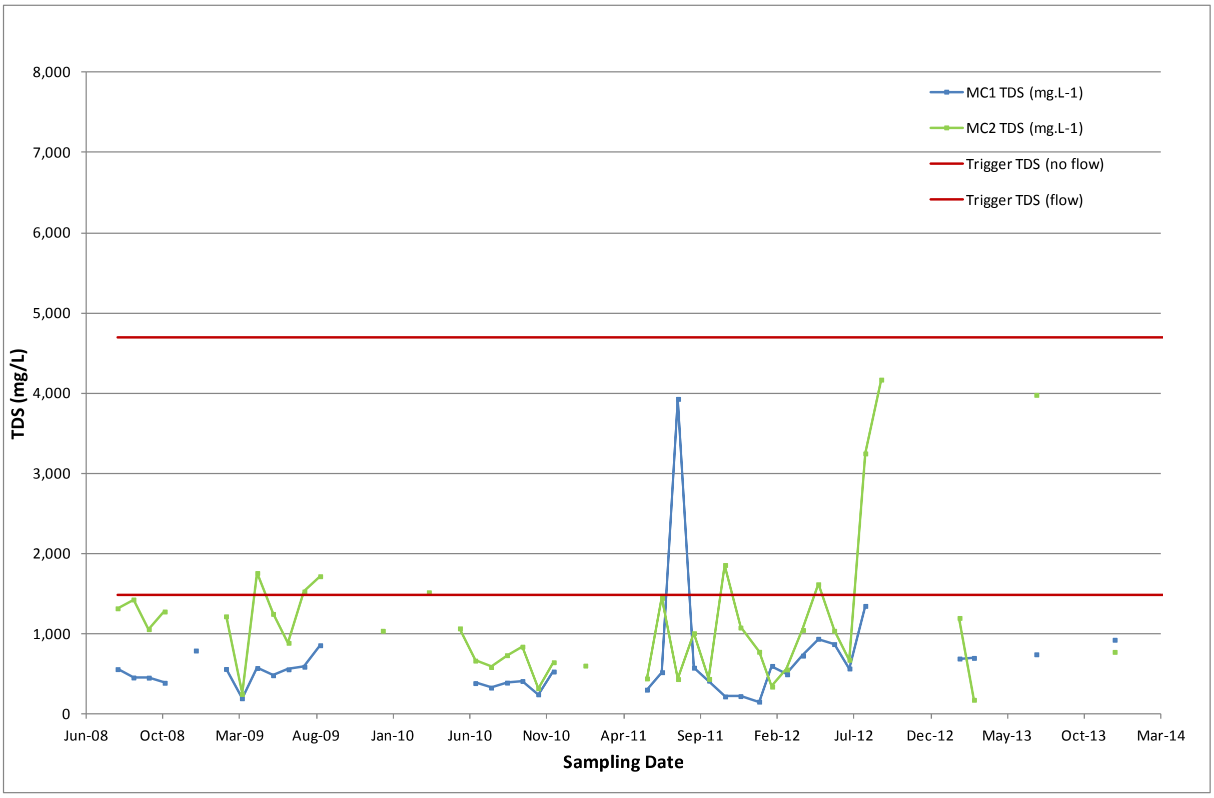


Figure A.20 - Main Creek Total Dissolved Solids

On Site Dams Water Quality Results

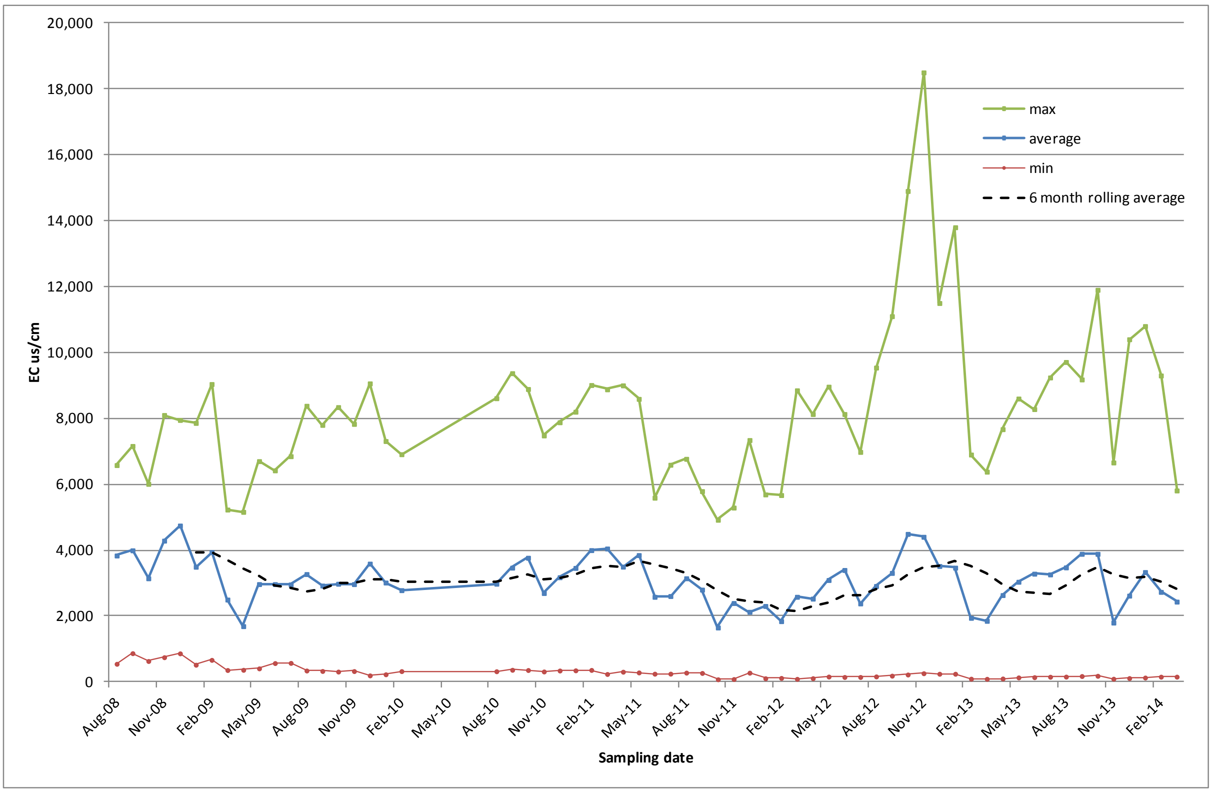


Figure A.21 - Electrical Conductivity for On Site Dams

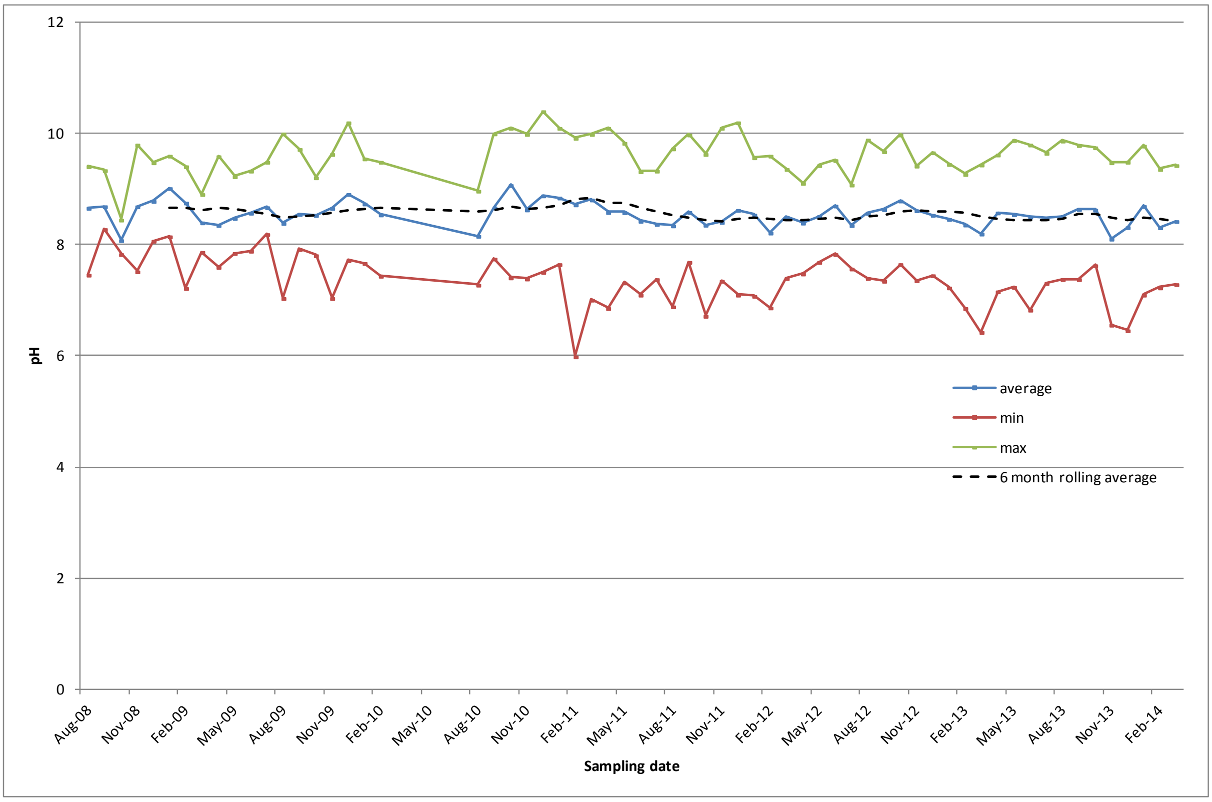


Figure A.22 - pH for On Site Dams

APPENDIX B

Water Balance Assessment

Inspired people | Dedicated team
Quality outcomes

WATER BALANCE ASSESSMENT

Mount Owen Continued Operations Project

FINAL

October 2014

GLENCORE

WATER BALANCE ASSESSMENT

Mount Owen Continued Operations Project

FINAL

October 2014

Prepared by
Umwelt (Australia) Pty Limited

on behalf of
Mt Owen Pty Limited

Project Director:	**Barbara Crossley**
Project Manager:	**Tim Browne**
Technical Director	**Susan Shield**
Report No.	**3109/R15/FINAL**
Date:	**October 2014**

umwelt

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

TABLE OF CONTENTS

1.0 Introduction

1.1 Overview

The Mount Owen Complex consists of three separate mines: Mount Owen Mine, Ravensworth East Mine and Glendell Mine. Coal from all three mines is processed at the Mount Owen Coal Handling and Preparation Plant (CHPP) which has approval to process 17 Mtpa of Run of Mine (ROM) coal feed.

Mount Owen expects, subject to market conditions, that mining will be completed within the currently approved area of the North Pit and the West Pit by 2018 and late 2014 respectively; and Glendell by 2022.

Mount Owen is seeking development consent for the Mount Owen Continued Operations Project (the Project) to extract these additional mineable coal tonnes through continued open cut mining methods. The Project proposes to continue the existing mining operations within the North Pit to the south beyond the current approved North Pit mining limit (the North Pit Continuation) in addition to continuing mining operations within the BNP area, sequentially followed by the proposed RERR Mining Area.

The Mount Owen Complex has an extensive existing water management system (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 the integrated WMS. In addition, the Mount Owen Complex is an integral part of the Greater Ravensworth Water Sharing System (GRWSS) with the Cumnock, Ravensworth Operations, Narama, Ravensworth Underground and Liddell mining operations. The GRWSS allows greater flexibility in the mine water management by the Mount Owen Complex.

The use and management of water within the Glendell Mine does not form part of the Project and will continue to be managed pursuant to Glendell's existing Development Consent. However, due to the integrated nature of the WMS, the overall water balance of the Mount Owen Complex (which includes water make and use at the Glendell Mine and the processing of ROM coal mined at Glendell within the Mount Owen CHPP) and the changes to the water balance associated with the Project are detailed in this document.

Inflows to the water balance include site rainfall runoff, tailings decant water, groundwater inflows to open cut pits, transfers from other mines within the GRWSS and water extracted under licence from Glennies Creek.

The water balance models are based in Microsoft Excel and utilise Palisade @Risk software to undertake a Monte Carlo analysis to calculate the probability of different water balance outcomes based on the variability of the model input data.

Daily timestep water balance models have been used to assess the gross water balance for the existing operations and the Project, the frequency and volume of water transfers to and from the Mount Owen Complex, the frequency and volume of spills, and final void water levels for the Project.

The Monte Carlo analysis considers the variations based on a normal distribution fitted to 10^{th} percentile, 50^{th} percentile and 90^{th} percentile values for each of the parameters listed below:

- rainfall;
- evaporation;
- catchment runoff;
- ROM coal, product coal and rejects moisture percentages; and
- haul road dust suppression water application rate.

2.0 Water Management Strategy

Water is supplied to the Mount Owen Complex from the Greater Ravensworth Water Sharing Scheme (GRWSS) and Glennies Creek. The Mount Owen Complex discharges water to the other Glencore mines in the GRWSS and also discharges excess water to the Hunter River in accordance with the requirements of the Hunter River Salinity Trading Scheme (HRSTS).

2.1 Water Sharing

2.1.1 Greater Ravensworth Water Sharing Scheme

As mentioned in **Section 1.0** the Mount Owen Complex forms an integral part of the GRWSS. The GRWSS consists of a range of existing infrastructure including storage dams, pumps and pipelines that allow the sharing of water between Glencore mining operations.

The Mount Owen Complex is connected to GRWSS via Ravensworth Operations (to the Narama Dam) and Liddell Coal Mine (Liddell) (to the underground workings). Mount Owen can transfer water to/from Ravensworth Operations at a rate of approximately 8.6 ML/day (100 L/s) and to/from Liddell at a rate of approximately 3.3 ML/day (40 L/s).

Glencore presently has a project underway to construct a new water storage, to be known as Reservoir North, at Liddell. Reservoir North will form an integral component of the GRWSS and be the primary off-site water storage for the Mount Owen Complex with a proposed storage capacity of 2 GL. The pipeline connecting the Mount Owen Complex with Reservoir North, which is subject to a separate approvals process, will be capable of transferring water at a rate up to 25.9 ML/day (300 L/s). In addition, the Bayswater North Pit will be investigated to be potentially used for ongoing operational water storage and allow for integration within the GRWSS, after the completion of mining in 2022.

For the water balance assessment it has been assumed that water will be imported from the GRWSS in preference to the importation of water from other external sources. In addition, any excess water from the Mount Owen Complex will be exported to the GRWSS or discharged via the HRSTS via either Ravensworth Operations and Liddell or from the Mount Owen Complex.

2.1.2 Water Access Licences

Mount Owen currently holds 1,056 ML/year of High Security Entitlement (HSE) licences and 861 ML/year of General Security Entitlement (GSE) licences under the *Hunter Regulated River Water Sharing Plan 2003*. In 2012 and 2013, the Mount Owen Complex sourced 139.5 ML and 146 ML respectively from the licensed extraction point on Glennies Creek for potable water use only.

2.1.3 Hunter River Salinity Trading Scheme

The Mount Owen Complex are able to discharge water under the HRSTS to Swamp Creek under the Mount Owen Environment Protection Licence (EPL 4460). During periods of high flow or flooding, the NSW Office of Water (NOW) permits controlled releases of water with elevated salinity levels to the Hunter River system. The quantity that may be released from each mine site for each event is dependent on the number of credits held by the mine, the salinity of the water to be released and the total mass of salt that NOW has indicated may be released. During flood conditions, NOW may also permit the release of unlimited quantities of saline water.

3.0 Climate

Daily rainfall data is available from sixty-one Bureau of Meteorology (BoM) Stations within a 50 kilometre radius of the Project. However, the data available from most of these stations is only for short periods of time or is incomplete. The BoM station closest to the Project with an extensive rainfall record (1898 to present) is the Jerrys Plains station (station 061086) which is approximately 18 kilometres from the Project Area. **Table 3.1** contains a summary of the Jerrys Plains rainfall data utilised for the water balance modelling.

Table 3.1 – Jerrys Plains Rainfall (mm)

10th Percentile	**50th Percentile**	**90th Percentile**
429	646	829

The BoM station closest to the Project with an extensive evaporation record (1965 to present) is the Scone SCS BoM station (station 061069) which is approximately 39 kilometres from the site. Average daily Scone evaporation data for each month of the year is shown in **Table 3.2**. An analysis of historical data indicates that average daily evaporation typically exceeds average daily rainfall through all months of the year.

Table 3.2 – Average Daily Pan Evaporation

Month	**Evaporation (mm/day)**
January	7.1
February	6.1
March	5.0
April	3.5
May	2.2
June	1.6
July	1.8
August	2.7
September	3.9
October	5.0
November	6.1
December	7.1

The Jerrys Plains rainfall data and average Scone evaporation data were used as inputs for a soil store model to estimate the relative runoff yields from natural, rehabilitated, impervious and disturbed catchments at the Mount Owen Complex.

The above climate data has been used as inputs to all of the water balance models.

4.0 Existing Complex Water Balance

4.1 Key Assumptions

The following values are sourced from previous water balance models undertaken for the Mount Owen Complex and are consistent with recent operating data and the Factual Report on Tailings (ATC Williams, 2012) undertaken for the Mount Owen Complex. Note: 50th percentile values are presented.

- CHPP and Tailings:
  - ROM moisture, 6%;
  - Product moisture, 9.8%;
  - Coarse Reject moisture, 14%;
  - Product as percent ROM, 60%;
  - Tailings as percent ROM, 18%;
  - Pumped Tailings solids, 31.6% (by weight);
  - Tailings water bleed rate as percentage of water pumped with tailings, 53%; and
  - ROM Feed to CHPP, 14.6 MT (estimated based on July 2014 to December 2014 production data supplied by Glencore).
- Haul road dust suppression watering rate of 0.0014 ML/m^2/year.

4.2 Data Sources

4.2.1 Catchments

Catchment areas used for the existing operations water balance were delineated using a combination of mine plans, recent topographical survey and aerial photography (refer to Section 3.0 of the Surface Water Assessment).

4.2.2 Production

ROM coal production and CHPP processing figures for the existing operations water balance are based on actual total production for 2013.

4.2.3 Groundwater

Table 4.3 shows the mine pit groundwater inflows used in the existing operations water balance.

Table 4.3 - Groundwater Inflow Summary

Mine Pit	Inflow (ML/year)
North Pit	437
Main Water Storage Dam/Stage 3 (Bayswater North Pit)	87
West Pit	214
Glendell Pit	196

Note: Jacobs, 2014

4.3 Existing Operations Water Balance Outputs

The predicted 10th percentile, 50th percentile and 90th percentile gross water balance results for the existing operations are presented in **Table 4.4**.

The gross water balance does not include water that may be transferred to or from the complex.

Table 4.4 – Existing Operations Gross Water Balance (ML)

10th Percentile	50th Percentile	90th Percentile
-2340	-800	1555

The model results indicate that the existing operations are likely to operate with a water deficit in most years.

5.0 Project Water Balance

The Project's water balance has been determined for the three conceptual Project stage plans: Year 1 (2016); Year 5 (2020); and Year 10 (2025). The modelling is based on the conceptual WMS developed for the Project for these three mine stage plans (refer to **Section 4.0** of the Surface Water Assessment).

5.1 Key Assumptions

General

The following values are sourced from previous water balance models undertaken for the Mount Owen Complex and are consistent with recent operating data and the Factual Report on Tailings (ATC Williams, 2012) undertaken for the Mount Owen Complex. Note: 50^{th} percentile values are presented.

- CHPP and Tailings
  - ROM moisture, 6%;
  - Product moisture, 9.8%;
  - Coarse Reject moisture, 14%;
  - Pumped Tailings solids, 31.6% (by weight); and
  - Tailings water bleed rate as percentage of water pumped with tailings, 53%.
- Haul road dust suppression watering rate of 0.0014 ML/m2/year.
- GRWSS (including Reservoir North) will always have sufficient storage capacity or stored water to cater for Project water surplus or deficit.

Salt Balance

- The following electrical conductivities were used as the basis to estimate complex water salt concentration:
  - Complex WMS, 3,000 µS/cm based on historical water quality within the WMS (refer to Section 2.2 Surface Water Assessment Report);
  - Natural Catchment Runoff, 500 µS/cm; and
  - Salt concentration was estimated by multiplying the EC listed above in µS/cm by a factor of 0.64 to give a salt concentration in mg/L.

Lumped Daily Timestep Water Balance

- Lumped daily timestep water balance was undertaken for a whole of complex catchment and a whole of complex water storage volume.
- Pit catchments were excluded from the lumped daily timestep model for the spills analysis as these catchments will not spill to the environment in a high rainfall event.
- Water storages servicing the catchment considered in the spills analysis are designed to accommodate a five day 95th percentile rainfall event.

- Maximum complex water storage capacity for the Project excluding the available storage in the BNP after mining and off-site storage within the GRWSS is approximately 500 ML. Dams included in this storage capacity are:
  - Dam 22;
  - Dam 23;
  - Environment Control Dams; and
  - Rail Loop Dam.
- Additional water storage capacity is available with North Pit, Bayswater North Pit, RERR Mining Area and the West Pit.
- For the daily timestep model, water is imported to the Project when the Project storage reaches 50% of capacity and water is discharged to maintain Project storage at the maximum capacity. Water import is ceased when maximum capacity (i.e. 500 ML) is reached.

5.2 Data Sources

5.2.1 Catchments and Storages

Catchment areas used for the Project's water balance have been delineated using a combination of mine plans and recent topographical surveys and aerial photography (refer to **Section 4.0** of the Surface Water Assessment).

The Project will potentially have three final voids (refer to **Section 5.3.5**), at the North Pit, BNP and RERR Mining Area. Final void stage storage relationships for these voids were developed from the final stage mine plans.

5.2.2 Production

Production data was provided for all conceptual Project years by Mount Owen. The data included total estimated ROM tonnes from each mine, product coal tonne and coarse reject tonnes. Fine reject tonnes were calculated by difference, i.e. Fine Rejects = ROM coal - Product Coal - Coarse Rejects. **Table 5.1** contains the complex production schedule used in the predictive models.

Table 5.1 – ROM Production (T)

Year	North Pit	Bayswater North Pit	RERR Mining Area	Glendell Pit	Total
2016	8,667,866	1,693,644		4,500,000	**14,861,511**
2017	8,441,461	1,568,660		4,500,000	**14,510,121**
2018	8,577,010	1,512,873		4,500,000	**14,589,883**
2019	8,325,271	1,512,873		1,512,873	**11,351,017**
2020	9,971,925	1,718,882		4,500,000	**16,190,807**
2021	6,832,123	1,328,372		4,207,988	**12,368,483**
2022	5,079,227	3,178,436			**8,257,663**
2023	5,347,392		645,892		**5,993,284**
2024	6,114,138		1,230,000		**7,344,138**
2025	5,988,305		1,300,000		**7,288,305**

Table 5.1 – ROM Production (T) (con.)

Year	North Pit	Bayswater North Pit	RERR Mining Area	Glendell Pit	Total
2026	4,924,065		1,300,000		**6,224,065**
2027	4,588,949		1,262,352		**5,851,301**
2028	5,290,418				**5,290,418**
2029	4,885,318				**4,885,318**
2030	4,504,993				**4,504,993**

5.2.3 Groundwater

Table 5.2 shows the Mount Owen Complex mine pit groundwater inflows used in the predictive water balance models operations water balance and the data source.

Table 5.2 - Groundwater Inflow Summary (ML/day)

Year	West Pit	North Pit	Bayswater North Pit	RERR Mining Area	Glendell Pit	Total
2016	0.60	1.23	0.28	0.00	0.51	2.62
2017	0.42	1.20	0.05	0.00	0.47	2.14
2018	0.34	1.10	0.04	0.00	0.65	2.13
2019	0.31	0.90	0.23	0.00	0.47	1.92
2020	0.00	1.27	0.03	0.00	0.44	1.74
2021	0.00	0.90	0.25	0.00	0.40	1.55
2022	0.00	1.04	0.11	0.00	1.25	2.40
2023	0.00	1.06	0.03	0.00	0.00	1.08
2024	0.00	1.15	0.00	0.90	0.00	2.04
2025	0.00	1.30	0.00	0.74	0.00	2.04
2026	0.00	1.27	0.00	0.60	0.00	1.88
2027	0.00	1.36	0.00	0.65	0.00	2.01
2028	0.00	1.08	0.00	0.62	0.00	1.70
2029	0.00	0.86	0.00	0.00	0.00	0.86
2030	0.00	0.79	0.00	0.00	0.00	0.79

Source: Jacobs, 2014

5.3 Project Water Balance Results

5.3.1 Gross Water Balance

Table 4.3 presents a summary of the gross water balance results for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.

Table 5.3 - Project Gross Water Balance (ML)

Scenario	10th Percentile	50th Percentile	90th Percentile
Year 1 (2016)	-2,325	-810	1,660
Year 5 (2020)	-2,200	-665	1,810
Year 10 (2025)	-800	340	2,310

The 50th percentile gross water balance results show that the Project is estimated to be in water deficit in Year 1 (2016) and Year 5 (2020). At Year 10 the Project is predicted to operate at a surplus as a result of lower ROM production and therefore lower CHPP demands and losses to tailings.

5.3.2 Gross Salt Balance

The salt balance was analysed for the three conceptual Project stage plans: Year 1 (2016); Year 5 (2020) and Year 10 (2025). For comparative purposes a salt balance was also estimated for an equivalent sized natural catchment area. As indicated by the gross water balance, the Project will have a water deficit for Year 1 and Year 5 (refer to **Table 5.3**). Transfers to and from the GRWSS will be required to meet the Project water deficit (refer to **Section 5.3.3**) and as such there will be no net export of salt from the Project.

Modelling indicates that the Project will have a water surplus during Year 10 of approximately 340 ML/year for a 50th percentile year. Based on water quality monitoring within the WMS (refer to Section 2.3 of the Surface Water Assessment Report) this water surplus is equivalent to an export of approximately 655 t/year of salt. A natural catchment of an equivalent area of the Project WMS in Year 10 is estimated to export approximately 380 t/year of salt. Salt exports from the Project will be either occur via net positive transfers off site to the GRWSS, discharges via the HRSTS or spills (refer to **Section 5.3.4**).

5.3.3 Mount Owen Complex Water Imports and Exports

While the gross water balance model assesses the gross site water surplus or deficit for a given year without importing or exporting water to site, the likely import and export volumes to meet daily operational requirements also needs to be understood. During periods of high or prolonged rainfall the complex may have a surplus of water at one time during the year while a prolonged dry period may result in a water deficit at another time. This is likely to result in water transfers to and from the complex that will be greater than the stated gross water balance (refer to **Table 5.3**).

5.3.3.1 Imports to the Mount Owen Complex

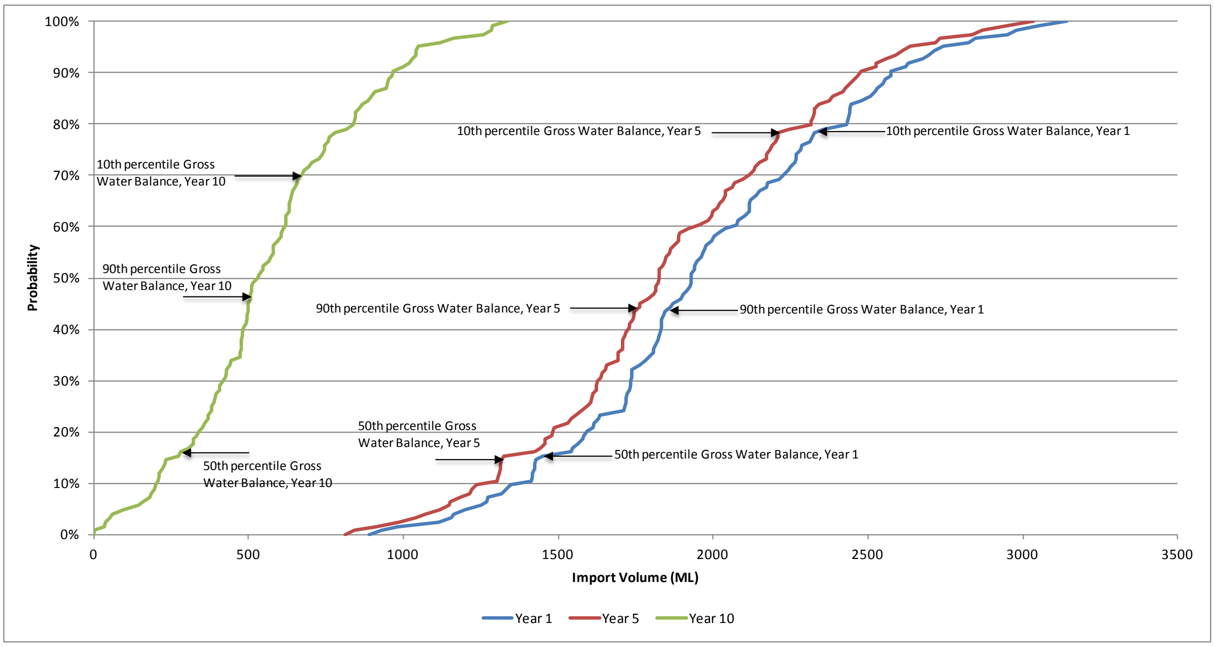
Imports to the Mount Owen Complex include water pumped from the GRWSS and water sourced from Glennies Creek under water access licences.

Table 5.4 presents the modelled annual import volumes corresponding to the 10th percentile, 50th percentile and 90th percentile gross water balance results for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project (refer to **Table 5.3**).

Table 5.4 - Annual Import Volumes (ML)

Scenario	10th Percentile	50th Percentile	90th Percentile
Year 1 (2016)	2,325	1,450	1,840
Year 5 (2020)	2,210	1,320	1,745
Year 10 (2025)	670	280	505

Graph 5.1 presents the full range of modelled annual import volume probabilities for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project. The analysis indicates that the sequencing of rainfall/runoff events has minimal influence on the requirement to import water from the GRWSS. As such the water import requirements for 10th percentile and 90th percentile gross water balance years can be similar in magnitude although total rainfall may vary significantly. The results presented in **Table 5.4** are highlighted on **Graph 5.1**.



Graph 5.1 - Annual Import Volume Probability

Table 5.5 presents the average modelled import frequencies for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.

Table 5.5 - Average Import Frequency

Scenario	Import Days/Year	Import Frequency
Year 1 (2016)	196	54%
Year 5 (2020)	188	52%
Year 10 (2025)	114	31%

Table 5.6 presents the maximum modelled daily import volumes for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.

Table 5.6 - Maximum Daily Import Volumes (ML)

Scenario	Maximum Daily Import Volume
Year 1 (2016)	11.3
Year 5 (2020)	11.3
Year 10 (2025)	5.8

The lower import volumes for Year 10 of mining operations are reflective of the lower production across the Mount Owen Complex and hence lower CHPP demand.

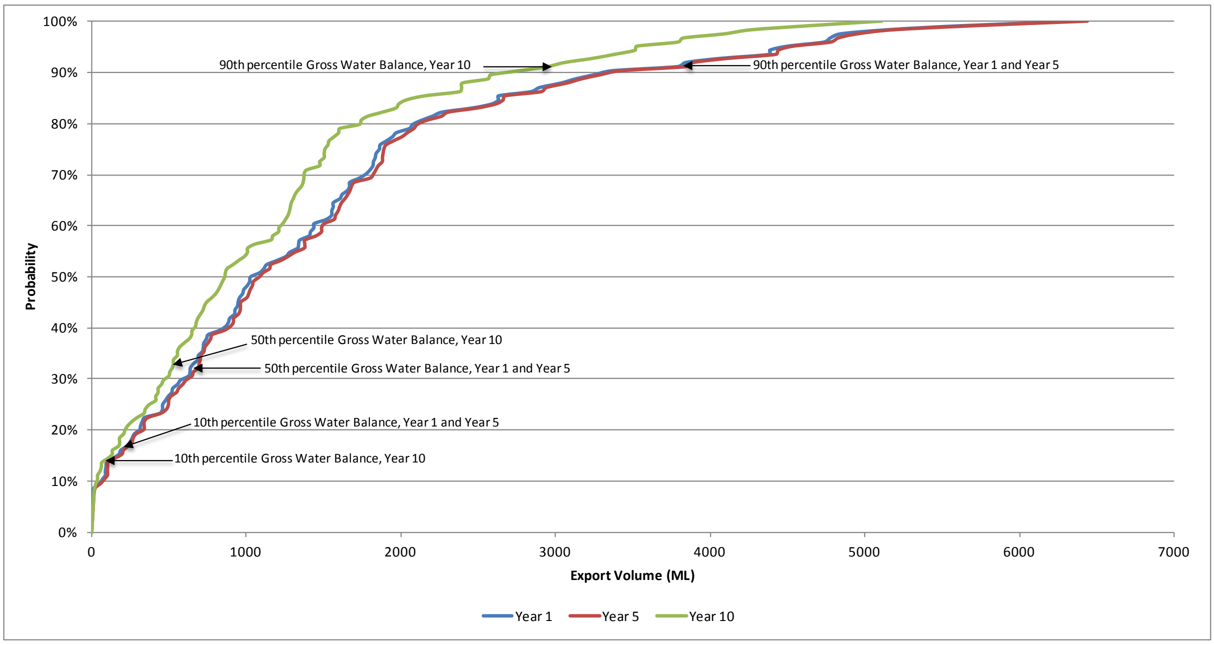
5.3.3.2 Exports from the Mount Owen Complex

Exports from the Mount Owen Complex include water transfers to the GRWSS, licensed discharges and spills. Spills are most likely to come from sediment dams in the dirty water management system when rainfall exceeds the five day 95th percentile rainfall event Blue Book design criteria as described in Section 4.1 of the Surface Water Assessment. **Table 5.7** presents the modelled annual export volumes corresponding to the 10th percentile, 50th percentile and 90th percentile gross water balance results for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.

Table 5.7 - Annual Export Volumes (ML)

Scenario	10th Percentile	50th Percentile	90th Percentile
Year 1 (2016)	190	640	3,790
Year 5 (2020)	195	650	3,840
Year 10 (2025)	105	530	2,950

Graph 5.2 presents the full range of annual export volume probabilities for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.



Graph 5.2 – Annual Export Volume Probability

Table 5.8 presents the modelled frequencies of exports for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project.

Table 5.8 - Average Export Frequency

Scenario	Export Days/Year	Export Frequency
Year 1 (2016)	9	2%
Year 5 (2020)	9	2%
Year 10 (2025)	10	3%

As detailed in **Section 2.0** the pipeline between the Mount Owen Complex and the proposed Reservoir North dam will have a capacity of up to 300 L/s or 25.9 ML/day. Water may also be transferred to the Narama Dam at the Ravensworth Operations as part of the GRWSS at a rate of approximately 100 L/s or 8.6 ML/day. For daily surplus volumes above 34.5 ML/day the Mount Owen Complex will either need to store water temporarily within water storages on site, mine storage areas or potentially the BNP after cessation of mining, or discharge/export water via other methods. These exports will include licensed discharges (e.g. HRSTS discharge to Swamp Creek) or the result of spills where dam design capacities are exceeded. **Table 5.9** presents the frequency of daily surplus volumes above 34.5 ML/day (the combined proposed export total transfer rate) for Year 1 (2016), Year 5 (2020) and Year 10 (2025) of the Project. The ability to export the full 34.5 ML/day will also be dependent on storage availability at the receiving dams. Daily water surpluses above 34.5 ML/day will be managed by either discharge via the HRSTS or transfers to on site storages.

Table 5.9 - Daily Surplus Volumes > 34.5 ML/day

Scenario	Export Days/Year	Frequency
Year 1 (2016)	5	1.4%
Year 5 (2020)	6	1.5%
Year 10 (2025)	5	1.3%

5.3.4 Spill Analysis

High or prolonged rainfall events can result in volumes of runoff from the WMS that exceed the water storage and pumping system design capacity. Spills are most likely to come from sediment dams within the dirty water management system that are designed to accommodate a five day 95th percentile rainfall event when rainfall exceeds the design criteria (refer to Section 4.1 of the Surface Water Assessment Report). These events may result in water spilling to the environment. **Table 5.10** contains a summary of the spills analysis modelling results.

Table 5.10 - Spills Analysis

Scenario	Average Number of Spills/Year	Average Spill Volume (ML)	Maximum Spill Volume (ML)
Year 1 (2016)	2	527	4,116
Year 5 (2020)	2	534	4,173
Year 10 (2025)	2	478	3,765

It is considered that the potential environmental impact of spills is limited. Spills are predicted to occur during large or prolonged rainfall events when Blue Book rainfall design criteria is exceeded. These events will typically correspond to large flow events in downstream watercourse and as such considerable dilution will occur to spill volumes reducing the potential for environmental impacts.

5.3.5 Final Void

The proposed final landform has been designed to minimise the catchment contributing to the proposed final voids: North Pit; BNP; and RERR Mining Area. In addition, Mount Owen will review the potential options to use the BNP void as an operational water storage. These options could provide benefits for other mines within the Greater Ravensworth area.

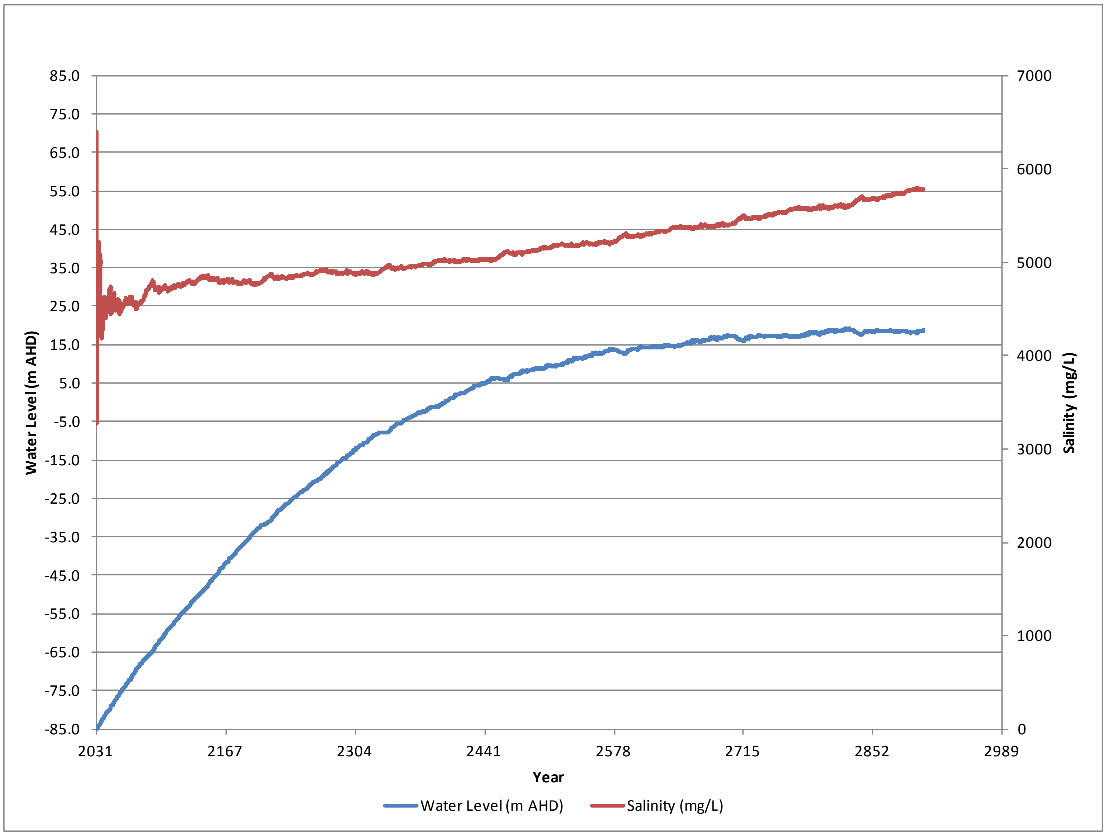
Graphs 5.3, **5.4 and 5.5** present the modelled final void water volume and salinity for the North Pit, BNP and RERR Mining Area respectively if the voids were to remain. Groundwater flows into and out of the final voids were estimated using relationships provided by Jacobs (2014). The water balance indicates the voids are not likely to spill and will reach an equilibrium level below the spill level. **Table 5.11** presents the predicted final void water levels and the approximate time to reach the equilibrium water level.

Table 5.11 - Final Void Model Results

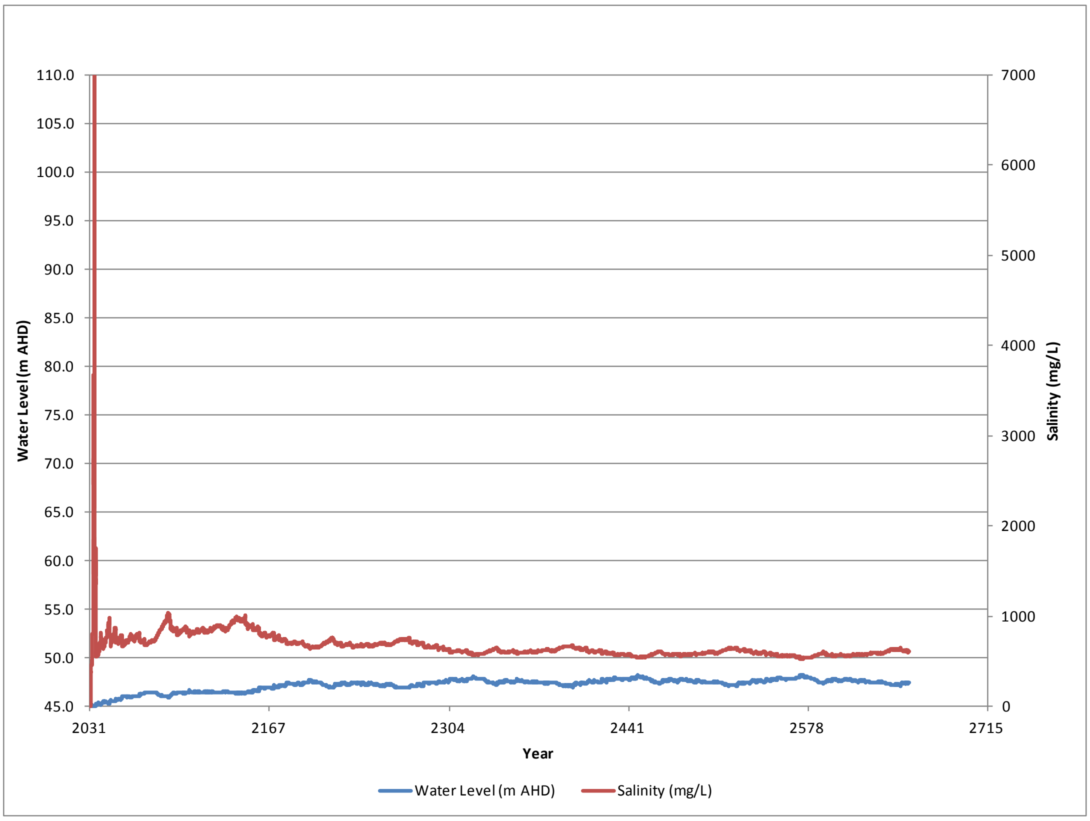
Final Void	**Equilibrium Water Level (mAHD)**	**Spill Level (mAHD)**
North Pit	19	85
Bayswater North Pit	47.5	110
RERR Mining Area	-8	90

Groundwater is expected to flow into the North Pit and RERR Mining Area final voids from the coal seam measures at the predicted equilibrium water levels at rates of approximately 0.22 ML/day and 0.24 ML/day respectively. Water is expected to flow out of the BNP final void via the coal seam measures at the predicted equilibrium water level at a rate of approximately 0.05 ML/day as the BNP is located above the regional groundwater table.

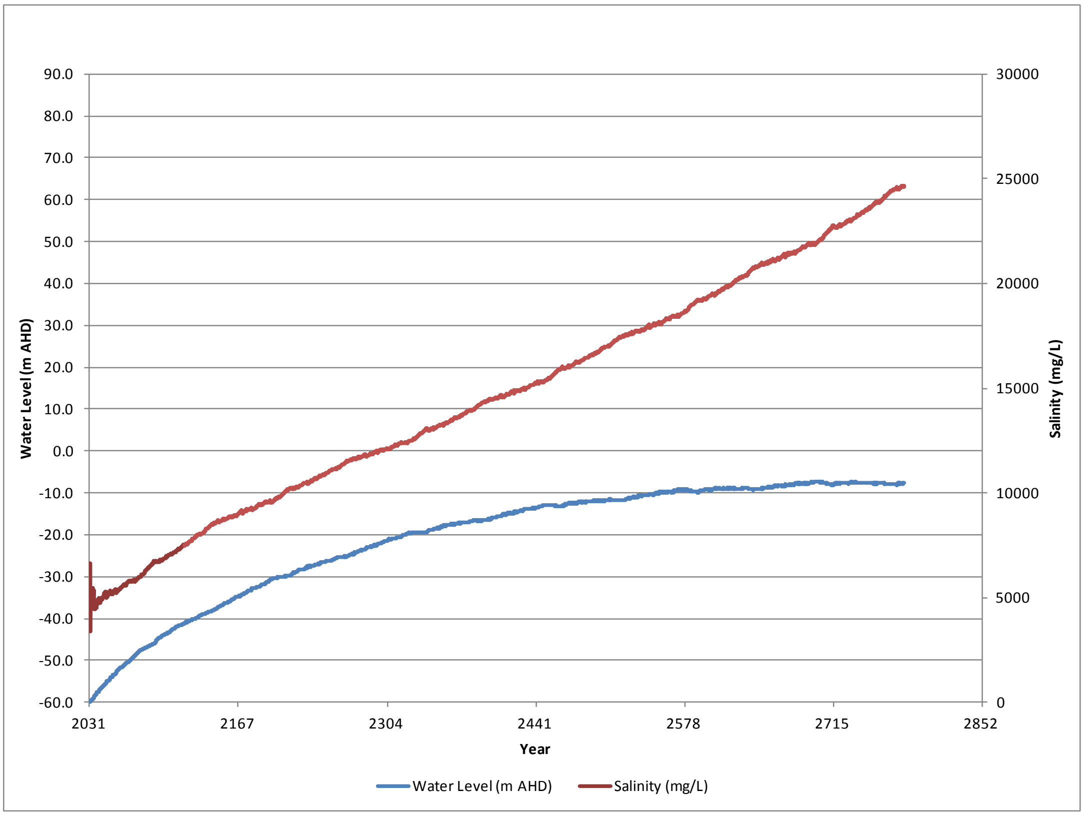
Salinity levels for the North Pit and the RERR Mining Area are expected to increase over time as a result of the continued inflow of high salinity groundwater and evapo-concentration. All three final voids will have initial higher peaks in salinity due to the initial low volumes stored in the voids compared to the salinity of inflows and high evaporation. The modelling indicates increasing salinity levels in the North Pit and RERR Mining Area when the water levels have reach equilibrium. However, the BNP salinity is predicted to vary between 500 mg/L and 700 mg/L as a result of continued seepage out of the final void to the surrounding coal measures.



Graph 5.3 – North Pit Final Void Level and Salinity



Graph 5.4 – Bayswater North Pit Final Void Level and Salinity



Graph 5.5 – RERR Mining Area Final Void Level and Salinity

6.0 Conclusions

The 50th percentile gross water balance results show that the Project is estimated to be in water deficit in Year 1 (2016) and Year 5 (2020). At Year 10 the Project is predicted to operate at a water surplus (refer to **Section 5.3.1**).

Transfers to and from the GRWSS will be required to meet the Project's water deficit and as such there will be no net export of salt from the Project for Year 1 and Year 5. Modelling indicates that the Project will have a water surplus during Year 10 of approximately 340 ML/year for a 50th percentile year.

As the primary water storage for the Mount Owen Complex will be located within the GRWSS (refer to **Section 2.1.1**) water will be transferred to the complex to meet water demands during dry periods and transferred from the complex to manage water surplus during wet periods. For example over the course of a single year, during periods of high or prolonged rainfall the complex may have a surplus of water at one time during the year while a prolonged dry period may result in a water deficit at another time. This is likely to result in water transfers to and from the complex that will be greater than the stated gross water balance.

For daily surplus volumes above 34.5 ML/day, the Mount Owen Complex will either need to store water temporarily within water storages on site, such as mining areas, or potentially the BNP after cessation of mining, or discharge. These exports will include licensed discharges (e.g. HRSTS discharge to Swamp Creek).

Groundwater flows into and out of the final voids were estimated using relationships provided by Jacobs (2014) (refer to **Section 5.3.5**). The water balance indicates that if the final voids remain in the final landform, the final voids are not likely to spill and will reach an equilibrium level below the spill level. The predicted equilibrium water levels with the North Pit final void, BNP final void and RERR final void are 19 mAHD, 47.5 mAHD and -8 mAHD respectively.

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au