Appendices

Appendix A – IESC Assessment Recommendations

Element	Where Addressed in this Report
Background data and modelling	
Identification of the water related assets (aquatic ecosystems, terrestrial ecosystems, drinking water supply, irrigation water supply, surface infrastructure, industry, regional communities, aquifers) including fauna, flora and species habitat surveys as they relate to the dependence on each identified water resource.	Section 3 Section 5
Identification of the geological formation/aquifer to which GDEs are connected and an estimate of the ecological water requirements of GDEs.	N/A
A site-specific water balance complemented by a regional water balance that includes the lateral extent of influence of underground mining.	*Northern Operations Water and Salt Balance* (GHD, 2014a)
A description of the water resources of the site and region (including current standing water levels and any records of seasonal and historical annual variations in level, quality).	Section 3
A description of the geology and hydrogeology at a local and regional level, including definition of the geological sequence, name of formations from youngest to oldest, surface geology and cross-sections.	N/A
A description of the hydraulic characteristics (hydraulic connectivity and storage characteristics) for each aquifer.	N/A
A definition of any geological structures and outlines of the influence of the structures on groundwater, in particular groundwater flow and recharge.	N/A
The depth to aquifers and standing water levels, hydro-chemical characteristics.	N/A
A description of the likely recharge sources for each aquifer, details of discharges from each aquifer, direction of groundwater flow and contours of groundwater elevations for all aquifers.	N/A
Assessment of the extent of hydrological interactions between water sources, including surface-groundwater connectivity, inter-aquifer connectivity.	Section 4 Section 8
Surface water assessment and model, including hydrology and water quality parameters.	Section 4 Section 7 Section 10

Element	Where Addressed in this Report
Groundwater assessment and numeric model (calibrated to baseline conditions), including hydrology and water quality parameters: • Enables a probabilistic evaluation of potential future scenarios. • Includes the model conceptualisation of aquifers, key assumptions and limitations. • Represents each aquifer, storage, flow characteristics of each aquifer, linkages between aquifers, existing recharge/discharge pathways of each aquifer and changes predicted to occur when the project commences. • Incorporates the various stages of the proposed project and predicts water level/pressure declines in each aquifer for the life of the project and beyond. • Provides information on the time to maximum drawdown and the time for drawdown equilibrium to be reached. • Identifies the volumes predicted to be dewatered on an annual basis, with an indication of the proportion supplied from each aquifer. • Provides information on water level recovery rates and timeframes in each aquifer for the life of the project and beyond. • Includes recommendations and a program to review and update the model as more information becomes available.	N/A
Relevant information to describe the existing state of water related ecosystems and processes at a regional scale.	*Northern Operations Water and Salt Balance* (GHD, 2014a)
An assessment of the quality of and risks inherent in the data used in the background data and modelling.	Section 4
Assessment of the likely significant impacts on water resources and water related assets	
Consideration of the State based policies and guidelines developed by the Department of Planning, the Office of Environment and Heritage and the Office of Water.	Section 2
How the project will change both local and regional water balances.	*Northern Operations Water and Salt Balance* (GHD, 2014a)
The aquifers that will be directly impacted, including the coal seam.	N/A
The aquifers that will be dewatered or indirectly impacted by dewatering in connected aquifers.	N/A

Element	Where Addressed in this Report
The extent of impact on hydrological interactions between water sources, including surface/groundwater connectivity, inter-aquifer connectivity.	Section 4 Section 8
Impacts associated with surface water diversions (where relevant).	Section 6 Section 8
Assessment of direct and indirect impacts on water related assets.	Section 9
Impacts on the hydraulic properties of aquifer geology including potential for physical transmission of water within and between formations, effects of depressurisation.	N/A
Estimates of the quantity and quality of operational discharges of water, including emergency discharges.	Section 7
Consideration of the impacts of water management infrastructure on the biodiversity assets (e.g. roads, pipelines, habitat fragmentation).	Section 10 Section 11
Assessment of the cumulative impact of the project with past, present and known future projects	*Northern Operations Water and Salt Balance* (GHD, 2014a)
Proposed mitigation measures for each identified impact.	Section 13

Appendix B – Northern Operations Water and Salt Balance

Centennial Coal

Northern Operations Water and Salt Balance

March 2014

Executive Summary

Overview

Centennial Coal Company Limited (Centennial) is currently in the process of planning extensions to its coal mining and handling operations in the Newcastle Coalfield. As part of this process, Centennial wishes to understand the potential cumulative impact of current and future operations on the regional water and salt balance by considering the cumulative water inputs and outputs of both Centennial-owned and non-Centennial operations in the region. GHD Pty Ltd was engaged by Centennial to develop this regional water and salt balance and identify interactions with the relevant surface water and groundwater Water Sharing Plans (WSPs) as well as compare current and future discharges with Centennial's Environment Protection Licence (EPL) limits.

Centennial currently has three operational mines located on the western side of Lake Macquarie: Mandalong Mine, Myuna Colliery and Newstan Colliery. One other small underground coal mine owned by Centennial, Mannering Colliery, is currently operated by LakeCoal Pty Ltd under a production sharing arrangement with Centennial.

Water Sources

The Study Area for the regional water and salt balance assessment has been defined by the surface water catchment to Lake Macquarie, which encompasses all Centennial sites in the Newcastle Coalfield and all surface water catchments that Centennial sites potentially interact with. This Study Area is regulated by one WSP and two draft WSPs made under Section 50 of the *Water Management Act 2000*. The Hunter Unregulated and Alluvial Water Sources WSP (HUA WSP) regulates the unregulated rivers and creeks and alluvial groundwater within the Study Area. Apart from alluvial groundwater, the majority of groundwater systems within the Study Area are currently managed by the *Water Act 1912*. Two draft WSPs, the Northern Coastal Sands Groundwater Sources WSP (NCS WSP) and the Northern Fractured and Porous Rock Groundwater Sources WSP (NFPR WSP) are under development by the NSW Office of Water (NOW) and are expected to commence in 2014.

Each WSP covering the Study Area consists of several water sources that are regulated by a water extraction entitlement. Overall, the assessed sites interact with five water sources including:

- Dora Creek water source (HUA WSP).
- North Lake Macquarie (HUA WSP).
- South Lake Macquarie (HUA WSP).
- Hawkesbury to Hunter Coastal Sands groundwater source (draft NCS WSP).
- Sydney Basin North Coast (draft NFPR WSP).

Assessment

The volume and salinity of extractions and discharges associated with the water sources listed above were determined by water and salt balance modelling. With regard to extractions, the water and salt balance assessment was limited to considering the licensed extractions, i.e. those regulated by Water Access Licences (WALs). With regard to discharges, the water and salt balance was limited to considering the licensed discharges, i.e. those regulated by EPLs and defined as licensed discharge points (LDPs).

The harvesting and use of runoff at each site was generally not considered, unless the flows contribute to a LDP or it was considered that Centennial may require a WAL for surface water transfers.

Groundwater extraction for this assessment is defined as the removal of groundwater from a groundwater source or aquifer, either by direct removal for use via a production bore or by incidental flow of groundwater from an aquifer into the mine workings during and after mining.

Where hydrogeological modelling had been previously undertaken, extractions from groundwater sources were estimated conceptually from existing information. For other sites, groundwater extraction was conceptually derived from available information or a conceptual hydrogeological model was developed. Predictions for LDP discharges were estimated from detailed site water and salt balance models where possible. Otherwise, information incorporated into the regional water and salt balance model was derived from existing available information or conceptual models developed with the appropriate level of detail to simulate any anticipated response of extractions and discharges to rainfall conditions.

The regional water and salt balance model incorporated predicted groundwater extractions and site operation data for a simulation timeline of 36 years from 2014 to 2050. Probabilistic modelling estimated the range of possible outcomes as a result of rainfall variation. The water and salt balance modelling estimated the predicted range of volume and salinity of licensed extractions and discharges over the simulation timeline for each site and water source. Predicted groundwater extractions between 2050 and 2200 have also been provided in addition to regional water balance outputs to indicate long term WAL requirements during the period of groundwater re-pressurisation following the completing of mining.

Outcomes

The cumulative impact of industry in the Lake Macquarie catchment was quantified by the outcomes of the water and salt balance modelling undertaken for Centennial-owned coal mines and other identified operations undertaken in the Study Area.

Current total extractions from the Sydney Basin North Coast groundwater source are estimated to be approximately 16,100 ML/year on average, of which approximately 7,500 ML/year on average is extracted by Centennial-owned sites. Peak extraction from the groundwater source is predicted to occur in 2027 at an average rate of approximately 19,600 ML/year. Extraction of groundwater from Centennial-owned sites is predicted to peak in 2032 at an average of approximately 9,900 ML/year. By the end of the assessment period in 2050, groundwater extraction from Centennial-owned sites is predicted to occur at an average rate of approximately 4,900 ML/year. Groundwater extraction over the post-2050 re-pressurisation period is predicted to be greater than 500 ML/year for approximately 30 years for Centennial sites specifically and approximately 60 years for all sites assessed.

Current extractions of salt associated with groundwater extraction from the Sydney Basin North Coast groundwater source are estimated to be approximately 158,800 t/year on average with salinity of approximately 14,700 µS/cm. Of this, approximately 77,900 t/year of salt with salinity of approximately 15,500 µS/cm is extracted by Centennial-owned sites. Salt extraction associated with groundwater extraction by all sites is expected to peak in 2027 at a rate of approximately 195,100 t/year with salinity of approximately 14,900 µS/cm. Salt associated with the extraction of groundwater by Centennial-owned sites is predicted to peak in 2031 at approximately 87,100 t/year with salinity of 13,100 µS/cm. By the end of the simulation period in 2050, extractions of salt from the groundwater source across all sites is largely attributable to Centennial-owned sites at a rate of approximately 22,700 t/year with salinity of approximately 6,900 µS/cm.

The cumulative impact on the Sydney Basin North groundwater source was estimated to vary according to the mining operations extracting from the source. The peak extraction estimated from the groundwater source was used to provide a recommended WAL requirement for groundwater extraction at Centennial-owned sites. Overall, Centennial will need to seek WAL entitlements when the NFPR WSP commences to operate in accordance with WSP rules throughout the assessment period.

The total discharges to all assessed water sources are dominated by discharges from Eraring Power Station and Vales Point Power Station. Current total discharges are estimated to be approximately 6.4 GL/year on average. This is predicted to decrease to approximately 2.4 GL/year after 2030, when Eraring Power Station is expected to cease discharging with decommissioning of the power station.

Not considering discharges from Eraring Power Station and Vales Point Power Station, total discharges are currently estimated to be approximately 15,100 ML/year. This is approximately 6% of total average annual runoff from the three surface water sources. Of this volume, approximately 6,800 ML/year on average (or approximately 3% of average annual catchment runoff) is predicted to be discharged by Centennial-owned sites. Peak discharge to all water sources is predicted to occur in 2015 at an average rate of 17,300 ML/year. Discharge by Centennial-owned sites is expected to occur in 2032 at approximately 9,700 ML/year. By the end of the assessment period in 2050, discharge from all assessed sites is minimal, with approximately 12 ML/year discharged by Centennial-owned sites.

Current total discharges of salt to all assessed water sources are also dominated by discharges from Eraring Power Station and Vales Point Power Station. Current total discharges are estimated to be approximately 236 Mtpa on average with salinity of approximately 55,000 µS/cm. This is predicted to decrease to approximately 88 Mtpa with salinity of approximately 55,000 µS/cm after 2030, when Eraring Power Station is expected to cease discharging with decommissioning of the power station.

Not considering discharges from Eraring Power Station and Vales Point Power Station, current total discharges of salt to all water sources are estimated to be approximately 154,200 t/year with salinity of 15,300 µS/cm. This is substantially higher than the salt load generated by the natural catchment. Of this, approximately 59,800 t/year of salt with salinity of 13,200 µS/cm is discharged by Centennial-owned sites. Salt discharged from all sites is predicted to peak in 2015 at a rate of approximately 160,600 t/year with salinity of approximately 13,800 µS/cm. Salt associated with Centennial-owned sites is predicted to peak in 2023 at approximately 66,900 t/year with salinity of approximately 11,100 µS/cm. By the end of the assessment period in 2050, discharges of salt to all water sources by Centennial-owned sites is expected to have decrease significantly to a rate of 11 t/year with salinity of approximately 1,400 µS/cm. Considering the salt associated with groundwater extractions entering water management systems at Centennial-owned sites, the results of the salt balance for discharges of salt into surface water sources indicate that Centennial-owned sites act as a net store of salt in the Study Area.

The cumulative impact on each surface water source varies according to the mining operations discharging into each water source. The licensed discharge from each water source is predicted to peak at different times throughout the assessment period. However, discharges to all water sources are predicted to significantly decrease by the end of the assessment period.

The peak discharges estimated for each water source enabled a comparison of the current and predicted LDP volumetric discharge limits for each Centennial-owned site based on future predicted groundwater extraction rates. It is recommended that the adequacy of LDP volumetric discharges is completed on a site-by-site basis to include the interaction of site-specific water cycles and catchment runoff.

Extractions from Lake Macquarie do not require licensing. Both surface water extractions from and discharges to Lake Macquarie are dominated by transfers associated with the operation of Eraring Power Station and Vales Point Power Station. As a result, discharges from Centennial-owned sites form up to approximately 0.4% of the total discharges to the lake. The salt associated with discharges form up to approximately 0.08% of the total.

The results of the water balance modelling were used to provide a recommended WAL requirement for surface water transfers at Mandalong Mine and Newstan Colliery. WALs will be required as a result of water reuse strategies that extract water from the water management system at each site that would otherwise be discharged into receiving waterways. No other Centennial-owned sites within the Study Area require a WAL.

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Glossary

Adit	Entrance to an underground mine.
Alluvial	Pertaining to material, such as sand or silt, deposited by running water.
Aquifer	Under the *Water Management Act 2000* an aquifer is a geological structure or formation, or an artificial landfill, which is permeated with water or is capable of being permeated with water. For the purposes of this study, an aquifer also includes flooded mine workings in equilibrium with the surrounding strata and perched aquifers recharged directly from rainfall infiltration.
Aquifer interference	The *Water Management Act 2000* defines an aquifer interference activity as that which involves any of the following: • The penetration of an aquifer. • The interference with water in an aquifer. • The obstruction of the flow of water in an aquifer. • The taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations. The disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.
Ash	A major by-product of coal fuelled electricity generation. Bottom ash is collected from the bottom of the boilers while fly ash is an inert mineral matter collected in a dust collection plant.
Bord and pillar	A mining system whereby coal is extracted leaving pillars of untouched coal to support the strata above.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Brackish water	Water that has more salinity than fresh water, but not as much as seawater. Typically containing between 0.5 and 30 grams of dissolved salt per litre of water.
Catchment	The land area draining through the main stream and tributary streams to a particular location.
Coal handling plant	A facility where coal is crushed and screened.
Coal handling and preparation plant	A facility where coal is washed, screened and prepared for transport off site.
Coal preparation plant	A facility where coal is washed and prepared for transport off site.
Depression storage	The volume of water that must be filled prior to the generation of runoff for a particular land use.

Dewatering	The removal or pumping of water from an above or below ground storage, including the mine water within the water collection system of mine workings. Water removed from mine workings is regarded as dewatering unless the workings are flooded and at equilibrium with the surrounding strata (in which case the removal is considered groundwater extraction).
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.
Electrical conductivity	A measure of the concentration of dissolved salts in water.
Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Groundwater	Water in a saturated zone, stratum or aquifer beneath the surface of the land.
Groundwater extraction	For the purposes of this study, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.
Guideline	Numerical value or narrative statement that provides appropriate guidance for a designated water use or impact.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Hydrology	The study of rainfall and surface runoff processes.
Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Interburden	The strata between coal seams.
Licenced discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site Environment Protection Licence.
Long-term average annual extraction limit	An estimated sustainable extraction limit for a groundwater source, based on the proportion of annual rainfall recharge that may sustainably be released for use.
Longwall mining	Underground coal mining where a block of coal is mined using a longwall shearer, supported by roadway development that is created using a continuous miner unit.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.

Outcrop	Where the bedrock is exposed at the ground surface.
Overburden	The strata between the recoverable topsoil and the upper coal seam.
Pan factor	Reduction factor applied to measured pan evaporation to simulate evaporation from natural water bodies and surface water storages.
Partial extraction	A continuous miner system of mining whereby some of the coal pillars in a panel, or parts thereof, are systematically extracted.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
pH	Value measure used to represent the acidity or alkalinity of an aqueous solution. A value of 7 is applied to a water that is neither acidic or alkaline. A value less than 7 represents an acidic condition.
Potable water	Water of a quality suitable for drinking.
Recharge	Inflow of water from surrounding strata into underground mine workings via infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Reject	The by-product resulting from the processing of coal, including rock and coal material that is out of sale specifications.
Runoff	Amount of rainfall that ends up as streamflow.
Run of mine	Raw coal production (unprocessed).
SILO	An enhanced climate data bank based on historical climate data from 1889 provided by the Bureau of Meteorology. Records are mainly based on observed data, with interpolation where there are data gaps.
Strata	Geological layers below the ground surface.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Unassigned water	The difference between the average long-term sustainable extraction limit for a water source and the actual total entitlement within that water source at any point in time. Unassigned water may be released via a Controlled Allocation Order.
Underground water	Water stored in underground aquifers. During the mining process a proportion of this water is released and managed by the underground settling and pumping system.
Water allocation	Total annual volume of water attributed to a share component of a water source. Usually one share equals 1 ML/year.

Water entitlement	Total annual volume of water available for extraction from a water source by a licence holder.
Water Sharing Plan	A legal document prepared under the *Water Management Act 2000* that establishes rules for sharing water between the environmental needs of the river or aquifer and water users and also different types of water use.

Abbreviations

AHD	Australian Height Datum
ANZECC	Australia New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AWBM	Australian Water Balance Model
BOD	Biological oxygen demand
BOM	Bureau of Meteorology
BS	Baseflow storage
Centennial	Centennial Coal Company Limited
Centennial Mandalong	Centennial Mandalong Pty Limited
Centennial Mannering	Centennial Mannering Pty Limited
Centennial Myuna	Centennial Myuna Pty Limited
Centennial Newstan	Centennial Newstan Pty Limited
CHP	Coal handling plant
CHPP	Coal handling and preparation plant
CPP	Coal preparation plant
DGRs	Director General's Environmental Assessment Requirements
DO	Dissolved oxygen
EC	Electrical conductivity
EIS	Environmental impact statement
EMU	Extraction management unit
EPA	Environment Protection Authority
EPL	Environment Protection Licence
GHD	GHD Pty Ltd
GL/year	Gigalitre per year
ha	Hectare
HUA WSP	Hunter Unregulated and Alluvial Water Sources Water Sharing Plan
km	Kilometre
L/s	Litre per second
LakeCoal	LakeCoal Pty Ltd

LDP	Licensed Discharge Point
LTAAEL	Long-term average annual extraction limit
m	Metre
m/year	Metre per year
m^2	Square metre
m^3/hr	Cubic metre per hour
mg/L	Milligram per litre
MHRDC	Maximum harvestable right dam capacity
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
Mtpa	Million tonnes per annum
MW	Megawatt
NCS WSP	Northern Coastal Sands Groundwater Sources Water Sharing Plan
NFPR WSP	Northern Fractured and Porous Rock Groundwater Sources Water Sharing Plan
NOW	NSW Office of Water
NTU	Nephelometric turbidity unit
O&G	Oil and grease
OCAL	Oceanic Coal Australia Pty Limited
POEO Act	*Protection of the Environment Operations Act 1997*
ROM	Run of mine
SS	Surface storage
SSTV	Site-specific trigger value
TSS	Total suspended solids
WAL	Water Access Licence
WM Act	*Water Management Act 2000*
WSP	Water Sharing Plan
µS/cm	Microsiemens per centimetre

1. Introduction

1.1 Background

Centennial Coal Company Limited (Centennial), a wholly owned subsidiary of Banpu Public Company Limited, is an Australian coal mining and marketing company supplying thermal and coking coal to domestic and export markets. Centennial is a major fuel supplier to the NSW energy industry, fuelling approximately 46% of the state's coal-fired electricity.

Centennial is one of the largest underground coal producers in NSW and is one of the major coal mine operators in the southern part of the Newcastle Coalfield surrounding Lake Macquarie, located in the north-east of the Sydney Basin. Abundant coal reserves in the Newcastle Coalfield have enabled a long history of coal mining in the region. Centennial currently has three operational mines located on the western side of Lake Macquarie: Mandalong Mine, Myuna Colliery and Newstan Colliery. One other small underground coal mine owned by Centennial, Mannering Colliery, is currently operated by LakeCoal Pty Ltd (LakeCoal) under a production sharing arrangement with Centennial. The regional locality of Centennial's existing operations is shown in Figure 1-1.

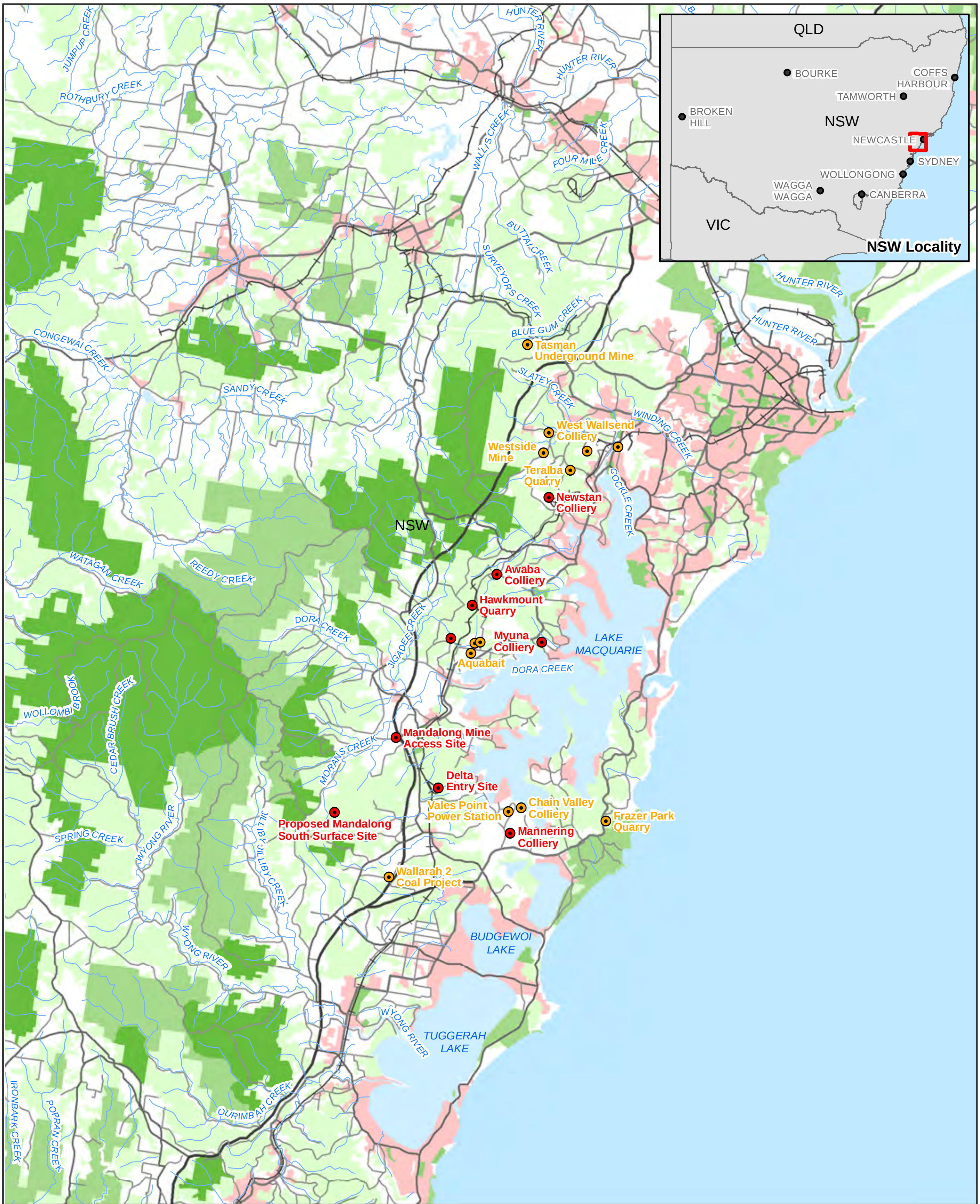
Centennial is currently in the process of planning extensions to its coal mining and handling operations in the Newcastle Coalfield, to be developed over the next 36 years. As part of this process, Centennial wishes to understand the potential cumulative impact of current and future operations on the regional water and salt balance by considering the cumulative water inputs and outputs of both Centennial-owned and non-Centennial operations in the region. GHD Pty Ltd (GHD) was engaged by Centennial to develop this regional water and salt balance and identify interactions with relevant surface water and groundwater Water Sharing Plans (WSPs), as well as compare current and future discharges with Centennial's Environment Protection Licence (EPL) limits.

1.2 Study Area

The Study Area for the regional water and salt balance assessment has been defined by the surface water catchment to Lake Macquarie, which encompasses all Centennial sites in the Newcastle Coalfield and all surface water catchments that Centennial sites potentially interact with. Generally, this area extends from Warners Bay in the north to Wyee in the south and from Toronto in the west to the Tasman Sea in the east. The boundary of the Study area is presented in Figure 1-2.

1.3 Purpose of this Document

The purpose of the regional water and salt balance is to provide context to the cumulative impacts of coal mining and other industries with respect to water demands and distribution in the Lake Macquarie catchment over the next 36 years. This document will support site-specific surface water and groundwater impact assessments prepared for proposed Centennial mining projects in the Study Area.



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0 1 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Existing Rail
- Waterway
- Dual Carriageway
- Principal Road
- Secondary Road
- Minor Road
- Waterbody
- Built Up Area
- Nature Conservation
- State Forest
- Forest Or Shrub

LOCATION	-
SEAM	NA
DRAWN	T,Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Locality Plan

Centennial Coal

DATE 24/03/2014 Figure 1-1

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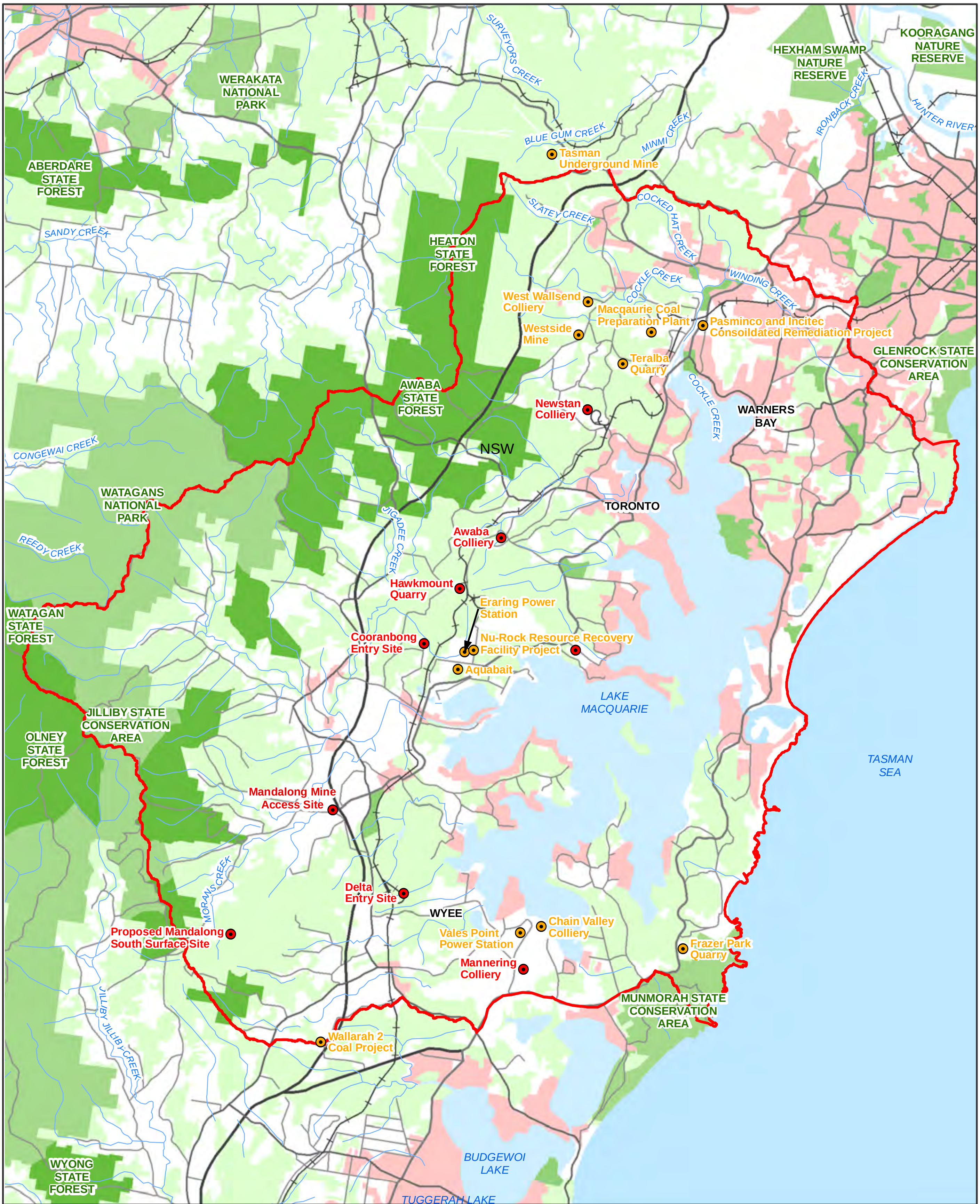

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Kilometres

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Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study Area
- Existing Rail
- Waterway
- Dual Carriageway
- Principal Road
- Secondary Road
- Minor Road
- Waterbody
- Built Up Area
- Nature Conservation
- State Forest
- Forest Or Shrub

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Study Area

Centennial Coal

DATE 24/03/2014 Figure 1-2

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1.4 Objectives of the Regional Water Balance

The objectives of the regional water and salt balance assessment have been defined as follows:

- Assess the cumulative impact of the major water users in the Lake Macquarie catchment with respect to licensed water extractions and licensed discharges between 2014 and 2050.
- Quantify the annual cumulative licensed water take and water discharge by Centennial-owned sites throughout the Lake Macquarie catchment for each year between 2014 and 2050 and assess the outcomes with respect to relevant WSP and EPL requirements.
- Quantify the annual cumulative licensed water take and water discharge by other identified major water users in the Lake Macquarie catchment for each year between 2014 and 2050.
- Quantify the annual cumulative salt input and output associated with water transfers by the major water users in the Lake Macquarie catchment for each year between 2014 and 2050.
- Catchment runoff modelling to compare Centennial's water and salt discharges to background flows and salt loads into Lake Macquarie.
- Identify potential Water Access Licence (WAL) or EPL volumetric limit shortfalls that may exist for each Centennial-owned site between 2014 and 2050.
- Estimate long-term groundwater inflows into mine workings during the period of re-pressurisation following completion of mining.
- Identify potential water quality issues arising from cumulative discharges to waterways by Centennial-owned sites.
- Inform Centennial's regional water management strategy for Northern Operations.

1.5 Scope of Work

The following tasks have been undertaken to develop the regional water and salt balance:

- Review existing relevant information that is available for Centennial-owned sites and non-Centennial sites. The surface sites that have been incorporated into the regional water and salt balance are considered to be the major water users and dischargers within the Study Area. The locations of these sites are shown in Figure 1-1.
- Collate existing spatial data (including mine plans, geology, waterways and catchments, WSP boundaries and topography data) into ArcGIS geodatabases.
- Review legislation, policies and guidelines relevant to the regional water and salt balance assessment and clarify water licensing rules under applicable WSPs.
- Develop water cycle schematics for modelled sites, including the underground workings associated with each site and the WSP water sources that interact with each site.
- Develop a regional-scale water cycle schematic which shows water transfers between WSP water sources and modelled sites.
- Represent the regional-scale water and salt cycles and site water and salt cycles in a GoldSim regional water and salt balance model, utilising existing water and salt balance models and reports where available, including the discharge into each WSP water source.

- Determine groundwater seepage rates into existing and future mine workings throughout the Study Area, utilising existing hydrogeological models and reports where available, including the extraction from each WSP groundwater source, and input into the GoldSim model.
- Run the regional water and salt balance model to quantify the cumulative water and salt take of each assessed site from each WSP water source and cumulative water and salt discharge to each WSP water source via licensed discharge points (LDPs) over the period of 2014 to 2050.
- Run the regional water and salt balance model to quantify the cumulative water and salt take from each WSP water source and for the major water users in the Lake Maquarie catchment and cumulative discharge to each WSP water source via LDPs over the period of 2014 to 2050. Compare the cumulative water and salt discharges to each water source by the major water users to background flows and salt loads generated from each water source catchment.
- Assess predicted water take and water discharge rates against WSP and EPL requirements to identify potential licensing shortfalls for Centennial-owned sites between 2014 and 2050.
- Prepare a regional water and salt balance report to document the assessment undertaken, the assumptions and limitations and the results and recommendations.

1.6 Assumptions and Limitations

1.6.1 Extent of the Regional Water and Salt Balance Assessment

The regional water and salt balance assessment considers the cumulative impact of coal mining and other operations in the Study Area on licensed water extractions and discharges. The sites assessed are limited to those listed in Table 1-1, which were determined in consultation with Centennial as the known major water users in the Study Area occurring over the next 36 year period. Other water users in the region have therefore not been considered in this assessment.

Table 1-1 Sites Incorporated into the Regional Water and Salt Balance Assessment

Site	Owner	Site details	Status
Aquabait	Aquabait Pty Ltd	Marine worm aquaculture operation	Operational
Chain Valley Colliery	LakeCoal Pty Limited	Underground coal mine	Operational
Coal Logistics Project	Northern Coal Services (Centennial)	Coal processing, handling and transport	Project
Eraring Power Station	Eraring Energy	Power station	Operational
Frazer Park Quarry	HB Frazer Park Pty Ltd	Quarry	Operational
Mandalong Mine	Centennial Mandalong Pty Limited	Underground coal mine	Operational and project

Site	Owner	Site details	Status
Mannering Colliery	Centennial Mannering Pty Limited	Underground coal mine	Care and maintenance
Myuna Colliery	Centennial Myuna Pty Limited	Underground coal mine	Operational
Newstan Colliery	Centennial Newstan Pty Limited	Underground coal mine	Operational and project
Nu-Rock Resource Recovery Facility Project	Nu-Rock Technology Pty Ltd	Proposed resource recycling plants	Project
Pasminco and Incitec Consolidated Remediation Project	Pasminco Cockle Creek Smelter Pty Ltd	Contaminated land remediation	Operational
Tasman Underground Mine	Newcastle Coal Company Pty Ltd	Underground coal mine	Operational
Teralba Quarry	Metromix Pty Ltd	Quarry	Operational
Vales Point Power Station	Delta Electricity	Power station	Operational
Wallarah 2 Coal Project	Wyong Areas Coal Joint Venture	Proposed underground coal mine	Project
West Wallsend Colliery	Oceanic Coal Australia Pty Limited	Underground coal mine	Operational
Westside Mine	Oceanic Coal Australia Pty Limited	Former open cut coal mine	Rehabilitation

For old underground workings in the region that are not part of the current water management system for a site, it has been assumed that these underground water storages are at equilibrium with the adjacent aquifer. Therefore, it is assumed there is no extraction from groundwater sources for these underground storages.

With regard to extractions, the regional water and salt balance assessment is limited to considering the licensed extractions, i.e. those currently regulated by WALs under the *Water Management Act 2000* (WM Act) or licenses under the *Water Act 1912*. With regard to discharges, the assessment is limited to considering the licensed discharges, i.e. those regulated by EPLs and defined as LDPs. The harvesting and use of runoff at each site has not been considered by the assessment, unless the flows contribute to a LDP.

The extraction from surface water sources for individual sites was not determined in the regional water and salt balance assessment. Surface water extractions are dependent on consultation with NOW on a site-by-site basis. The impacts of variations to surface water runoff regimes and collection have not been considered by this assessment.

Potable water supply and wastewater discharges from sites have also been excluded by the regional water and salt balance assessment, as sites do not require extraction licences for the supply of potable water and wastewater discharges (although licensed) do not contribute to surface water sources as generating runoff from these activities is typically not permitted.

1.6.2 Availability of Information

In developing the water and salt balance for the Newcastle Coalfield region, information relating to the water and salt cycle at each site has been drawn upon from a range of sources. For Centennial-owned sites where detailed site information was available, GHD has developed detailed representations of the water cycle in the modelling software. For other sites where GHD has not developed a modelled representation of an individual site, information and data relating to these sites has been determined from reviewing available information. This information and data is typically limited to publicly available material. GHD has endeavoured to interpret information presented in these reports as accurately as possible in the modelling undertaken, however cannot be responsible for inaccuracies due to misleading or absent information in the reports reviewed.

1.6.3 Timing of Operations

The commencement and cessation of operations have an impact on the assessment of licensing requirements undertaken. If project timelines change from the timelines assumed for the water and salt balance assessment, the recommended licensing requirements may be impacted.

1.6.4 Trading of Water Access Licences

The regional water and salt balance assessment assumes WALs will be traded freely between Centennial-owned sites within WSP water sources to meet project water demands of different mining operations. These trades are subject to applicable local impact management restrictions which have not been considered by this assessment.

1.6.5 Climate Change

The impacts of climate change have not been considered by the regional water and salt balance assessment. The assessment period extends for a 36 year period from 2014 to 2050 and any potential impacts of climate change over this time period are unlikely to affect the outcomes from the water and salt balance for the following reasons:

- The outcomes from modelling have been presented as a range of possible values (10th percentile, mean and 90th percentile). The variation due to climate change is likely to be within the variation of values presented.
- One of the primary drivers for the regional modelling are changes to groundwater extractions and the distribution of this water over the simulation timeline. The impacts of climate change on groundwater over such a timescale are insignificant due to limited correlation between inflows into underground workings and rainfall.
- The inputs into the modelling for some sites are adopted from other reports which were derived from models GHD has not had access to. Incorporating the impacts of climate change was not possible without access to the models.

2. Legislation and Policy

This section provides an overview of the legislation, policies and guidelines relevant to this regional water balance assessment. It should be noted that extractions from the waterbody of Lake Macquarie does not require licensing.

2.1 Water Act 1912

The *Water Act 1912* is administered by the NSW Office of Water (NOW) and has historically been the main legislation managing water resources in NSW. The *Water Act 1912* governs access, trading and allocation of licences associated with both surface and underground water sources and is currently being progressively phased out and replaced by WSPs under the WM Act, discussed in Section 2.2. The elements to which the *Water Act 1912* applies include extraction of water from a river, extraction of water from underground sources, aquifer interference and capture of surface runoff in dams.

The majority of groundwater systems within the Study Area are currently still managed by the *Water Act 1912*. Two draft WSPs covering the Study Area, the Northern Coastal Sands Groundwater Sources WSP (NCS WSP) and the Northern Fractured and Porous Rock Groundwater Sources WSP (NFPR WSP), are under development and are expected to commence in 2014 (NOW, 2014a). Once a WSP commences, existing licences under the *Water Act 1912* are converted to WALs and water supply works and use approvals under the WM Act.

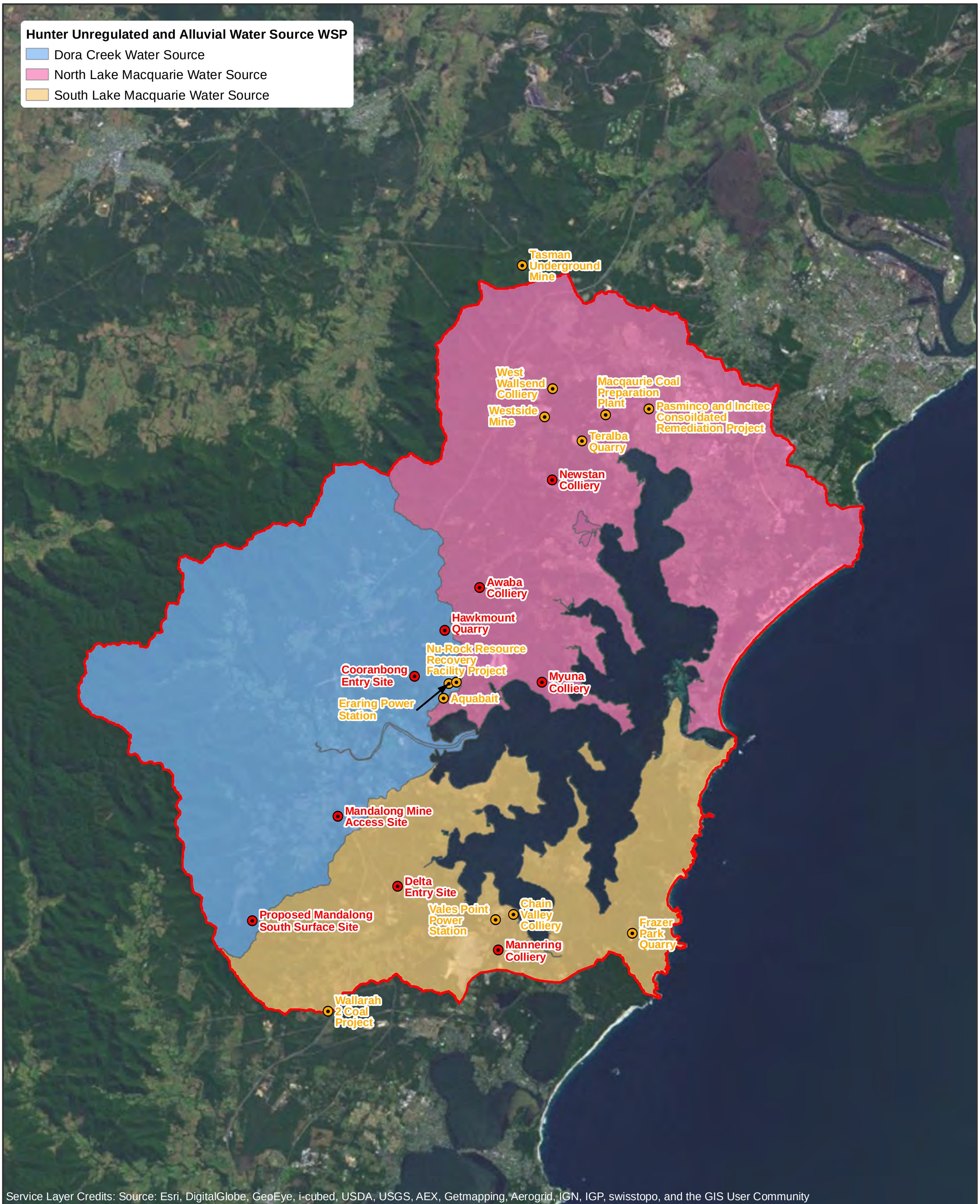
In preparation for the commencement of the groundwater sources WSPs, the regional water and salt balance assessment has considered the draft WSPs and assumed that any licences currently held by Centennial-owned sites under the *Water Act 1912* associated with groundwater interference, bore installation and extraction of groundwater will be transferred to WALs under the WM Act.

2.2 Water Management Act 2000

The WM Act, also administered by NOW, is progressively being implemented throughout NSW to manage water resources, superseding the *Water Act 1912*. The aim of the WM Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions. Fresh water sources throughout NSW are managed via WSPs under the WM Act. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

An amendment to the WM Act (Section 60I) came into effect on 1 March 2013. This amendment provides that it is an offence for a person without an access licence to take, remove or divert water from a water source or relocate water from one part of an aquifer to another part of an aquifer in the course of carrying out a mining activity. Various activities are captured by the provisions of the amendment including mining, mineral exploration and petroleum exploration.

The Study Area is regulated by one WSP that has commenced and two draft WSPs made under Section 50 of the WM Act. The Hunter Unregulated and Alluvial Water Sources WSP (HUA WSP) regulates the unregulated rivers and creeks and alluvial groundwater within the Study Area. As discussed in Section 2.1, two draft groundwater WSPs cover the Study Area: the NCS WSP and NFPR WSP. The boundaries of the applicable surface water and draft groundwater WSPs are shown in Figure 2-1 and Figure 2-2 respectively and are outlined in the following sections.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study Area

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Surface Water WSP Boundaries

Centennial Coal

DATE 24/03/2014

Figure 2-1

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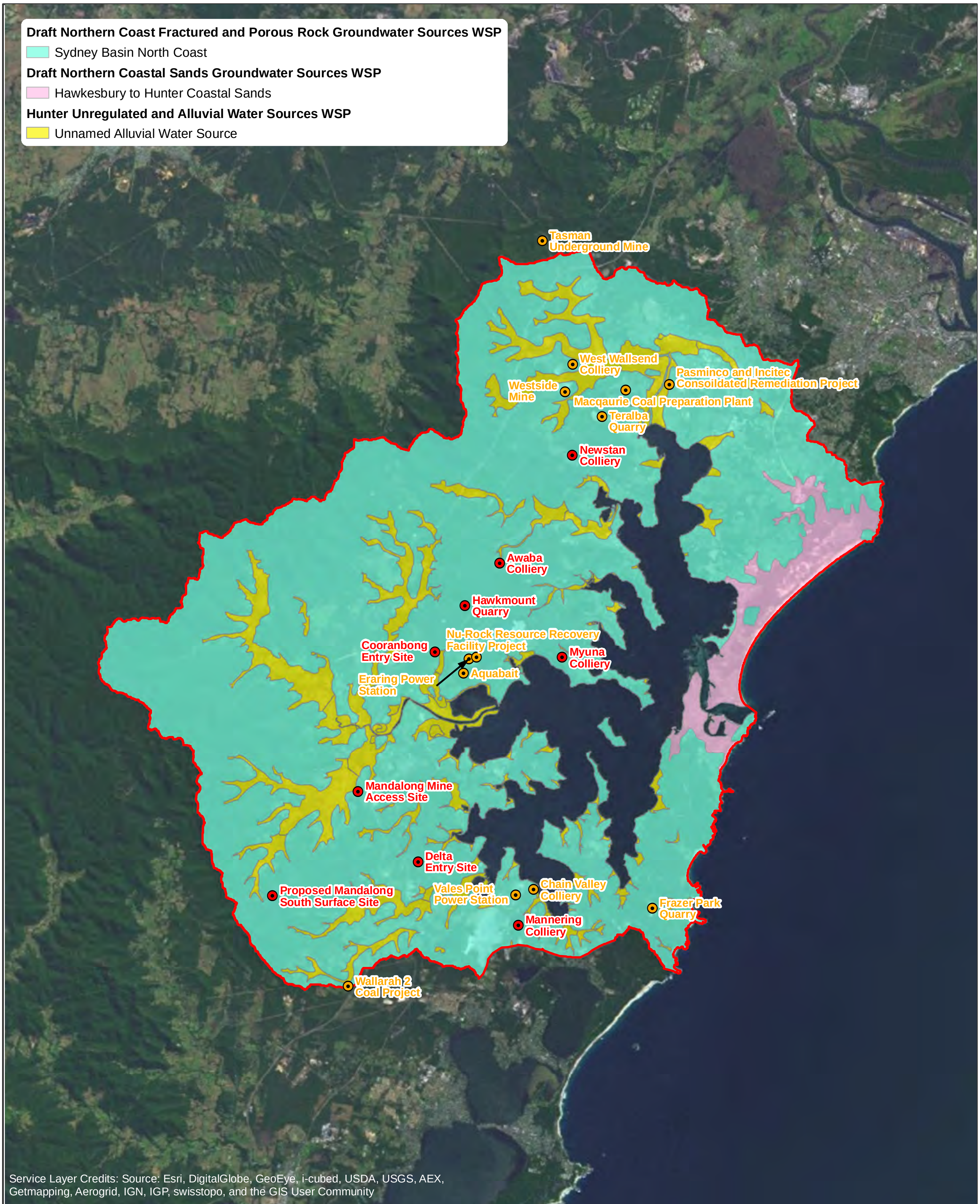

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Groundwater WSP Boundaries

Centennial Coal

DATE 25/03/2014 Figure 2-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB003_GW_WSPBoundaries_A.mxd

2.2.1 Hunter Unregulated and Alluvial Water Sources Water Sharing Plan

The HUA WSP includes the unregulated rivers and creeks and alluvial groundwater within the Hunter region and is categorised into four extraction management units (EMUs) and further broken down into water sources. The area covered by the WSP includes 39 surface water and alluvial groundwater sources.

Table 2-1 identifies the water extraction entitlement for each water source within the HUA WSP as well as the active licences at the commencement of the WSP in August 2009. The extraction limit is the yearly volume of water that can be extracted by all access licences within the water source. The water sources applicable to the Study Area are highlighted in bold in Table 2-1 and are discussed below.

Table 2-1 HUA WSP Extraction Entitlement and Licences

Water source	Surface water entitlement (ML/year)	Surface water licences	Groundwater entitlement (ML/year)	Groundwater licences
Baerami Creek	1,490	11	2,259	14
Black Creek	5,206	129	–	–
Bow River	200	5	5	1
Bylong River	65	2	5,843	23
Dart Brook	1,538	67	28,051	163
Dora Creek	**864**	**13**	–	–
Doyles Creek	570	2	–	–
Glendon Brook	1,546.5	49	–	–
Glennies	260	13	–	–
Halls Creek	3,466	47	431	9
Hunter Regulated River Alluvial	–	–	29,055	244
Hunter River Tidal Pool**	–	–	–	–
Isis River	1,932	27	–	–
Jerrys	10,278	22	–	–
Krui River	1,449	14	5	1
Lower Goulbern River	14,205	66	2,494	15
Lower Wollombi Brook	6,663	110	5,071	38
Luskintyre	389	16	–	–

Water source	Surface water entitlement (ML/year)	Surface water licences	Groundwater entitlement (ML/year)	Groundwater licences
Martindale Creek	3,241	25	588	7
Merriwa River	4,756	52	900	4
Munmurra River	164	2	10	2
Muswellbrook	598	44	–	–
Newcastle	551	7	–	–
North Lake Macquarie	**1,216**	**10**	**–**	**–**
Pages River	16,667	89	8,059	36
Paterson/Allyn Rivers	3,557	163	–	–
Paterson River Tidal Pool**	–	–	–	–
Rouchel Brook	1,097	25	–	–
Singleton	967.5	23	–	–
South Lake Macquarie	**169**	**5**	**–**	**–**
Upper Goulburn River	1,661	14	2	1
Upper Hunter	3,412	65	–	–
Upper Paterson	196	8	–	–
Upper Wollombi Brook	2,703	79	10	2
Wallis Creek	492	17	–	–
Wallis Creek Tidal Pool**	–	–	–	–
Widden Brook	2,836	3	1,191	5
Williams River	8,263	177	–	–
Wollar Creek	78	8	1,354	3

** A process for licensing water users in tidal pool areas is currently underway.

The Lake Macquarie EMU covers the surface water catchment to Lake Macquarie and encompasses all Centennial-owned sites in the Newcastle Coalfield and all surface water catchments that Centennial sites potentially interact with. The boundary of the Lake Macquarie EMU is shown in Figure 2-1.

The Lake Macquarie EMU covers three surface water sources within the HUA WSP. For the surface water sources within the Lake Macquarie EMU, these rules provide guidance on:

- Access rules – providing specific access rules including 'cease to pump' limits and reference points.
- Trading rules – providing specific management strategies for trading into and within the water source.

Due to the lack of flow gauges and the small amount of users for each of the water sources in the Lake Macquarie EMU, access rules have been limited to 'cease to pump' rules that prevent extraction when there is no visible flow at specific reference points within the catchment.

The trading rules specify that trading into the Dora Creek and South Lake Macquarie water sources is not permitted, however trading into the North Lake Macquarie Water Source is permitted, subject to assessment. For all the water sources within the Lake Macquarie EMU, trading within the water source is permitted subject to assessment and conversion to a high flow access licence or aquifer access licence is not permitted.

The details of the rules applicable to the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources are presented in Table A-1, Table A-2 and Table A-3 of Appendix A respectively.

2.2.2 Draft Northern Coastal Sands Groundwater Sources

The NCS WSP is currently under development and is anticipated to commence in 2014. Limited information about the WSP was available from NOW. The WSP is expected to cover 10 groundwater sources on the east coast of NSW. The Hawkesbury to Hunter Coastal Sands groundwater source is expected to be the only groundwater source within the WSP applicable to the Study Area (K. Mahony, personal communication, 26 February 2014). The water extraction entitlement for each groundwater source is currently unknown; however it is expected to be based on existing groundwater extraction licences under the *Water Act 1912* and the long-term average annual extraction limit (LTAAEL). The LTAAEL is an estimated sustainable extraction limit for each of the groundwater sources, based on the proportion of annual rainfall recharge that may sustainably be released for use.

It is expected that the draft NCS WSP will provide rules for each groundwater source, which may include:

- Access rules.
- Rules for managing water allocation accounts.
- Rules for granting and amending water supply works approvals.
- Rules for the use of water supply works approvals.
- Limits to the availability of water.
- Trading rules.

2.2.3 Draft Northern Fractured and Porous Rock Groundwater Sources

Similar to the draft NCS WSP, the WSP for the Northern Fractured and Porous Rock Groundwater Sources is currently under development and is anticipated to commence in 2014. Limited information about the WSP was available from NOW. The Sydney Basin North Coast groundwater source is expected to be the only groundwater source within the WSP applicable to the Study Area (K. Mahony, personal communication, 26 February 2014). The water extraction entitlement for each groundwater source is currently unknown; however it is expected to be based on existing groundwater extraction licences under the *Water Act 1912* and the LTAAEL.

It is expected that the draft NFPR WSP will provide rules for each groundwater source, which may include:

- Access rules.
- Rules for managing water allocation accounts.
- Rules for granting and amending water supply works approvals.
- Rules for the use of water supply works approvals.
- Limits to the availability of water.
- Trading rules.

2.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Environment Protection Authority (EPA), which is an independent statutory authority and the primary environmental regulator for NSW. The objectives of the POEO Act are to protect, restore and enhance the quality of the environment. Some of the mechanisms that can be applied under the POEO Act to achieve these objectives include reduction of pollution at source and monitoring and reporting of environmental quality. The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal and for water, air, land and noise pollution.

Under the POEO Act, an EPL is required for premises at which a 'scheduled activity' is conducted. Schedule 1 of the POEO Act lists activities that are scheduled activities for the purposes of the Act. Table 4-2 lists the EPLs for each site in the Study Area and relevant licensed discharge information.

2.4 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining activities.

The Aquifer Interference Policy outlines the water licensing requirements under the *Water Act 1912* and WM Act and identifies that the Policy does not exempt an activity from the requirement to obtain an EPL under the POEO Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void) even where that water is not being used consumptively as part of the activity's operation.

Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times. Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Where the WSP provides for unassigned water in a water source (i.e. the total entitlement is less than the LTAAEL), a controlled allocation order may be made under Section 65 of the WM Act to release more water.

Many mining operations continue to take water from groundwater sources after operations have ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The Policy also identifies the assessment process for aquifer interference activities including the minimum environmental impact considerations for various water sources including alluvial and porous and fractured rock.

Many aspects of this Policy will be given legal effect in the future through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced on 30 June 2011.

3. Existing Environment

This section defines the existing environment within Lake Macquarie, outlining the landform, surface water catchment hydrology, geology and hydrogeology.

3.1 Landuse and Topography

3.1.1 Landuse

Land uses in the Lake Macquarie catchment vary from residential areas to industrial areas, parkland and large agricultural areas west of Lake Macquarie. As shown in Figure 3-1, residential areas in the Lake Macquarie catchment lie predominantly to the north-east of the lake and include the suburbs of Warners Bay and Belmont. The remaining residential zones are predominantly concentrated along the edges of Lake Macquarie.

Significant bushland to the east of Lake Macquarie include Wallarah National Park and Lake Macquarie State Recreation Area. The slopes along the western boundary of the Study Area include Heaton, Awaba and Onley State Forests. West of Lake Macquarie features large areas of agricultural land primarily used for grazing of stock. Major surface infrastructure within the Study Area includes Eraring Power Station, Vales Point Power Station, the Sydney-Newcastle Freeway (M1 Pacific Motorway), and the Main Northern Railway line.

3.1.2 Topography

The topography of the Lake Macquarie catchment is characterised by elevated areas to the west, typically up to elevation in the order of 400 m AHD. The Lake Macquarie catchment area is 59,031 ha, although the Lake Macquarie EMU extends to an area of 65,387 ha (considering catchments which drain to the ocean). A ridgeline along the east of Lake Macquarie separates catchments draining to Lake Macquarie and those draining to the ocean.-

The properties of Lake Macquarie are such that ocean tidal range average (±0.5 m) has very limited difference on the lake levels.

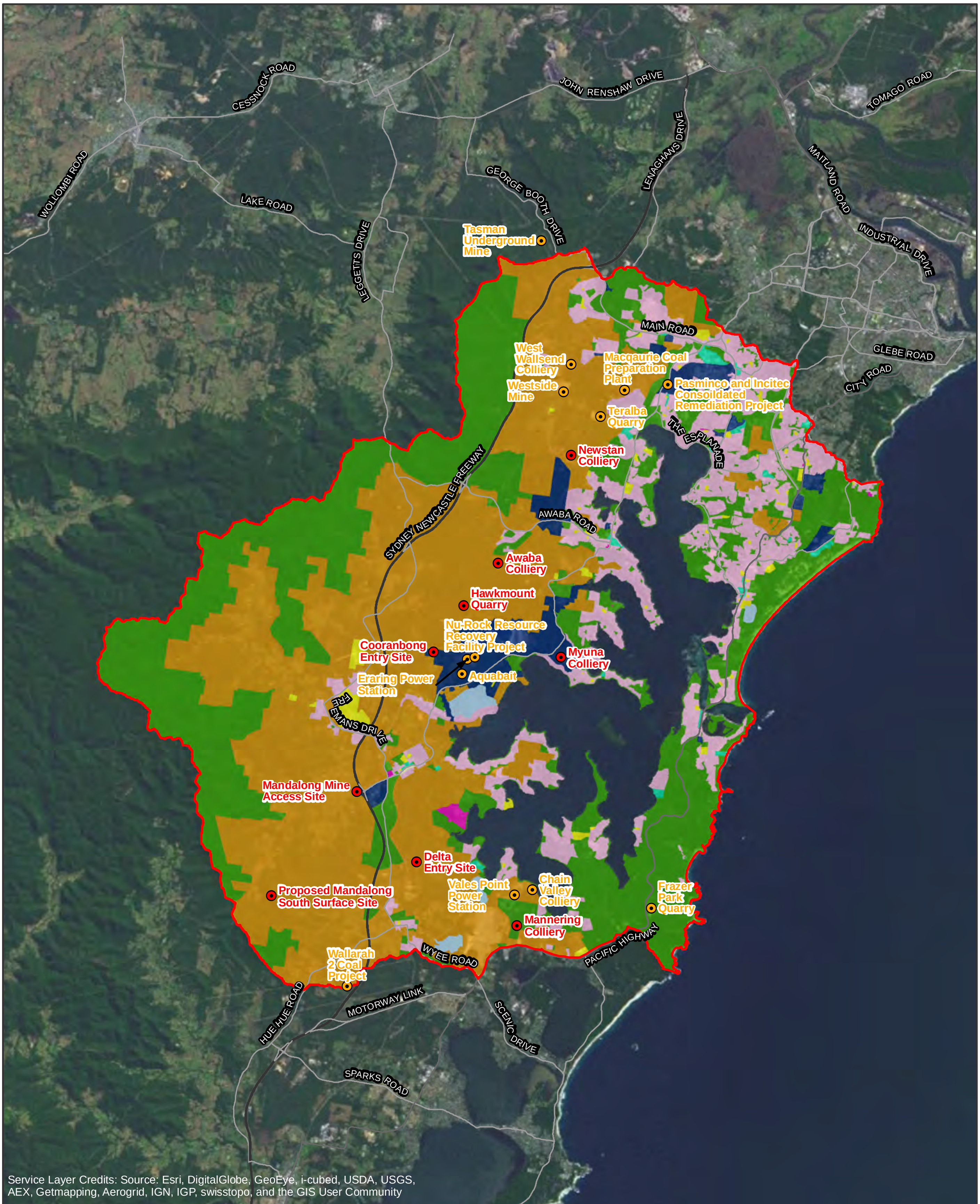
The management zones for Lake Macquarie are spilt into the following area allocations:

- North Lake Macquarie – 26,971 ha.
- Dora Creek – 23,227 ha.
- South Lake Macquarie – 15,188 ha.

Soil landscapes present within the Study Area include the Gosford, Cooranbong Coastal Slopes, Watagan Ranges and Newcastle Coastal Alluvial Plains. The majority of the Lake Macquarie catchment contains the Gosford-Cooranbong Coastal Slopes landscape while the elevated areas to the west typically have the Watagan Ranges landscape present. The Alluvial plains landscape follows the areas mapped as alluvium by the HUA WSP.

The area covered by the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources each have varying characteristics specific to hydrological performance. The North Lake Macquarie water source has the largest developed catchments area with the urban centres of Warners Bay, Belmont and Toronto present. The catchment extent has an elevation range of between 0 m AHD and 400 m AHD.

The Dora Creek water source contains the majority of area used for agricultural industries with topography extending to a height of 400 m AHD to 460 m AHD. The Dora Creek watercourse is the largest singular catchment contributing to Lake Macquarie.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Study area
- Non-Centennial Site Location
- Centennial Site Location

Land Use

- Agricultural
- Commercial
- Education
- Hospital/Medical
- Industrial
- Parkland
- Residential
- Transport
- Water

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Land Use within Study Area

Centennial Coal

DATE 24/03/2014

Figure 3-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB014_LandUse_A.mxd

© LPI: DTDB 2012; NSW DPI: Geology, 2010; ESRI: Aerial Imagery, 2013. ABS: Land use data, 2011.

The South Lake Macquarie water source comprises of mainly the Wyee Creek catchment with generally low lying areas between the southern end of Lake Macquarie and the northern features of Tuggerah Lakes.

3.2 Surface Water

Lake Macquarie is a coastal salt water lake with a surface area of approximately 10,000 ha. The Lake is connected to the Tasman Sea by Swansea Channel which joins Lakes Entrance on the south-eastern side of Lake Macquarie.

The watercourses within the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources are shown in Figure 3-2, Figure 3-3 and Figure 3-4 respectively.

The sub-catchments of most significance across the Lake Macquarie catchment include:

- Dora Creek.
- Wyee Creek.
- Cockle Creek.
- Stony Creek.

Dora Creek has a catchment area of 11,417 ha and originates in the Watagan Mountains to the west of Lake Macquarie. The creek flows south-east and is joined by its tributaries Jigadee Creek and Stockton Creek before flowing easterly into Lake Macquarie near the village of Dora Creek.

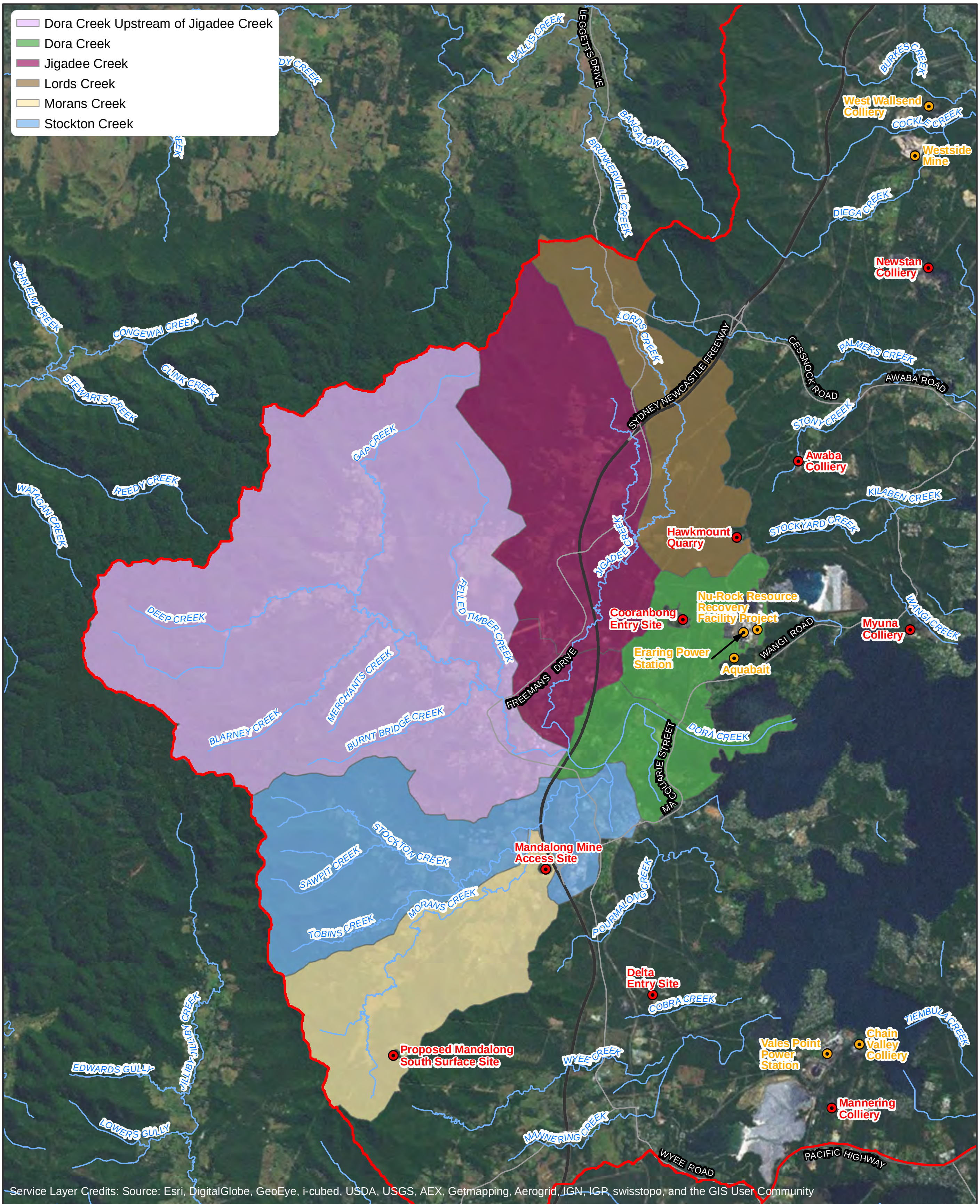
Cockle Creek and Stony Creek lie within the North Lake Macquarie water source. Cockle Creek flows south into Lake Macquarie at Boolaroo. Tributaries of Cockle Creek include Burkes Creek, Brush Creek, Diega Creek, Winding Creek, Flaggy Creek and Cocked Hat Creek. Stony Creek flows into Lake Macquarie at Toronto.

The South Lake Macquarie water source includes Wyee Creek. Wyee Creek flows into Lake Macquarie at Wyee Bay.

Generally many of the significant creek catchments are located within the North Lake Macquarie water source. Much of the sub-catchments within the northern portion of the Lake Macquarie catchment have been urbanised in contrast with the southern portions.

The North Lake Macquarie water source has the largest catchment contributing to Lake Macquarie followed by Dora Creek and South Lake Macquarie water sources. The size of this contributing catchment area to Lake Macquarie is estimated at 25,490 ha (excluding known development footprints). Known development footprints are estimated to total approximately 1269 ha (0.3% of total catchment area) across all three water sources.

The Dora Creek, North Lake Macquarie and South Lake Macquarie water sources include a proportion of catchment which drains to the Tasman Sea. This approximately accounts for 10% of the total area for the Lake Macquarie EMU. The main sub-catchments that contribute to the ocean include Crockers Creek and Middle Camp Creek located within the North Lake Macquarie and South Lake Macquarie water sources respectively.



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0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

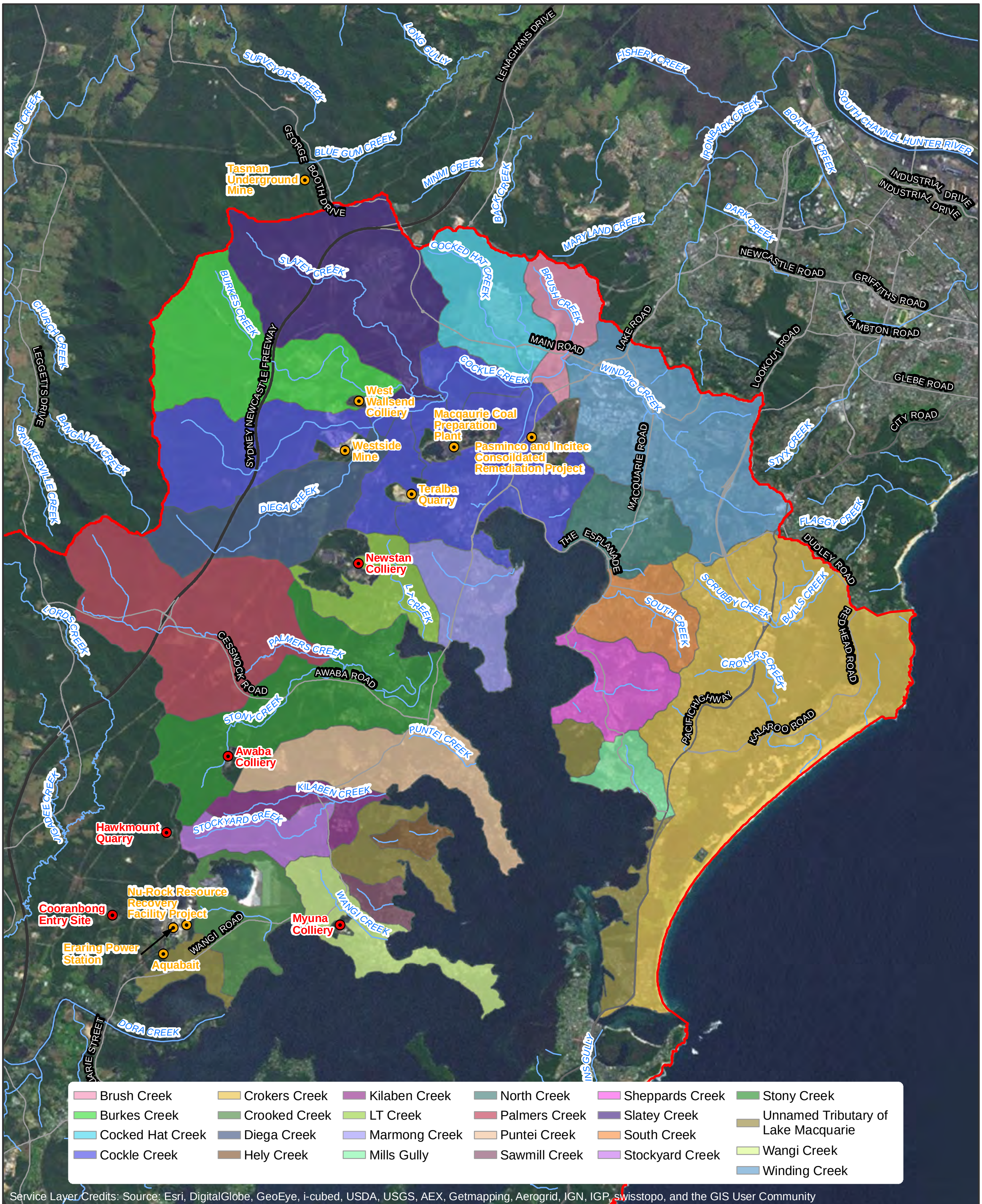
Surface Water Catchments
Dora Creek Water Source

Centennial Coal

DATE 24/03/2014

Figure 3-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB007_SW_Dora_WaterSources_A.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

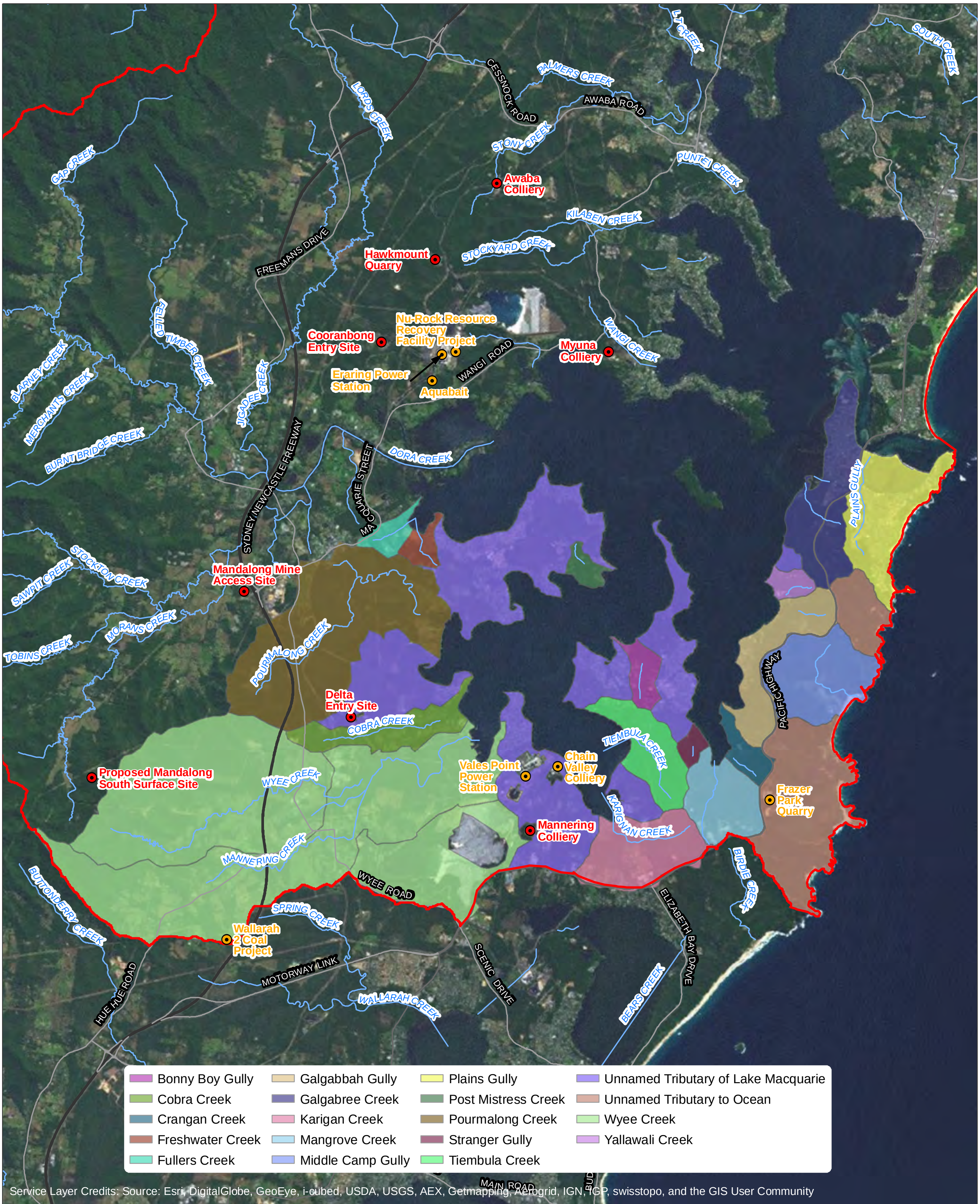
Surface Water Catchments
North Lake Macquarie Water Source

Centennial Coal

DATE 24/03/2014

Figure 3-3

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB005_SW_North_WaterSources_A.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND
- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Surface Water Catchments
South Lake Macquarie Water Source

Centennial Coal

DATE 24/03/2014 Figure 3-4

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB006_SW_South_WaterSources_A.mxd

© LPI: DTDB, 2012; NSW Office of Water: Surface Water Data, 2013; ESRI: Aerial Imagery, 2012.

3.3 Geology

The Study Area is geologically located within the north-east portion of the Sydney Basin. The stratigraphy of the region consists of material from the Quaternary, Triassic and Permian periods. A geological map of the Study Area is shown in Figure 3-5.

The Sydney Basin is characterised by coal, shale and sandstone sedimentary beds of Permo-Carboniferous age. The Study Area is underlain by Triassic claystone, sandstone and conglomerate, Permian rocks of the Newcastle Coal Measures as well as Quaternary alluvial sediments along watercourses. The strata dip gently at approximately 1 to 2 degrees to the south-west of the Study Area.

The Newcastle Coal Measures generally outcrop along the northern portion of the Study Area while the Triassic Narrabeen Group outcrops across the southern portion. The Narrabeen Group comprises variable sequences of interbedded claystones, siltstones and fine to coarse grained sandstones.

There are four significant coal seams within the Lake Macquarie region, listed in descending stratigraphical order as follows:

- Wallarah Seam.
- Great Northern Seam.
- Fassifern Seam.
- West Borehole Seam (comprising the Young Wallsend, Yard and Borehole Seams).

3.4 Hydrogeology

3.4.1 Aquifers

The main groundwater sources throughout the Study Area include:

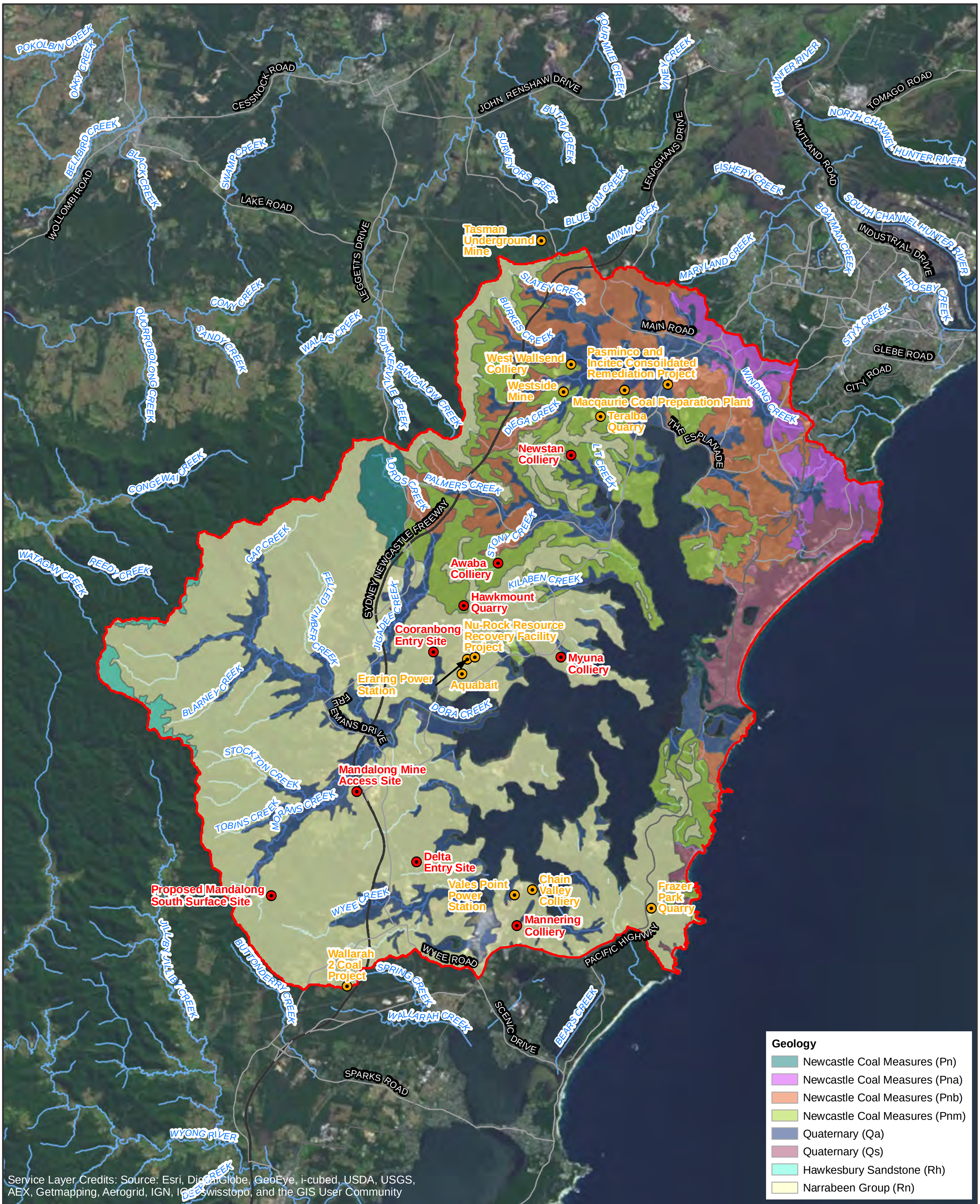
- Quaternary alluvium.
- Fractured sandstone of the Narrabeen Group.
- Coal seams within the Permian Newcastle Coal Measures, separated by Permian interburden sediments (functioning as aquitards).

The properties of each of the aquifer systems are summarised in Table 3-1.

3.4.2 Groundwater Quality

Previous groundwater quality assessments have been made with respect to Australia New Zealand Environment Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ, 2000) criteria and environmental value.

The alluvial groundwater is generally slightly acidic and with electrical conductivity (EC) ranging from fresh to saline. Groundwater present in the Permian aquifers is typically slightly alkaline and of brackish to saline quality. Groundwater quality within the Triassic overburden sediment aquifers has been found to exhibit considerable variability, with groundwater generally slightly acidic to strongly alkaline and brackish to saline.



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0 0.75 1.5 3 4.5 6

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Geological Map

Centennial Coal

DATE 24/03/2014

Figure 3-5

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© LPI: DTDB 2012; NSW DPI: Geology, 2010; ESRI: Aerial Imagery, 2013.

Table 3-1 Aquifer Properties

Aquifer system	Properties
Quaternary alluvium	Unconfined shallow aquifers. Saturated zones are laterally discontinuous and occur in isolated pockets. Perched groundwater present in unconsolidated sands, silts and peat. Generally isolated, of minimal thickness and low groundwater yield.
Fractured Triassic sandstone	Water-bearing zones within the Narrabeen Group. Complex with perched water tables and semi-confined, separated by relatively impermeable claystone layers. Porosity: • Primary: low flow, inter-granular. • Secondary: higher flow, fractures, bedding partings and fissures.
Permian Newcastle Coal Measures	Overburden/interburden sandstones, siltstones and mudstones (primarily coal seams). Variable hydraulic conductivity, generally in the order of 0.03 m/year to 30 m/year. Recharge of coal seams occurs in areas of seam subcrop.

4. Site Overviews

4.1 Individual Site Summaries

A brief overview of the sites that have been included in the regional water and salt balance is given in this section. Figure 4-1 presents the location of each site and existing mine workings associated with Centennial-owned sites with respect to groundwater sources. All groundwater intercepted within the Study Area occurs within the Sydney Basin North Coast groundwater source.

4.1.1 Centennial-Owned Sites

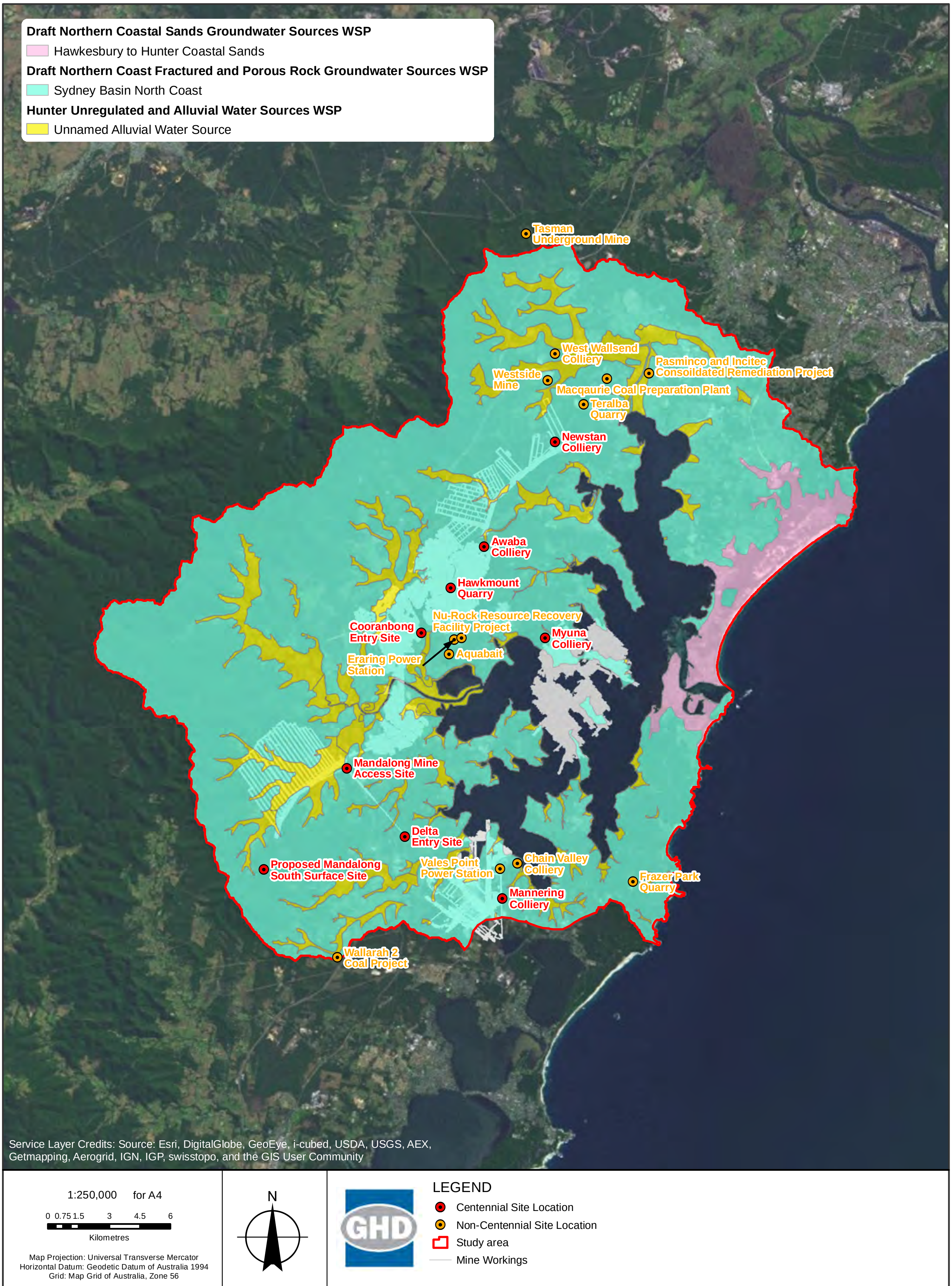
Mandalong Mine

Mandalong Mine is an underground coal mine located approximately 35 km south-west of Newcastle on the western side of Lake Macquarie and is an extension of the Cooranbong Colliery workings. Centennial Mandalong Pty Limited (Centennial Mandalong) acquired Mandalong Mine in 2002, with mining operations commencing in 2005. Mandalong Mine currently has approval to extract up to 6 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the West Wallarah Seam utilising a combination of continuous miner and longwall mining methods.

Mandalong Mine consists of surface facilities located at three sites: Mandalong Mine Access Site, Cooranbong Entry Site and Delta Entry Site. Mined coal is transferred from the Mandalong Mine underground workings via drift conveyor systems to either the Cooranbong Entry Site or the Delta Entry Site. At Cooranbong Entry Site, ROM coal is processed in the coal handling plant (CHP) before being transferred by overland conveyor to Eraring Power Station or by private haul road to Newstan Colliery for further transfer to the Port of Newcastle by rail for the export market. From the Delta Entry Site, ROM coal is transferred to the Vales Point Power Station by overland conveyor via the Wyee coal unloader.

Centennial Mandalong is currently seeking approval to continue underground mining operations using a combination of continuous miner and longwall mining methods. As part of the Mandalong Southern Extension Project, it is proposed to construct a new surface facility site for the Mandalong Southern Extension mining area to operate surface infrastructure.

Water is required at Mandalong Mine for underground mining activities, dust suppression and washdown and is supplied by surface water storages and potable water sourced from Hunter Water Corporation. Groundwater extraction from the Sydney Basin North Coast groundwater source occurs into the underground workings by incidental flow due to aquifer interference. Excess water is discharged from LDPs at the Cooranbong Entry Site into the Dora Creek surface water source. One LDP is proposed as part of the Mandalong Southern Extension Project from the Mandalong Mine Access Site, which will also discharge into the Dora Creek surface water source.



Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Groundwater WSP Boundaries
with Mine Workings

Centennial Coal

DATE 24/03/2014

Figure 4-1

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Mannering Colliery

Mannering Colliery is an underground coal mine located at Mannering Park on the south-west side of Lake Macquarie, approximately 40 km south of Newcastle. Development of Mannering Colliery (formerly Wyee State Mine) commenced in 1960 in conjunction with the construction of Vales Point Power Station. Coal resources in the Fassifern and Great Northern coal seams have been mined at Mannering Colliery using both longwall and bord and pillar mining methods for over 50 years. Centennial Mannering Pty Limited (Centennial Mannering) acquired Mannering Colliery in 2002, which was in a care and maintenance phase. Coal production recommenced in late 2005 to supply coal via overland conveyor to Vales Point Power Station. Currently Mannering Colliery has approval to extract up to 1.1 Mtpa of ROM coal.

Mannering Colliery moved to a care and maintenance phase in January 2013, during which time mining operations ceased. In October 2013, Centennial Mannering entered into a production sharing arrangement with LDO's Chain Valley Colliery. LDO has assumed responsibility for site activities for the 10 year duration of the Mining Cooperation Deed, until 2023.

Water is required at Mannering Colliery for underground mining activities and dust suppression and is supplied by potable water sourced from Wyong Shire Council. Underground mining operations at Mannering Colliery results in interaction with the Great Northern and Fassifern coal seams. Natural recharge of the active underground workings occurs due to incidental flow from the surrounding strata that originates from Lake Macquarie and rainfall. This groundwater extraction occurs from the Sydney Basin North Coast groundwater source. Groundwater is collected in underground storages to allow settling of fines prior to transfer to the surface and discharge off-site. Licensed water discharges occur through two LDPs located within the South Lake Macquarie surface water source.

Myuna Colliery

Myuna Colliery is an underground coal mine located on the western side of Lake Macquarie at Wangi Wangi, approximately 25 km south-west of Newcastle. Development of Myuna Colliery commenced in 1979, with underground mining of the Wallarah, Great Northern and Fassifern coal seams using bord and pillar mining methods occurring since 1982. Centennial Myuna Pty Limited (Centennial Myuna) acquired Myuna Colliery in 2002 and has operated the site since this time. Currently Myuna Colliery has approval to extract up to 2 Mtpa of ROM coal, with all coal delivered by trucks on dedicated private haul roads to Eraring Power Station, located approximately 5 km west of the surface facilities area at Myuna Colliery.

Water is required at Myuna Colliery for underground mining activities and dust suppression and is supplied by surface water storages and potable water sourced from Hunter Water Corporation. Groundwater extraction from the Sydney Basin North Coast groundwater source occurs into the underground workings by incidental flow due to aquifer interference. Groundwater is collected in underground storages to allow settling of fines prior to transfer to the surface and discharge off-site. Licensed water discharges occur through two LDPs located within the North Lake Macquarie surface water source.

Newstan Colliery

Newstan Colliery is an underground coal mine located approximately 25 km south-west of Newcastle on the western side of Lake Macquarie. The colliery is owned and operated by Centennial Newstan Pty Limited (Centennial Newstan). Mining operations at Newstan Colliery first commenced in 1887 and extensive mining has been undertaken within the Young Wallsend, Great Northern, Fassifern, Borehole and West Borehole coal seams. Mining is currently undertaken using a combination of modern longwall retreat and bord and pillar mining methods. Centennial Newstan currently has approval to produce up to 3.5 Mtpa of ROM coal, which is transported by private haul road to Eraring Power Station for domestic power generation and by rail to the Port of Newcastle for the export market.

Awaba Colliery is a former underground coal mine located approximately 6.2 km south-west of Newstan Colliery that is owned and operated by Centennial Newstan. Coal production commenced at Awaba Colliery in 1947 using bord and pillar mining methods. Underground mining operations ceased in March 2012 and the removal of coal handling infrastructure at Awaba Colliery commenced in late 2012.

Centennial Newstan is currently seeking approval for the Newstan Extension of Mining Project, which involves the continuation and expansion of underground mining activities at Newstan Colliery and an increase in coal extraction to up to 4.5 Mtpa of ROM coal. Mine staff will be progressively relocated to the surface site at Awaba Colliery, with surface site infrastructure proposed to be upgraded to provide access to the underground workings and support increased staff numbers.

Water is required at Newstan Colliery for underground mining activities, coal processing, dust suppression and washdown and is supplied by surface water storages and potable water sourced from Hunter Water Corporation. Groundwater extraction from the Sydney Basin North Coast groundwater source occurs into the underground workings at Newstan and Awaba by incidental flow due to aquifer interference. Excess water is discharged from LDPs at Newstan Colliery and Awaba Colliery into the Dora Creek and North Lake Macquarie water sources.

Northern Coal Services

Centennial's Northern Coal Services is currently seeking approval for the Coal Logistics Project, which proposes to integrate the coal processing, handling and transport from Mandalong Mine and Newstan Colliery. The project centres on the utilisation of the existing infrastructure at the Cooranbong Entry Site at Mandalong Mine and at the Newstan Colliery Surface Site, along with existing private haul roads and rail loading infrastructure. The Coal Logistics Project is complementary to the Mandalong Southern Extension Project and Newstan Extension of Mining Project and aims to provide the required flexibility and infrastructure to meet future opportunities in domestic and export coal markets.

Water management at the Cooranbong Entry Site at Mandalong Mine and the Newstan Colliery Surface Site will be assessed as part of the Coal Logistics Project. However, for the purposes of the regional water and salt balance assessment, the Cooranbong Entry Site has been considered as part of the Mandalong Mine water management system and the Newstan Colliery Surface Site has been considered as part of the Newstan Colliery water management system, as detailed above.

4.1.2 Non-Centennial Sites

Aquabait

Aquabait is an aquaculture farm owned by Aquabait Pty Ltd located on the western edge of Lake Macquarie, adjacent to Eraring Power Station approximately 30 km south-west of Newcastle. Aquabait breeds and sells marine worms for use in recreational fishing, scientific research and other aquaculture operations.

The aquaculture facility operates a number of open water storages for breeding of marine worms, with a total pondage area of approximately 1,000 m^2. Currently, Aquabait extract water from the cooling water inlet channel to Eraring Power Station. Overflow from settlement ponds is discharged through a single LDP back into the cooling water inlet channel, which is located within the Dora Creek water source.

Chain Valley Colliery

Chain Valley Colliery is an underground coal mine located at the southern end of Lake Macquarie, approximately 60 km south of Newcastle. The colliery is operated by LakeCoal on behalf of the Wallarah Coal Joint Venture. Coal production commenced at Chain Valley Colliery in 1962 using bord and pillar and miniwall mining methods. Currently the colliery has approval to extract up to 1.5 Mtpa of ROM coal from the Fassifern Seam, which is delivered by truck to the adjacent Vales Point Power Station or to the Port of Newcastle for the export market. Approval for the extension of underground mining operations and an increase in coal extraction rate was granted in December 2013.

Water is required at Chain Valley Colliery for underground mining activities, dust suppression and washdown and is supplied by potable water obtained from Wyong Shire Council and surface water storages. Groundwater extraction occurs from the Sydney Basin North Coast groundwater source into the underground workings by incidental inflow due to aquifer interference. This water is pumped to the surface for treatment and discharge off-site through a single LDP into the South Lake Macquarie water source.

Eraring Power Station

Eraring Power Station is owned and operated by Origin Energy and is located on the western shores of Lake Macquarie near the township of Dora Creek, approximately 30 km south-west of Newcastle. Construction of the power station started in 1977, with four generating units commencing service between 1982 and 1984. The four 720 megawatt (MW) coal-fired generating units have a combined capacity of 880 MW. Eraring Power Station and Vales Point Power Station are the greatest surface water users within the Study Area, due to the large volume of water required for the process of cooling process.

Water required for the cooling process is supplied from Lake Macquarie via an inlet channel and the majority of the water flows through the condensers in the power station to cool the superheated steam used to drive the turbines. The remaining water is used for attemperation of the water prior to discharge into Lake Macquarie via an outlet canal to control water temperature by combining the cooler inlet canal water with the warmer water exiting the condensers.

Secondary treated effluent from the Dora Creek Wastewater Treatment Works is also supplied to Eraring Power Station and recycled on-site in a Water Reclamation Plant and Demineralisation Plant. This produces pure process water required for heating in boilers to create steam to drive the turbines.

No groundwater is extracted by Eraring Power Station. Discharge of water occurs from LDPs located within the North Lake Macquarie water source.

Frazer Park Quarry

Frazer Park Quarry is an extractive and processing operation located east of Lake Macquarie approximately 3 km south of Catherine Hill Bay and approximately 32 km south-west of Newcastle. The quarry is owned and operated by HB Frazer Park Pty Ltd and was granted development consent by Wyong City Council in 1983. The development consent allows extraction of conglomerate and sand by blasting. The quarry is considered to contain significant construction material resources able to supply local markets for at least 20 years.

An Environmental Impact Statement (EIS) is understood to have been prepared by VGT Environmental Compliance Solutions for Frazer Park Quarry; however, the document is not publically available. The EPL held by Frazer Park Quarry indicates that the site has two LDPs, which most likely discharge to the Tasman Sea based on aerial images and topographical information.

Nu-Rock Resource Recovery Facility Project

Nu-Rock Resource Recovery Facility Project is a proposed resource recovery facility located within the grounds of Eraring Power Station, approximately 30 km south-west of Newcastle. Nu-Rock Technology Pty Ltd is seeking approval for the project, which involves the construction of two resource recycling plants and the recycling of coal combustion product or fly ash produced by Eraring Power Station into materials for the building and construction industry. The Nu-Rock Resource Recovery Facility Project proposes to recycle a total of 0.5 Mtpa of fly ash.

The *Director General's Environmental Assessment Requirements* (DGRs) for the Nu-Rock Resource Recovery Facility Project (State Significant Development 13_5877) were issued in April 2013 (DPI, 2013). An EIS for the project is expected to be publicly exhibited in 2014. Due to the limited information currently publicly available, the operation of the resource recovery facility has been excluded from the regional water and salt balance.

Pasminco and Incitec Consolidated Remediation Project

The Pasminco and Incitec Consolidated Remediation Project involves the remediation of contaminated lands at the former Pasminco Cockle Creek Smelter and former Incitec Fertiliser Cockle Creek site. The remediation project is located near the township of Boolaroo, approximately 15 km south-west of Newcastle. The disposal of waste products from the Pasminco Cockle Creek Smelter and the Incitec Fertiliser Cockle Creek site has resulted in heavy metal contamination of the soil and groundwater at the site.

Pasminco Cockle Creek Smelter Pty Ltd operated a smelter that was established in 1897 and operated primarily as a lead smelter until it closed in 2003. In addition to lead smelting, operations at the site also included acid production and zinc refinery. Pasminco Cockle Creek Smelter Pty Ltd was placed in voluntary administration in 2001 and the Fitzwalter Group Pty Ltd was appointed in 2003 to manage the remediation and redevelopment of the site. Remediation of the Pasminco Cockle Creek Smelter site was approved in 2007.

The Incitec Fertiliser Cockle Creek site is a former fertiliser manufacturing facility owned by Incitec Fertilizers Limited (a subsidiary of Incitec Pivot Limited) and located immediately east of the Pasminco Cockle Creek Smelter. The former smelter supplied sulfuric acid to the fertiliser manufacturing facility for the production of superphosphate. Operations at the Incitec Fertiliser Cockle Creek site ceased in 2009 and remediation of the site continuing.

Consolidation of the remediation projects at the former Pasminco Cockle Creek Smelter and former Incitec Fertiliser Cockle Creek site in 2012 allowed for the remaining remediation of the two sites to be undertaken as a single project. The consolidation project is managed by the Fitzwalter Group Pty Ltd under the Pasminco Cockle Creek Smelter remediation project development approval.

The site has one existing groundwater bore licence (20BL166544) which has an extraction limit of 250 ML/yr. From existing information available for the site, groundwater is extracted and treated for a number of elevated water quality parameters before being discharged to the surface where it can infiltrate in to the shallow aquifer.

Water is required for the consolidated remediation project for dust suppression and washdown and is supplied by existing surface water storages present during the operation of the smelter and fertiliser manufacturing facility. Contaminated water is treated within an effluent treatment plant on-site prior to discharge into Cockle Creek through an LDP, located in the North Lake Macquarie water source. Minimal groundwater is extracted by the Pasminco and Incitec Consolidated Remediation Project as a result of interception by cut-off trenches.

Tasman Underground Mine

Tasman Underground Mine is an underground coal mine located approximately 20 km west of Newcastle, north of Lake Macquarie. The mine is owned and operated by Newcastle Coal Company Pty Ltd, a wholly owned subsidiary of Donaldson Coal Pty Limited. Tasman Underground Mine was approved in 2002, with coal production commencing in 2006. The mine is currently approved to extract up to 1.5 Mtpa of ROM coal using bord and pillar mining methods. Underground mining currently occurs in the Fassifern Seam and is expected to cease by the end of 2014. The extension of underground mining operations into the West Borehole Seam is anticipated to commence in 2015. ROM coal is transferred to the coal handling and preparation plant (CHPP) located within the Bloomfield Colliery lease to the north of the mine via public roads for processing and transport by rail to the Port of Newcastle. As part of the Tasman Extension Project approved in March 2013, a new pit top and associated ROM coal handling infrastructure will be developed at Tasman Underground Mine.

Water is required at Tasman Underground Mine for underground mining activities, dust suppression and washdown and is supplied by surface water storages. Groundwater extraction from the Sydney Basin North Coast groundwater source occurs into the underground workings by incidental flow due to aquifer interference. Excess water from the site, including groundwater inflow into the active underground workings, is transferred to historic underground workings in the West Borehole Seam, resulting in no discharges off-site.

Although the Tasman Mine workings are slightly outside the Study Area boundary, the groundwater interception by the workings has been incorporated into the regional water and salt balance model as the operation extracts coal from the Newcastle Coal Measures.

Teralba Quarry

Teralba Quarry is a conglomerate quarry owned and operated by Metromix Pty Ltd and located near the suburb of Teralba approximately 20 km south-west of Newcastle. Operations at the Teralba Quarry commenced in 1964 and currently the quarry produces roadbases, drainage aggregates, sands and fill products for the local civil construction industry.

Water is required at Teralba Quarry for conglomerate processing, dust suppression and washdown and is supplied by surface water storages. Groundwater extraction occurs from the Sydney Basin North Coast groundwater source due to flow from the flooded mine adit at Rhondda Colliery into surface water storages. Excess water is discharged through an LDP located in the North Lake Macquarie water source.

Vales Point Power Station

Vales Point Power Station is owned and operated by Delta Electricity and is located on the southern shores of Lake Macquarie near the township of Mannering Park, approximately 35 km south-west of Newcastle. The power station was constructed in the 1960s and currently comprises two coal-fired generating units. Eraring Power Station and Vales Point Power Station are the greatest surface water users within the Study Area, due to the large volume of water required for the process of cooling process.

Similar to Eraring Power Station, water required for the cooling process is supplied from Lake Macquarie to cool superheated steam used to drive the turbines at the Vales Point Power Station prior to returning the water back to the lake. Secondary treated effluent from the Mannering Park Sewage Treatment Plant is also supplied to the power station for recycling on-site in a Demineralisation Plant. This pure process water is then used for heating in boilers to create steam to drive the turbines.

No groundwater is extracted by Vales Point Power Station. Discharge of water occurs from LDPs located within the South Lake Macquarie water source.

Wallarah 2 Coal Project

The Wallarah 2 Coal Project is a proposed underground coal mine located approximately 5 km north-west of Wyong and approximately 43 km south-west of Newcastle. Wyong Areas Coal Joint Venture is currently seeking approval to develop the Wallarah 2 Coal Project. It is proposed to extract coal using longwall mining methods to produce up to 5 Mtpa of ROM coal. All coal will be transported by rail to the Port of Newcastle for export or to local domestic power stations.

Water will be required at the Wallarah 2 Coal Project for underground mining activities, coal processing and dust suppression, which will be supplied by surface water storages and supplemented by potable water supplied by the Central Coast Water Corporation. Groundwater extraction will occur from the Sydney Basin North Coast groundwater source into the underground workings by incidental inflow due to aquifer interference. One LDP is proposed to be established, with excess water treated within a water treatment plant prior to discharge into Wallarah Creek, which is located within the Central Coast Unregulated Water Sources WSP. Although the Wallarah 2 Coal Project is located on the border of the HUA WSP, it is not expected that any water will be discharged into the South Lake Macquarie water source and therefore discharge from this site has not been considered in the regional water and salt balance. However, the groundwater interception by the workings has been incorporated into the regional water and salt balance model as the operation extracts coal from the Newcastle Coal Measures.

Westside Mine

Westside Mine is a former open cut coal mine located approximately 20 km south-west of Newcastle. The mine is managed by Oceanic Coal Australia Pty Limited (OCAL), wholly owned by Glencore Xstrata Pty Ltd, on behalf of the Macquarie Coal Joint Venture (MCJV). Westside Mine commenced operation in 1992 and ceased in 2012 with progressive rehabilitation of the site continuing.

Surface water runoff from contributing catchments is collected in several surface water storages that overflow through LDPs. In addition, excess water from the underground workings at the adjacent West Wallsend Colliery is transferred to Westside Mine for discharge through an LDP. All LDP discharges from Westside Mine are located in the North Lake Macquarie water source. Groundwater extraction occurs via inflows into the final void from the Sydney Basin North Coast groundwater source.

West Wallsend Colliery

Operations at West Wallsend Colliery, Teralba Colliery and Macquarie Coal Preparation Plant (MCPP) are conducted under a single EPL and managed by OCAL on behalf of MCJV. For the purposes of the regional water and salt balance, licensed extractions and discharges for the three sites have been considered as occurring from West Wallsend Colliery.

West Wallsend Colliery is an underground coal mine located approximately 25 km south-west of Newcastle. Mining operations commenced in 1969, with coal resources in the Borehole Seam and West Borehole Seam currently mined using longwall mining methods. West Wallsend Colliery currently has approval to extract up to 5.5 Mtpa of ROM coal. Coal is delivered by trucks on a private haul road to MCPP, located approximately 3 km east of the pit top at the colliery.

Water is required at West Wallsend Colliery for underground mining activities, dust suppression and washdown and is supplied by surface water storages and potable water sourced from Hunter Water Corporation. Treated effluent is transferred to maturation ponds at MCPP and used as process water within the preparation plant. Groundwater extraction from the Sydney Basin North Coast groundwater source occurs into the underground workings at West Wallsend by incidental flow due to aquifer interference. Excess water from the underground workings is transferred to Westside Mine for discharge through an LDP. Licensed water discharges from West Wallsend Colliery and MCPP occur into the North Lake Macquarie water source.

Teralba Colliery is a former underground coal mine located approximately 4 km south-east of West Wallsend Colliery. Mining operations at Teralba Colliery commenced in 1978, with longwall mining undertaken until 2001 when the site moved to a care and maintenance phase. In 2004, a coal mine gas power station was commissioned to utilise fugitive methane emissions from the old underground workings. Groundwater extraction from the Sydney Basin North Coast groundwater source into the underground workings occurs by incidental flow due to aquifer interference. Dewatering of the workings occurs periodically with water discharged through an LDP located within the North Lake Macquarie water source.

4.2 Licences

4.2.1 Water Management Act 2000

Groundwater Licences

The existing groundwater extraction licences held by each Centennial-owned and non-Centennial site within the Study Area are listed in Table 4-1. Monitoring bore licences have not been included as they do not have a volumetric allocation. The locations of licensed bores are presented in Figure 4-2.

The existing groundwater extraction licences within the Study Area held by coal mining operations were obtained under Part 5 of the *Water Act 1912* and are located within the Sydney Basin North Coast groundwater source under the draft NFPR WSP. It is expected that these groundwater extraction licences will be converted into WALs upon the commencement of the WSP.

Table 4-1 Groundwater Extraction Licences

Site	Licence number	Extraction volume	Additional information	Source
Chain Valley Colliery	20BL173107	4,443 ML/year	Issued under *Water Act 1912*. Expires March 2018.	LDO (2013)
Mandalong Mine	20BL173524	1,825 ML/year	Issued under *Water Act 1912*. Expires July 2014.	Centennial
Mannering Colliery	20BL172016	450 ML/year	Issued under *Water Act 1912*.	Centennial
Pasminco and Incitec Consolidated Remediation Project	20BL166544	250 ML/year	Issued under *Water Act 1912*.	NSW Office of Water (2014b)
Tasman Underground Mine	20BL171792	NI	Issued under *Water Act 1912*. Expired March 2013.	RWC (2013)
West Wallsend Colliery	20BL169793	360 ML/year	Issued under *Water Act 1912*. Expires August 2015.	Umwelt (2013)

NI – no publically available information

Surface Water Licences

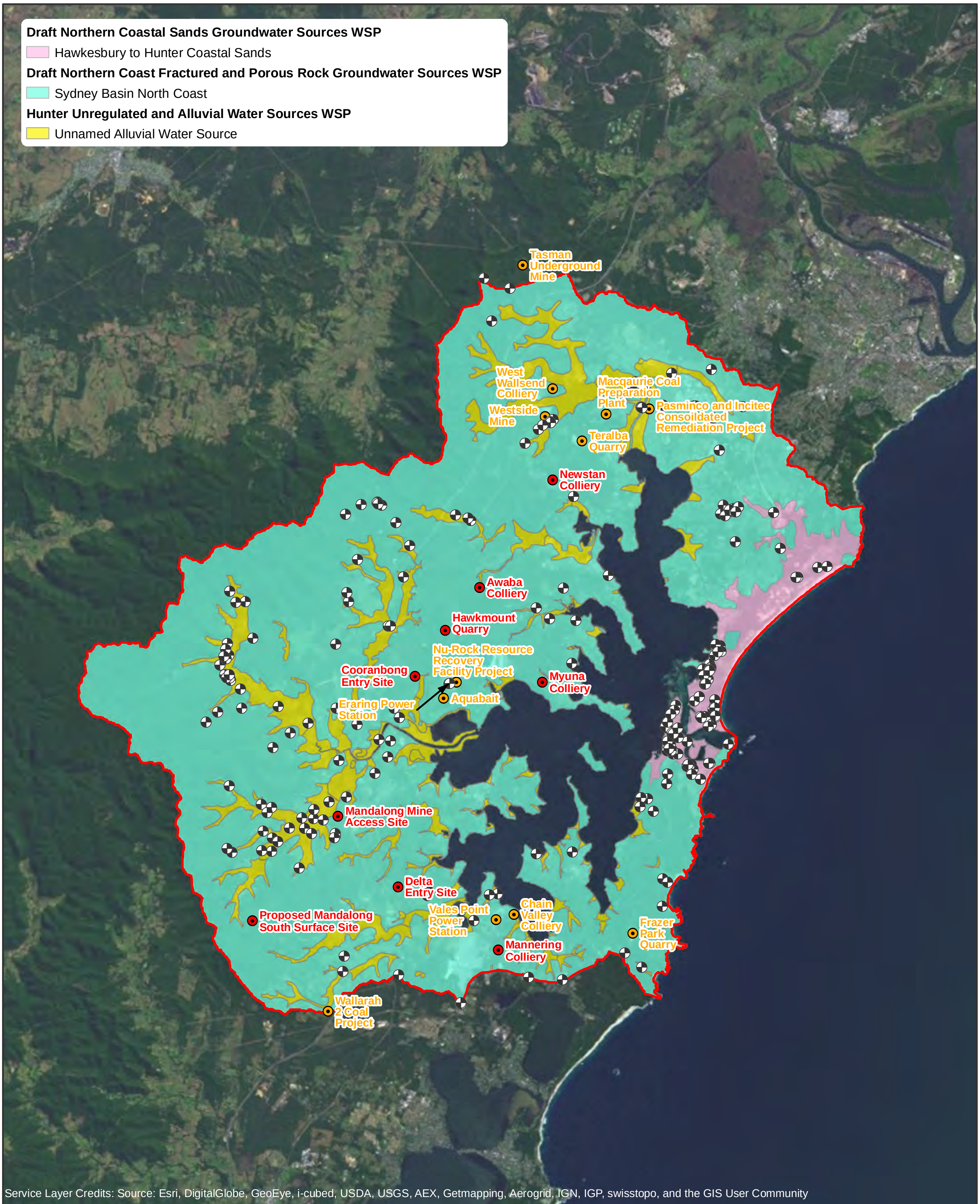
Newstan Colliery currently holds one WAL (WAL 18735) to pump water from the Main By-Wash Dam to supplement water supply to the coal preparation plant (CPP) and other demands at the Newstan Colliery Surface Site. Extractions from the Main By-Wash Dam occur occasionally during dry periods or when other supplies are compromised due to infrastructure failures and are limited to 110 L/s (9.5 ML/day). No other surface water extraction licences are held by Centennial-owned sites under the WM Act within the Study Area.

4.2.2 Protection of the Environment Operations Act 1997

Each currently operational site requires an EPL which specifies conditions under which water is to be discharged from each site. LDPs are the defined locations for such discharges and have been used as the reference point for discharges to be modelled for the regional water and salt balance. Figure 4-3, Figure 4-4 and Figure 4-5 present the location of each existing LDP with respect to surface water sources that are intersected by the Study Area for the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources respectively.

Table 4-2 and Table 4-3 below summarise the licence conditions for LDPs for each site for Centennial-owned and non-Centennial sites respectively. The regional water and salt balance identifies whether any Centennial-owned site may have a shortfall over the next 36 years in the volumetric limit for any of the LDPs compared to the water that requires discharge and whether predicted discharge EC is likely to exceed any existing limits.

It should be noted that discharges from Teralba Quarry have previously been licensed under EPL 3139, held by Coal and Allied Industries Limited (owner of Rhondda Colliery). Approval for the surrender of EPL 3139 was granted by the EPA on 30 January 2013 (NSW EPA, 2013). Table 4-3 presents the summary of licence conditions for Teralba Quarry specified by EPL 3139 as it is expected that the licence conditions related to discharges will be transferred to EPL 536, held by Metromix Pty Ltd (owner of Teralba Quarry) in the near future.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND
Groundwater Bore
Study area

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
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SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

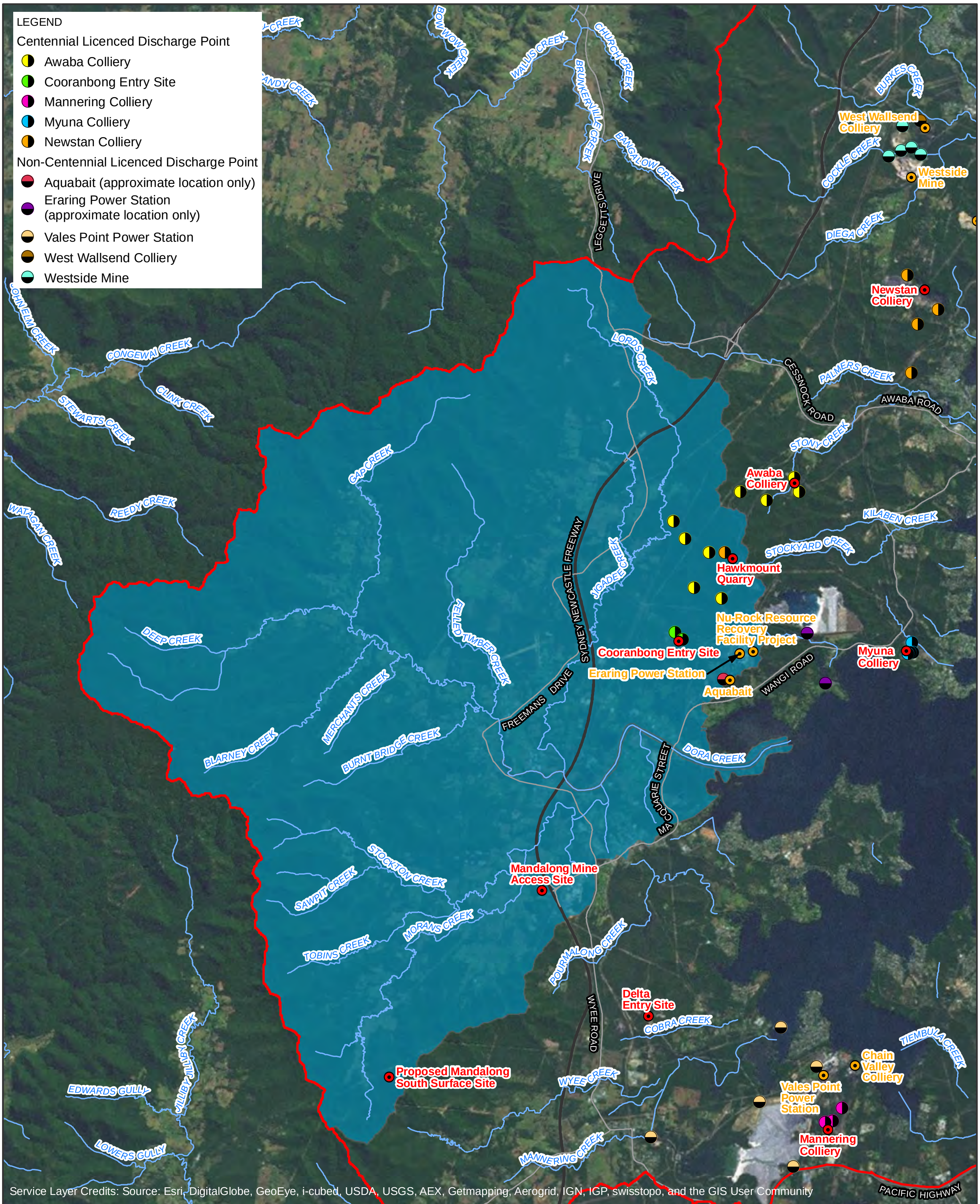
Licensed Bore Locations

Centennial Coal

DATE 24/03/2014

Figure 4-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB013_GW_WSPBdys_LicencedBores_A.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

Hunter Unregulated and Alluvial Water Source

- Dora Creek Water Source

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

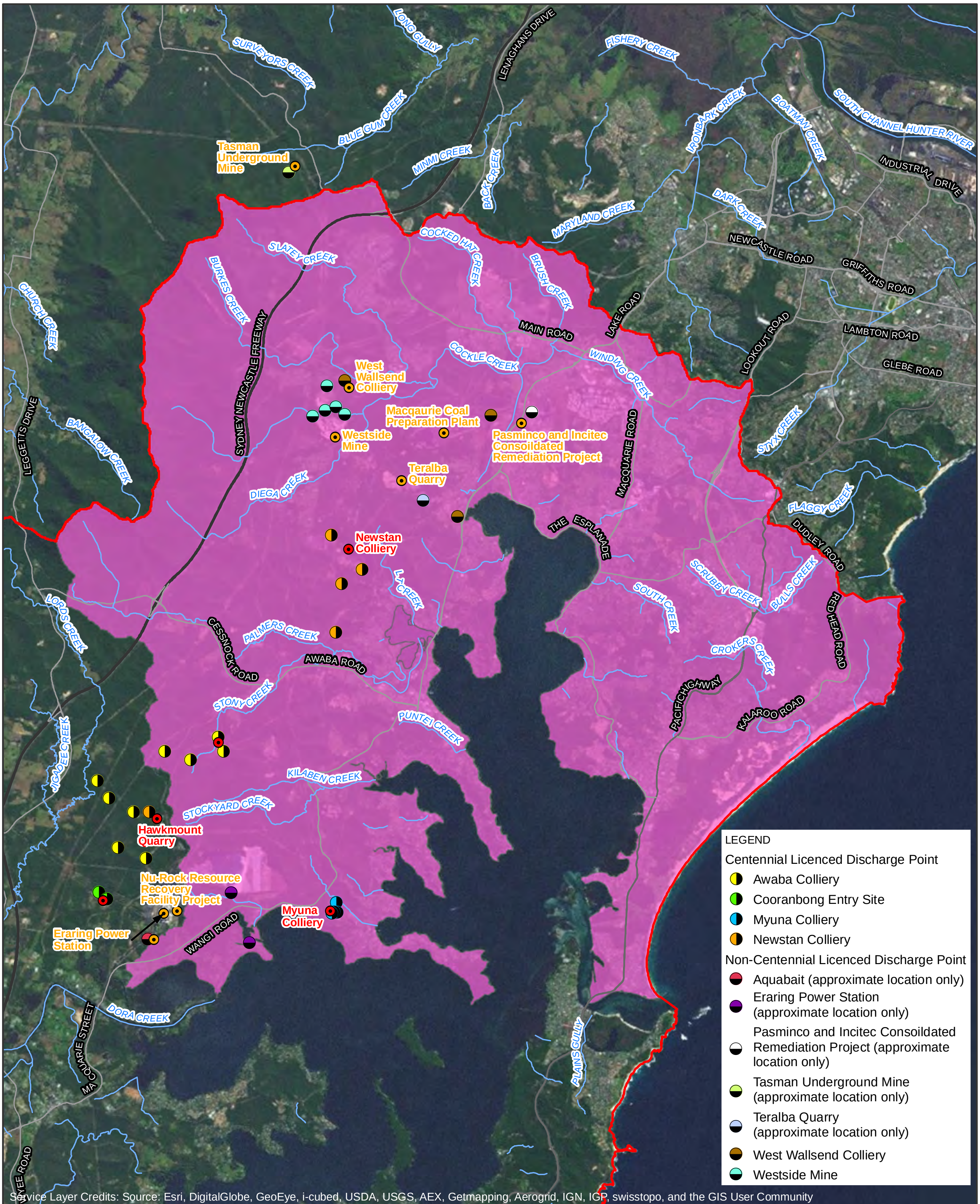
Surface Water Source Boundaries
and Current LDP Locations
Dora Creek Water Source

Centennial Coal

DATE 24/03/2014

Figure 4-3

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB012_SW_Dora_WSPBdys_LDP_A.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

Hunter Unregulated and Alluvial Water Source

- North Lake Macquarie Water Source

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

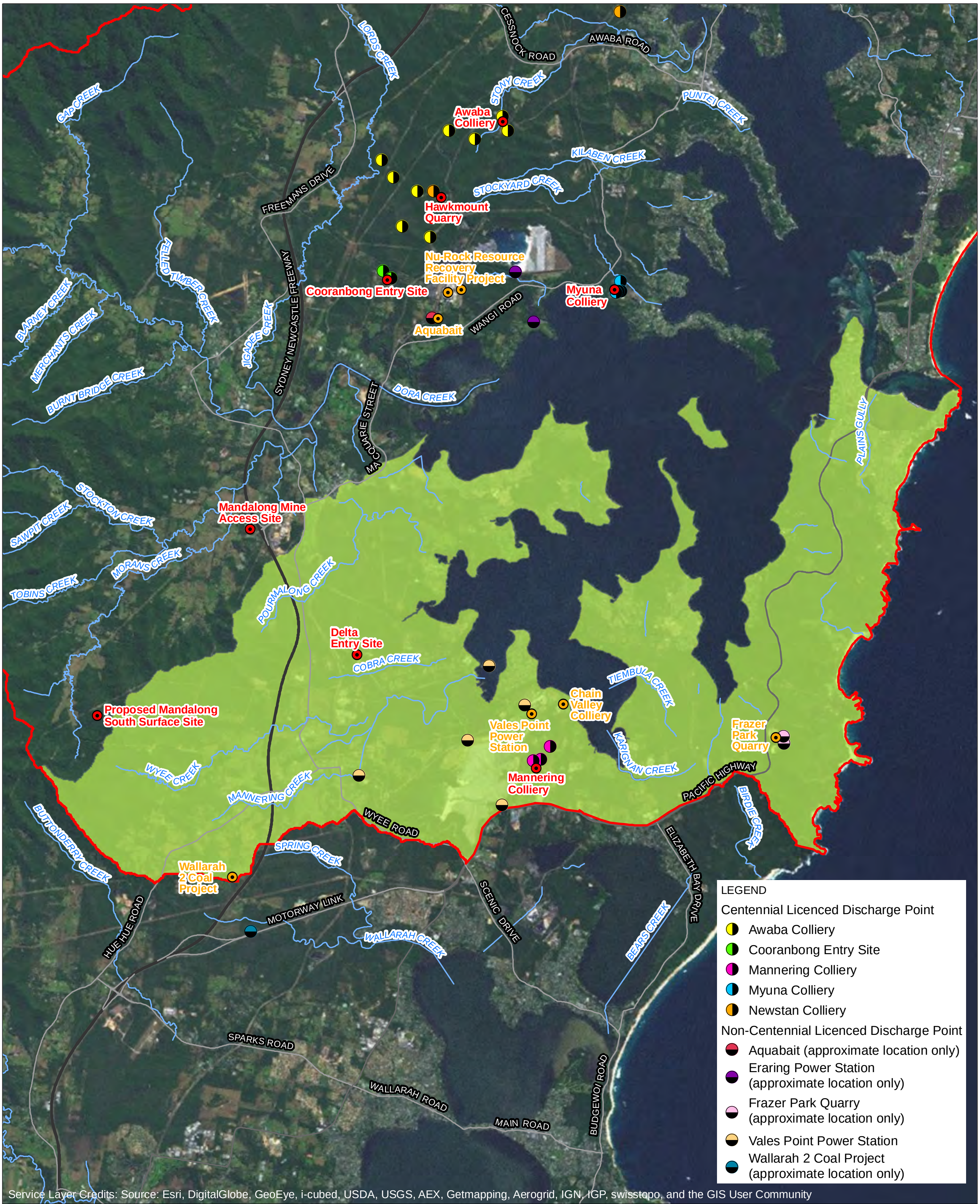
Northern Operations
Water and Salt Balance

Surface Water WSP Boundaries
and Existing LDP Locations
North Lake Macquarie Water Source

Centennial Coal

DATE 24/03/2014 Figure 4-4

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB010_SW_North_WSPBdys_LDP_A.mxd



1:140,000 for A4

0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study area
- Motorway
- Primary Road
- Arterial Road
- Waterway

Hunter Unregulated and Alluvial Water Source

- South Lake Macquarie Water Source

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Surface Water Source Boundaries
and Current LDP Locations
South Lake Macquarie Water Source

Centennial Coal

DATE 24/03/2014

Figure 4-5

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB011_SW_South_WSPBdys_LDP_A.mxd

Table 4-2 Environment Protection Licences – Centennial-Owned Sites

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements: Water quality	Monitoring requirements: Volume	Licenced discharge limit	Creek catchment
Mandalong Mine	365	1	Y	LDP001	O&G; pH; TSS	Y	5 ML/day	Dora Creek
		2	Y	LDP002	O&G; pH; TSS	N	No limit specified	Dora Creek
Mannering Colliery	191	1	Y	LDP1	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); B; Ba; Be (filt); Be (total); Ca; Cd (filt); Cd (total); Co (filt); Co (total); Cr (filt); Cr (total); Cu (filt); Cu (total); EC; Fe; Hg (filt); Hg (total); K; Li; Mg; Mn (filt); Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); O&G; Pb (filt); Pb (total); P; pH; Sb; Se (filt); Se (total); silica; Sn; sulphur; Ti; TSS; V (filt); V (total); Zn (filt); Zn (total)	Y	4 ML/day	Unnamed tributary of Lake Macquarie
		2	Y	LDP2	–	N	No limit specified	Unnamed tributary of Lake Macquarie
Myuna Colliery	366	9	Y	LDP A	O&G; pH; TSS	Y	13 ML/day	Wangi Creek
		10	Y	LDP B	–	N	No limit specified	Wangi Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Newstan Colliery	395	1	Y	LDP001	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); B; B (filt); Ba; Ba (filt); Be (filt); Be (total); bicarbonate alkalinity; Ca; Cd (filt); Cd (total); chloride; Co (filt); Co (total); Cr (filt); Cr (total); Cu (filt); Cu (total); EC; Fe; Fe (filt); Hg (filt); Hg (total); K; Li; Li (filt); Mg; Mn (filt); Mn (total); Mo (filt); N (total); Ni (filt); Ni (total); O&G; P; pH; Pb (filt); Pb (total); Sb; Se (filt); Se (total); silica; silica (filt); Sn; sodium; sulfate; Ti; TKN-N; total heavy metals; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	Y	11 ML/day	LT Creek
		2	Y	LDP002	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); B; Ba; Be (filt); Be (total); Ca; Cd (filt); Cd (total); Co (filt); Co (total); Cr (filt); Cr (total); Cu (filt); Cu (total); EC; Fe; Hg (filt); Hg (total); K; Li; Mg; Mg (filt); Mo (filt); Mo (total); N (total); Ni (filt); Ni (total); O&G; P; Pb (filt); Pb (total); pH; Sb; Se (filt); Se (total); silica; Sn; sodium; sulfate; Ti; total heavy metals; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	Y	No limit specified	LT Creek
		3	N	SP003	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total);Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); O&G; P; Pb (filt); Pb (total); pH; Se (filt); Se (total); total heavy metals; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	LT Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Newstan Colliery	395	4	N	SP004	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total);Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); O&G; P; Pb (filt); Pb (total); pH; Se (filt); Se (total); total heavy metals; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	LT Creek
		5	N	WMP13	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total);Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); O&G; P; Pb (filt); Pb (total); pH; Se (filt); Se (total); total heavy metals; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	LT Creek
		6	N	WMP7	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total);Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); O&G; P; Pb (filt); Pb (total); pH; Se (filt); Se (total); total heavy metals; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	LT Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Newstan Colliery	395	17	Y	LDP017	Ag (filt); Al (filt); Al (total); As (filt); As (total); B (filt); Ba (filt); Be (filt); Be (total); bicarbonate alkalinity; Ca; Cd (filt); Cd (total); chloride; Co (filt); Co (total); Cr (filt); Cr (total); Cu (filt); Cu (total); EC; Fe; Fe (filt); Hg (filt); Hg (total); K; Li (filt); Mg; Mn (filt); Mo (filt); Mo (total); Ni (filt); Ni (total); O&G; P; Pb (filt); Pb (total); pH; Sb; Se (filt); Se (total); silica (filt); Sn; sodium; sulfate; temp; Ti; TKN-N; TSS; turbidity; V (filt); V (total); Zn (filt); Zn (total)	Y	No limit specified	Stony Creek
		18	N	WMP20	Temp	–	Not applicable	Stony Creek
		19	N	WMP3	Cu (filt); Pb (filt); Se (filt); Zn (filt)	–	Not applicable	LT Creek
	443	1	Y	LDP001	EC; O&G; pH; TSS	Y	0.2 ML/day	Lords Creek
		2	Y	LDP002	EC; O&G; pH; TSS	Y	0.2 ML/day	Lords Creek
		3	Y	LDP003	EC; O&G; pH; TSS	Y	2 ML/day	Stony Creek
		4	Y	LDP004	EC; O&G; pH; TSS	Y	2 ML/day	Lords Creek
		5	Y	LDP005	EC; O&G; pH; TSS	Y	0.2 ML/day	Stony Creek
		6	Y	LDP006	EC; O&G; pH; TSS	Y	0.2 ML/day	Lords Creek
		7	Y	LDP007	EC; O&G; pH; TSS	Y	0.5 ML/day	Lords Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Newstan Colliery	443	8	Y	LDP008	O&G; pH; TSS	N	No limit specified	Stony Creek
		9	Y	LDP009		Y	8 ML/year	Stony Creek

Table 4-3 Environment Protection Licences – Non-Centennial Sites

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Aquabait	11259	1	Y	EPA ID 1	BOD; NH_3-N; nitrate; nitrite; orthophosphate; P (total); TSS; TKN	Y	10 ML/day	Dora Creek
Chain Valley Colliery	1770	1	Y	LDP 1	BOD; enterococci; faecal coliforms; pH; TSS	Y	12.161 ML/day	Unnamed tributary of Lake Macquarie
Eraring Power Station	1429	1	Y	EROC	Cu; Fe; Se; temp	Y	11,000 ML/day	Lake Macquarie
		2	Y	EPA ID 2	pH; Se; TSS	N	150 ML/day	Crooked Creek
		3	Y	EPA ID 3	–	N	0.25 ML/day	Crooked Creek
		4	N	LM10	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Eraring Power Station	1429	5	N	LM7	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie
		6	N	LM12	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie
		7	N	LM4	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie
		8	N	ERIC	Cu; Fe; Se; temp	–	Not applicable	Lake Macquarie
		10	N	ERAD	Cd; Cu; Fe; Mn; nitrate + nitrite; P (reactive); P (total); Pb; pH; Se; TSS; Zn	–	Not applicable	Crooked Creek
		17	Y	ERTOE	Cd; Cu; Fe; Mn; nitrate + nitrite; P (total); Pb; pH; Se; Zn	Y	No limit specified	Crooked Creek
		20	N	EPA ID 20	–	Y	Not applicable	Crooked Creek
Frazer Park Quarry	1246	1	Y	EPA ID 1	O&G; pH; TSS	N	No limit specified	Unnamed tributary to ocean
		2	Y	EPA ID 2	O&G; pH; TSS	N	No limit specified	Unnamed tributary to ocean

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Nu-Rock Resource Recovery Facility	No licence							
Pasminco and Incitec Consolidated Remediation Project	5042	18	Y	EPA ID 18	As; Cd; Hg; Pb; pH; Se; TSS; Zn	Y	4.5 ML/day	Cockle Creek
		19	N	EPA ID 19	As; Cd; Hg; Pb; Se; TSS; Zn	–	Not applicable	Cockle Creek
		21	N	EPA ID 21	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek
		27	N	EPA ID 27	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek
		44	N	EPA ID 44	As; Cd; Hg; Pb; Se; TSS; Zn	–	Not applicable	Cockle Creek
		45	N	EPA ID 45	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek
		46	N	EPA ID 46	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek
		47	N	EPA ID 47	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek
		48	N	EPA ID 48	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Pasminco and Incitec Consolidated Remediation Project	5042	49	N	EPA ID 49	Ammonia; bicarbonate; Ca; Cd; chloride; EC; fluoride; K; Pb; Mg; ORP; pH; sodium; sulfate; TSS; Zn	–	Not applicable	Cockle Creek
Tasman Underground Mine	12483	1	Y	EPA ID 1	Ag (filt); Ag (total); Al (filt; Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total); Mo (filt); Mo (total); Ni (filt); Ni (total); Pb (filt); Pb (total); pH; Se (filt); Se (total); TSS; V (filt); V (total); Zn (filt); Zn (total)	Y	No limit specified	Blue Gum Creek
		2	N	EPA ID 2	Ag (filt); Ag (total); Al (filt; Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total); Mo (filt); Mo (total); Ni (filt); Ni (total); Pb (filt); Pb (total); pH; Se (filt); Se (total); TSS; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	Blue Gum Creek
		3	N	EPA ID 3	BOD; N (total); P (total); TSS	–	Not applicable	Blue Gum Creek
Teralba Quarry	3139	1	Y	EPA ID 1	EC; N (ammonia); P (total); pH; TSS	N	25 ML/day	Cockle Creek
		2	Y	EPA ID 2	–	N	25 ML/day	Cockle Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements: Water quality	Monitoring requirements: Volume	Licenced discharge limit	Creek catchment
Vales Point Power Station	761	1	Y	LDP1	Cl (free residual); O&G; temp	Y	6,500 ML/day	Lake Macquarie
Vales Point Power Station	761	2	Y	LDP2	Ammonia; Cd; Cu; Mn; N (total); nitrate + nitrite; P (total); P (reactive); Pb; pH; Se; TKN; TSS; Zn	Y	120 ML/day	Unnamed tributary of Lake Macquarie
Vales Point Power Station	761	3	Y	LDP3	–	N	0.38 ML/day	Wyee Creek
Vales Point Power Station	761	4	N	LDP4	Ammonia; Cd; Cu; Mn; N (total); nitrate + nitrite; P (total); Pb; pH; Se; TKN; TSS; Zn	Y	No limit specified	Wyee Creek
Vales Point Power Station	761	6	N	EPA ID 6	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie
Vales Point Power Station	761	7	N	EPA ID 7	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie
Vales Point Power Station	761	8	N	EPA ID 8	DO; EC; temp; water clarity; zooplankton (total count)	–	Not applicable	Lake Macquarie
Vales Point Power Station	761	18	N	LDP18	Ammonia; Cd; Cu; Mn; N (total); nitrate + nitrite; P (total); Pb; pH; Se; TKN; TSS; Zn	Y	Not applicable	Wyee Creek
Wallarah 2 Coal Project	No licence							

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Westside Mine	4033	2	Y	EPA Point 2	EC; pH; TSS	Y	No limit specified	Cockle Creek
		3	Y	EPA Point 3	EC; pH; TSS	Y	No limit specified	Cockle Creek
		4	Y	EPA Point 4	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total); Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); P; Pb (filt); Pb (total); pH; Se (filt); Se (total); TSS; V (filt); V (total); Zn (filt); Zn (total)	Y	No limit specified	Cockle Creek
		5	Y	EPA Point 5	EC; pH; TSS	Y	2 ML/day	Burkes Creek
		6	Y	EPA Point 6	EC; pH; TSS	Y	No limit specified	Cockle Creek
		14	N	EPA Point 14	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total); Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); P; Pb (filt); Pb (total); pH; Se (filt); Se (total); TSS; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	Cockle Creek

Site	Licence number	EPA ID	Discharge point	Discharge point name	Monitoring requirements		Licenced discharge limit	Creek catchment
					Water quality	Volume		
Westside Mine	4033	15	N	EPA Point 15	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total); Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); P; Pb (filt); Pb (total); pH; Se (filt); Se (total); TSS; V (filt); V (total); Zn (filt); Zn (total)	–	Not applicable	Cockle Creek
		16	Y	EPA Point 16	Ag (filt); Ag (total); Al (filt); Al (total); As (filt); As (total); Be (filt); Be (total); Cd (filt); Cd (total); Cr (filt); Cr (total); Co (filt); Co (total); Cu (filt); Cu (total); EC; Hg (filt); Hg (total); Mo (filt); Mo (total); N (ammonia); Ni (filt); Ni (total); P; Pb (filt); Pb (total); pH; Se (filt); Se (total); TSS; V (filt); V (total); Zn (filt); Zn (total)	Y	14 ML/day	Cockle Creek
West Wallsend Colliery	1360	1	Y	EPA Point 1	EC; O&G; pH; TSS	Y	6 ML/day	Cockle Creek
		2	Y	EPA Point 2	EC; pH; TSS	Y	4 ML/day	Burkes Creek
		3	Y	EPA Point 3	EC; pH; TSS	Y	10 ML/day	Cockle Creek
		11	Y	EPA Point 11	EC; pH; TSS	Y	17.28 ML/day	Brush Creek

5. Water Quality

Water quality within the Lake Macquarie catchment and at LDPs at Centennial-owned and non-Centennial sites within the Study Area is discussed in this section to highlight existing and potential future water quality issues. EC data for the catchment areas and LDPs have been incorporated into the regional salt balance.

5.1 Water Quality Assessment Methodology

The assessment of surface water quality was undertaken by comparing water quality monitoring results to default trigger values presented by the ANZECC and ARMCANZ (2000) guidelines and to EPL limits applicable to each site considered in the regional water and salt balance. Default trigger values have been adopted for preliminary assessment purposes and should not be adopted as EPL concentration limits.

Within the ANZECC and ARMCANZ (2000) guidelines, the applicable default trigger values for the surface water resources within the Study Area fall into different categories depending on the water quality parameter and the type of water resource (freshwater or estuarine/marine). The default trigger values used to assess water quality are presented in Table 5-1.

Table 5-1 ANZECC and ARMCANZ (2000) Default Trigger Values

Parameter	Lowland rivers/ freshwater trigger value	Estuarine/marine water trigger value	Additional information
Physicochemical parameters			
pH	6.5-9.0	7.0-8.5	NSW lowland river/estuaries (Table 8.8.2).
TSS	50 mg/L	6 mg/L	NSW lowland river/estuaries (Table 8.2.12).
EC	2,200 µS/cm	–	Lowland rivers in south-east Australia (Table 3.3.3).
Turbidity	50 NTU	10 NTU	Lowland rivers/estuarine & marine in south-east Australia (Table 3.3.3).
Nutrients			
Ammonia as N	0.9 mg/L	0.91 mg/L	Freshwater/marine water trigger values for 95% species protection (Table 3.4.1).
Nitrogen (total)	0.5 mg/L	0.3 mg/L	Lowland river/estuaries (Table 3.3.2).
Phosphorus (total)	0.05 mg/L	0.03 mg/L	Lowland river/estuaries (Table 3.3.2).

Parameter	Lowland rivers/ freshwater trigger value	Estuarine/marine water trigger value	Additional information
Filterable/dissolved metals			
Aluminium	0.055 mg/L	–	Freshwater trigger value for 95% species protection (Table 3.4.1). Applies for pH >6.5.
Arsenic	0.024 mg/L	–	Freshwater trigger value for 95% species protection for As(V) (Table 3.4.1).
Boron	0.37 mg/L	–	Freshwater trigger value for 95% species protection (Table 3.4.1).
Cadmium	0.0002 mg/L	0.0055 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1). Calculated using hardness of 30 mg/L $CaCO_3$.
Chromium	0.001 mg/L	0.0044 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1). Calculated using hardness of 30 mg/L $CaCO_3$.
Cobalt	–	0.001 mg/L	Marine water trigger value for 95% species protection (Table 3.4.1).
Copper	0.0014 mg/L	0.0013 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1). Calculated using hardness of 30 mg/L $CaCO_3$.
Iron	0.3 mg/L	–	Canadian guideline level recommended by ANZECC and ARMCANZ (2000) (Section 8.3.7.1).
Lead	0.0034 mg/L	0.0044 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1). Calculated using hardness of 30 mg/L $CaCO_3$.

Parameter	Lowland rivers/ freshwater trigger value	Estuarine/marine water trigger value	Additional information
Manganese	1.9 mg/L	–	Freshwater trigger value for 95% species protection (Table 3.4.1).
Mercury	0.0006 mg/L	0.0004 mg/L	Freshwater/marine water trigger values for 95% species protection for inorganic Hg (Table 3.4.1).
Nickel	0.011 mg/L	0.07 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1).
Selenium	0.011 mg/L	–	Freshwater trigger values for 95% species protection for total Se (Table 3.4.1).
Silver	0.00005 mg/L	0.0014 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1).
Vanadium	–	0.1 mg/L	Marine water trigger value for 95% species protection (Table 3.4.1).
Zinc	0.008 mg/L	0.015 mg/L	Freshwater/marine water trigger value for 95% species protection (Table 3.4.1).

5.2 Background Water Quality

5.2.1 Dora Creek Water Source

Background water quality monitoring within the Dora Creek water source has been carried out on a monthly basis by Centennial. The monitoring period and available water quality data for this assessment are:

- Morans Creek (January 2007 to July 2013).
- Stockton Creek (January 2007 to May 2013).
- Dora Creek (July 2011 to April 2013).
- Lords Creek (June 2011 to February 2013).

Background water quality data reported pH levels within the Dora Creek water source to range from 6 to 8 pH units for all four creeks, indicating that the natural catchment is generally neutral however can move between slightly acidic to slightly alkaline.

EC observed during the monitoring period varied between 28 µS/cm and 500 µS/cm at the Dora Creek and Lords Creek locations, indicating fresh waters. Increased conductivity was noted during 2012 within Morans Creek, reporting a maximum level of 1,860 µS/cm. Increases in conductivity levels are additionally noted for downstream Stockton Creek.

The upstream Stockton Creek location reported a maximum conductivity of 1,700 µS/cm during late 2012, whereas downstream peaks ranging between 4,000 µS/cm and 7,000 µS/cm were reported during 2009 and late 2012. This is likely due to the geochemistry of the natural catchment, including the alluvium. Generally, however, the water within Morans Creek and Stockton Creek varied between fresh upstream to slightly brackish downstream. The overall median background EC throughout the Dora Creek water source, based on available data, is calculated to be 355 µS/cm.

Dissolved metal samples within the Dora Creek water source reported elevated concentrations when compared to default trigger values for aluminium, iron and zinc, indicating a high presence of these metals within the natural catchment.

Total nitrogen and total phosphorus concentrations were also elevated in comparison to ANZECC and ARMCANZ (2000) default trigger values.

5.2.2 North Lake Macquarie Water Source

Background water quality monitoring within the North Lake Macquarie water source has been undertaken on a monthly basis by Centennial. The monitoring period and available water quality data for this assessment are:

- LT Creek (January 2011 to January 2013).
- Stockyard Creek (January 2013 to January 2013).
- Kilaben Creek (June 2011 to February 2013).
- Stony Creek (June 2011 to February 2013).
- Puntei Creek (June 2011 to February 2013).
- Wangi Creek (January 2008 to March 2013).

pH levels within the North Lake Macquarie water source varied between 5 and 8 pH units. Water sampled at Stockyard Creek and Kilaben Creek ranged between 5 and 7 pH units and showed a decreased level further downstream, indicating neutral to slightly acidic water. Samples collected at LT Creek, Stony Creek, Puntei Creek and Wangi Creek had slightly higher pH levels to those of Stockyard Creek and Kilaben Creek, reporting water to be slightly acidic to neutral.

Overall, EC ranged between 67 µS/cm and 1,000 µS/cm, indicating fresh to slightly brackish water. Stockyard Creek and Kilaben Creek recorded increased conductivity downstream with samples ranging between 643 µS/cm and 730 µS/cm. Conductivity samples at LT Creek and Stony Creek were fresh with a maximum value of 285 µS/cm. The unnamed creek within the Puntei Creek catchment reported conductivity generally between 70 µS/cm and 1,000 µS/cm. The overall median background EC throughout the North Lake Macquarie water source, based on available data, is calculated to be 233 µS/cm.

Dissolved metal samples reported elevated concentrations compared to default trigger values for aluminium, copper, iron and zinc, suggesting a high presence of these metals contained within the natural catchment. Additionally, slightly elevated concentrations of arsenic, boron, chromium and nickel were evident within the Puntei Creek catchment.

Elevated total nitrogen and total phosphorus concentrations were reported during the monitoring period at all locations.

5.2.3 South Lake Macquarie Water Source

Background water quality monitoring data within the South Lake Macquarie water source for assessment is very limited. For the purpose of a background catchment assessment, monitoring location LDP 2 at Mannering Colliery has been identified as a suitable site. LDP 2 discharges consist of water captured from rainfall and catchment runoff from non-mining operation areas.

During the monitoring period from January 2010 through to December 2011, Centennial collected water quality data at LDP 2 during discharges. These samples have been obtained daily for physicochemical parameters and monthly for nutrients and metals. Monitored data provided the following observations:

- pH levels varied between 7.1 and 7.7 pH units, suggesting a neutral to slightly alkaline water.
- Conductivity sampled during the monitoring period was consistently below the ANZECC and ARMCANZ (2000) default trigger value and generally ranged between 90 µS/cm and 550 µS/cm indicating fresh water.
- Dissolved metal samples reported elevated concentrations when compared to default trigger values for copper, iron and zinc within the local catchment.

Due to minimal data within the Dora Creek water source, a higher observed conductivity of 550 µS/cm was considered to be representative of the catchment.

5.3 Centennial-Owned Sites

5.3.1 Mandalong Mine

Surface water quality monitoring at Mandalong Mine is conducted at several locations on either a monthly or quarterly basis. Monthly water quality data observed at monitoring locations upstream of LDP001 at Cooranbong Entry Site was used to derive site-specific trigger values (SSTVs) based on ANZECC and ARMCANZ (2000) guidelines as part of a water quality assessment undertaken in May 2013 by GHD (2013a).

For the purpose of this assessment, water quality data for three locations have been evaluated. The locations assessed were:

- LDP001 – Licensed discharges from Cooranbong Entry Site.
- LDP002 – Licensed discharges from Cooranbong Entry Site.
- SW018 – Proposed LDP at Mandalong Mine Access Site.

The period of data reviewed is presented in Table 5-2.

Table 5-2 Extent of Mandalong Mine Water Quality Data Assessed

Location	Frequency	From	To
LDP001	Daily (physicochemical parameters) Monthly (metals)	January 2010	November 2013
LDP002	Daily during discharge	January 2010	November 2013
SW018	Monthly	August 2012	November 2013

The current EPL discharge limits that apply to discharges through LDP001 and LDP002 at Cooranbong Entry Site are shown in Table 5-3.

Table 5-3 EPL 365 Discharge Limits for Mandalong Mine

Parameter	EPL limit
pH	6.5-8.5
TSS	50 mg/L
Oil and grease	10 mg/L

A statistical summary of water quality at the above locations is provided in Table 5-4.

Table 5-4 Statistical Summary of Water Quality at Mandalong Mine

Parameter	Unit	LDP001 (50th percentile)	LDP002 (50th percentile)	SW018 (50th percentile)
Physicochemical parameters				
pH	pH units	8.0	7.2	7.2
TSS	mg/L	5	14	24
EC	µS/cm	4,140	130	657
Turbidity	NTU	19	32	34
Oil and grease	mg/L	2	2	2
Nutrients				
Ammonia as N	mg/L	0.65	0.02	1.11
Nitrogen (total)	mg/L	1.1	0.5	3.4
Phosphorus (total)	mg/L	0.01	0.04	1.68
Filterable/dissolved metals				
Aluminium	mg/L	0.01	0.12	0.08
Antimony	mg/L	0.001	0.001	–
Arsenic	mg/L	0.001	0.001	0.001
Barium	mg/L	0.23	0.01	0.04
Beryllium	mg/L	0.001	0.001	–
Boron	mg/L	0.22	0.05	0.17
Cadmium	mg/L	0.0001	0.0001	0.0001
Chromium	mg/L	0.001	0.001	0.001
Cobalt	mg/L	0.006	0.001	0.002

Parameter	Unit	LDP001 (50th percentile)	LDP002 (50th percentile)	SW018 (50th percentile)
Copper	mg/L	0.001	0.001	0.001
Iron	mg/L	0.15	0.13	1.85
Lead	mg/L	0.001	0.001	0.001
Manganese	mg/L	0.073	0.009	–
Mercury	mg/L	0.0001	0.0001	0.0001
Molybdenum	mg/L	0.001	0.001	–
Nickel	mg/L	0.054	0.001	0.008
Selenium	mg/L	0.01	0.01	0.01
Silver	mg/L	0.001	0.001	0.001
Tin	mg/L	0.001	0.001	–
Titanium	mg/L	0.01	0.01	–
Vanadium	mg/L	0.01	0.01	–
Zinc	mg/L	0.005	0.03	0.02

From the available monitoring data, the water sampled was generally slightly alkaline with turbidity generally found to be below 50 NTU.

EC levels generally ranged between 2,500 µS/cm and 5,000 µS/cm for LDP001, decreasing to below 4,100 µS/cm during 2013. EC was in the fresh range at LDP002 and SW018.

Sampling undertaken at LDP001 and LDP002 reported instances of total suspended solids (TSS) in exceedance of the limit specified in the EPL for Mandalong Mine, though this was generally during 2011. LDP001 and LDP002 50th percentile results showed that LDP002 recorded a TSS concentration of 14 mg/L compared with that of 5 mg/L at LDP001.

Nitrogen concentrations generally exceeded the ANZECC and ARMCANZ (2000) default trigger value. Nitrogen concentrations sampled from discharges through LDP001 and LDP002 indicated a 50th percentile statistic of 1.1 mg/L and 0.5 mg/L respectively.

Dissolved metal concentrations were generally less than the ANZECC and ARMCANZ (2000) default trigger value with the exception of aluminium, nickel and zinc. Although aluminium and zinc may be attributable to the natural Dora Creek catchment, the elevated nickel concentration at LDP001 most likely originates from the underground mine workings.

5.3.2 Mannering Colliery

Mannering Colliery monitors three locations as part of their surface water monitoring program. These three locations are LDP 1, LDP 2 and a point downstream of LDP 1 along the unnamed creek that the colliery discharges to known as ‘Downstream’. Discharges via LDP 1 are made up of a large proportion of mine water pumped from the underground workings. In contrast, discharges via LDP 2 consist of water captured from rainfall and catchment runoff from non-mining operation areas.

For the purpose of this assessment, water quality data for LDP 1 and Downstream have been evaluated. Available water quality data is shown in Table 5-5.

Table 5-5 Extent of Mannering Colliery Water Quality Data Assessed

Location	Frequency	From	To
LDP 1	Daily (physicochemical parameters) Monthly (metals)	March 2011	October 2013
Downstream	Monthly	January 2010	October 2013

The current EPL discharge limits that apply to discharges through LDP 1 at Mannering Colliery are shown in Table 5-6.

Table 5-6 EPL 191 Discharge Limits for Mannering Colliery

Parameter	EPL limit
pH	6.5-8.5
TSS	50 mg/L
Oil and grease	10 mg/L

A statistical summary of water quality at the above locations is provided in Table 5-7. Sampling of nutrients and metals is undertaken annually at the 'Downstream' sampling location as part of the existing monitoring program. To date, one sampling round of nutrients and metals has been conducted by Centennial in December 2012 and these concentrations are identified in the table.

Table 5-7 Statistical Summary of Water Quality at Mannering Colliery

Parameter	Unit	LDP1 (50th percentile)	Downstream
Physicochemical parameters			
pH	pH units	8.0	8.2
TSS	mg/L	5	9
EC	µS/cm	24,000	25,900
Turbidity	NTU	1	7
Oil and grease	mg/L	2	2
Nutrients			
Ammonia as N	mg/L	0.84	0.1
Nitrogen (total)	mg/L	0.7	-
Phosphorus (total)	mg/L	0.01	0.01

Parameter	Unit	LDP1 (50th percentile)	Downstream
Filterable/dissolved metals			
Aluminium	mg/L	0.01	0.01
Antimony	mg/L	0.001	0.001
Arsenic	mg/L	0.001	0.001
Barium	mg/L	0.27	0.26
Beryllium	mg/L	0.001	0.001
Boron	mg/L	0.3	0.26
Cadmium	mg/L	0.0001	0.0001
Chromium	mg/L	0.001	0.001
Cobalt	mg/L	0.001	0.001
Copper	mg/L	0.001	0.001
Iron	mg/L	0.05	0.05
Lead	mg/L	0.001	0.001
Manganese	mg/L	0.038	0.024
Mercury	mg/L	0.0001	0.0001
Molybdenum	mg/L	0.026	0.028
Nickel	mg/L	0.006	0.005
Selenium	mg/L	0.01	0.01
Silver	mg/L	0.001	0.001
Tin	mg/L	0.001	0.001
Titanium	mg/L	0.01	0.01
Vanadium	mg/L	0.01	0.01
Zinc	mg/L	0.011	0.005

From the water quality monitoring undertaken through LDP 1, the 50th percentile concentrations of most analytes were below ANZECC and ARMCANZ (2000) default trigger values.

The following exceptions are noted:

- The reported EC at LDP 1 ranged from 781 µS/cm to 39,400 µS/cm. The results of the conductivity indicate a discharge range of brackish to saline water. While these levels exceed the ANZECC and ARMCANZ (2000) trigger value range for lowland rivers/freshwater, the receiving environment is essentially an estuarine, salt water system and has been receiving saline underground water discharge for several years. LDP 1 is approximately located 1,300 m from the foreshore of Lake Macquarie where the water is saline.
- Total nitrogen was typically above default trigger values, though limited data was available.
- TSS exceeded the EPL limit at LDP 1 in 2011. It is considered that elevated total metal concentrations in 2011 are attributable to elevated TSS concentrations.

5.3.3 Myuna Colliery

Myuna Colliery has two operational LDPs under the EPL 366. LDP A is located at the outlet of the Settling Pond 3, and LDP B is located on the outlet of the CHP Dam (also known as Settling Pond 1).

For the purposes of this assessment, water quality data for LDP B and 'Downstream' monitoring locations has been evaluated. 'Downstream' is located approximately 180 m downstream of a channel conveying discharge water from Myuna Colliery and Wangi Creek. Additionally, as part of Centennial's monitoring program, data has been collected from Wangi Bay within Lake Macquarie and these samples have been included as part of this assessment. Available water quality data is shown in Table 5-8.

Table 5-8 Extent of Myuna Colliery Water Quality Data Assessed

Location	Frequency	From	To
LDP B	Daily (physicochemical parameters) Monthly (metals)	January 2011	November 2013
Downstream	Monthly	January 2011	November 2013
Lake Macquarie	Monthly	January 2011	November 2013

The current EPL discharge limits that apply to discharges through LDP B at Myuna Colliery are shown in Table 5-9.

Table 5-9 EPL 366 Discharge Limits for Myuna Colliery

Parameter	EPL limit
pH	6.5-8.5
TSS	50 mg/L
Oil and grease	10 mg/L

A statistical summary of water quality at the above locations is provided in Table 5-10. 95th percentile concentrations have been calculated for downstream sites in accordance with ANZECC and ARMCANZ (2000) guidelines for comparison against default trigger values.

Table 5-10 Statistical Summary of Water Quality at Myuna Colliery

Parameter	Unit	LDPB (50th percentile)	Downstream (95th percentile)	Lake Macquarie (Wangi Bay) (95th percentile)
Physicochemical parameters				
pH	pH units	7.7	7.9	8.1
TSS	mg/L	6	34	8
EC	µS/cm	43,200	44,710	56,525
Turbidity	NTU	11	36	4
Oil and grease	mg/L	2	2	2
Nutrients				
Ammonia as N	mg/L	-	-	-
Nitrogen (total)	mg/L	-	-	-
Phosphorus (total)	mg/L	0.01	0.01	0.09
Filterable/dissolved metals				
Aluminium	mg/L	0.1	0.1	0.1
Antimony	mg/L	0.01	0.01	0.01
Arsenic	mg/L	0.001	0.001	0.001
Barium	mg/L	0.14	0.25	0.13
Beryllium	mg/L	0.001	0.001	0.01
Boron	mg/L	0.69	0.87	5.07
Cadmium	mg/L	0.0001	0.0001	0.0002
Chromium	mg/L	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001
Copper	mg/L	0.001	0.002	0.003
Iron	mg/L	0.5	0.51	0.5
Lead	mg/L	0.001	0.001	0.001
Manganese	mg/L	0.37	0.62	0.02
Mercury	mg/L	0.0001	0.0001	0.0001
Molybdenum	mg/L	0.001	0.002	0.018
Nickel	mg/L	0.001	0.004	0.01

Parameter	Unit	LDPB (50th percentile)	Downstream (95th percentile)	Lake Macquarie (Wangi Bay) (95th percentile)
Selenium	mg/L	0.01	0.01	0.01
Silver	mg/L	0.001	0.001	0.001
Tin	mg/L	0.01	0.01	0.01
Titanium	mg/L	0.001	0.02	0.1
Vanadium	mg/L	0.1	0.1	0.1
Zinc	mg/L	0.005	0.16	0.005

Based on the available data during the monitoring period, the water sampled at LDP B was slightly alkaline and saline. The elevated EC is associated with the underground mine water pumped to the surface. For monitored parameters TSS, oil and grease and turbidity, levels were generally below the EPL limits and ANZECC and ARMCANZ (2000) default trigger values, with minimal exceedences reported.

Limited data was available to assess nutrients; however from the minimal samples collected all were above the ANZECC and ARMCANZ (2000) default trigger values.

For dissolved metals, aluminium, boron, and iron consistently exceeded the default trigger values, although are likely to be attributable to natural catchment runoff.

'Downstream' monitoring data followed similar trends to that of LDP B. The water sampled at 'Downstream' was saline and slightly alkaline. No exceedences of TSS, oil and grease and turbidity were noted and limited data was available for nutrients.

Dissolved metal concentrations were similar to that of LDP B.

5.3.4 Newstan Colliery

Surface water quality monitoring at Newstan Colliery is conducted at several locations on either a daily or monthly basis.

For the purpose of this assessment, water quality data for ten locations have been evaluated. The locations assessed are specified on the EPL for ongoing monitoring and are as follows:

- LDP001 – Licensed discharges from Newstan Colliery.
- LDP002 – Licensed discharges from Newstan Colliery.
- LDP003 – Proposed LDP at Newstan Colliery.
- LDP017 – Stony Creek pipeline (WMP19).
- SP003 – Upstream from LDP002.
- WMP3 – Downstream of LDP001.
- WMP7 – Downstream of Newstan Colliery.
- WMP13 – Southern arm of LT Creek.
- WMP9 – Upstream of southern arm of LT Creek.
- WMP20 – Upstream of LDP017 on Stony Creek.

The period of data reviewed is presented in Table 5-11.

Table 5-11 Extent of Newstan Colliery Water Quality Data Assessed

Location	Frequency	From	To
LDP001	Daily (physicochemical parameters) Weekly (metals)	January 2011	November 2013
LDP002	Daily during discharge	January 2011	July 2011
LDP003	Monthly	January 2011	December 2013
LDP017 (WMP19)	Daily during 2011 and 2012 Monthly during 2013	January 2011	November 2013
SP003	Monthly	January 2011	November 2013
WMP3	Monthly	January 2011	November 2013
WMP7	Monthly	January 2011	November 2013
WMP13	Monthly	January 2011	November 2013

The current EPL discharge limits that apply to discharges through LDP001, LDP002 and LDP017 at Newstan Colliery are shown in Table 5-12. It is noted that these have only applied since October 2012. Default ANZECC and ARMCANZ (2000) trigger values have also been used in order to maintain consistency between sites. As for Mandalong Mine, SSTVs have previously been calculated to assess impacts of discharges from LDP001 at Newstan Colliery.

Table 5-12 EPL 395 Discharge Limits for Newstan Colliery

Parameter	EPL limit
LDP001, LDP002 and LDP017	
pH	6.5 – 8.5
TSS	50 mg/L
LDP002	
Oil and grease	10 mg/L
LDP001 and LDP017	
Aluminium (dissolved)	0.22 mg/L
Antimony	0.009 mg/L
Arsenic (dissolved)	0.042 mg/L
Barium (dissolved)	0.25 mg/L
Beryllium (dissolved)	0.004 mg/L
Bicarbonate alkalinity	711 mg $CaCO_3$/L
Boron (dissolved)	0.37 mg/L
Cadmium (dissolved)	0.0004 mg/L

Parameter	EPL limit
Calcium	38 mg/L
Chloride	516 mg/L
Chromium (dissolved)	0.006 mg/L
Cobalt (dissolved)	0.003 mg/L
Copper (dissolved)	0.007 mg/L
EC	3,250 µS/cm
Iron (dissolved)	0.230 mg/L
Lead (dissolved)	0.023 mg/L
Lithium (dissolved)	0.164 mg/L
Magnesium	16 mg/L
Manganese (dissolved)	1.2 mg/L
Mercury (dissolved)	0.0006 mg/L
Molybdenum (dissolved)	0.045 mg/L
Nickel (dissolved)	0.024 mg/L
Nitrogen (total)	2.7 mg/L
Oil and grease	6 mg/L
Phosphorus (total)	0.41 mg/L
Potassium	6 mg/L
Selenium (total)	0.011 mg/L
Silver (dissolved)	<0.001 mg/L
Sodium	635 mg/L
Sulfate	232 mg/L
Tin	0.003 mg/L
Titanium	0.01 mg/L
Total Kjehldahl nitrogen	2.6 mg/L
Vanadium (dissolved)	<0.01 mg/L
Zinc (dissolved)	0.04 mg/L

A statistical summary of water quality at the above locations is provided in Table 5-13. The 95th percentile concentrations have been calculated for downstream sites in accordance with ANZECC and ARMCANZ (2000) guidelines for comparison against default trigger values.

Table 5-13 Statistical Summary of Water Quality at Newstan Colliery

Parameter	Unit	50th percentile								95th percentile	
		LDP001	LDP002	LDP003	SP003	WMP3	WMP9	WMP20	LDP017	WMP7	WMP13
Physicochemical parameters											
pH	pH units	7.8	8.1	8.0	8.5	8.3	6.8	7.1	7.6	8.5	7.0
TSS	mg/L	5	489	29	10	5	158	17	6	75	301
EC	µS/cm	2340	388	484	2180	2240	121	222	1515	2750	869
Turbidity	NTU	2	84	196	5	3	2300	86	21	106	217
Oil and grease	mg/L	2	2	2	2	2	2	2	2	2	2
Nutrients											
Ammonia as N	mg/L	0.09	–	–	0.01	0.04	0.01	0.03	0.02	0.5	0.078
Nitrogen (total)	mg/L	0.2	–	0.8	0.3	0.2	3	0.8	0.3	0.5	1.4
Phosphorus (total)	mg/L	0.01	–	0.05	0.01	0.02	0.46	0.05	0.4	0.1235	0.1975
Filterable/dissolved metals											
Aluminium	mg/L	0.01	0.37	0.145	0.015	0.01	1.82	0.78	0.06	0.116	1.936
Antimony	mg/L	0.001	–	–	0.001	–	–	0.001	0.001	–	–
Arsenic	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
Barium	mg/L	0.067	0.022	0.0575	0.0685	0.07	0.01	0.051	0.042	0.1188	0.0715
Beryllium	mg/L	0.001	0.001	–	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Parameter	Unit	50th percentile								95th percentile	
		LDP001	LDP002	LDP003	SP003	WMP3	WMP9	WMP20	LDP017	WMP7	WMP13
Boron	mg/L	0.2	0.05	0.06	0.18	0.18	0.05	0.05	0.11	0.246	0.05
Cadmium	mg/L	0.0001	0.0001	–	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium	mg/L	0.001	0.001	–	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	–	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.001	0.002	0.001	0.001	0.001	0.004	0.003	0.001	0.002
Iron	mg/L	0.05	0.19	0.285	0.05	0.05	0.89	1.05	0.12	0.218	1.268
Lead	mg/L	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001
Manganese	mg/L	0.132	–	0.008	0.01	0.006	0.009	0.067	0.164	0.015	0.135
Mercury	mg/L	0.0001	0.0001	–	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Molybdenum	mg/L	0.021	0.012	–	0.019	0.018	0.001	0.001	0.006	0.031	0.001
Nickel	mg/L	0.012	0.001	–	0.01	0.008	0.001	0.004	0.009	0.016	0.001
Selenium	mg/L	0.01	0.01	–	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.001	0.001	–	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tin	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Parameter	Unit	50th percentile								95th percentile	
		LDP001	LDP002	LDP003	SP003	WMP3	WMP9	WMP20	LDP017	WMP7	WMP13
Titanium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.094
Vanadium	mg/L	0.01	0.01	–	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.006	0.005	0.005	0.005	0.005	0.005	0.02	0.009	0.008	0.01025

LDP001

Based on the available data for the monitoring period (January 2011 to December 2013), the discharge water sampled at LDP001 is slightly alkaline and brackish. TSS has exhibited some exceedences but is generally below the EPL concentration limit. The recent commissioning of the Clean Water Plant at Newstan Colliery in Decmber 2013 will ensure TSS concentrations are low at this location. There has been some variation in EC and major ion concentrations since late 2011 (including a decrease in EC and increase in sulfate), which is most likely attributable to changes in the volume of groundwater from the West Borehole Seam that is transferred into the Fassifern Underground Storage prior to discharge through LDP001.

Dissolved metal concentrations were generally below the EPL concentration limit throughout the monitoring period. In the case of barium, boron, molybdenum and nickel, decreases in concentrations are evident since August 2011.

Total nitrogen and total phosphorus concentrations were generally below the EPL concentration limit over the monitoring period, with a few outliers reported in mid-2012 (although the EPL limits did not apply at that time).

Overall, the primary water input to LDP001 is underground water from the Fassifern Underground Storage, which is now treated at the Clean Water Plant prior to discharge. It follows that the primary source of any elevated TSS, conductivity or metals that may be reported at LDP001 is from the underground water and generally the result of interaction between water and the coal seam and overlying strata.

LDP002, LDP003 and LDP017 (WMP19)

The discharged water sampled during the monitoring period reported a pH of generally between 6 and 8.5. LDP017 reported levels slightly lower than LDP003 indicating slightly more acidic waters. EC has consistently been below the ANZECC and ARMCANZ (2000) default trigger value of 2,200 µS/cm.

Elevated TSS was noted during late 2011 and early 2012 with concentrations as high as 600 mg/L to 800 mg/L at LDP002 (emergency discharge point), however during 2013, concentrations have generally been below 50 mg/L. Turbidity follows a similar trend to TSS. The upgraded Final Pollution Control Dam at Newstan Colliery will reduce the frequency and TSS concentration of discharges at LDP002.

Total nitrogen concentrations were elevated during the monitoring period, with peaks evident during March through May 2012 at LDP017 and at LDP003. An increasing trend is noted since early 2013.

Dissolved metals concentrations were generally below the ANZECC and ARMCANZ (2000) default trigger values or limit or reporting, with the exception of aluminium, iron and nickel.

LT Creek/Stony Creek Water Quality

Water quality monitoring along LT Creek and Stony Creek reported a slightly alkaline water at locations SP003, WMP3, WMP7 and WMP9, whereas for monitoring locations WMP20 and WMP13 the water is slightly acidic. Elevated ECcompared to the default trigger value is reported at SP003, WMP3 and WMP7 with levels reported generally between 2,000 µS/cm and 3,000 µS/cm.

TSS concentrations at upstream locations WMP9 and WMP20 generally exceeded those of the other locations reporting samples between 200 mg/L and 1,000 mg/L.

Dissolved metals concentrations are similar to those of the above LDPs with exceedences of the ANZECC and ARMCANZ (2000) default trigger values for aluminium, iron and nickel.

Awaba Colliery

Awaba Colliery has not discharged since December 2011. During December 2011, four discharges occurred, three from LDP004 and one from LDP009. The results of these discharges reported the following:

- pH levels ranged between 7.0 and 7.5 pH units reported neutral to slightly alkaline waters.
- Conductivity at LDP004 reported a range of 1,610 µS/cm to 1,670 µS/cm.
- Dissolved metal concentrations reported elevated nickel and zinc at groundwater extraction locations.

5.4 Non-Centennial Sites

5.4.1 Aquabait

Water quality monitoring of EPL Discharge Point 1 has been undertaken quarterly between August 2012 and August 2013. The following observations were reported during the monitoring period:

- Concentrations of biological oxygen demand, ammonia, nitrate, nitrite, orthophosphate and total phosphorus were consistently below the limit of reporting.
- Total Kjehldahl nitrogen reported a concentration range of 0.2 mg/L to 0.4 mg/L during the monitoring period.
- TSS reported a range of 3 mg/L to 17 mg/L.

5.4.2 Chain Valley Colliery

Monthly water quality monitoring of LDP1 is undertaken at Chain Valley Colliery. Parameters monitored included pH, EC, TSS, metals, nutrients and faecal coliforms. During the period from April 2012 to September 2013, the following observations were made:

- pH levels ranged between 7.8 and 8.1 indicating that the water is slightly alkaline.
- EC samples reported the water to be saline.
- Concentrations of zinc consistently exceeded default ANZECC and ARMCANX (2000) default trigger values with peaks during June through September 2013 with a maximum concentration of 0.04 mg/L.

5.4.3 Eraring Power Station

Monthly and quarterly monitoring of four locations, EPA1, EPA8, EPA10 and EPA17 is undertaken at Eraring Power Station under EPL 1429. During the monitoring period April 2012 through to October 2013, the following observations were made:

- For pH, the 50th percentiles at locations EPA10 and EPA17 were 8.8 and 6.7 pH units respectively.
- TSS monitored at EP10 was generally below 7 mg/L.
- Elevated concentrations of dissolved iron and selenium were reported during 2013.

5.4.4 Frazer Park Quarry

No monitoring data was available for assessment for Frazer Park Quarry, as there is limited information available for this site publicly. It is expected that due to the extraction operations at the site, likely monitoring criteria would be for physical parameters such as TSS.

It should be noted that Frazer Park Quarry is predicted to discharge to the ocean and not contribute any discharges to Lake Macquarie.

5.4.5 Nu-Rock Resource Recovery Facility

Nu-Rock Technology proposes to lease 1 ha of land from Eraring Power Station to build and construct a resource recovery facility. Currently, Nu-Rock Resource Recovery Facility does not hold a discharge licence.

5.4.6 Pasminco and Incitec Consolidated Remediation Project

At the Pasminco and Incitec Consolidated Remediation Project, South Dam discharge monitoring and Cockle Creek ambient water quality monitoring is undertaken at locations MP48 and MP40 to MP46, respectively. These locations are monitored under EPL 5042. Monitoring data was not available for MP40 to MP46.

Water quality monitoring sampled during June 2012 indicated:

- A pH of 6.6 was recorded indicating slightly acidic water.
- A conductivity of 462 µS/cm was reported suggesting typically fresh water.
- Exceedences of default ANZECC and ARMCANZ (2000) default trigger values were noted in dissolved metals for aluminium, zinc and copper.
- Total phosphorus reported a concentration of 5.7 mg/L.

5.4.7 Tasman Underground Mine

Water quality at the existing Tasman Underground Mine, as reported within the Annual Environmental Management Report for the site from June 2011 to May 2012 (RWC, 2012), was assessed at two locations: BG1 and BG2. BG1 is located on Blue Gum Creek, downstream of George Booth Drive and BG2 is located within Tributary 3, upstream of Tasman Underground Mine. Over the monitoring period only one sample was recorded for BG2.

BG1 reported a pH of close to neutral and the water had a low conductivity (215 µS/cm to 790 µS/cm), indicating typically fresh water. TSS was reported over the period between 2 mg/L and 61 mg/L. BG2 reported a pH of 7.8 and a conductivity of 162 µS/cm. TSS at BG2 was recorded at 8 mg/L.

Water quality monitoring undertaken for the Tasman within the Tasman Extension Project Area reported the following observations (Evans and Peck, 2012):

- The water is slightly acidic and pH ranged between 6.2 and 7.4.
- High concentrations of dissolved iron were present.
- Exceedences of aluminium, cadmium, chromium, copper, lead and zinc were reported during the monitoring period.

It should be noted that Tasman Underground Mine discharges are outside of the Lake Macquarie catchment and contribute to the Hunter River.

5.4.8 Teralba Quarry

At Teralba Quarry, EPL 3139 stipulates the need to monitor pH, TSS, EC, ammonia and total phosphorus. Historic water quality monitoring data, from September 1998 to November 2011, was reported by BMT WBM (2011) and the following observations were made:

- pH range of between 6.5 and 8.5.
- Exceedences of TSS have been reported since 2006, with a maximum reported concentration of 150 mg/L.
- EC is reported between 2,300 µS/cm and 12,300 µS/cm, however a decreasing trend is evident since 2006.
- Phosphorus and nitrogen consistently exceeded the default ANZECC and ARMCANZ (2000) trigger value during the monitoring period by up to a maximum of ten times for nitrogen and up to eight times for phosphorus.
- No metals concentrations have been reported.

5.4.9 Vales Point Power Station

Water quality monitoring at Vales Point Power Station is sampled on a monthly basis. Available data for assessment was from February 2013 through to October 2013. During this time water quality has been monitored at locations VPOC, VPADB, VPADS and EPA18. These locations have been monitored for pH, oil and grease, nutrients and dissolved metals as directed under EPL 761. The following observations were made:

- A pH range of 7.4 to 8.8.
- No exceedences of dissolved metals or nutrients were reported.

5.4.10 Wallarah 2 Coal Project

The Wallarah 2 Coal Project is located within the Tuggerah Lakes Basin and includes creek catchments for Wyong River, Jilliby Jilliby Creek and Ourimbah Creek. At present, the Wallarah 2 Coal Project does not hold a licence for a discharge point.

5.4.11 Westside Mine

Water quality monitoring at Westside Mine is reported monthly. Monitoring data available for assessment was for the period April 2012 through to September 2013. Four locations are monitored for pH, TSS, EC, nutrients and metals, which included:

- EPA4 – Discharge waters from Dam E and mine waters from West Wallsend Colliery and Westside Mine.
- EPA14 – Cockle Creek, immediately upstream of its entry to Westside Mine.
- EPA15 – Cockle Creek, immediately downstream of its exit from Westside Mine.
- EPA16 – Cockle Creek, immediately upstream of Wakefield Road.

The results from sampling indicated:

- pH results indicated slightly acidic waters upstream of the mine moving to slightly alkaline downstream.
- Conductivity reported a 50th percentile of 570 µS/cm at EPA14, with a range of 4,800 µS/cm to 5,150 µS/cm reported at EPA4, EPA15 and EPA16.
- TSS was generally below EPL 4033 and ANZECC and ARMCANZ (2000) default trigger values at all locations during the monitoring period.
- Increased concentrations of dissolved metals for aluminium, nickel and zinc are noted.

5.4.12 West Wallsend Colliery

Under EPL 1360, OCAL is licensed to discharge via three locations at West Wallsend Colliery. The water quality of these locations is noted below. The monitoring period assessed extended from April 2012 to October 2013.

West Wallsend Colliery (LDP001)

- pH ranged between 7.1 and 7.9 indicating slightly alkaline waters.
- Conductivity ranged between 500 µS/cm and 913 µS/cm.
- Exceedences of ANZECC and ARMCANZ (2000) default trigger values are noted for dissolved aluminium, chromium and copper.
- Extremely high exceedences of dissolved zinc are noted during the monitoring period with ranges between 0.085 mg/L and 8.57 mg/L.

Macquarie Coal Preparation Plant (LDP002)

- pH ranged between 7.2 and 9.4.
- A decreasing trend in conductivity is evident with levels during 2013 reported to be less than 500 µS/cm.
- Dissolved metals concentrations were generally below the ANZECC and ARMCANZ (2000) default trigger values.

Teralba Colliery (LDP003)

- pH ranged between 7.2 and 9.4.
- Conductivity ranged between 320 µS/cm and 1,700 µS/cm.

5.5 Water Quality Summary

Background catchment runoff within the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources is generally slightly acidic to slightly alkaline and fresh to brackish. Concentrations of total nitrogen, total phosphorus, dissolved aluminium, dissolved iron, dissolved copper and dissolved zinc typically exceed ANZECC and ARMCANZ (2000) default trigger values.

The water quality of existing licensed discharges from Centennial-owned sites within the Study Area are generally within EPL limits and/or default trigger values with the exception of:

- Elevated EC and dissolved nickel concentrations at LDP001 located at Cooranbong Entry Site (part of Mandalong Mine).
- Elevated EC in mine water discharge at Mannering Colliery and Myuna Colliery, although these sites discharge into estuarine waterways and the underground workings are hydraulically connected to Lake Macquarie (hence the elevated EC).
- Elevated TSS and turbidity on occasions at discharge locations at Newstan Colliery. Water management upgrades including the installation of the Clean Water Plant, installation of a control valve at the Stony Creek pipeline outlet and enlargement of the Final Pollution Control Dam are assisting in reducing the frequency and concentrations of these discharges.

The assessment of water quality of existing licensed discharges from non-Centennial sites identified the following water quality issues, based on available data:

- Elevated nutrients and metal concentrations in discharges to Cockle Creek from the Pasminco and Incitec Consolidated Remediation Project.
- Elevated TSS and nutrient concentrations discharged to Cockle Creek from Teralba Quarry.
- Elevated dissolved zinc concentrations discharged from West Wallsend Colliery at LDP001.

6. Modelling Methodology

This section provides an overview of the general modelling methodology for all sites. Further information regarding site-specific data and assumptions is provided in Section 7.1. A representation of the water cycle for each Centennial-owned site is provided as a schematic in Appendix B.

6.1 Water Balance Modelling

6.1.1 Modelling Representation

The model used to represent the inputs and outputs from each site over time was GoldSim Version 10.50 (GoldSim Technology, 2011). This software is a graphical object oriented system for simulating either static or dynamic systems. It is like a 'visual spreadsheet' that allows one to visually create and manipulate data and equations.

GoldSim was used as the platform for data from all sites to be entered into. All the sites were simulated over time in GoldSim which statistically summarised selected outputs from the modelled systems.

Time Steps and Simulation Timeline

The GoldSim model simulated conditions for all identified sites from current conditions in 2014 to 2050 using daily time steps. Daily time steps were used for the modelling as daily rainfall data was the shortest period of data available and changes in operational conditions are typically made on a daily (or shorter) basis.

Groundwater extraction has been accounted for at all sites up to recovery of the coal seams post-mining. In some cases, this recovery period has extended beyond 2050. Since groundwater inflow is the only water transfer during this period it was not necessary to model using daily time steps in GoldSim. Instead, groundwater inflows between 2050 and 2200 have been summed for Centennial-owned and non-Centennial sites and it was assumed that this water would remain within the coal seam as storage rather than be transferred to the surface.

Probabilistic Modelling

To assess the impact of rainfall on the modelled sites, the water balance modelling was completed by applying 113 different rainfall patterns over the simulation timeline. To complete this, the simulation timeline was modelled for 113 'realisations', where each realisation represented a single model run. The only variation between realisations was that each realisation modelled a different continuous historical rainfall pattern.

The 113 realisations were applied as the historical rainfall data extended from January 1901 to December 2013 (refer Section 7.1.1), which represents 113 years of complete rainfall data available. The 113 years of rainfall data provides 113 rainfall patterns as the seasonality in rainfall is maintained for each model run, e.g. the 1st January in the model was simulated with 1st January historical rainfall data. For each realisation, a continuous pattern of historical rainfall was applied over the simulation timeline. When the end of the continuous historical rainfall record was reached in a realisation, the rainfall looped back to the start of the rainfall record. A graphical explanation of the rainfall simulation process is provided in Figure 6-1.

The above repetition process provided 113 values for each simulated element in the model, for each day of the simulation timeline. Each extraction, discharge or transfer was then statistically assessed to provide estimates of the mean, 10th percentile and 90th percentile annual totals for each year over the simulation timeline where appropriate.

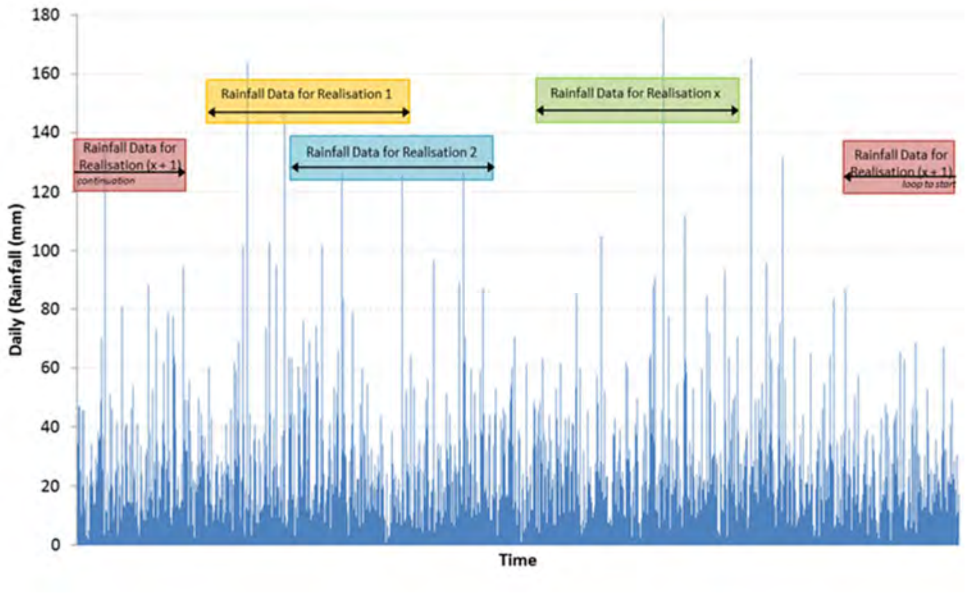


Figure 6-1 Rainfall Simulation Conceptualisation

6.1.2 Key Variables

The key variables that were reported on for each site were associated with the major extractions and discharges. If applicable, the following variables were incorporated into the modelling of each site over the simulation timeline:

- Extractions from groundwater sources.
- Extractions from surface water sources (typically waterways and not including harvesting runoff by dirty water collection systems).
- Discharges from sites through LDPs into surface water systems.

In addition to the key variables discussed above, the water and salt balance model also predicted the catchment runoff expected to contribute to Lake Macquarie, excluding the sites assessed within the Study Area.

6.1.3 Available Information

The available information associated with the water cycle at each site was categorised into one of the following data sources:

- Case 1 –Sites for which GHD has previously completed a detailed water balance.
- Case 2 –Sites for which a water balance has been completed by others and the water balance report was available.
- Case 3 –Sites for which no relevant or available water balance has been completed previously.

Case 1

For sites which GHD has previously completed a water balance model, GHD was able to directly incorporate the entire detailed water balance into the regional water and salt balance. The key variables were then referenced from the relevant model elements.

Case 2

For sites where a water balance has been completed previously and the water balance model report was available, GHD reviewed the available information and interpreted what relevant data was to be included into the model. For these sites, GHD did not model the water cycle, but directly input the relevant data presented in the reports into the GoldSim regional water and salt balance model.

Where the key variables provided in the reports varied with annual or daily rainfall totals, this variation was included in the GoldSim model such that the appropriate extraction or discharge value was simulated by the model depending on the annual or daily rainfall being simulated.

Information was typically provided in terms of daily discharge data. For incorporation into the regional water and salt balance model, this data was interpreted so that values could be provided for daily time steps for any given rainfall year.

Where estimates were provided for discharges from a site for various annual rainfall percentile years, values for the percentiles not provided were estimated by either a log or linear interpolation. A log interpolation was applied to discharges that were determined to be predominantly influenced by variations in rainfall. Linear interpolations were applied to discharges predominantly influenced by dewatering or groundwater inflow rates. For data sets where the predominant influence was not known, a comparison was conducted on the available data to assess whether a log or linear fit was most appropriate.

Case 3

For sites where an appropriate water balance has not been previously completed, GHD developed a water balance cycle representation in GoldSim. Information for these sites was based on the review of available information and the provision of information from Centennial. Such models were developed so that the appropriate level of detail was included to simulate any anticipated response of extractions and discharges to rainfall conditions.

6.1.4 Rehabilitation and Closure

After the active mining phase, it was assumed that each site then commenced a rehabilitation phase. In the absence of site-specific information, rehabilitation was assumed to continue over a seven year period. Over the rehabilitation phase it was assumed that disturbed areas would be progressively rehabilitated and diverted away from the LDP catchments, thereby decreasing the discharge through these locations over time progressively to nil. The discharge from LDPs was assumed to scale down linearly over the rehabilitation phase from the final year of operations.

6.1.5 Lake Macquarie Catchment Modelling

In addition to determining the volume of discharges contributing to Lake Macquarie from the assessed sites, the volume of surface water runoff contributing to Lake Macquarie was assessed within the GoldSim model. As discussed in Section 1.2, the Study Area has been defined by the surface water catchment to Lake Macquarie. The sub-catchments within the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources were delineated and are summarised in Appendix C. The development footprint of each assessed site was excluded from the corresponding sub-catchment area. An estimate of the runoff volume from each water source to Lake Macquarie was determined using the Australian Water Balance Model (AWBM), which is a catchment water balance model that calculates runoff from rainfall. Hydrologic modelling with the AWBM is discussed further in Section 6.4.

6.2 Salt Balance Modelling

The salt balance was developed as an extension of the water balance within GoldSim. The structure of the water balance model remained unchanged, with expected concentrations of salt applied to inputs within the model. The salt balance provides the expected salt loads and concentration of salt associated with each water transfer within the water balance. Chemical reactions have not been incorporated into the salt balance modelling. Salt transfers were simulated in parallel with the water balance model.

Inputs to the water and salt balance model were assigned a specific concentration of salt depending on the source of water. Salt concentrations were based upon recorded water quality data and typical concentration values for similar sites, usually provided in units of µS/cm. A conversion factor of 0.67 was used to convert salinity data in µS/cm to mg/L as recommended by the Queensland Department of Natural Resources and Water (DNRW, 2007).

6.2.1 Available Information

Similar to the water balance, the available information associated with the salt cycle at each site was categorised into one of the following data sources:

- Case 1 – Sites for which GHD had previously completed a detailed salt balance.
- Case 2 – Sites for which no relevant salt balance has been completed previously.

Case 1

For sites which GHD had previously completed a salt balance model, GHD was able to directly incorporate the entire detailed salt balance into the regional water and salt balance model. The key variables (as detailed in Section 6.1.2) were then referenced from the relevant model elements.

Expected salt concentrations were applied to water inflows to the system. Transfers of the resulting salt loads were modelled throughout the site. The mass and concentration of salt within particular storages was established such that a mass balance was achieved after allowing for salt discharged via extraction and overflows. Extractions and overflows from each storage assumed instantaneous mixing.

Case 2

For sites where an appropriate salt balance has not been previously completed, GHD developed a salt balance in GoldSim. Information for these sites was based on the review of available information and the provision of information from Centennial. Information was typically provided as water quality monitoring data which was statistically analysed to determine the most appropriate salt concentration applied to each water transfer incorporated into the model.

6.2.2 Rehabilitation and Closure

As discussed in Section 6.1.4, over the rehabilitation phase modelled for each site it was assumed that disturbed areas would be progressively rehabilitated, decreasing the discharge through LDPs over time progressively to nil. The salt concentration of each discharge was assumed to scale down linearly with the volume of the discharge to a site-specific value that represented the final rehabilitated surface.

6.3 Hydrogeological Modelling

Extractions from groundwater sources were derived separately from GoldSim on a site-by-site basis. For the purposes of this study, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either by direct removal for use via a production bore or by incidental flow of groundwater from an aquifer into mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.

The removal of water from the collection system within mine workings is regarded as dewatering and is considered to be an operational transfer of water at a mining operation rather than the extraction from a groundwater source. In the same way, the transfer of mine water into mine workings for operational or water storage purposes is also considered to be an operational transfer of water and not an injection into a groundwater source.

The definitions of groundwater extraction, dewatering and operational transfers are shown schematically in Figure 6-2 and Figure 6-3.

6.3.1 Available Information

Similar to the water and salt balance modelling, the hydrogeological modelling methodology adopted to estimate extractions from groundwater sources depended on the available information for each site. The available information was categorised into one of the following data sources:

- Case 1 – Sites for which GHD or others have previously completed a hydrogeological model.
- Case 2 – Sites for which no relevant or available hydrogeological model has been completed previously.

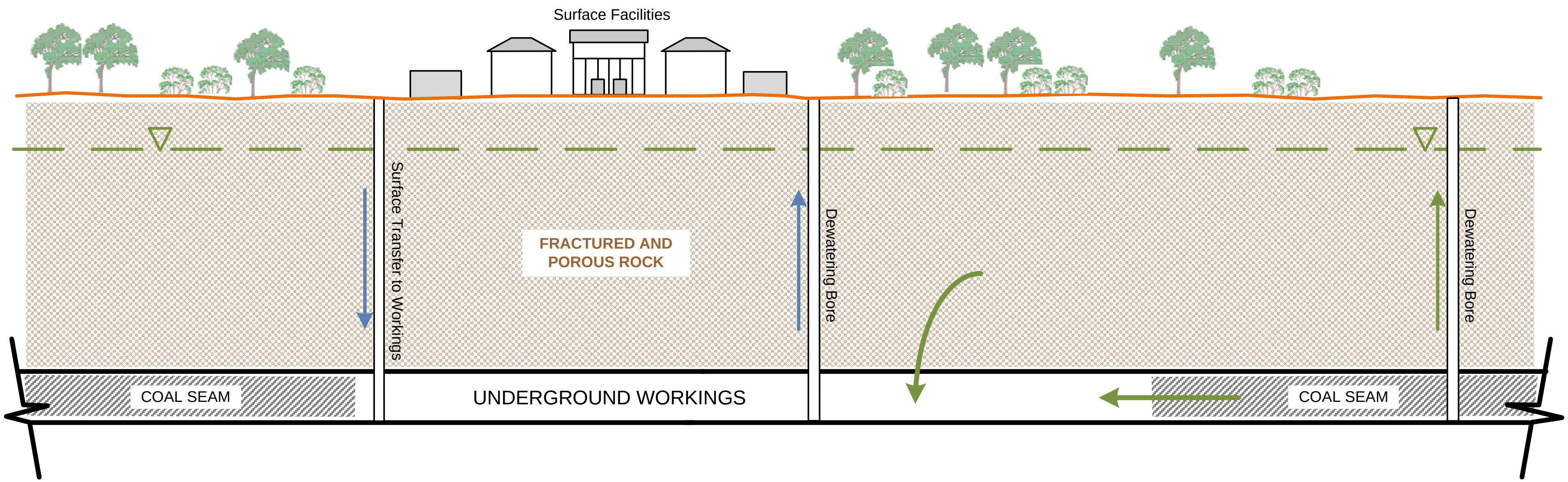
At sites where there are no current or future groundwater extractions, hydrogeological calculations were not undertaken.

Case 1

For the majority of sites with groundwater extractions, a site hydrogeological model has been developed in the past by GHD or others to predict current and future inflow or extraction of groundwater. Most hydrogeological models have been developed in a version of MODFLOW, a three-dimensional finite difference groundwater flow model from the United States Geological Survey and one of the industry standard codes for numerical groundwater modelling.

Where models have been developed for the full simulation period between 2014 and 2050, predicted annual groundwater extraction volumes over this period were input directly into GoldSim.

Where models had not been developed for the full simulation period between 2014 and 2050, the models developed by GHD were run for an extended time period (up to 2200) to allow for input into GoldSim (up to 2050) and then provide groundwater inflow predictions for the recovery period. Where an existing model was not developed by GHD, the available hydrogeological modelling predictions were extrapolated according to the local hydrogeological environment and available mine plans.



Extraction from Groundwater Source

Operational Transfer of Mine Water

LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	SG
APPROVED	SG
SCALE	NTS

Northern Operations Water and Salt Balance

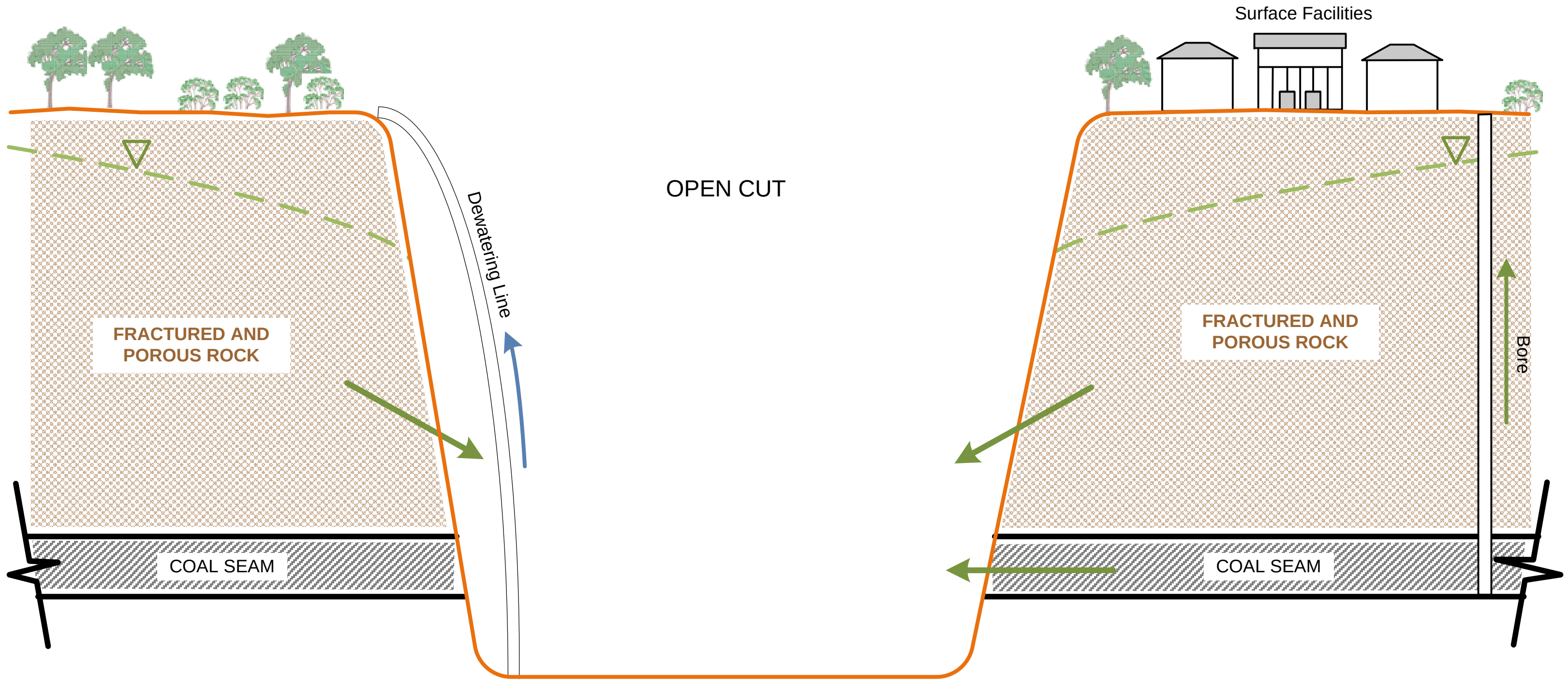
Aquifer Interception by Underground Mine Workings

Centennial Coal

DATE Mar 2014

Figure 6-2

G:\22\17054\Visio\2217054_FIG6-2_AquiferInterceptionbyUndergroundMineWorkings.vsd



Extraction from Groundwater Source

Operational Transfer of Mine Water

LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	SG
APPROVED	SG
SCALE	NTS

Northern Operations Water and Salt Balance

Aquifer Interception by Open Cut Operations

Centennial Coal

DATE Mar 2014

Figure 6-3

G:\22\17054\Visio\2217054_FIG6-3_AquiferInterceptionbyOpenCutMine.vsd

Case 2

For those sites with no hydrogeological model, estimates of groundwater extraction were based on the mine water balance models and/or recorded dewatering rates. Groundwater extraction at these sites is linked to site water demands, rainfall infiltration into old mine workings and the regional flow of groundwater between old workings.

6.3.1 Proportioning Between Groundwater Sources

As only one groundwater source is intercepted by all sites (Sydney Basin North Coast groundwater source of the draft NFPR WSP), it was not necessary to proportion groundwater extraction between groundwater sources.

6.4 Hydrologic Modelling

To estimate runoff from rainfall, the AWBM was incorporated within the wider GoldSim model. The AWBM was adopted as the most suitable model as it is widely used throughout Australia, has been verified through comparison with large amounts of recorded streamflow data, and literature is available to assist in estimating input parameters based on recorded streamflow data (Boughton and Chiew, 2003). Another advantage of the AWBM is the consideration of soil moisture retention when determining runoff.

The AWBM is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. As seen in Figure 6-4, the model consists of three storages representing factors such as infiltration into the soil. Rainfall initially enters these storages and once a storage element is full, any additional rainfall is considered to be excess rainfall. Of this excess rainfall, a proportion is routed to the groundwater/baseflow storage (BS) while the remainder is routed to surface storage (SS). The discharge from the groundwater storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total daily runoff is equal to the combined volume of water discharged from these two storages. The definition of AWBM parameters is provided in Table 6-1.

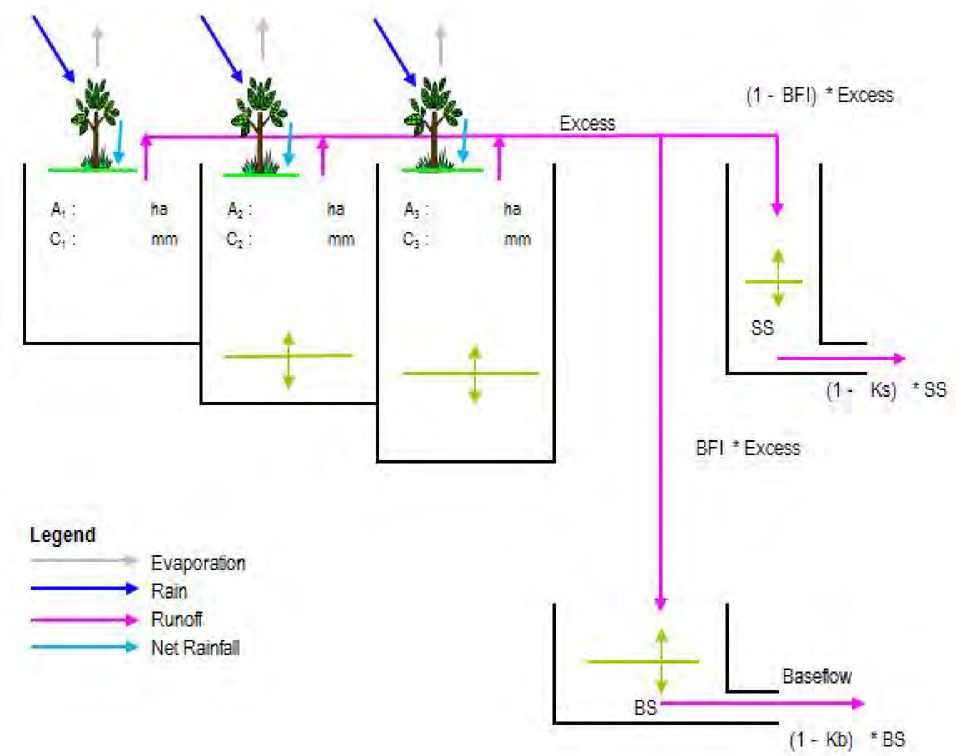


Figure 6-4 Australian Water Balance Model Representation

Table 6-1 Description of Australian Water Balance Model Parameters

Parameter	Description
A_1, A_2, A_3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively
C_1, C_2, C_3	The capacity of storages 1, 2 and 3 respectively (mm)
BFI	The proportion of excess rainfall flowing to the baseflow
Excess	Excess from storages C_1, C_2 and C_3
SS	Surface Storage Recharge
BS	Baseflow Storage Recharge
Kb	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day. Not applicable for these catchments as there is no baseflow component
Ks	The proportion of the surface flow storage remaining in the storage at the end of each day

6.5 Regional Water Balance Conceptualisation

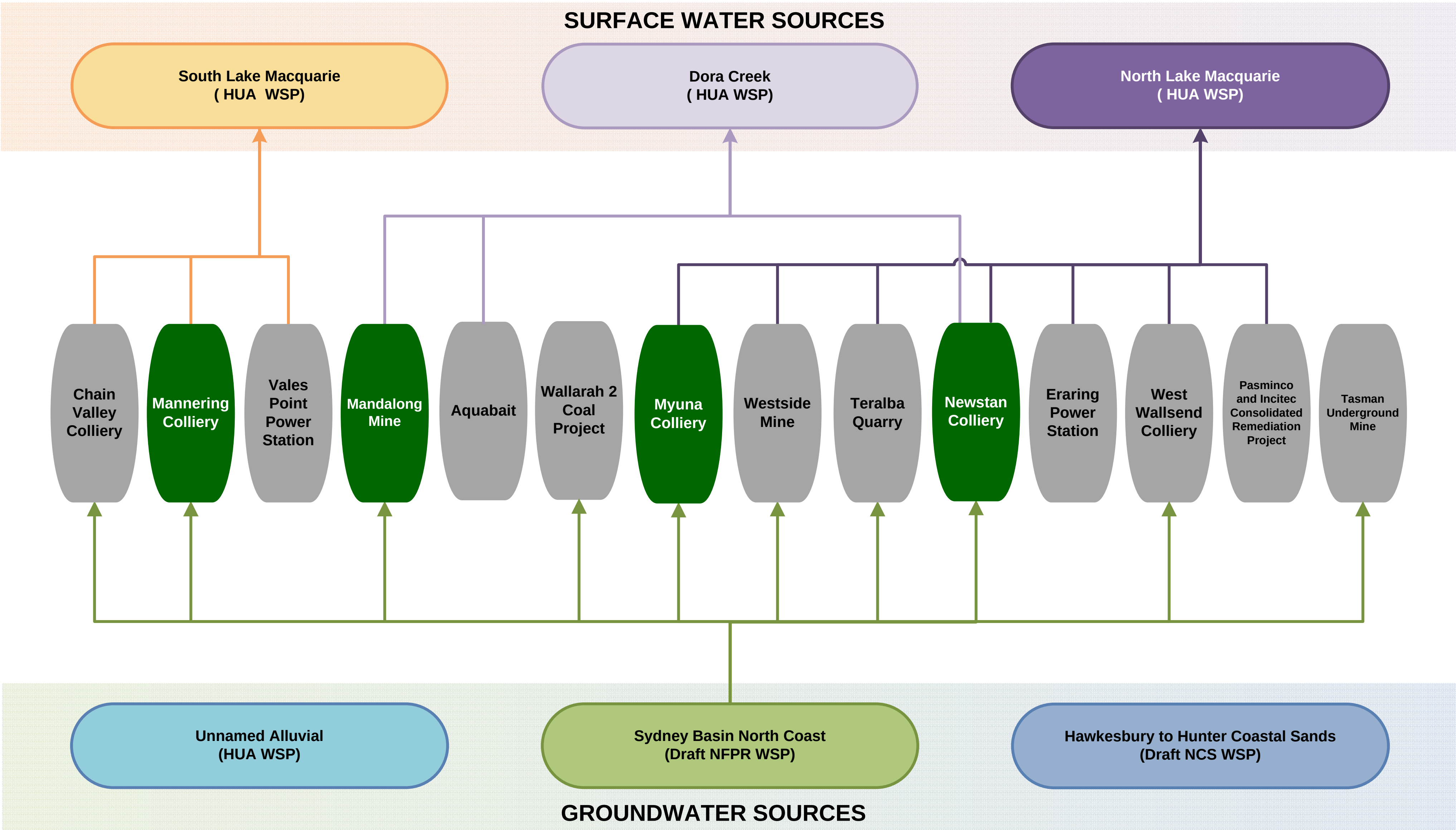
Each modelled extraction and discharge was assigned to a groundwater or surface water source as defined by the WSPs. Figure 4-1 presents the location of mine workings for Centennial-owned sites and LDPs for all sites in relation to groundwater and surface water sources respectively. Typically, extractions occur from groundwater sources and discharges feed into surface water sources via LDPs.

A conceptual representation of the potential interactions of each site with respective groundwater and surface water sources is provided in Figure 6-5.

As described in Section 6.1.1, all sites were assessed over the simulation timeline (2014 to 2050). The outputs for the key variables at each site were then aggregated so that the total annual extractions and discharges from the site were categorised by source and further aggregated to determine the distribution of total extractions and discharges by site over time.

The key variables were grouped further such that the extractions and discharges across sites were aggregated by the water source being drawn from or discharged to. This enabled an assessment of the operations across the study area by water source.

For each water transfer output from the model, the predicted mass and concentration of each associated salt transfer was also output.



GHD

→ Extraction/Discharge

Centennial

Non-Centennial

LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coalfield Water Balance

Interactions Between Sites and Water Sharing Plan Water Sources

Centennial Coal

DATE Mar 2014

Figure 6-5

G:\22\17054\Visio\2217054_FIG6-5_Regional Water Sharing Schematic.vsd

7. Data

7.1 Regional Data

7.1.1 Rainfall

Rainfall data from a number of Bureau of Meteorology (BOM) stations in the vicinity of Lake Macquarie and the Study Area were assessed. For this assessment, daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular BOM station with missing data 'patched in' by interpolation with nearby stations. For this assessment, SILO data was obtained for BOM Cooranbong (Avondale) Station (station number 61012). The rainfall data was selected based on the length and quality of the data record and proximity to the sites assessed.

The period of rainfall data used in this assessment extended from January 1901 to December 2013 and is summarised as annual totals in Figure 7-1. The statistics for this rainfall set are:

- Minimum annual rainfall – 531 mm in 1944.
- Average annual rainfall – 1,108 mm.
- Median annual rainfall – 1,043 mm.
- Maximum annual rainfall – 2,040 mm in 1990.

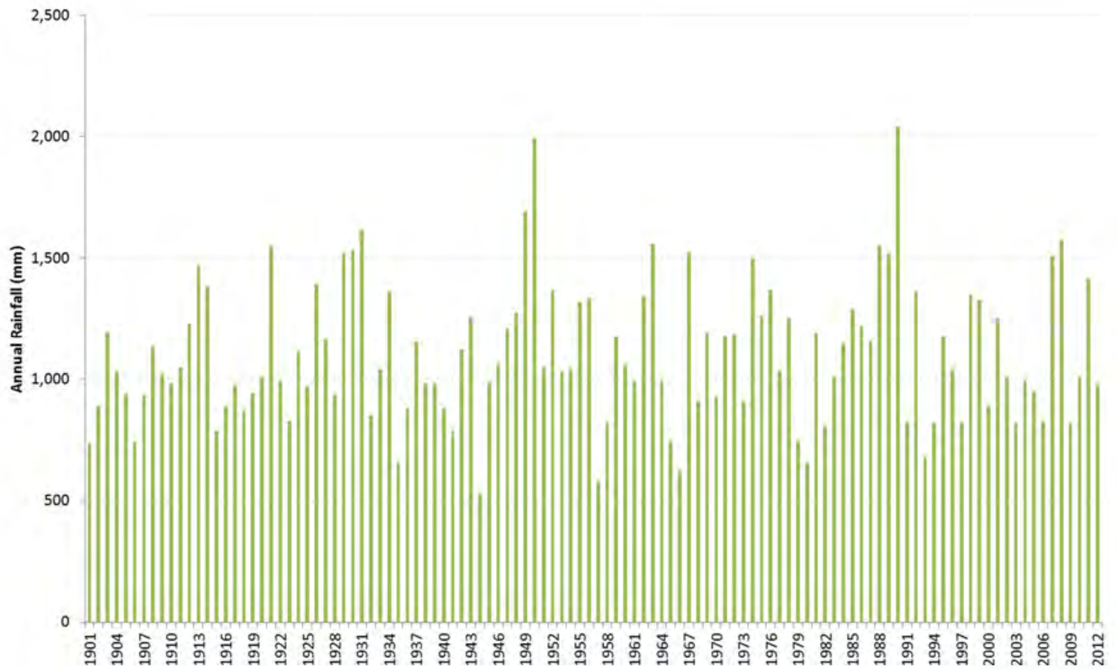


Figure 7-1 Annual Rainfall Recorded at Cooranbong (Avondale) Station

The monthly rainfall statistics were also determined for the period of record for the Cooranbong (Avondale) BOM station and selected statistics are provided in Figure 7-2. The average monthly rainfall was observed to vary from a low of approximately 61 mm in August to a high of approximately 126 mm in March. Figure 7-2 shows a significant variation in the maximum recorded monthly rainfall with the maximum monthly rainfall value being approximately 682 mm in February to a lowest maximum monthly value of approximately 232 mm in September. The minimum monthly rainfall values were 0 mm between June and November.

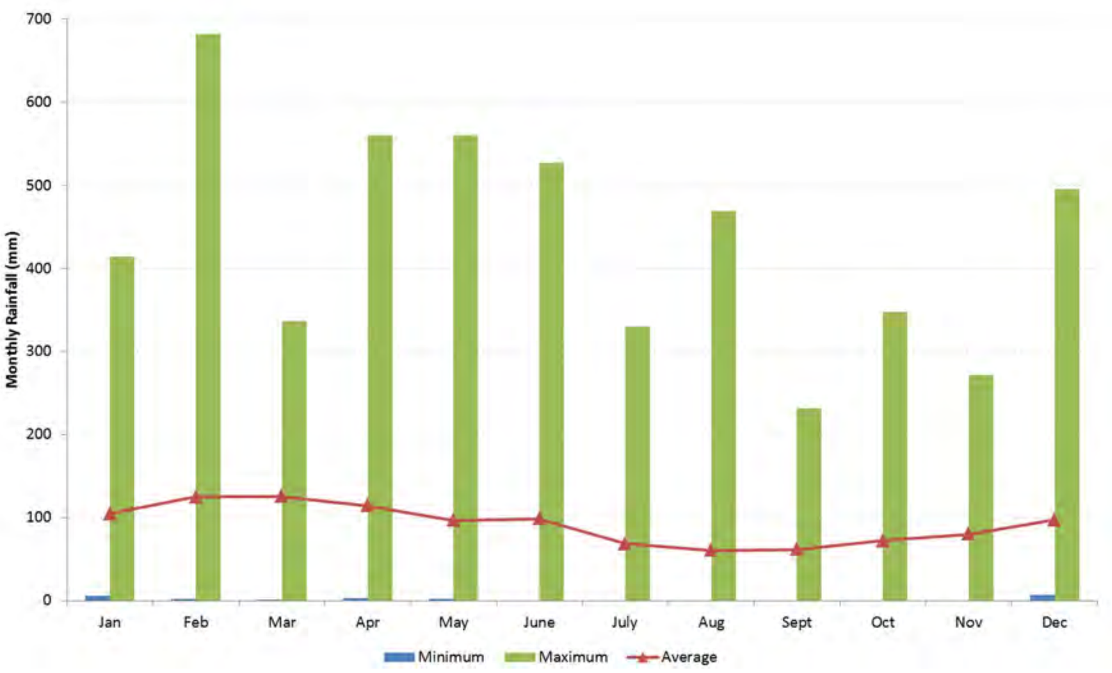


Figure 7-2 Monthly Rainfall Statistics for Cooranbong (Avondale) Station

An analysis of the rainfall data was undertaken to enable an understanding of the likely rainfall patterns for the Study Area. For various intervals of daily rainfall, the average number of days per year which have rainfall within each interval are presented in Figure 7-3, with non-rainfall days (less than 0.1 mm of rainfall) excluded. The figure also presents the cumulative days per year as a percentage against the same rainfall intervals. The average number of non-rainfall days (less than 0.1 mm of rainfall) per year is approximately 254, which is approximately 70% of days in a year.

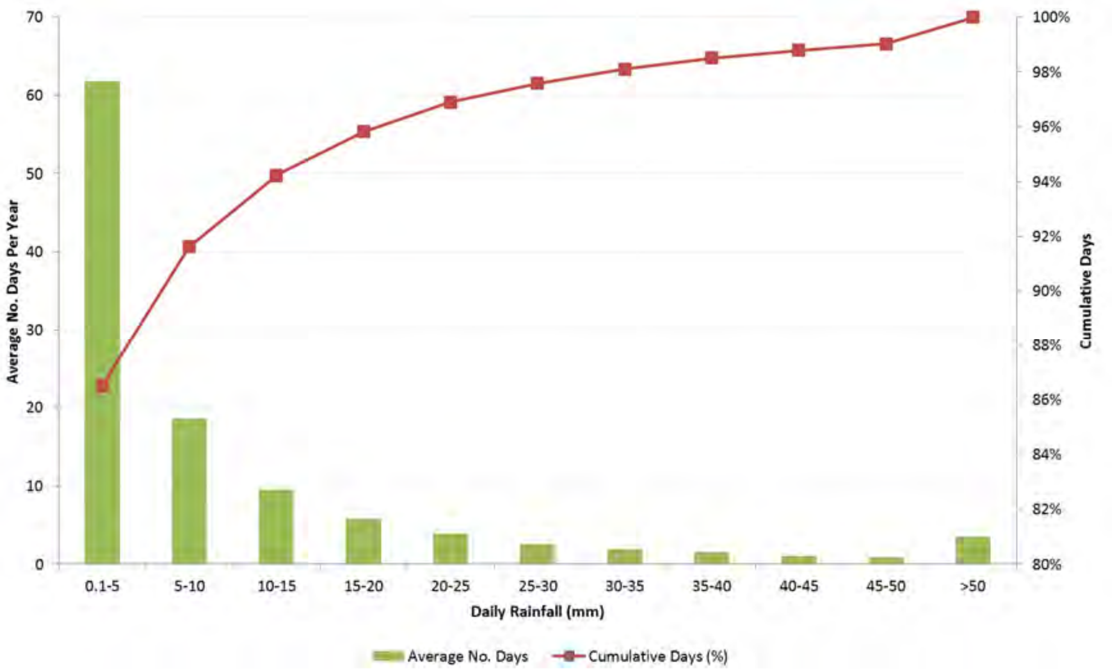


Figure 7-3 Number of Rain Days of Various Magnitudes for Cooranbong (Avondale) Station

As shown in Figure 7-3, 17% of days per year (or 62 days) receive between 0.1 mm and 5 mm of rainfall. Daily rainfall depths are greater than 10 mm for approximately 8% of the year (or 30 days per year) on average, with approximately 3% of days in the year (or 11 days) receiving greater than 25 mm of rain.

A comparison of average monthly rainfall recorded at the Cooranbong (Avondale) BOM station and the corresponding SILO Patched Point Data is presented in Figure 7-4. The figure indicates that the interpolated SILO data reasonably represents the historical recorded rainfall from the BOM station.

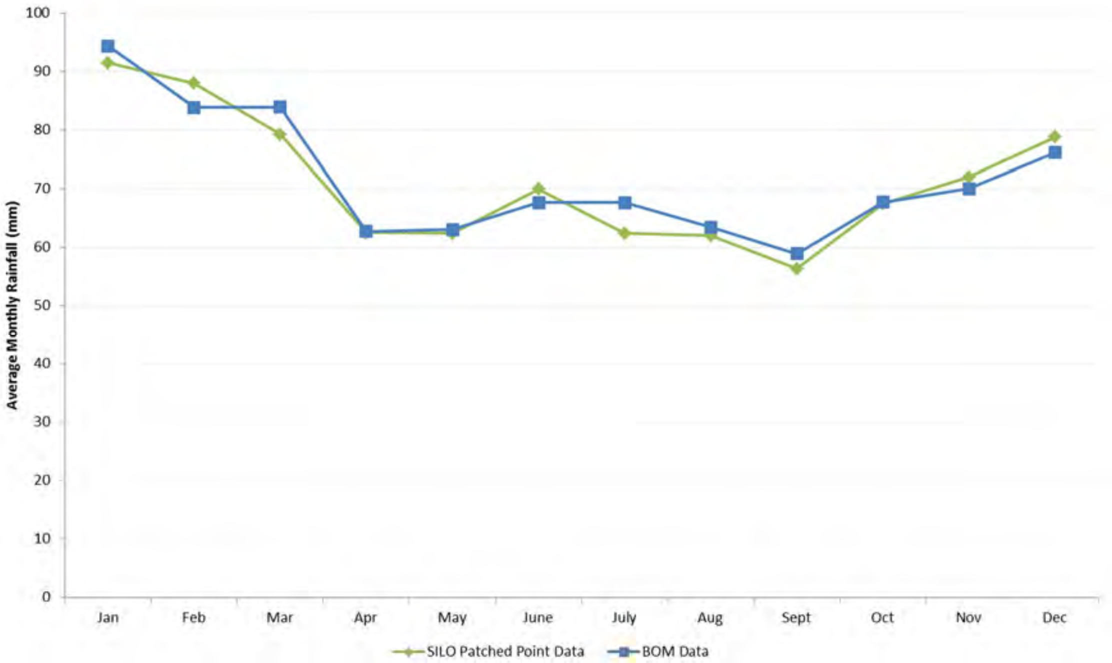


Figure 7-4 Comparison of Average Monthly Rainfall Data from BOM and SILO Patched Point Data for Cooranbong (Avondale) Station

7.1.2 Evaporation

Information provided at the closest BOM site which records evaporation, Peats Ridge Station (station number 61351), was reviewed and average monthly evaporation rates determined for input to the water balance. The average daily evaporation adopted for the water balance is presented in Figure 7-5.

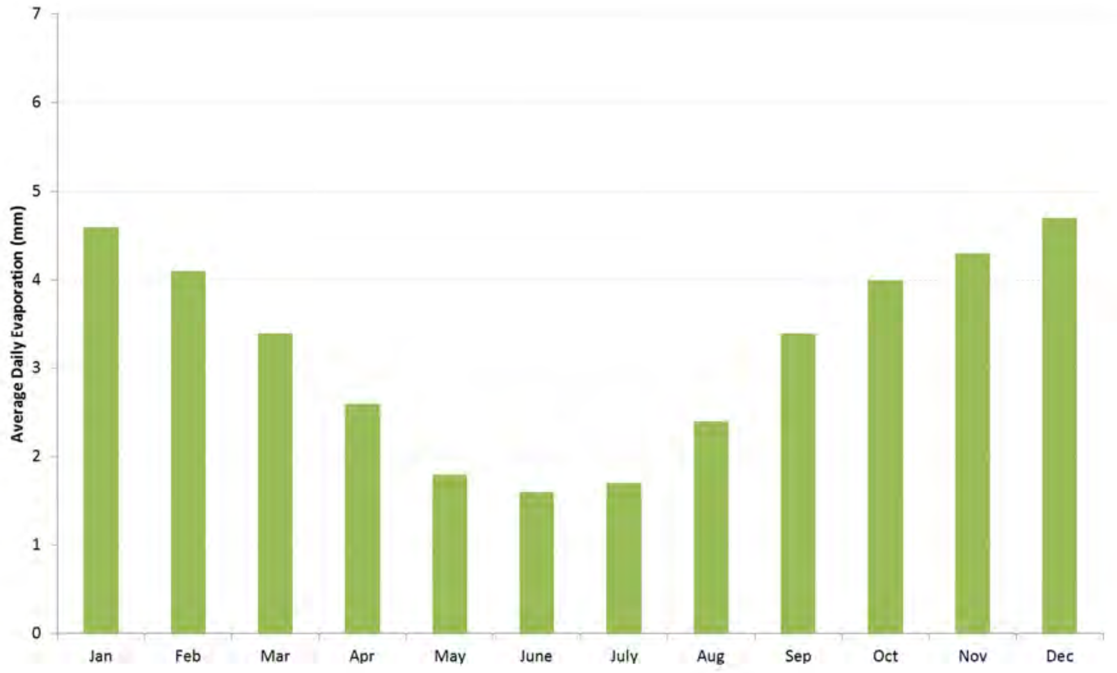


Figure 7-5 Average Daily Evaporation Each Month from Peats Ridge Station

A pan factor of 0.9 was applied to the daily evaporation rates to simulate the evaporation of water from surface storages. Evapotranspiration factors were applied in the hydrologic model to simulate evapotranspiration losses from impervious and vegetated catchments.

7.1.3 Hydrologic Model Data

The relevant site catchments were divided into two areas representing bushland/vegetation and impervious areas. The areas were modelled with a different set of AWBM parameters for sites with modelled catchment runoff contributing to surface water storages. The AWBM parameters adopted for the water and salt balance are presented in Table 7-1.

The parameters for bushland/vegetation areas were determined based on available literature where historical streamflow data had been used to provide recommendations on parameter selection. The nearest location for which AWBM parameters have been determined by Boughton and Chiew (2003) was Jigadee Creek, located approximately 30 km south-west of Newcastle. The recommended parameters relating to baseflow were adjusted to reflect the ephemeral nature of drainage lines adjacent to the sites.

The impervious areas were modelled without infiltration into the soil and without surface storage or baseflow storage. Only one storage was assigned a non-zero capacity. This storage represents depression storage of 5 mm for impervious areas. The baseflow parameters were adjusted to reflect no baseflow as the relevant site catchments are not typically large enough to generate baseflow.

The runoff for each relevant catchment was then calculated by scaling the runoff depth to reflect the sub-catchment bushland/vegetation area and impervious area. The runoff parameters were considered reasonable given a lack of site-specific flow gauging data in the region and the significant variability in catchment runoff characteristics that can occur.

A sensitivity analysis of the most sensitive AWBM parameters was undertaken to ensure that the results of the water and salt balance model were not significantly affected by uncertainty in the adopted AWBM parameters. The results of the sensitivity analysis are provided in Appendix D.

Table 7-1 Australian Water Balance Model Parameters

Parameter	Bushland/vegetation areas	Impervious areas
A_1, A_2, A_3	0.134, 0.433, 0.433	1.0, 0.0, 0.0
C_1, C_2, C_3	3.75, 38.1, 76.2	5.0, 0.0, 0.0
BFI	0.0	0.0
Excess	Calculated	Calculated
SS	(1-BFI) x Excess	(1-BFI) x Excess
BS	BFI x Excess	BFI x Excess
K_b	N/A	N/A
K_s	0.5	0.0

7.1.4 Lake Macquarie Catchment Data

The creek sub-catchments for the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources that contribute to Lake Macquarie were delineated and are summarised in Appendix C. The development footprint of each of the sites assessed as part of the regional water and salt balance are also provided in Appendix C.

To determine the salt load contributing to Lake Macquarie associated with catchment runoff, background water quality data, discussed in Section 5.2, was assessed to characterise the sub-catchments within the Dora Creek, North Lake Macquarie and South Lake Macquarie water source. From this characterisation, indicative salinity of runoff from each water source was estimated.

Dora Creek water source was estimated to have a median surface water conductivity of 355 µS/cm. This estimate was based on available monitoring data at Dora Creek, Lords Creek and Stockton Creek. The typical range in results from the monitoring data available was between 28 µS/cm and 1,860 µS/cm. Periods were observed where EC peaked between 4,000 µS/cm and 7,000 µS/cm within Stockton Creek.

The North Lake Macquarie water source was estimated to have a median surface water conductivity of 233 µS/cm, based on data from Stockyard Creek, Puntei Creek, Kilaben Creek, LT Creek and Stony Creek. EC for this water source was observed to range between 67 µS/cm and 1,000 µS/cm.

The South Lake Macquarie water source had limited water quality data available for waterways unaffected by industry. Of the data available, EC was observed to range from 90 µS/cm and 550 µS/cm. The EC used to represent the salt load associated with runoff from this source was determined as 550 µS/cm, given the dominant presence of estuarine environments that are present between Lake Macquarie and Tuggerah Lakes in the south.

7.2 Operational Timeline

The water and salt balance model simulates the conditions at each site from 2014 to 2050. As the operational conditions at each site were not specifically available for all sites over this timeframe, several assumptions have been made with respect to each site's operational phases over this time. A summary of the assumed operational phases for each site is provided in Figure 7-6.

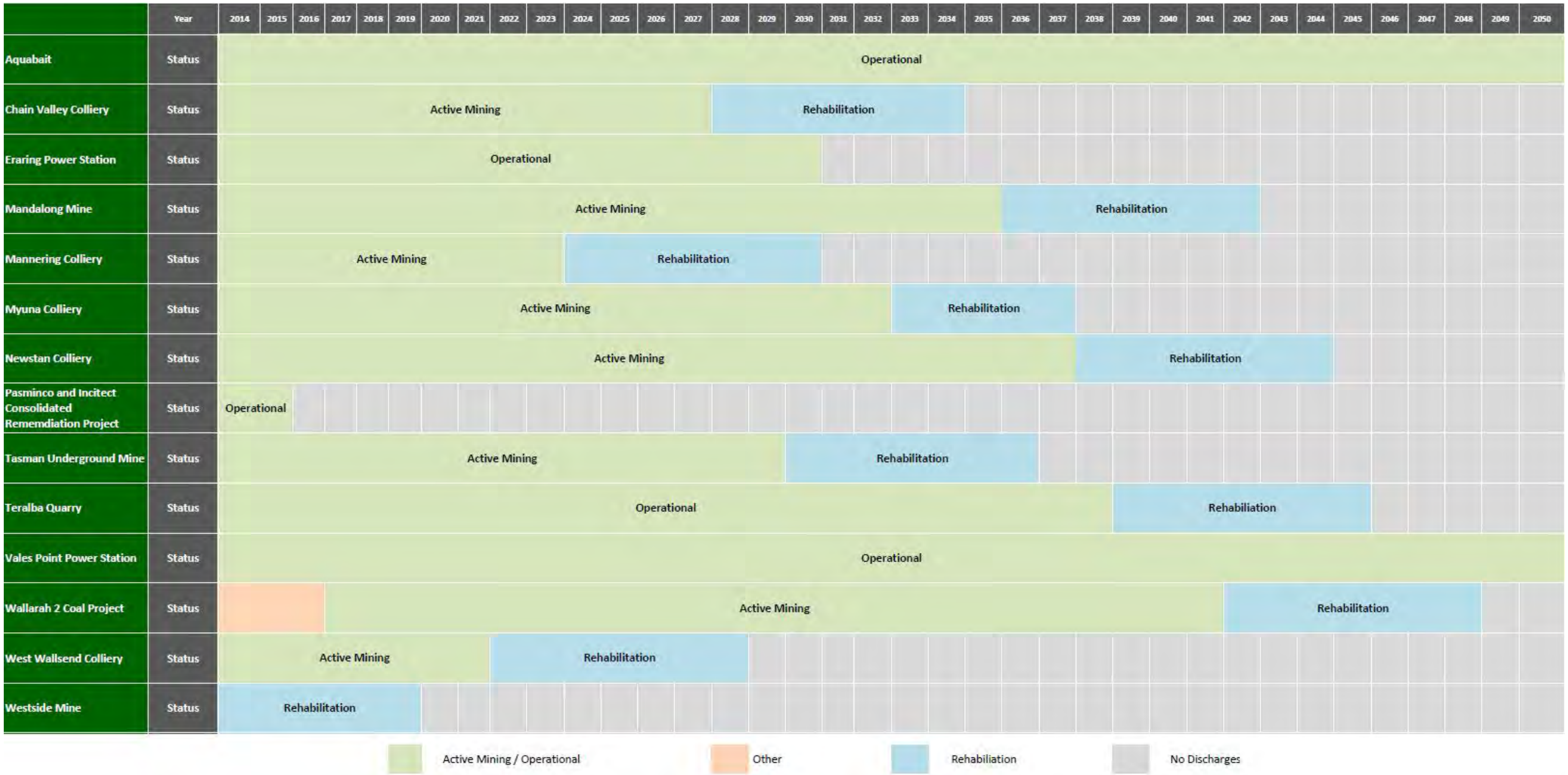


Figure 7-6 Operational Timeline

7.1 Site-Specific Data

7.1.1 Salinity Data

A summary of the site-specific salinity data incorporated into the water and salt balance model is provided in Appendix E. Data was sourced from available information, typically water quality monitoring data, and the salinity values applied to corresponding water transfers were assessed on a site-by-site basis. Generally, average values were applied; however maximum values were used on occasion where deemed appropriate.

7.1.2 Centennial-Owned Sites

The sources of data used for Centennial-owned sites in the regional water and salt balance are presented in Appendix F.

Mandalong Mine

Mandalong Mine is currently seeking approval for the continuation of underground mining operations using a combination of continuous miner and longwall mining methods.

GHD has developed a detailed site water and salt balance for Mandalong Mine in GoldSim, which simulated the complete water and salt cycles at the site (GHD, 2013b). The water and salt balance assumed the site would commence operations of the proposed project in 2015 and continue for a period of 25 years.

Underground mining undertaken as part of the proposed project is expected to produce groundwater inflows in the order of up to 5.9 ML/day. These estimates were made using hydrogeological modelling for Mandalong Mine and the Mandalong Southern Extension Area previously developed by GHD (2013c). The predicted groundwater inflows obtained from the MODFLOW three-dimensional numerical model over the period 2014 to 2050 were incorporated into the water and salt balance model in GoldSim. The existing hydrogeological model was extended to run from 2050 to 2200 to assess recovery and re-pressurisation of the coal seam. It was assumed that the mine workings stay dewatered throughout the working life of the mine (i.e. up to 2036 for Mandalong). The in situ moisture associated with ROM coal extracted at the mine was also considered to be groundwater extraction.

Groundwater inflows enter the underground water system at Mandalong Mine throughout various areas in the active and old underground workings. Water from these areas is transferred to the surface at the Cooranbong Entry Site prior to discharge off-site through an LDP in the Dora Creek Water Source. Other discharges through LDPs at Mandalong Mine are a result of overflows from surface water collection system, which are also located in the Dora Creek Water Source. As the rehabilitation phase has been assumed to last seven years, LDP discharges from Mandalong Mine were modelled to cease from 2043.

Mannering Colliery

Mannering Colliery currently has approval to extract up to 1.1 Mtpa of ROM coal. The colliery moved to a care and maintenance phase in January 2013, during which mining operations ceased. In October 2013, Centennial Mannering entered into a production sharing arrangement with LDO’s Chain Valley Colliery. LDO has assumed responsibility for site activities for the ten year duration of the Mining Cooperation Deed, until 2023.

GHD has developed a detailed site water balance for Mannering Colliery in GoldSim, which simulated the complete water cycle at the site (GHD, 2013d). A salt balance was developed as an extension to the water balance, with transfers of salt loads throughout the site modelled. The water and salt balance assumed the site would recommence operations in 2014 at the maximum ROM coal production rate and continue until the end of the Mining Cooperation Deed with LDO in 2023.

Groundwater is intercepted at Mannering Colliery by underground mining activities, resulting in the extraction from the North Coast Fractured and Porous Rock groundwater source. Groundwater inflows were estimated from the observed inflow data and modelling assumed these inflows were constant over the life of mining. Due to uncertainty regarding the future extent of mining at this site, only the currently approved mining areas were considered. The in situ moisture associated with ROM coal extracted at the mine was also considered as groundwater extraction.

Groundwater extractions into the workings are pumped to the surface for discharge off-site through an LDP to the South Lake Macquarie surface water source. Discharges through one other LDP at Mannering Colliery are a result of overflows from the surface water collection system and also discharge into the South Lake Macquarie surface water source. The water and salt balance model assumed that rehabilitation would commence in 2023 and continue for a period of seven years until 2030.

Myuna Colliery

Myuna Colliery currently has approval to extract up to 2 Mtpa of ROM coal using bord and pillar mining methods.

GHD has developed a detailed site water and salt balance for Myuna Colliery in GoldSim, which simulated the complete water and salt cycles at the site (GHD, 2013e). The water and salt balance assumed the site would continue underground mining until 2032, which is the end of the current mining approval, at the maximum ROM coal production rate.

A MODFLOW hydrogeological model was developed by GHD to estimate groundwater inflows into the workings for all three seams. The model could not be calibrated under steady state conditions due to the absence of monitoring bore data (the mine is entirely under Lake Macquarie) however material properties adopted for other models in the Study Area were adopted for this model. The transient model was calibrated using dewatering data over the period 2010 to 2013. It was assumed that all groundwater inflow is removed from the underground workings.

The transient hydrogeological model was run between 1980 and 2200 for annual stress periods and an annual time step. It was assumed that future workings within each seam would cover approximately 2.5 million m^2. This was calculated from the tonnage of coal reserves remaining, the bulk density of coal (0.83 tonnes/m^3) and an average coal seam thickness of 3 m. It was assumed that the future workings in each year would be a constant volume until the end of 2032. The in situ moisture associated with ROM coal extracted at the mine was also considered as groundwater extraction.

Groundwater extractions into the workings are pumped to the surface for discharge off-site through an LDP to the North Lake Macquarie surface water source. Discharges through one other LDP at Myuna Colliery are a result of overflows from the surface water collection system and also discharge into the North Lake Macquarie surface water source. The water and salt balance model assumed that rehabilitation would commence in 2032 and continue for a period of five years until 2037, as specified in the Statement of Commitments in the *Myuna Colliery Extension of Mining Environmental Assessment* (AECOM, 2011).

Newstan Colliery

Newstan Colliery is currently seeking approval for the continuation and expansion of underground mining operations and an increase in coal extraction up to 4.5 Mtpa of ROM coal.

GHD has developed a detailed site water and salt balance for Newstan Colliery in GoldSim, which simulated the completed water and salt cycles at the site (GHD, 2013f). The water and salt balance assumed the site would commence operations of the proposed project in 2019 and continue for a period of 30 years.

Groundwater inflows into the West Borehole Seam were estimated using an existing hydrogeological model previously developed by GHD (2013g). The predicted groundwater inflows obtained from the MODFLOW three-dimensional numerical model over the period 2014 to 2050 were incorporated into the water and salt balance model in GoldSim. The transient model was extended to run from 2050 to 2200 to assess recovery and re-pressurisation of the coal seam. It was assumed that the West Borehole Seam would remain dewatered until the end of active mining (i.e. up to 2038) while dewatering of the Fassifern Underground Storage via the Fassifern No. 1 Bore would continue until the end of the rehabilitation period

Groundwater extraction at Newstan Colliery included the inflows into the active underground workings within the West Borehole Seam, inflows and rainfall infiltration to Fassifern Underground Storage and the in situ moisture associated with ROM coal extracted. Rainfall infiltration and in situ coal moisture were modelled to cease from 2038 when mining is assumed to cease.

Groundwater inflows into the active underground workings are transferred to the surface for treatment and discharged off-site through an LDP to the North Lake Macquarie surface water source. During wet periods when water inflows into the Fassifern Underground Storage exceed outflows, a relief pipeline discharges water directly through an LDP located in same surface water source. Discharges through other LDPs at Newstan Colliery are a result of overflows from the surface water collection system and discharge into the Dora Creek water source and North Lake Macquarie water source. All discharges were modelled to decrease from 2038 when rehabilitation was assumed to commence.

7.1.3 Non-Centennial Sites

Aquabait

Aquabait is an aquaculture face located adjacent to Eraring Power Station that breeds and sells marine worms. Currently, Aquabait extract water from the cooling water inlet channel to Eraring Power Station. Overflow from settlement ponds is discharged through a single LDP back into the cooling water inlet channel.

An estimate of the surface water extractions and discharges at Aquabait was determined from the discharge limit of 10 ML/day specified by EPL 11259. Although there was limited publicly available information relating to water management at Aquabait, the site was included in the regional water and salt balance due to the relatively large discharge limit imposed by the EPL. The maximum volume of 10 ML/day was assumed to be extracted from and discharged to the cooling water inlet channel to Eraring Power Station, which is located in the Dora Creek water source. Aquabait was assumed to operate for the entire simulation period from 2014 to 2050.

Chain Valley Colliery

Chain Valley Colliery currently has approval to extract up to 1.5 Mtpa of ROM coal using bord and pillar and miniwall mining methods.

An existing water balance model was not available for Chain Valley Colliery. An understanding of water management at the site was developed from a review of the following documents:

- *Chain Valley Colliery: Water Management Plan* (GSS Environmental, 2012).
- *Chain Valley Colliery Mining Extension 1 Project: Surface Water Assessment* (GSS Environmental, 2013).

Groundwater inflows into the mine workings were estimated from existing dewatering volumes and peak groundwater inflows of 10.5 ML/day reported by GeoTerra (2013). It was assumed that recovery of the coal seam would take place over a 20 year period from the end of active mining in 2027.

GSS Environmental (2012) reported that a comparison of the expected LDP discharge volume with mine dewatering rates indicate that approximately 98% of the volume of discharges off-site are attributable to groundwater inflows into the underground workings. Due to the large contribution of groundwater to the estimated LDP discharge, it is not expected to vary significantly with rainfall. The assumed value adopted for modelling of LDP discharges for current and future conditions is 10.7 ML/day, based on the average daily LDP discharge predicted by GSS Environmental (2013). It should be noted that this volume is a conservative estimate based on the predicted peak groundwater inflow rates expected to occur on occasions in the later stages of mining at Chain Valley Colliery (GSS Environmental, 2013).

The water and salt balance assumed Chain Valley Colliery would continue underground mining until 2027, which is the end of the current mining approval. Rehabilitation was assumed to last seven years, with LDP discharges modelled to cease from 2034.

Eraring Power Station

Eraring Power Station has a once-through cooling water system that uses water drawn from Lake Macquarie to provide a continuous supply of water to the condensers of the power station. Additional water is required for attemperation prior to discharge into Lake Macquarie to control water temperature by combining the cooler inlet canal water with the warmer water exiting the condensers.

An existing water and salt balance model was not available for Eraring Power Station. An understanding of the site water management was developed from a review of the following documents:

- *Environmental Assessment – Eraring Energy Capacity Increase and Attemperation Reservoir* (HLA-Envirosciences, 2007a).
- *Cooling Water Attemperation Reservoir Assessment – Eraring Energy Capacity Increase and Attemperation Reservoir* (HLA-Envirosciences, 2007b).

The maximum volume of cooling water extracted from Lake Macquarie by Eraring Power Station is 11,000 ML/day, determined by the capacity of six pumps located in the cooling water inlet canal (HLA-Envirosciences, 2007a). It was assumed that all water entering the cooling water system discharges into the cooling water outlet canal through an LDP into Lake Macquarie within the North Lake Macquarie water source. It should be noted that this assumption is conservative as in reality the demand from Eraring Power Station for cooling water would vary depending on operational needs. Discharges from the site were assumed to cease with the decommissioning of Eraring Power Station, reported to occur in 2030 (HLA-Environsciences, 2007c).

Although Eraring Power Station has another LDP located on the outflow of the ash dam north east of the power station, limited information was available on the volumetric discharges from the site. Discharges have been reported as mostly generated by stormwater runoff and are not expected to be significant in relation to other discharges entering the catchment. Therefore, surface water discharges from Eraring Power Station in addition to cooling water discharges have not been included in the regional water and salt balance model.

Frazer Park Quarry

There was limited publicly available information about Frazer Park Quarry, particularly regarding the water management at the site. The EPL held by Frazer Part Quarry indicates that the site has two LDPs which discharge water from settling dams. These LDPs have no volumetric limits imposed by the EPL. However, aerial images and topographical information indicate that discharges from Frazer Park Quarry most likely discharge to the Tasman Sea. Therefore, the site has been assumed to have no net impact on the Lake Macquarie catchment and has not been included in the regional water and salt balance.

Nu-Rock Resource Recovery Facility

Nu-Rock Resource Recovery Facility is a proposed resource recovery facility located within the grounds of Eraring Power Station. An EIS for the project is anticipated to be publicly exhibited in 2014 and include a detailed site water balance, as required by the DGRs for the project. Due to the limited information currently publicly available, the site has been excluded from the regional water and salt balance.

Pasminco and Incitec Consolidated Remediation Project

The Pasminco and Incitec Consolidation Remediation Project involves the remediation of contaminated lands at the former Pasminco Cockle Creek Smelter and former Incitec Fertiliser Cockle Creek site.

An existing water and salt balance model was not available for the Pasminco and Incitec Consolidation Remediation Project. An understanding of the site water management was developed from a review of the following documents:

- *Remediation Action Plan: Pasminco Cockle Creek Smelter Site, Boolaroo, NSW* (Fitzwalter Group, 2005).
- *Site Audit Report: Review of Proposed Groundwater Remediation and Monitoring – Pasminco Cockle Creek Smelter Site* (HLA-Envirosciences, 2005).
- *Environmental Assessment Report for the Pasminco Cockle Creek Smelter Site Remediation Project* (Fitzwalter Group, 2006).
- *Water Quality and Water Cycle Management Report: Pasminco Cockle Creek Smelter* (Maunsell Australia, 2006).
- *Cockle Creek Stage 1: Environmental Assessment* (Manidis Roberts, 2008).
- *Environmental Assessment of the Combined Pasminco Cockle Creek Smelter Pty Ltd and Incitec Fertiliser Pty Ltd Remediation Project* (WSP Environment and Energy, 2012).

The water management system at the Pasminco and Incitec Consolidated Remediation Project currently involves several surface water storages that collect surface water runoff from the site. Water is treated within an effluent treatment plant on-site prior to discharge through an LDP located in the North Lake Macquarie water source. LDP discharges were modelled as the capacity of the effluent treatment plant of 90 m^3/hr (2.16 ML/day). Discharges from the Pasminco and Incitec Consolidated Remediation Project were assumed to continue until the end of 2015, which is the end of the current project approval.

As part of the Pasminco and Incitec Consolidated Remediation Project, groundwater is extracted and treated prior to being discharged to the surface where it infiltrates into a shallow aquifer. The groundwater is extracted from the Sydney Basin North Coast groundwater source and was estimated at approximately 0.1 ML/day (Fitzwalter Group, 2005; HLA-Envirosciences, 2005).

Tasman Underground Mine

Tasman Underground Mine currently has approval to extract up to 1.5 Mtpa of ROM coal using bord and pillar methods.

An existing water balance model was not available for Tasman Underground Mine. An understanding of water management at the site was developed from a review of the *Tasman Extension Project: Surface Water Assessment* (Evans and Peck, 2012), prepared as part of the Tasman Extension Project approved in March 2013.

Groundwater extraction volumes over the life of the mine were predicted by RPS Aquaterra (2012) using a calibrated MODFLOW-SURFACT groundwater model. Groundwater inflows to the Tasman Underground Mine are predicted to peak at approximately 1.35 ML/day in 2024 (RPS Aquaterra, 2012). Groundwater intercepted by underground mining activities is extracted from the Sydney Basin North Coast groundwater source. It was assumed that re-pressurisation of the coal seam would occur over a 30 year period from 2035 to 2065.

The water collected in surface water storages, including groundwater inflow into the active underground workings transferred to the surface, is discharged into historic underground workings in the West Borehole Seam. Water is not currently discharged to surface water sources via an LDP and therefore no discharges have been included in the water and salt balance modelling for Tasman Underground Mine.

Teralba Quarry

An existing water and salt balance model was not available for Teralba Quarry. An understanding of the site water management was developed from a review of the following documents:

- *Surface Water Assessment* (BMT WBM, 2011).
- *Environmental Assessment for the Teralba Quarry Extensions* (RWC, 2011).

Surface water discharge from Teralba Quarry occurs through one LDP into the North Lake Macquarie water source of 2,413 ML/year. This was adopted from the results of the water balance presented by BMT WMB (2011). The water and salt balance model assumed that operations at the quarry would continue until 2038, which is the end of the current project approval. As the rehabilitation phase has been assumed to last seven years, LDP discharges were modelled to cease in 2045.

Groundwater at Teralba Quarry is extracted from the Sydney Basin North Coast groundwater source via inflows from the Great Northern Seam into the old underground workings at Rhonnda Colliery which flow into the Mine Adit Dam at the quarry. According to the results of the water balance presented by BMT WMB (2011), the average groundwater inflow into the Mine Adit Dam is 2,835 ML/year. It has been assumed that this groundwater inflow is maintained until the end of the rehabilitation phase in 2045, at which time it is assumed that the mine adit would be sealed and groundwater flows to the surface would cease.

Vales Point Power Station

Similar to Eraring Power Station, Vales Point Power Station has a once-through cooling water system that uses water drawn from Lake Macquarie to provide a continuous supply of water to the condensers of the power station. Water from Lake Macquarie is pumped through the condensers via an inlet canal and returns to the lake through an outlet canal.

An existing water and salt balance model was not available for Vales Point Power Station. An understanding of the site water management was developed from a review of the following documents:

- *Hydraulic Model Investigation of Cooling Water Screen Chamber: Vales Point Power Station, NSW* (Dudgeon, 1960).
- *Vales Point Power Station* (Electricity Commission of New South Wales, 1964).
- *Your Guide to Vales Point Power Station* (Electricity Commission of New South Wales, 1969).
- *Trace Element Removal Techniques with Iron Oxyhydroxides and the Adsorption/Co-Precipitation Removal Mechanism* (Laucht, 2011).

Vales Point Power Station discharges water through three LDPs located in the South Lake Macquarie water source. Discharges from the power station were assumed to occur for the entire simulation period from 2014 to 2050.

The maximum volume of cooling water extracted from Lake Macquarie was assumed to be 6,500 ML/day, with all extracted water assumed to be discharged back into the lake through an LDP. This estimate was based on the discharge limit specified in EPL 761. It should be noted that this assumption is conservative as in reality the demand from Vales Point Power Station for cooling water would vary depending on operational needs.

Discharge from the ash water recycling system to Lake Macquarie via the cooling water outlet canal through an LDP was assumed to range between 9 ML/day and 63 ML/day, based on recorded discharges between 1997 and 2009 (Laucht, 2011). The estimated discharges were interpolated to provide daily discharge values in response to modelled rainfall.

Licensed discharges through one other point at Vales Point Power Station were modelled as the maximum discharge limit imposed by EPL 761. The application of effluent from the Ash Dam located to the east of the dam was assumed to be 0.38 ML/day.

Wallarah 2 Coal Project

The Wallarah 2 Coal Project is a proposed underground coal mine located on the border of the HUA WSP with the Central Coast Unregulated Water Sources WSP. Water is not expected to be discharged to surface water sources within the HUA WSP. Only groundwater extraction has been considered and predicted inflows have been sourced from the hydrogeological modelling report prepared for the project (MER, 2013). Following the completion of mining in year 28, it was assumed that re-pressurisation would follow a similar pattern to that modelled by GHD for Mandalong Mine since the Wallarah 2 Coal Project proposes to extract coal from the West Wallarah Seam.

Westside Mine

Westside Mine is a former open cut coal mine that ceased mining operations in 2012 with progressive rehabilitation of the site continuing.

An existing water and salt balance model was not available for Westside Mine. An understanding of the site water management was developed from a review of the following documents:

- *Westside Mine Final Void Management Plan* (GHD, 2010).
- *Water Management Plan: West Wallsend Colliery* (Xstrata Coal, 2013a).

Westside Mine discharges water through five LDPs located within the North Lake Macquarie water source. The water management system at the mine primarily involves several surface water storages that collect surface water runoff from the site and overflow through LDPs (Points 2, 3, 5 and 6). Point 4 at Westside Mine discharges excess water from the underground workings at West Wallsend Colliery. Discharge through all LDPs at Westside Mine is monitored daily and recorded volumes from April 2012 to January 2014 were reviewed to determine daily discharge volumes per daily rainfall percentile. The values presented in Table 7-2 were incorporated into the regional water and salt balance. It should be noted that no discharges were recorded below the 35th percentile of rainfall.

GHD (2010) calculated groundwater inflow into the final void to vary from 2.1 ML/year to 4.7 ML/year, depending on the water level in the void. Once the void is full, it is assumed that there is no further groundwater inflow into the void.

All discharges from Westside Mine occur in the North Lake Macquarie water source and groundwater extraction occurs from the Sydney Basin North Coast groundwater source. Rehabilitation was assumed to last for seven years, with LDP discharges from Points 2, 3, 5 and 6 modelled to cease from 2020. Discharges from Point 4 of underground water from West Wallsend Colliery were modelled to cease from 2022, which is the end of the current mining approval for West Wallsend Colliery.

Table 7-2 Westside Mine Surface Water Discharge Volumes

Daily rainfall statistic	Point 2 (ML/day)	Point 3 (ML/day)	Point 4 (ML/day)	Point 5 (ML/day)	Point 6 (ML/day)
Minimum	0.000	0.000	0.000	0.000	0.000
30th percentile	0.000	0.000	0.000	0.000	0.000
35th percentile	0.000	0.000	0.079	0.000	0.000
40th percentile	0.000	0.000	1.500	0.000	0.000
45th percentile	0.000	0.000	3.000	0.000	0.000
50th percentile	0.000	0.000	4.350	0.000	0.000
55th percentile	0.000	0.000	4.845	0.000	0.000
60th percentile	0.000	0.000	5.000	0.000	0.000
65th percentile	0.000	0.000	5.200	0.000	0.000
70th percentile	0.000	0.000	5.300	0.000	0.000

Daily rainfall statistic	Point 2 (ML/day)	Point 3 (ML/day)	Point 4 (ML/day)	Point 5 (ML/day)	Point 6 (ML/day)
75th percentile	0.000	0.000	5.400	0.000	0.000
80th percentile	0.000	0.000	5.500	0.000	0.000
85th percentile	0.000	0.010	5.700	0.000	0.000
90th percentile	0.000	0.431	5.900	0.000	0.000
95th percentile	0.541	0.841	6.653	0.000	0.143
Maximum	2.540	4.330	10.700	2.017	5.790

West Wallsend Colliery

West Wallsend Colliery currently has approval to extract up to 5.5 Mtpa of ROM coal using longwall mining methods.

An existing water and salt balance model was not available for West Wallsend Colliery. An understanding of the site water management was developed from a review of the following documents:

- *Surface Water Assessment: West Wallsend Colliery Continued Operations Project* (Umwelt, 2010).
- *Water Management Plan: West Wallsend Colliery* (Xstrata Coal, 2013a).
- *West Wallsend Colliery Surface Water Management Plan* (Xstrata Coal, 2013b).

Water is discharged through three LDPs at West Wallsend Colliery, MCPP and Teralba Colliery. Discharge through all LDPs is monitored daily and recorded volumes from April 2012 to January 2014 were reviewed to determine daily discharge volumes per daily rainfall percentile. The values presented in Table 7-3 were incorporated into the regional water and salt balance. It should be noted that no discharges were recorded below the 20th percentile of rainfall.

Groundwater inflow into the Teralba Colliery underground workings was estimated to be 38 ML/week based on personal communication with the Operations Manager (Lawrie Ireland, personal communication, 25 February 2014). It was assumed that groundwater inflow would continue at this rate for a further 20 years after which re-pressurisation of the Teralba Colliery underground workings would follow a similar pattern to that modelled by GHD for the West Borehole Seam at Newstan..

Existing groundwater extraction by the West Wallsend Colliery underground workings was estimated to be 2.5 ML/day, based on available dewatering data. It was assumed that re-pressurisation would follow a similar pattern to that modelled by GHD for the West Borehole Sema at Newstan from the end of mining in December 2021.

All discharges from West Wallsend Colliery occur in the North Lake Macquarie water source and groundwater extraction occurs from the Sydney Basin North Coast groundwater source. Operations at West Wallsend Colliery were assumed to continue until the end of 2021, which is the end of the current mining approval. Rehabilitation was assumed to last for seven years, with LDP discharges modelled to cease from 2029.

Table 7-3 West Wallsend Colliery Surface Water Discharge Volumes

Daily rainfall statistic	Point 1 (ML/day)	Point 2 (ML/day)	Point 3 (ML/day)
Minimum	0.000	0.000	0.000
15th percentile	0.000	0.000	0.000
20th percentile	0.000	0.000	0.001
25th percentile	0.000	0.000	0.003
30th percentile	0.000	0.000	0.004
35th percentile	0.000	0.000	0.006
40th percentile	0.000	0.000	0.008
45th percentile	0.000	0.000	0.011
50th percentile	0.000	0.000	0.015
55th percentile	0.000	0.000	0.020
60th percentile	0.000	0.000	0.031
65th percentile	0.000	0.000	0.050
70th percentile	0.000	0.000	0.071
75th percentile	0.000	0.000	0.094
80th percentile	0.000	0.000	0.161
85th percentile	0.000	0.003	0.305
90th percentile	0.000	0.027	0.859
95th percentile	0.351	0.067	1.771
Maximum	5.039	9.295	5.819

8. Modelling Results

8.1 Interpretation of Results

8.1.1 Water Balance Results

The water management timeline was simulated using a historic time series of daily rainfall data extending over 113 years. A total of 113 simulations were applied to this timeline with each simulation modelling a different rainfall pattern (refer Section 6.1.1). As a result, for each year of the timeline 113 annual totals were available for each transfer element within the water management system, thereby representing a wide range of possible rainfall conditions.

The results of the water balance presented have been annualised per calendar year and show average annual volumes and 10th percentile and 90th percentile values. The purpose of displaying the three results for each element is to show an average annual volume as well as an indication of the possible range of volumes.

The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value. The 10th percentile and 90th percentile values have been used (rather than the minimum and maximum values) to remove the impact of skewing by infrequent to extreme wet and dry conditions.

8.1.2 Salt Balance Results

Similar to the water balance, the salt balance modelling provided 113 possible annual totals for each transfer element. The results presented show the average annual salt mass (and 10th percentile and 90th percentile values) for each of the water management elements. In addition, the average EC of each transfer is also presented.

8.1.3 Extraction/Discharge Graphs

Outputs from each site have been developed which summarise the annual licensed extractions and discharges by groundwater and surface water source from each site over the simulation timeline. The net extraction or discharge of each site is also provided which is equal to the estimated discharges through LDPs minus the estimated extractions. This provides an indication of the net water and salt consumption of each site and the net withdrawal or addition of water and salt removed from the water cycle on a site-by-site basis.

The estimated licensed extractions and discharges for each site were aggregated to provide the total estimated annual licensed extraction and discharge of sites in the Study Area for each water source. Results are provided for Centennial sites and total for all sites (i.e. Centennial-owned plus non-Centennial sites assessed).

8.2 Individual Site Results

8.2.1 Water Balance Results

The estimated volume of annual licensed water extractions and discharges for each groundwater and surface water source for each site are provided in Appendix F. The following three graphs are provided for each site, where appropriate:

- Licensed extraction by source.
- Licensed discharge by source.
- Net extraction or discharge.

The information presented in these graphs was aggregated into the results by water source provided in Section 8.3.1 and used to provide recommendations for current and future licensing requirements provided in Section 8.4.

8.2.2 Salt Balance Results

Similar to the water balance, the estimated mass of salt associated with annual water extractions and discharges from each groundwater and surface water source for each site are provided in Appendix H. The information presented in these graphs was aggregated into the results by water source provided in Section 8.3.2.

The average salinity of water extractions and discharges for each groundwater and surface water source for each site and each water source are also presented in addition to salt transfer quantities.

8.3 Water Source Results

8.3.1 Water Balance Results

Extractions from Groundwater Sources

The estimated annual extractions from groundwater sources in the Study Area between 2014 and 2050 are presented in Figure 8-1. The figure presents the contribution of Centennial-owned operations as well as the contribution of all assessed sites in the Lake Macquarie catchment.

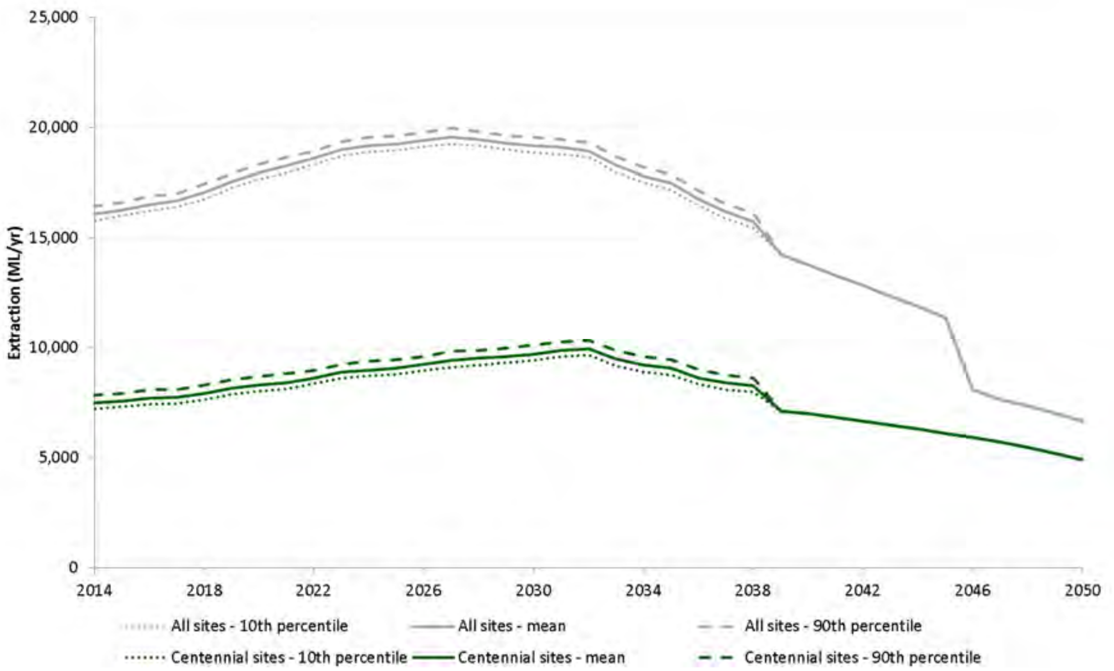


Figure 8-1 Sydney Basin North Coast Groundwater Source – Estimated Volume of Aggregate Extractions

As shown in Figure 8-1, current total extractions from the Sydney Basin North Coast groundwater source is estimated to be approximately 16,100 ML/year on average, of which approximately 7,500 ML/year on average is extracted by Centennial-owned sites. Peak extraction from the groundwater source is predicted to occur in 2027 at an average rate of approximately 19,600 ML/year. Extraction of groundwater from Centennial-owned sites is predicted to peak in 2032 at an average of approximately 9,900 ML/year. By the end of the assessment period in 2050, groundwater extraction from Centennial-owned sites is predicted to occur at an average rate of approximately 4,900 ML/year. There are no extractions from the alluvium within the HUA WSP from Centennial-owned or non-Centennial sites.

Groundwater extraction over the post-2050 re-pressurisation period was calculated separately from GoldSim. Six sites were considered in this assessment including Mandalong Mine, Myuna Colliery, Newstan Colliery, Tasman Underground Mine, Wallarah 2 Coal Project and West Wallsend Colliery. Predicted groundwater extraction from the Sydney Basin North Coast groundwater source over the period 2050 to 2200 is shown in Figure 8-2 and provides in indication of WAL requirements over this period.

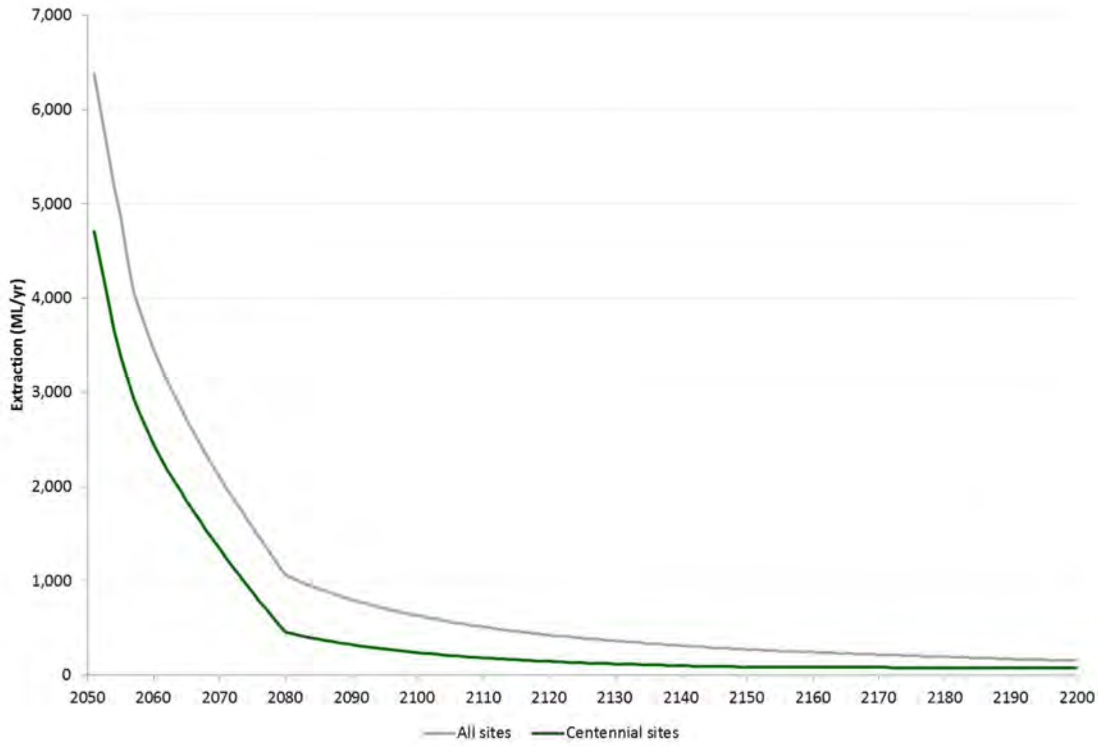


Figure 8-2 Estimated Volume of Groundwater Extraction for Recovery Period up to 2200

Figure 8-2 indicates that due to the nature and size of the underground mines assessed as part of the re-pressurisation assessment groundwater interception volumes are likely to be greater than 500 ML/year for approximately 30 years for Centennial sites specifically and for approximately 60 years for all sites assessed.

Discharges to Surface Water Sources

The estimated annual discharges of coal mining and other operations in the Study Area to surface water sources over the period from 2014 to 2050 are presented in Figure 8-3 to Figure 8-7. Each figure presents the contribution of Centennial-owned sites as well as the contribution of all assessed sites in the Study Area. For reference, these figures are also provided in Figure 8-10.

The information presented in these figures provides an indication of the distribution of extracted groundwater to surface water sources. It should be noted when reviewing these figures that catchment runoff to the LDPs contribute to the discharge and therefore estimated provided are not completely related to groundwater extractions.

It should be noted that for the results presented for discharges into the North Lake Macquarie and South Lake Macquarie water sources, two graphs are presented for each water source. This provides results with and without discharges from Eraring Power Station and Vales Point Power Station, as these sites contribute significantly larger volumes of water to each water source when compared to other sites assessed.

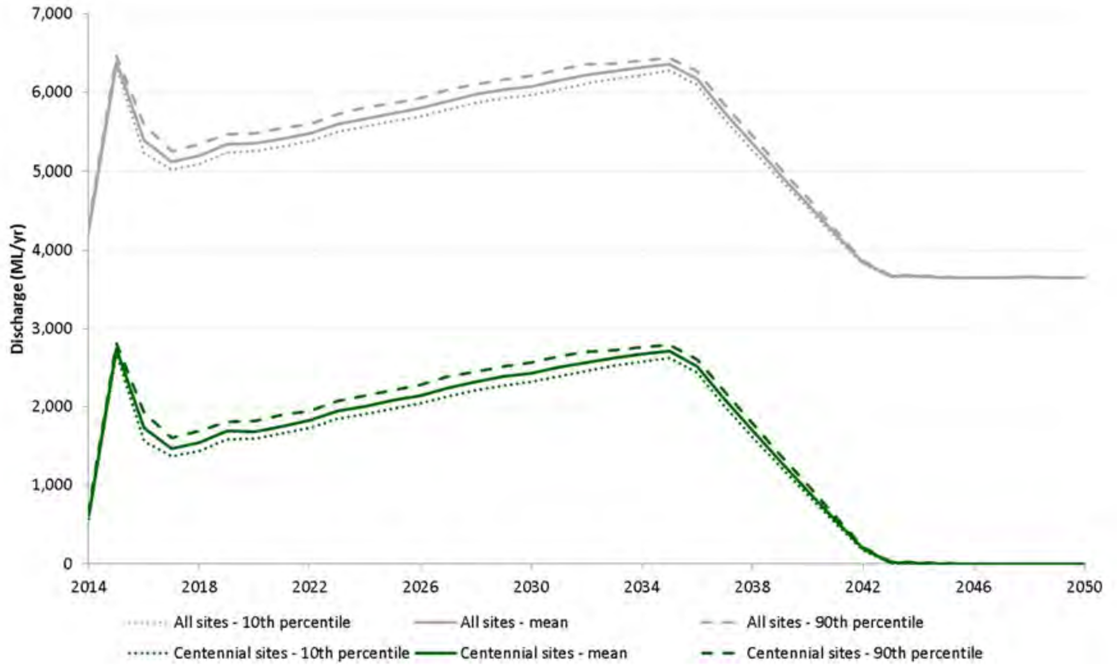


Figure 8-3 Dora Creek Water Source – Estimated Volume of Aggregate Discharges

As seen in Figure 8-3, discharges to the Dora Creek water source increase steadily from 2017, which is attributable to the expected gradual increase in discharge resulting from the expansion project at Mandalong Mine. Discharges decrease from 2036 with the assumed cessation of mining activities at Mandalong Mine. After 2043, the contribution of Centennial-owned sites to the water source is predicted to be minimal.

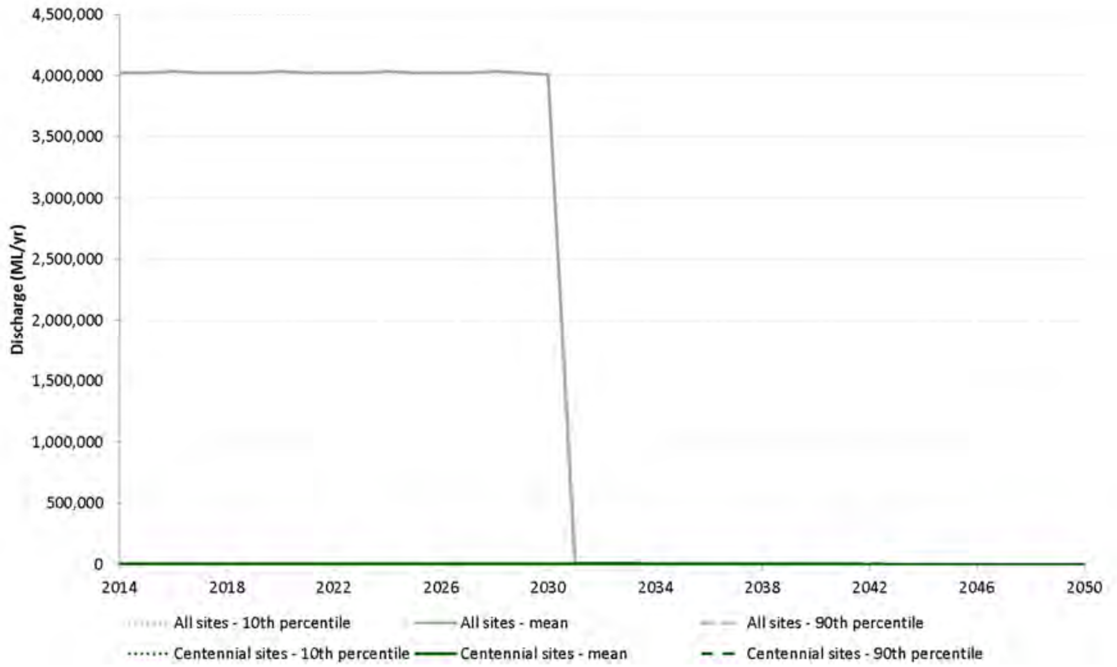


Figure 8-4 North Lake Macquarie Water Source – Estimated Volume of Aggregate Discharges

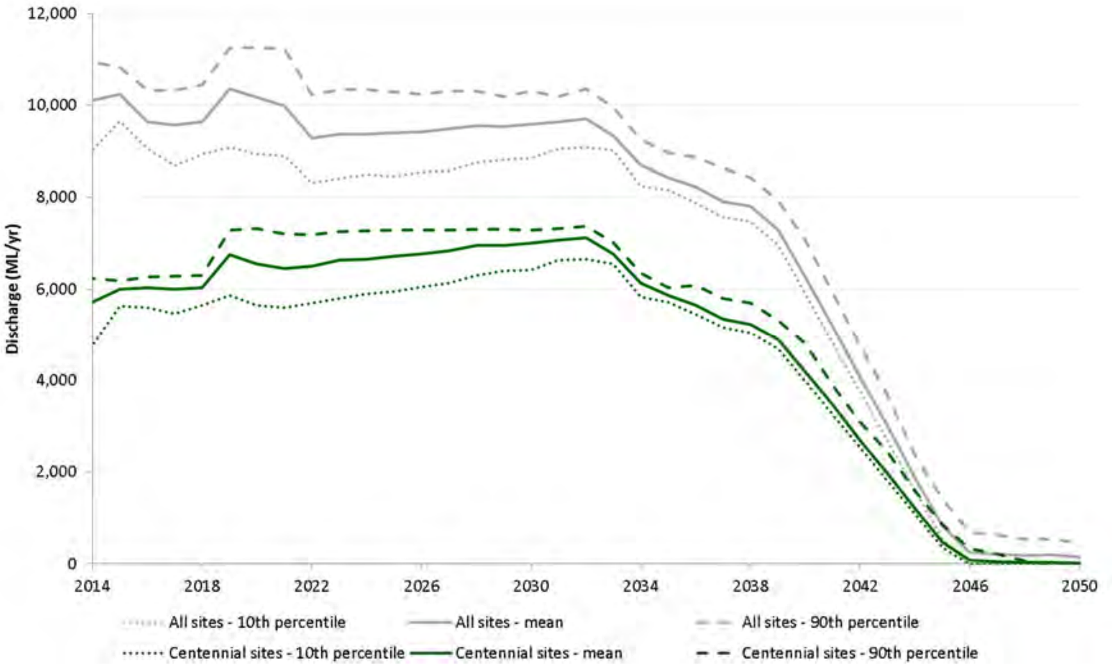


Figure 8-5 North Lake Macquarie Water Source – Estimated Volume of Aggregate Discharges (Without Contribution of Eraring Power Station)

As seen in Figure 8-4 and Figure 8-5, Eraring Power Station contributes significantly more discharges to the North Lake Macquarie water source than other sites. Discharges from the power station are predicted to cease after 2030 with the decommissioning of the facility. Discharges from all other sites are predicted to decrease over the simulation timeline, with minimal discharges to the water source after 2046.

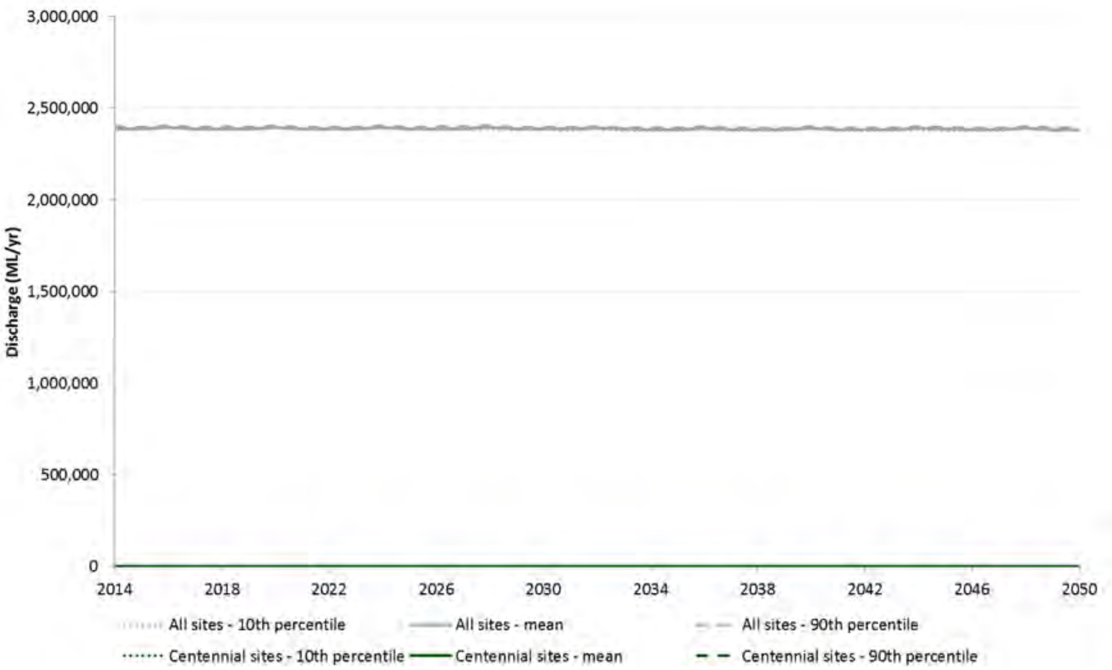


Figure 8-6 South Lake Macquarie Water Source – Estimated Volume of Aggregate Discharges

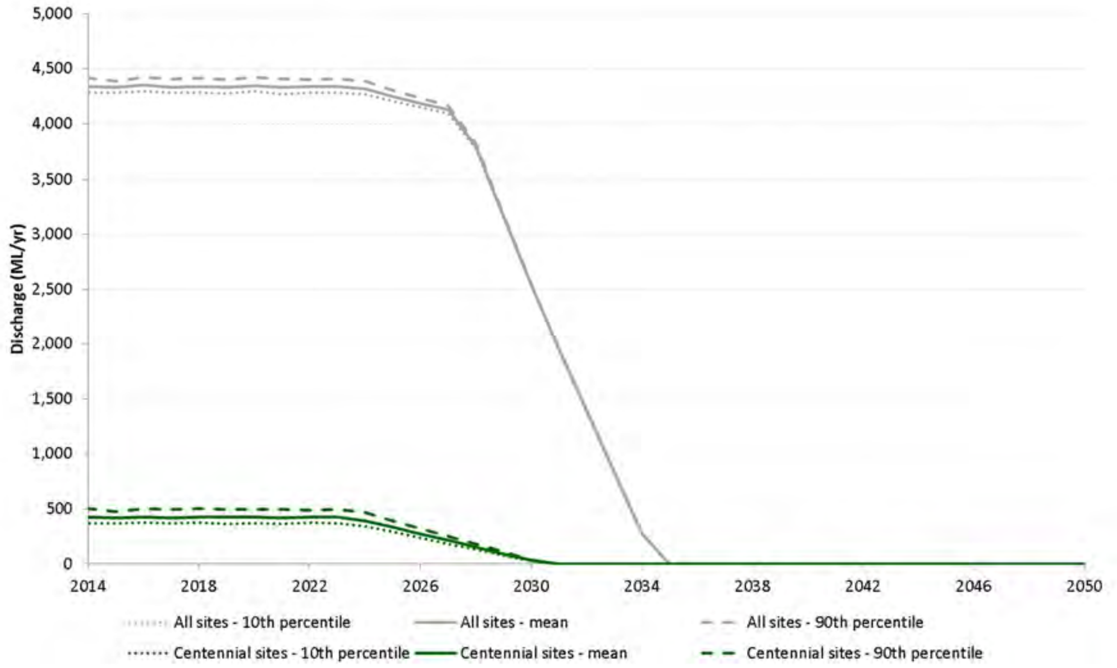


Figure 8-7 South Lake Macquarie Water Source – Estimated Volume of Aggregate Discharges (Without Contribution of Vales Point Power Station)

As shown in Figure 8-6, discharges from Vales Point Power Station dominate the total discharges to the South Lake Macquarie water source. Figure 8-7 presents the discharges contributing to the water source from all other sites. Discharges from Mannering Colliery, the only Centennial-owned site in the South Lake Macquarie water source, are expected to decrease to nil from 2031. Discharges from Chain Valley Colliery, the other site that contributes to the water source, are expected to cease from 2035.

The total estimated licensed discharge to all assessed water sources is presented in Figure 8-8. The volume of total discharges to surface water sources without the contribution of Eraring Power Station and Vales Point Power Station is presented in Figure 8-9.

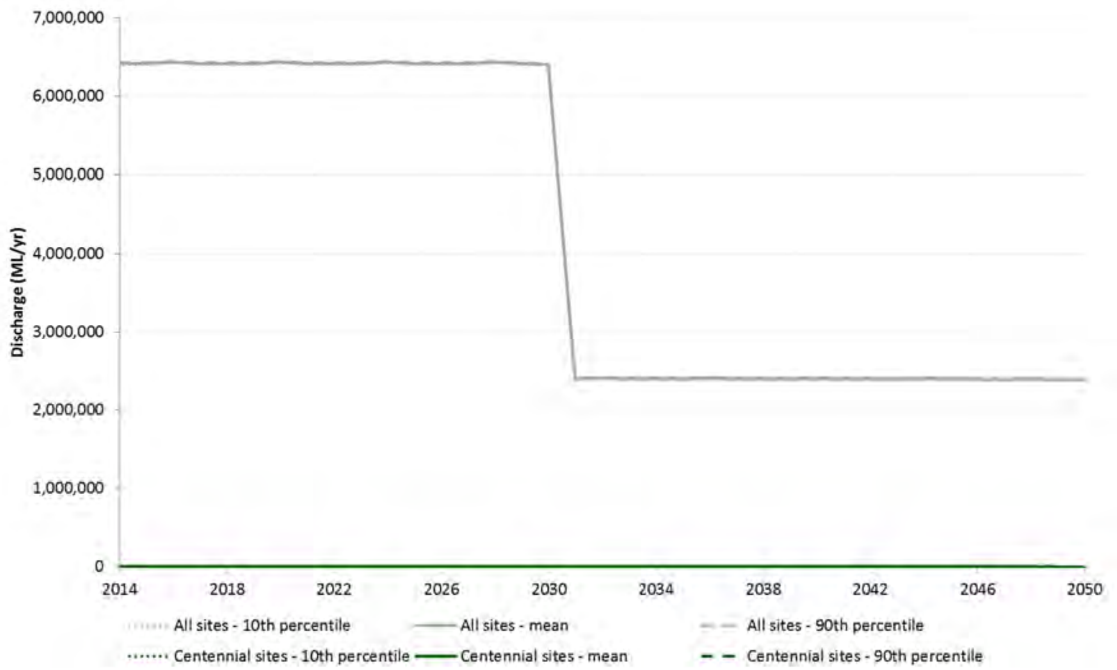


Figure 8-8 Volume of Total Discharges to Surface Water Sources

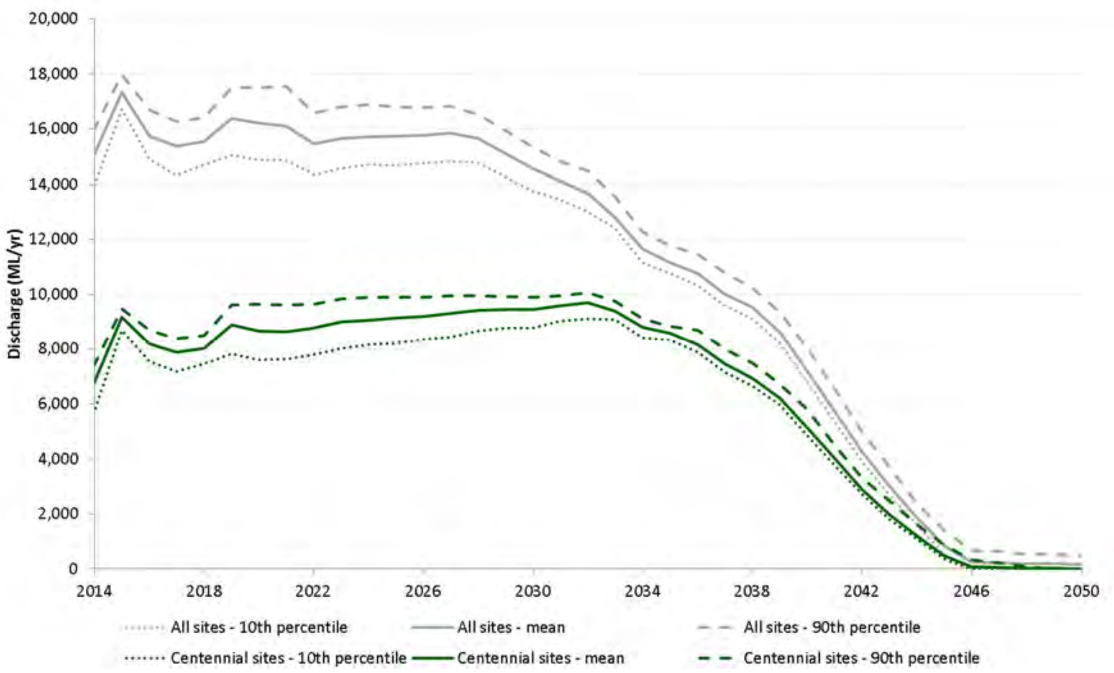
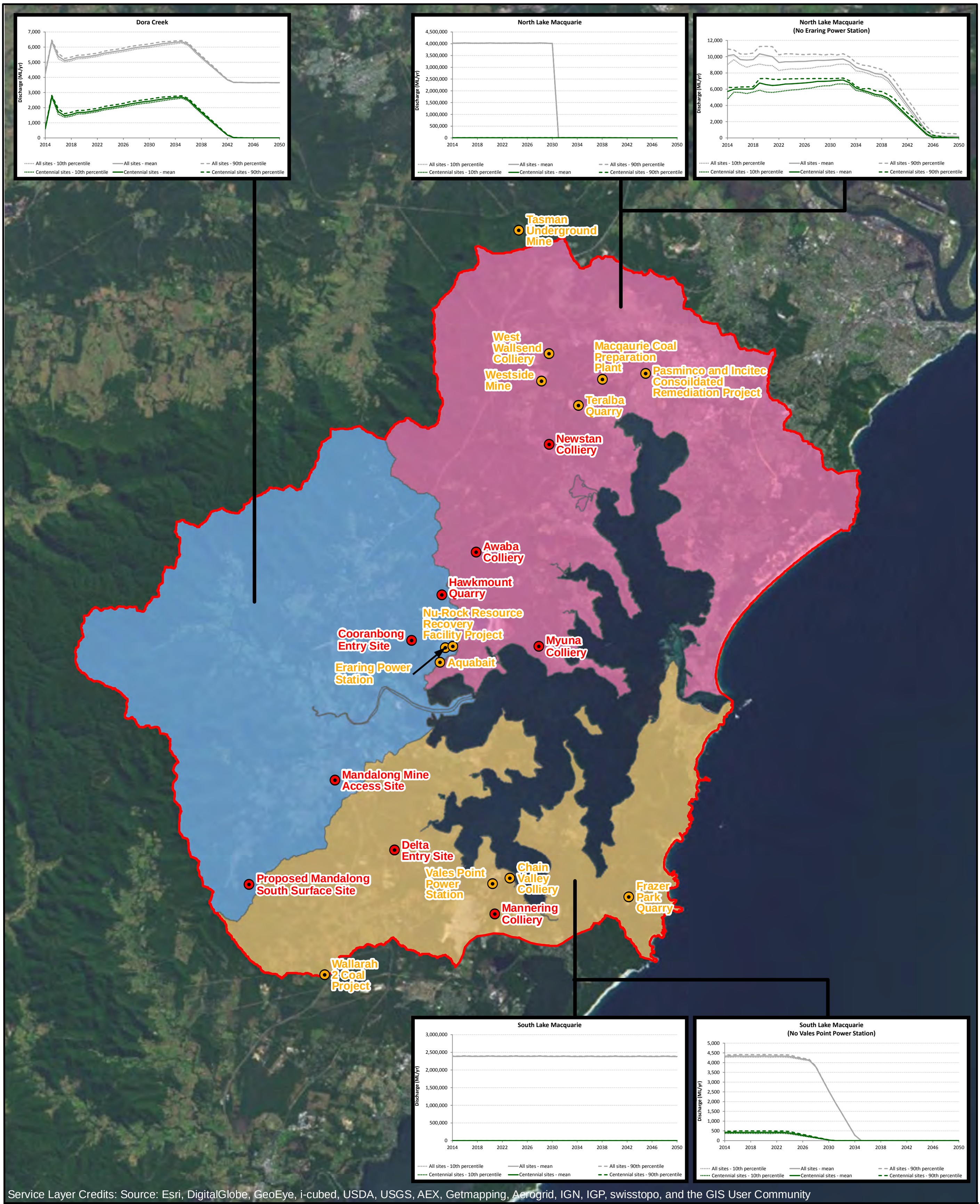


Figure 8-9 Volume of Total Discharges to Surface Water Sources (Without Contribution of Eraring and Vales Point Power Stations)

The total discharges to all assessed water sources are dominated by discharges from Eraring Power Station and Vales Point Power Station. As shown in Figure 8-8, current total discharges are estimated to be approximately 6.4 GL/year on average. This is predicted to decrease to approximately 2.4 GL/year after 2030, when Eraring Power Station is expected to cease discharging with decommissioning of the power station.

Not considering discharges from Eraring Power Station and Vales Point Power Station, total discharges are currently estimated to be approximately 15,100 ML/year, as shown in Figure 8-9. Of this volume, approximately 6,800 ML/year on average is predicted to be discharged by Centennial-owned sites. Peak discharge to all water sources is predicted to occur in 2015 at an average rate of 17,300 ML/year. Discharge by Centennial-owned sites is expected to occur in 2032 at approximately 9,700 ML/year. By the end of the assessment period in 2050, discharge from all assessed sites is minimal, with approximately 12 ML/year discharged by Centennial-owned sites.



1:250,000 for A4

0 0.75 1.5 3 4.5 6

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Centennial Site Location
- Non-Centennial Site Location
- Study Area

Water Source

- Dora Creek Water Source
- North Lake Macquarie Water Source
- South Lake Macquarie Water Source

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	
APPROVED	
SCALE	Refer to scalebar

Northern Operations
Water and Salt Balance

Estimated Discharges by
Surface Water Source

Centennial Coal

DATE 25/03/2014

Figure 8-10

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Regional\Deliverables\2217054\WaterAndSaltBalance\2217054_WSB015_SW_Statistics_A.mxd

Extractions from Surface Water

Surface water extractions from Lake Macquarie that were incorporated into the water and salt balance model are associated with Aquabait, Eraring Power Station and Vales Point Power Station. The operation of these sites requires the withdrawal of substantial volumes of water from Lake Macquarie. Figure 8-11 presents the predicted average volumes of water extracted by Aquabait, Eraring Power Station and Vales Point Power Station.

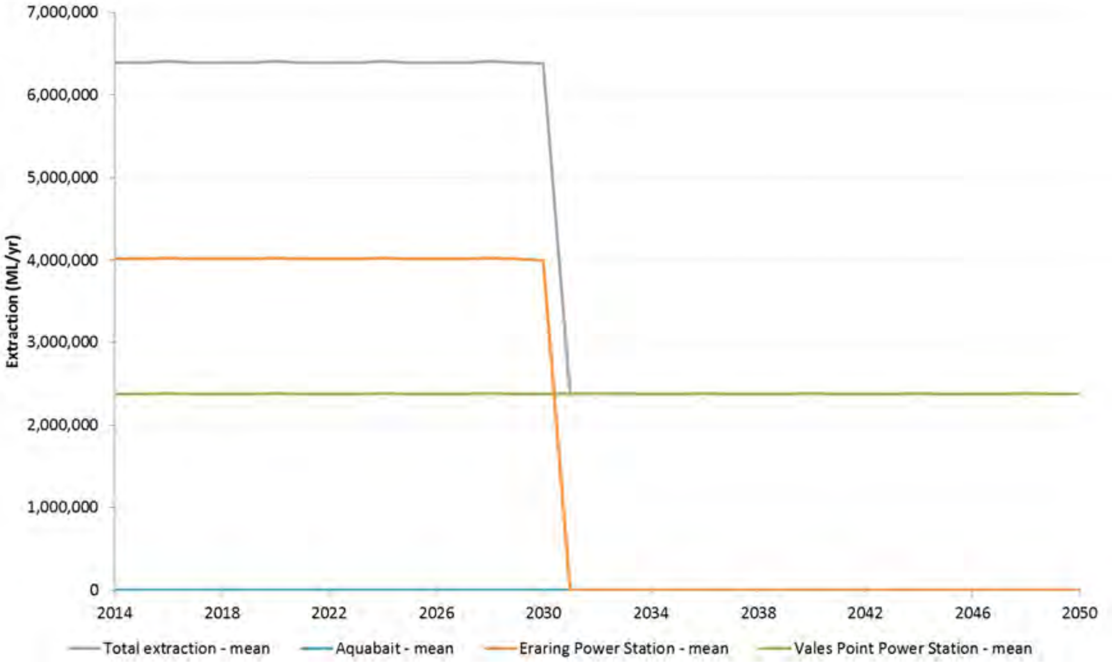


Figure 8-11 Volume of Total Extractions from Lake Macquarie

As shown in Figure 8-11, the estimated average withdrawal from Lake Macquarie is approximately 6.4 GL/year in 2014 and is expected to decrease to 2.4 GL/year by 2031. The total contribution of assessed sites excluding the power stations into Lake Macquarie, as shown in Figure 8-9, is predicted to be significantly less than the extractions from Lake Macquarie. The discharge into Lake Macquarie from assessed operations (excluding the power stations) is predicted to be between 7,300 ML/year and 20,600 ML/year. Natural catchment runoff also contributes to the lake.

As discussed in Section 1.6.1, the extraction of surface water for individual sites was not determined in this assessment. Surface water extractions for mine sites are typically minor compared to groundwater extractions and licensing of these extractions is dependent on consultation with NOW on a site-by-site basis.

8.3.2 Salt Balance Results

Extractions from Groundwater Sources

The estimated annual salt mass and salinity of extractions from operations in the Study Area from groundwater sources over the period from 2014 to 2050 are presented in Figure 8-12 and Figure 8-13 respectively. Both figures present the contribution of Centennial-owned operations as well as the contribution of all assessed sites. Salt mass is expressed in tonnes per year (t/year).

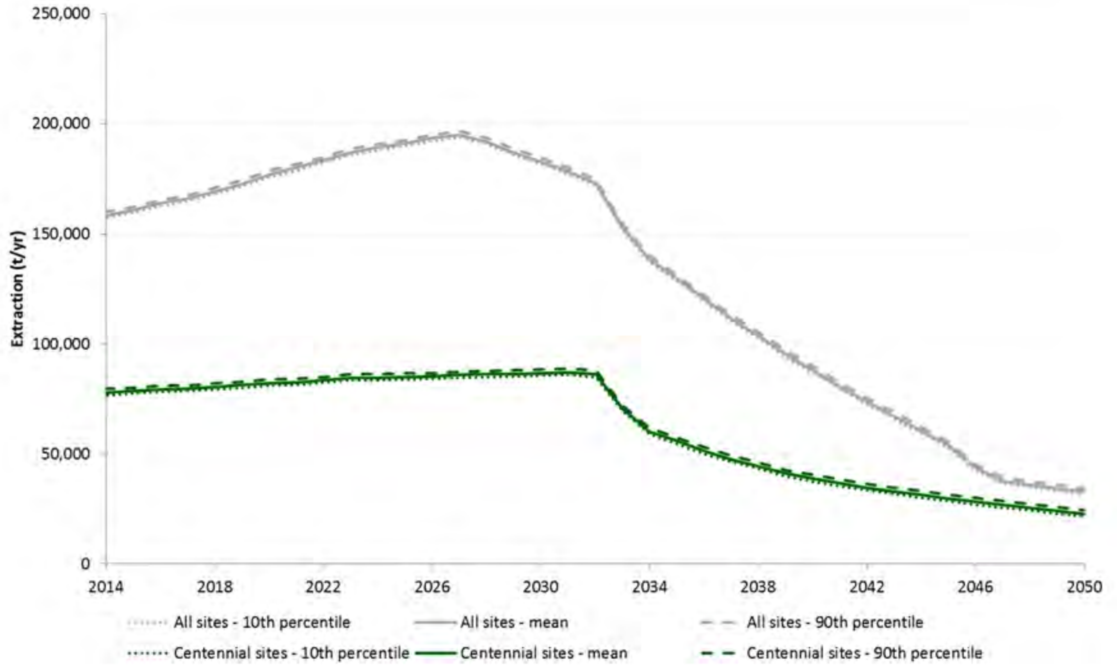


Figure 8-12 Sydney Basin North Coast Groundwater Source – Estimated Salt Mass of Aggregate Extractions

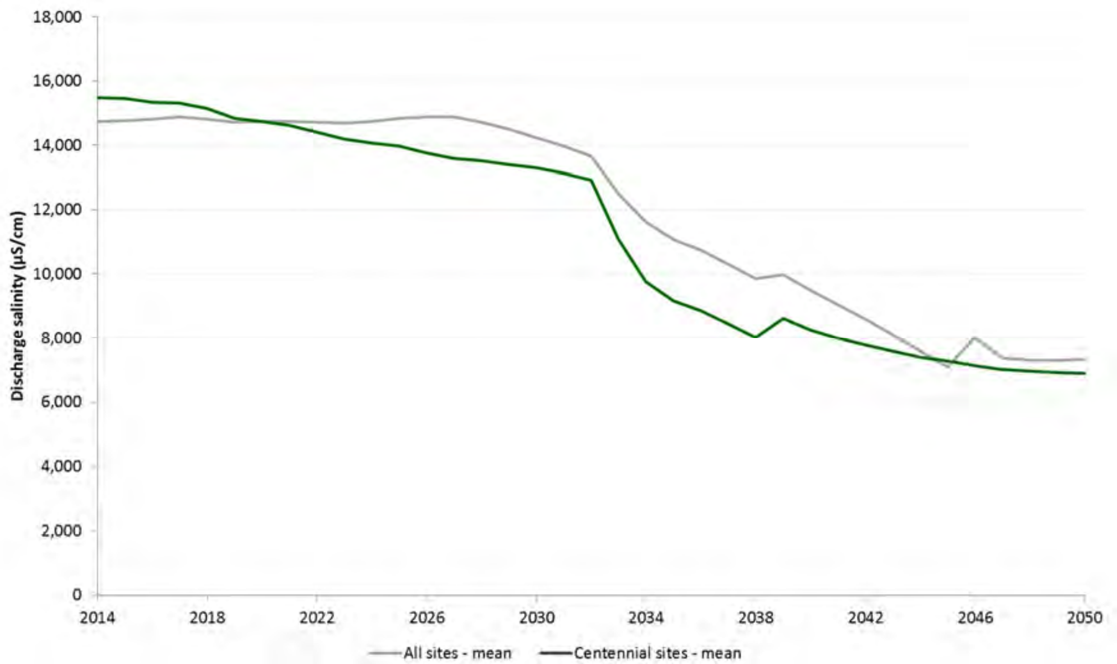


Figure 8-13 Sydney Basin North Coast Groundwater Source – Estimated Salinity of Aggregate Extractions

As shown in Figure 8-12, current total extractions from the Sydney Basin North Coast groundwater source are estimated to be approximately 158,800 t/year of salt on average with salinity of approximately 14,700 µS/cm. Of this, approximately 77,900 t/year of salt with salinity of approximately 15,500 µS/cm is extracted by Centennial-owned sites. Salt extraction associated with groundwater extraction by all sites is expected to peak in 2027 at a rate of approximately 195,100 t/year with salinity of approximately 14,900 µS/cm. Salt associated with the extraction of groundwater by Centennial-owned sites is predicted to peak in 2031 at approximately 87,100 t/year with salinity of 13,100 µS/cm. By the end of the simulation period in 2050, extractions of salt from the groundwater source across all sites is largely attributable to Centennial-owned sites at a rate of approximately 22,700 t/year with salinity of approximately 6,900 µS/cm.

Discharges to Surface Water Sources

The estimated annual salt mass and salinity of discharges from operations in the Study Area to surface water sources of the period from 2014 to 2050 are presented in Figure 8-14 and Figure 8-23. Each figure presents the contribution of Centennial-owned operations as well as the contribution of all assessed sites.

As with the water balance results, two graphs are presented for discharges into the North Lake Macquarie and South Lake Macquarie water sources. This provides the results with and without salt associated with discharges from Eraring Power Station and Vales Point Power Station, as these sites contribute significantly larger amounts of salt to each water source when compared to other sites.

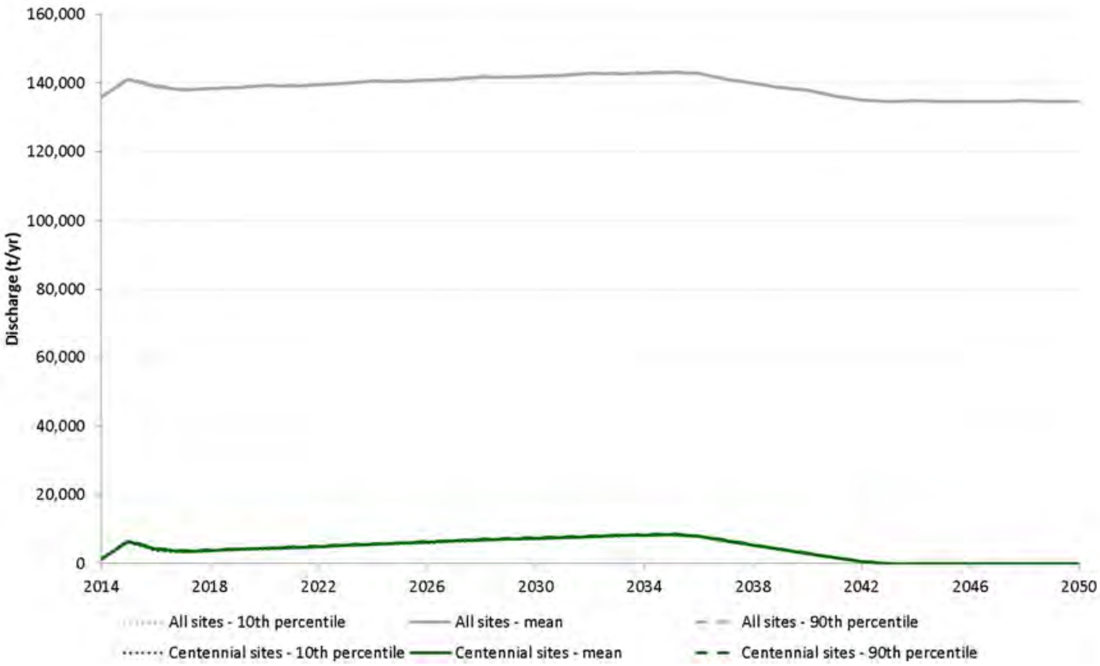


Figure 8-14 Dora Creek Water Source – Estimated Salt Mass of Aggregate Discharges

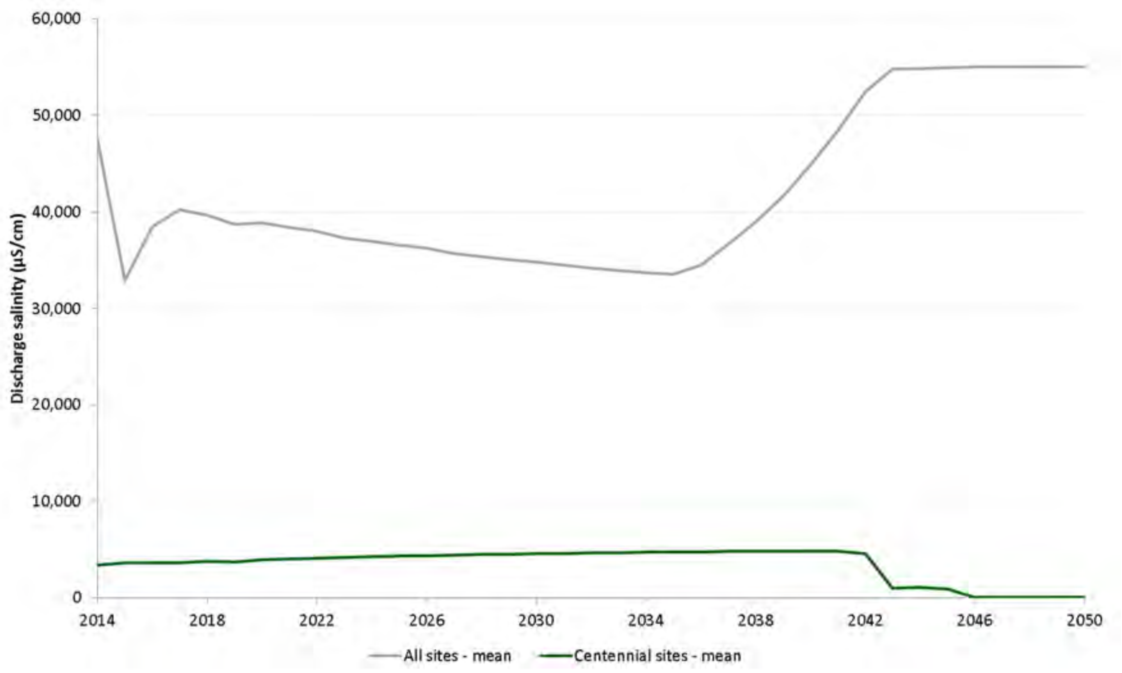


Figure 8-15 Dora Creek Water Source – Estimated Salinity of Aggregate Discharges

As seen in Figure 8-14 and Figure 8-15, the quantity of salt associated with discharges and salinity of discharges to the Dora Creek water source is dominated by discharges from Aquabait, the only non-Centennial site that contributes to the water source. Salt discharges from Centennial-owned sites are predicted to decrease from 2043, after discharges from Mandalong Mine are expected to cease.

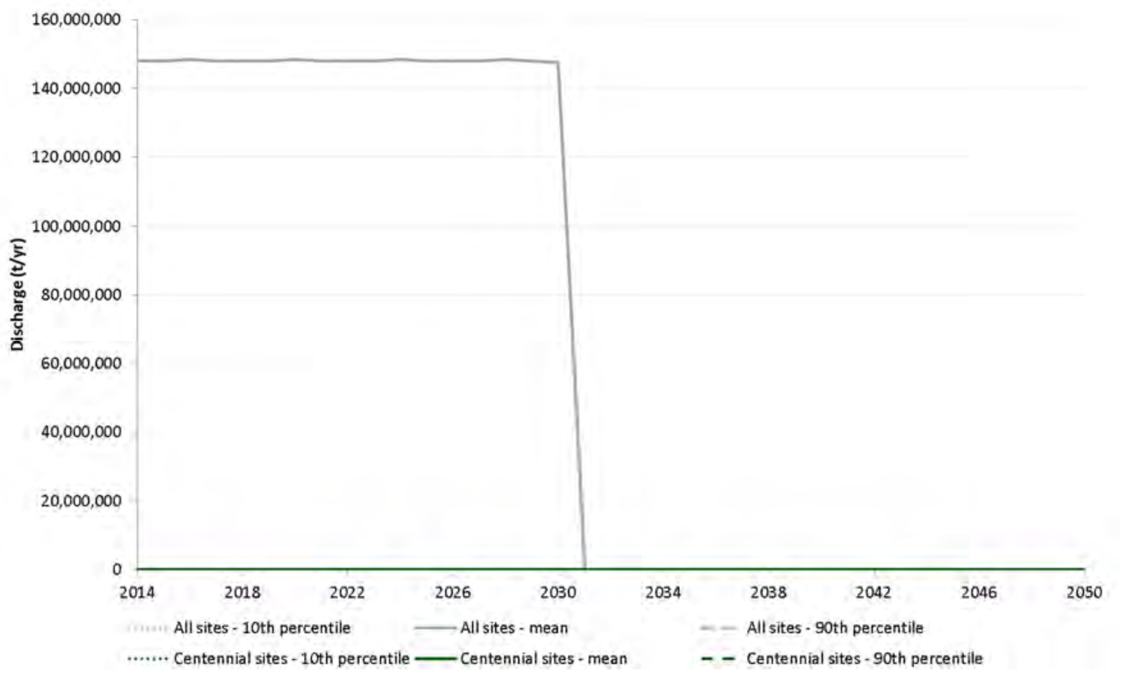


Figure 8-16 North Lake Macquarie Water Source – Estimated Salt Mass of Aggregate Discharges

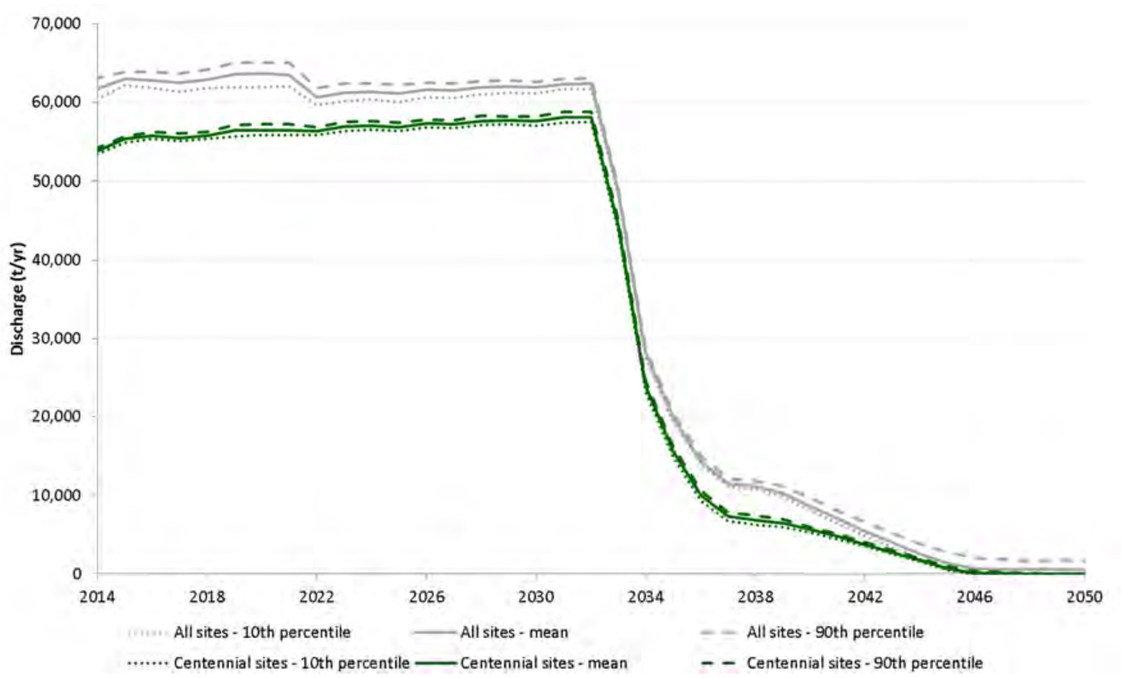


Figure 8-17 North Lake Macquarie Water Source – Estimated Salt Mass of Aggregate Discharges (Without Contribution of Eraring Power Station)

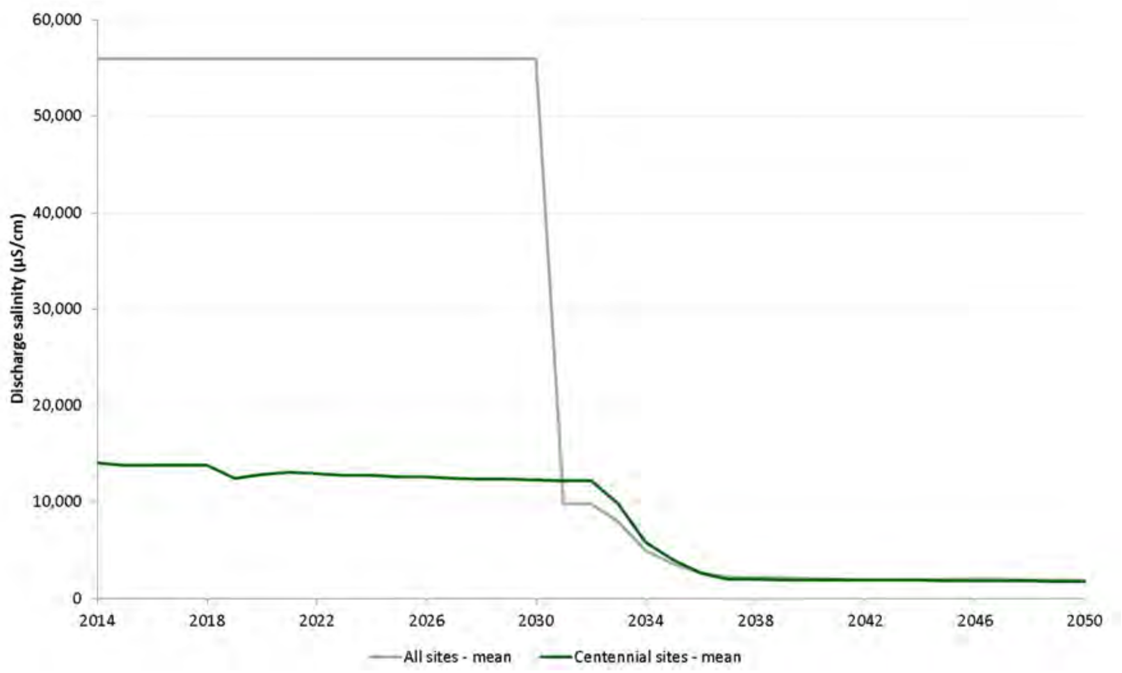


Figure 8-18 North Lake Macquarie Water Source – Estimated Salinity of Aggregate Discharges

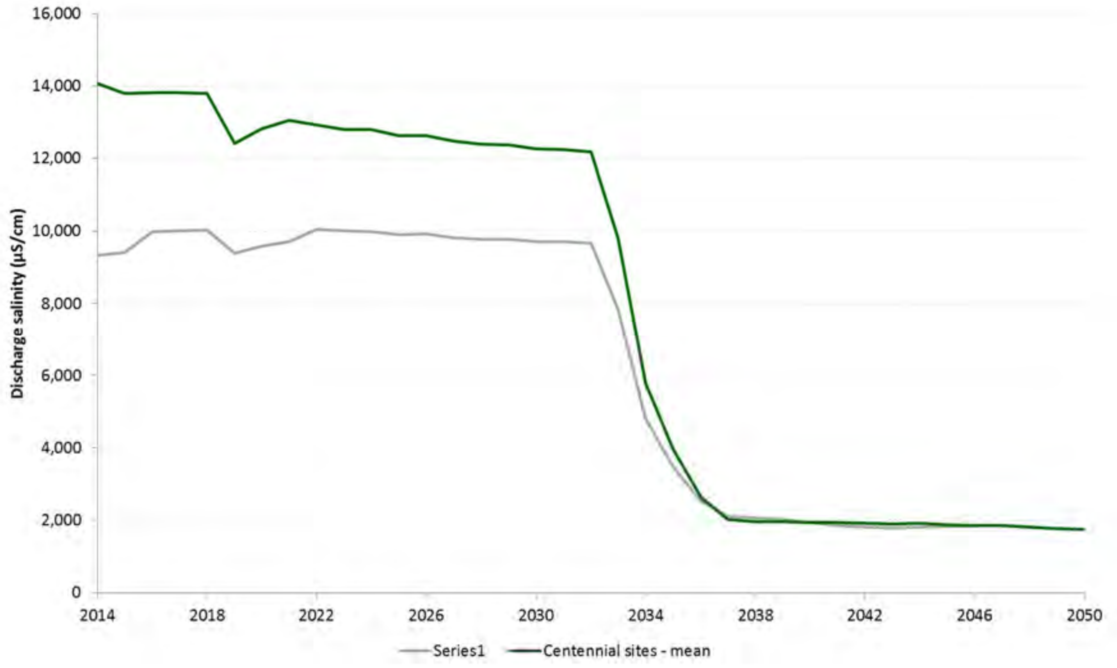


Figure 8-19 North Lake Macquarie Water Source – Estimated Salinity of Aggregate Discharges (Without Contribution of Eraring Power Station)

Figure 8-16 and Figure 8-17 present the quantity of salt associated with discharges into the North Lake Macquarie water source, while Figure 8-18 and Figure 8-19 present the salinity of discharges. Eraring Power Station is responsible for the majority of salt associated with discharges into the water source. The salt mass and salinity associated with discharges is expected to decrease significantly from 2032 when discharges from West Wallsend Colliery cease.

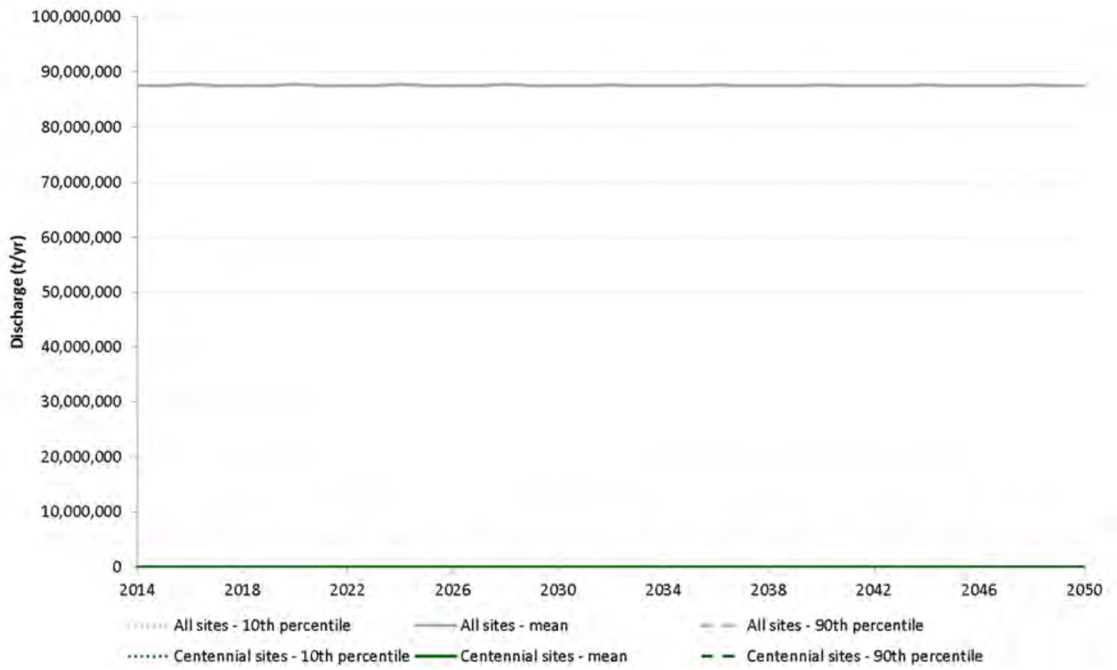


Figure 8-20 South Lake Macquarie Water Source – Estimated Salt Mass of Aggregate Discharges

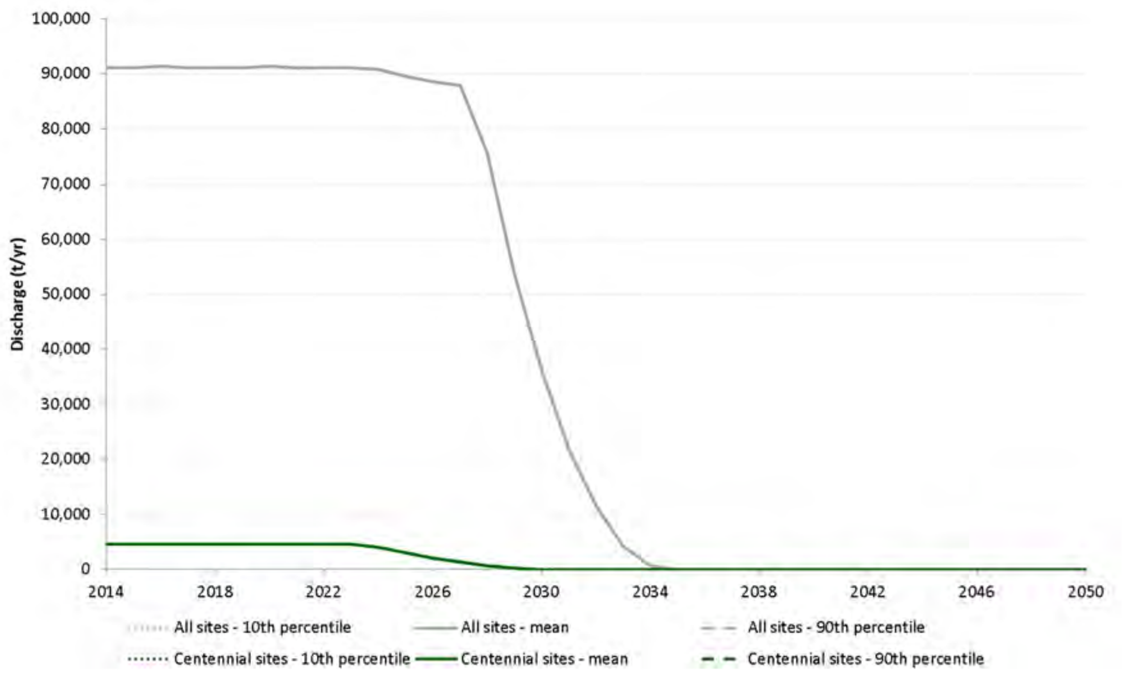


Figure 8-21 South Lake Macquarie Water Source – Estimated Salt Mass of Aggregate Discharges (Without Contribution of Vales Point Power Station)

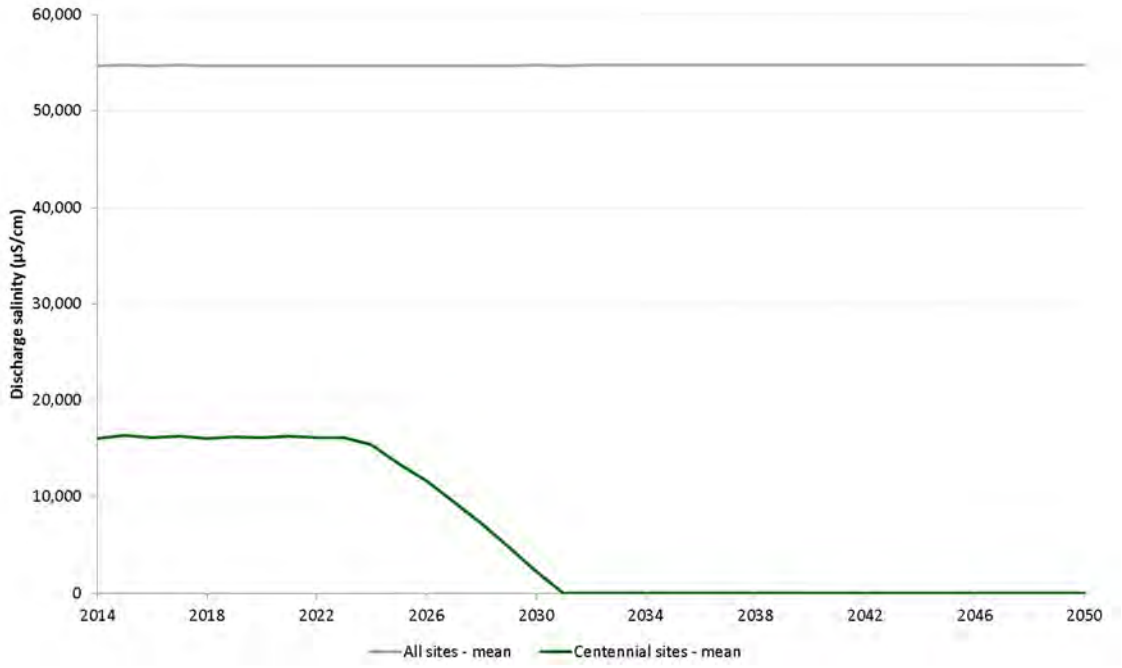


Figure 8-22 South Lake Macquarie Water Source – Estimated Salinity of Aggregate Discharges

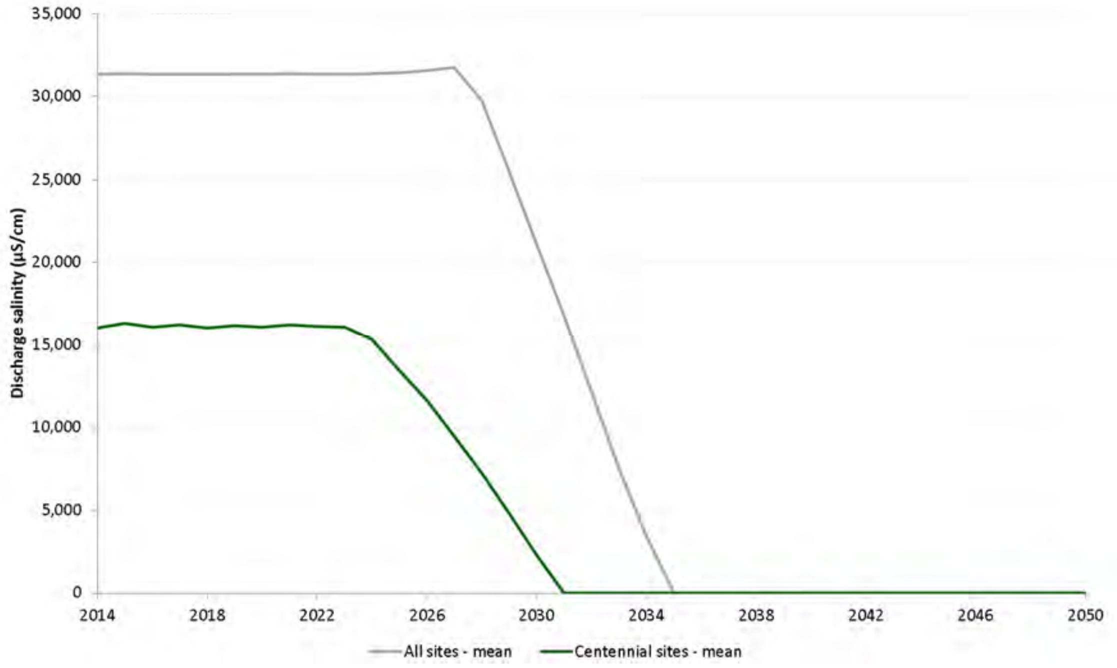


Figure 8-23 South Lake Macquarie Water Source – Estimated Salinity of Aggregate Discharges (Without Contribution of Vales Point Power Station)

Figure 8-20 and Figure 8-21 present the quantity of salt associated with discharges into the South Lake Macquarie water source, while Figure 8-22 and Figure 8-23 present the salinity of discharges. Vales Point Power Station is responsible for the majority of salt associated with discharges into the water source. The salt mass and salinity associated with discharges is expected to decrease significantly from 2024 when discharges from Chain Valley Colliery cease.

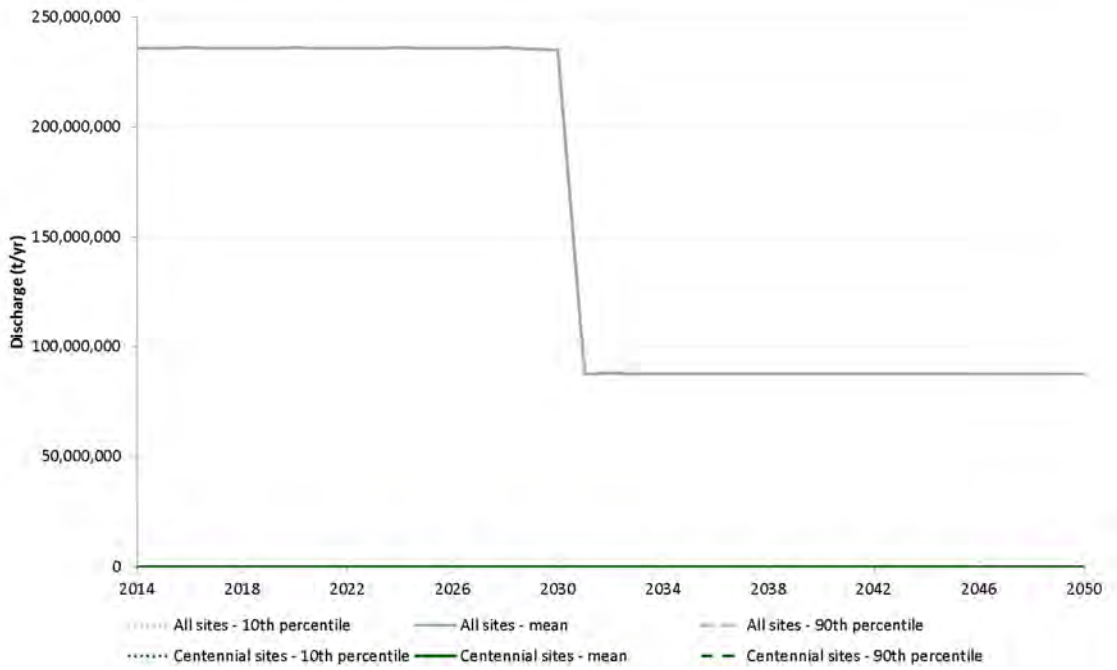


Figure 8-24 Salt Mass of Total Discharges to Surface Water Sources

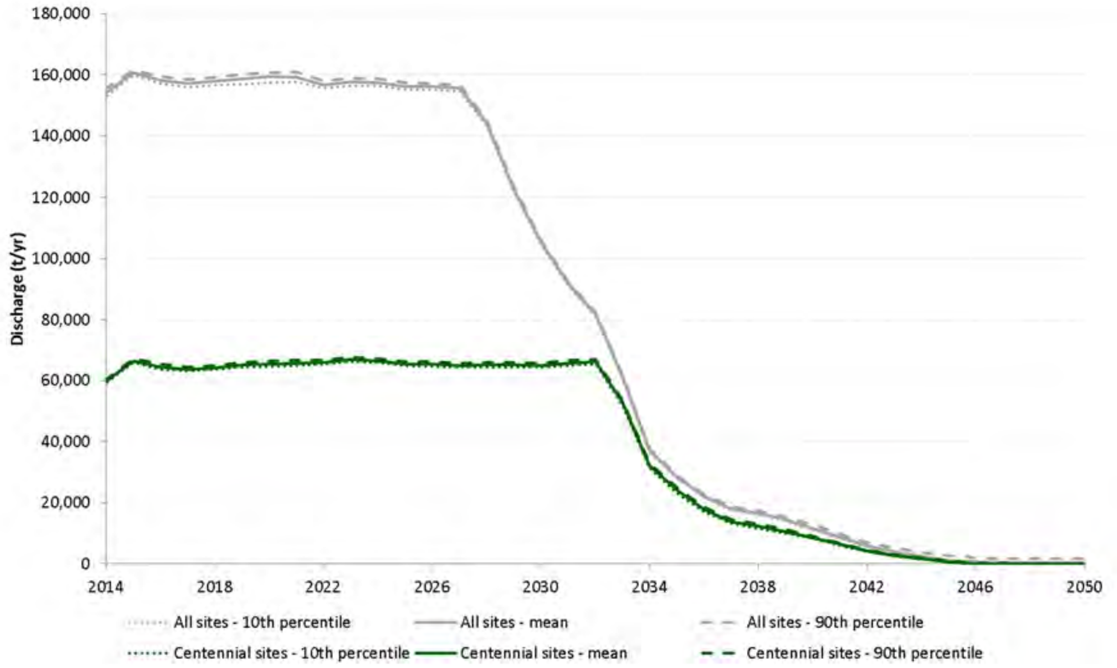


Figure 8-25 Salt Mass of Total Discharges to Surface Water Sources (Without Contribution of Eraring and Vales Point Power Stations)

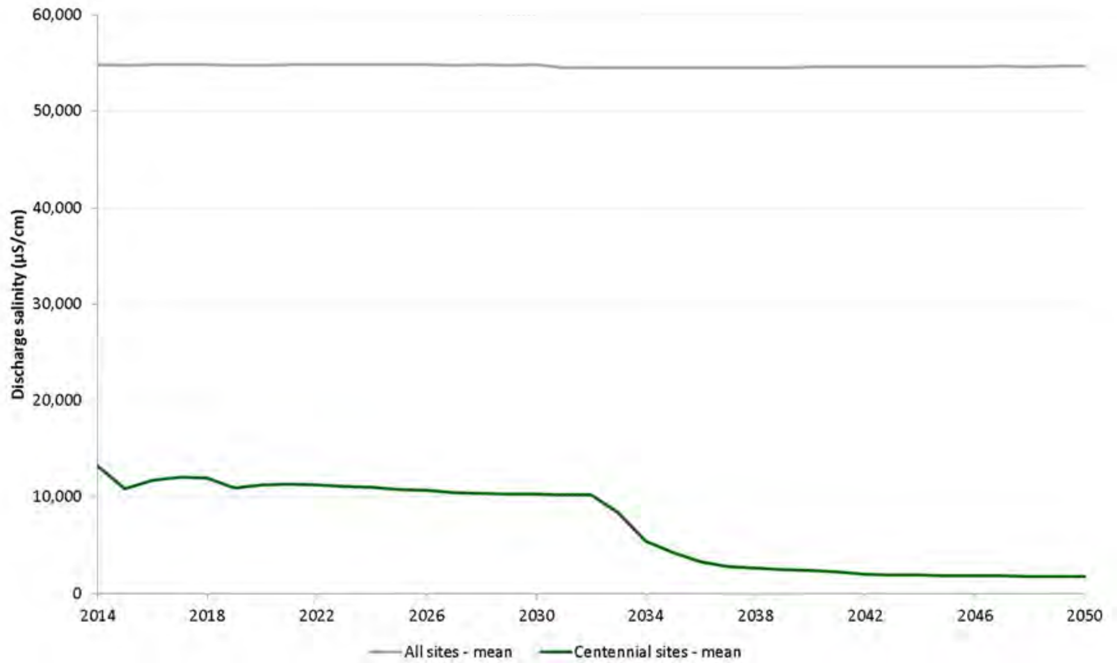


Figure 8-26 Salinity of Total Discharges to Surface Water Sources

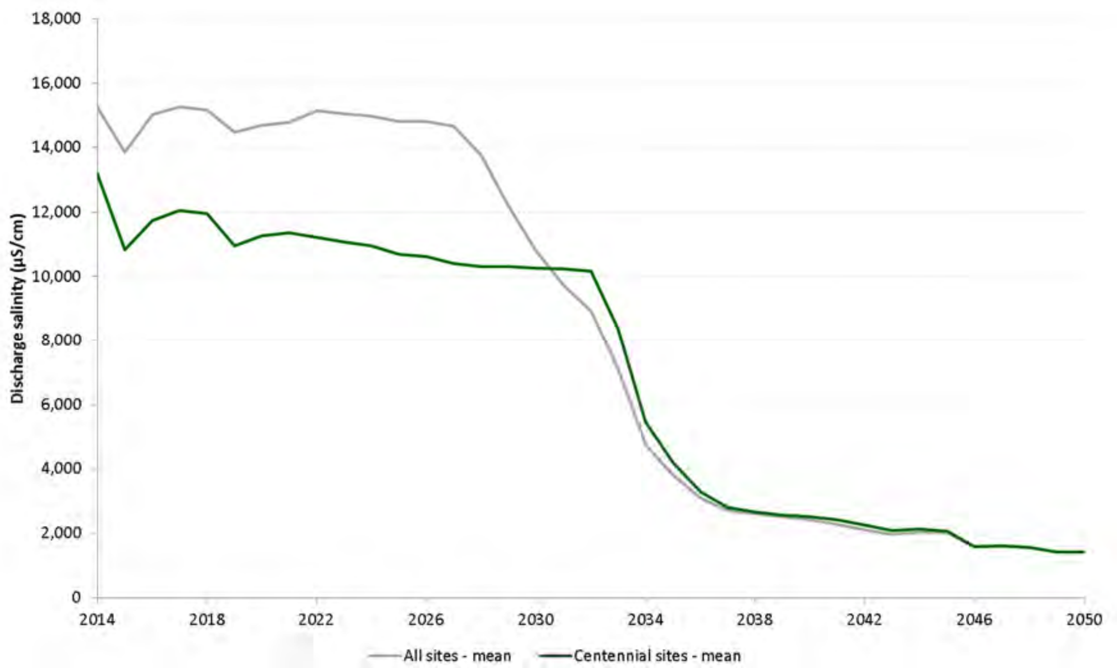


Figure 8-27 Salinity of Total Discharges to Surface Water Sources (Without Contribution of Eraring and Vales Point Power Stations)

As with the water balance results, the salt balance results indicate total discharges of salt to all assessed water sources are dominated by discharges from Eraring Power Station and Vales Point Power Station. As shown in Figure 8-24 and Figure 8-26, current total discharges are estimated to be approximately 236 Mtpa on average with salinity of approximately 55,000 µS/cm. This is predicted to decrease to approximately 88 Mtpa with salinity of approximately 55,000 µS/cm after 2030, when Eraring Power Station is expected to cease discharging with decommissioning of the power station.

Not considering discharges from Eraring Power Station and Vales Point Power Station, as shown in Figure 8-25 and Figure 8-27, current total discharges of salt to all water sources are estimated to be approximately 154,200 t/year with salinity of 15,300 µS/cm. Of this, approximately 59,800 t/year of salt with salinity of 13,200 µS/cm is discharged by Centennial-owned sites. Salt discharged from all sites is predicted to peak in 2015 at a rate of approximately 160,600 t/year with salinity of approximately 13,800 µS/cm. Salt associated with Centennial-owned sites is predicted to peak in 2023 at approximately 11,100 t/year with salinity of approximately 66,900 µS/cm. By the end of the assessment period in 2050, discharges of salt to all water sources by Centennial-owned sites is expected to have decrease significantly to a rate of 11 t/year with salinity of approximately 1,400 µS/cm.

Extractions from Surface Water

Figure 8-28 presents the predicted average salt quantities associated with surface water extracted by Aquabait, Eraring Power Station and Vales Point Power Station from Lake Macquarie. The average salinity of the extractions is shown in Figure 8-29.

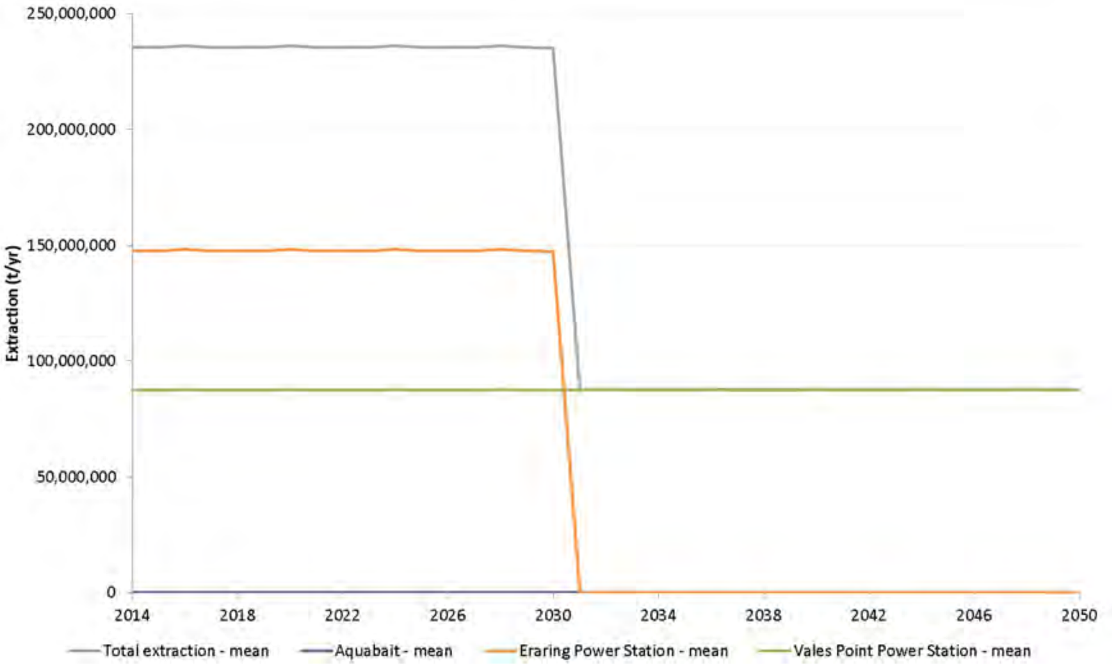


Figure 8-28 Salt Mass of Total Extractions from Lake Macquarie

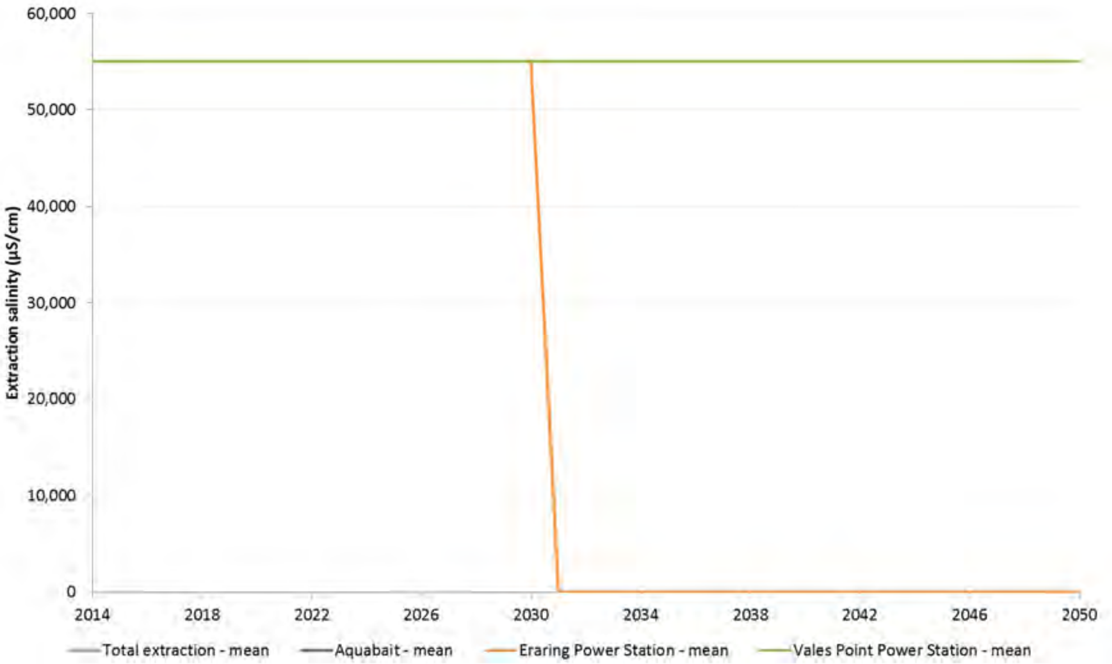


Figure 8-29 Salinity of Total Extractions from Lake Macquarie

As shown in Figure 8-28, the estimated average salt extraction from Lake Macquarie is approximately 236 Mtpa in 2014 and is expected to decrease to approximately 88 Mtpa by 2031. The salinity of Lake Macquarie is estimated to be approximately 55,000 µS/cm, as shown in Figure 8-29.

8.4 Lake Macquarie Catchment Modelling

8.4.1 Water Balance Results

The estimated annual surface water runoff contributing from the Lake Macquarie catchment for Dora Creek, North Lake Macquarie and South Lake Macquarie water source is presented in Table 8-1. The development footprint of each assessed site was excluded from the determination of catchment runoff to Lake Macquarie.

Table 8-1 Surface Water Runoff Contribution to Lake Macquarie

Water source	Average runoff (ML/year)	Percentage of total runoff
Dora Creek	69,160	26.9%
North Lake Macquarie	123,871	48.2%
South Lake Macquarie	64,111	24.9%
Total to Lake Macquarie	**257,144**	**100%**

As seen in Table 8-1, the majority of surface water runoff contributing to Lake Macquarie is from the sub-catchments within the North Lake Macquarie water source, consistent with the water source being the largest area within the Lake Macquarie catchment.

Table 8-2 presents the surface water runoff determined for sub-catchments that Centennial-owned sites are located in. Runoff was calculated for each sub-catchment excluding the development footprint of each of the assessed sites.

From the results presented in Table 8-2, it is clear that Delta Entry Site (part of Mandalong Mine), Mannering Colliery, Myuna Colliery and Newstan Colliery Surface Site are located within sub-catchments that typically contribute a small volume of surface water runoff to Lake Macquarie. Of these sites, Newstan Colliery Surface Site has the largest development footprint at approximately 46% of the LT Creek catchment.

Table 8-2 Surface Water Runoff from Centennial-Owned Sites

Site	Location	Creek catchment	Water source	Average runoff (ML/year)
Mandalong Mine	Cooranbong Entry Site	Unnamed tributary of Lake Macquarie	Dora Creek	5,007
	Delta Entry Site	Unnamed tributary of Lake Macquarie	South Lake Macquarie	2,717
	Mandalong Mine Access Site	Stockton Creek	Dora Creek	1,851
	Proposed Mandalong South Surface Site	Morans Creek	Dora Creek	12,124
Mannering Colliery		Unnamed tributary of Lake Macquarie	South Lake Macquarie	386
Myuna Colliery		Wangi Creek	North Lake Macquarie	3,353

<table>
<tr><th>Site</th><th>Location</th><th>Creek catchment</th><th>Water source</th><th>Average runoff (ML/year)</th></tr>
<tr><td rowspan="4">Newstan Colliery</td><td rowspan="2">Newstan Colliery Surface Site</td><td>LT Creek</td><td>North Lake Macquarie</td><td>2,912</td></tr>
<tr><td rowspan="2">Stony Creek</td><td rowspan="2">North Lake Macquarie</td><td rowspan="2">9,876</td></tr>
<tr><td>Awaba Colliery</td></tr>
<tr><td>Hawkmount Quarry</td><td>Lords Creek</td><td>Dora Creek</td><td>10,634</td></tr>
</table>

8.4.2 Salt Balance Results

The estimated annual salt load associated with surface water runoff contributing to Lake Macquarie for Dora Creek, North Lake Macquarie and South Lake Macquarie water source is presented in Table 8-3.

Table 8-3 Surface Water Runoff Salt Load Contribution to Lake Macquarie

Water source	Average salt load (t/year)	Percentage of total salt load
Dora Creek	16	27%
North Lake Macquarie	19	32%
South Lake Macquarie	24	41%
Total to Lake Macquarie	**59**	**100%**

As indicated in Table 8-3, the results indicated that on average the total Lake Macquarie catchment (excluding development footprints of assessed sites) contribute approximately 59 tonnes of salt each year to the lake. Considering the range of salinity observed in the Dora Creek, North Lake Macquarie and South Lake Macquarie water sources, the salt load contributing to Lake Macquarie could be as high as 200 tonnes every year.

8.5 Modelling Limitations

GHD has developed the regional water and salt balance models for the Lake Macquarie catchment based on information supplied by Centennial and publicly available information. Where data was not available, GHD has made assumptions as appropriate. The limitations of the models and an indication of confidence levels of the data used to develop the models are presented in Table F-6 of Appendix F.

8.6 Licensing Overview of Centennial Sites

8.6.1 Water Management Act 2000

An assessment of the results of the water balance was undertaken to determine the predicted groundwater and surface water WAL requirements at each Centennial-owned site within the Study Area.

The predicted peak WAL requirement and the estimated year the peak will occur is provided for each site by water source. The purpose of providing the year of the predicted peak is to give an indication of when the individual site is predicted to require the peak WAL volume.

The recommended WAL requirement for each water source is also provided to give an indication of the maximum WAL volume Centennial would need to purchase to meet the predicted water extraction requirements between 2014 and 2050. The recommended WAL requirement for each water source is not necessarily equal to the sum of all the individual site peaks, as the interaction of timing of the peaks is considered and the maximum volume for the entire water source over the simulation timeline was used to predict this WAL requirement.

The WAL requirement by water source has been considered as WALs can be traded within water sources (but not between water sources) and it has been assumed that Centennial will trade water licences between the Centennial-owned sites. The estimation of the recommended WAL requirement was determined as the 90th percentile requirement (if the extractions are affected by rainfall) for the year of the peak, rounded to the nearest 50 ML.

Groundwater Licensing Requirements

A summary of the groundwater licensing requirements for Centennial-owned sites for the Sydney Basin North Coast groundwater source is provided in Table 8-4. The predicted groundwater WAL requirement includes groundwater inflows into underground workings and in situ moisture associated with extracted coal at Mandalong Mine, Mannering Colliery and Myuna Colliery. For Newstan Colliery, in addition to groundwater inflows into underground workings and in situ moisture associated with extracted coal, groundwater extraction included groundwater inflows and rainfall infiltration into the Fassifern Underground Storage.

Table 8-4 Summary of Centennial Groundwater WAL Requirements

Site	Current estimated extraction (2014)	Peak WAL requirement	Date of peak	Recommended WAL requirement for water source
Mandalong Mine	1,050 ML/year	2,500 ML/year	2035	10,400 ML/year
Mannering Colliery	350 ML/year	350 ML/year	2014-2023	
Myuna Colliery	2,250 ML/year	2,400 ML/year	2024-2032	
Newstan Colliery	3,900 ML/year	5,700 ML/year	2036	

Surface Water Licensing Requirements

As detailed in Section 60I of the WM Act, a WAL is required for water used in mining activities where surface water is removed or diverted from a water source. Mandalong Mine and Newstan Colliery Surface Site (part of Newstan Colliery) will require WALs as a result of water reuse strategies in place that extract water from the water management system at each site that would otherwise be discharged into receiving waterways. As discussed in Section 4.2.1, one WAL is currently held by Newstan Colliery to supplement water supply from the Main By-Wash Dam. No other Centennial-owned sites in the Study Area hold a WAL.

The predicted surface water WAL requirement for Mandalong Mine includes:

- Dust suppression and spray irrigation from the Sediment Control Dam at the Mandalong Mine Access Site.
- Transfers from the 5 ML Dam, Sediment Dam 1 and Sediment Dam 2 at Cooranbong Entry Site to the Cooranbong Longwall Void.
- Transfers from the proposed Sediment Control Dam at the Mandalong South Surface Site to the Cooranbong Longwall Void.

The predicted surface water WAL requirement for Newstan Colliery Surface Site includes:

- Dust suppression from Connolly's Dam.
- CPP usage from Connolly's Dam and the Clean Water Plant.
- Transfers to active mining areas underground from the Clean Water Plant.
- Seepage and transfers from the TSF to the Fassifern Underground Storage.
- Transfers from the Pollution Transfer Tanks, Seepage Dam, Clean Water Dam and Connolly's Dam to the Fassifern Underground Storage

A summary of the surface water licensing requirements for Centennial-owned sites is provided in Table 8-5. The volumes presented in Table 8-5 were determined from the results of the water balance for the transfers requiring licensing, as detailed above. However, it should be noted that volumetric limits may not be applied to all these transfers. Centennial is currently in consultation with NOW with respect to water licensing requirements.

Table 8-5 Summary of Centennial Surface Water WAL Requirements

Water source	Site	Current estimated volume (2014)	Peak WAL requirement	Date of peak	Recommended WAL requirement for water source
Dora Creek	Mandalong Mine	134 ML/year	156 ML/year	2018	150 ML/year
North Lake Macquarie	Newstan Colliery	1,838 ML/year	1,887 ML/year	2022	1,900 ML/year

There will be no licensing requirements for proposed surface water storages at Centennial-owned sites. This is as a result of one or more of the following reasons:

- Surface water storages have been constructed for the purpose of erosion and sediment control.
- Surface water storages have been constructed for the purpose of managing potential water quality contaminants.
- Surface water storages have been constructed without a catchment and hence do not collect runoff.

8.6.2 Protection of the Environment Operations Act 1997

An assessment of the outcomes from the results for individual sites was undertaken to compare the current and predicted LDP volumetric discharge limit. An indication of the recommended volumetric limit required to meet future groundwater discharges is provided for each applicable site. The recommended volumetric requirement does not take into consideration runoff or surface water discharges from each LDP.

Where LDPs discharge primarily due to catchment runoff, a recommended volumetric discharge volume is not provided and 'rainfall based' is noted. For LDPs where both runoff and groundwater extractions contribute to the LDP discharge, an indication of the required volumetric limit is provided.

The assessment determined that there are currently no identifiable licensing shortfalls for volumetric discharges through LDPs with respect to groundwater discharges. LDP001 at Cooranbong Entry Site and LDP001 at Newstan Colliery Surface Site are predicted to increase in volumetric discharge as a result of expansion projects at Mandalong Mine and Newstan Colliery respectively. It is recommended that the adequacy of LDP volumetric discharges is completed on a site-by-site basis to include the interaction of site water cycles and catchment runoff.

Table 8-6 Summary of Licensed Discharge Point Requirements

Site	LDP	Current LDP volumetric limit (ML/day)	Recommended volumetric limit (ML/day)
Mandalong Mine	LDP001	5	8
	LDP002	No limit specified	Rainfall based
	Proposed LDP (Mandalong Mine Access Site)	Not currently licensed	Rainfall based
Mannering Colliery	LDP 1	4	Maintained at current limit
	LDP 2	No limit specified	Rainfall based
Myuna Colliery	LDP A	13	Maintained at current limit
	LDP B	No limit specified	Rainfall based
Newstan Colliery	LDP001	11	14.5
	LDP002	No limit specified	Rainfall based
	LDP003	No limit specified	Rainfall based
	LDP017	No limit specified	Rainfall based
	Proposed LDP (Hawkmount Quarry)	Not currently licensed	Rainfall based
Awaba Colliery	LDP001	0.2	Maintained at current limit
	LDP002	0.2	Maintained at current limit
	LDP003	2	Maintained at current limit
	LDP004	2	Maintained at current limit
	LDP005	0.2	Maintained at current limit
	LDP006	0.2	Maintained at current limit
	LDP007	0.5	Maintained at current limit
	LDP009	8	Maintained at current limit

9. Conclusions

The cumulative impact of industry in the Lake Macquarie catchment has been quantified by the outcomes of water and salt balance modelling undertaken for Centennial-owned coal mines and other identified operations undertaken in the Study Area.

Current total extractions from the Sydney Basin North Coast groundwater source are estimated to be approximately 16,100 ML/year on average, of which approximately 7,500 ML/year on average is extracted by Centennial-owned sites. Peak extraction from the groundwater source is predicted to occur in 2027 at an average rate of approximately 19,600 ML/year. Extraction of groundwater from Centennial-owned sites is predicted to peak in 2032 at an average of approximately 9,900 ML/year. By the end of the assessment period in 2050, groundwater extraction from Centennial-owned sites is predicted to occur at an average rate of approximately 4,900 ML/year. Groundwater extraction over the post-2050 re-pressurisation period is predicted to be greater than 500 ML/year for approximately 30 years for Centennial sites specifically and approximately 60 years for all sites assessed.

Current extractions of salt associated with groundwater extraction from the Sydney Basin North Coast groundwater source are estimated to be approximately 158,800 t/year on average with salinity of approximately 14,700 µS/cm. Of this, approximately 77,900 t/year of salt with salinity of approximately 15,500 µS/cm is extracted by Centennial-owned sites. Salt extraction associated with groundwater extraction by all sites is expected to peak in 2027 at a rate of approximately 195,100 t/year with salinity of approximately 14,900 µS/cm. Salt associated with the extraction of groundwater by Centennial-owned sites is predicted to peak in 2031 at approximately 87,100 t/year with salinity of 13,100 µS/cm. By the end of the simulation period in 2050, extractions of salt from the groundwater source across all sites is largely attributable to Centennial-owned sites at a rate of approximately 22,700 t/year with salinity of approximately 6,900 µS/cm.

The cumulative impact on the Sydney Basin North groundwater source was estimated to vary according to the mining operations extracting from the source. The peak extraction estimated from the groundwater source was used to provide a recommended WAL requirement for groundwater extraction at Centennial-owned sites. Centennial will need to seek WAL entitlements when the NFPR WSP commences to operate in accordance with WSP rules throughout the assessment period. The recommended WAL requirement for the groundwater source is 10,400 ML/year, occurring in 2036. It should be noted that the recommended WAL requirement is heavily dependent on the timing of mining operations over the assessment period.

The total discharges to all assessed water sources are dominated by discharges from Eraring Power Station and Vales Point Power Station. Current total discharges are estimated to be approximately 6.4 GL/year on average. This is predicted to decrease to approximately 2.4 GL/year after 2030, when Eraring Power Station is expected to cease discharging with decommissioning of the power station.

Not considering discharges from Eraring Power Station and Vales Point Power Station, total discharges are currently estimated to be approximately 15,100 ML/year. This is approximately 6% of total average annual runoff from the three surface water sources. Of this volume, approximately 6,800 ML/year on average (or approximately 3% of average annual catchment runoff) is predicted to be discharged by Centennial-owned sites. Peak discharge to all water sources is predicted to occur in 2015 at an average rate of 17,300 ML/year. Discharge by Centennial-owned sites is expected to occur in 2032 at approximately 9,700 ML/year. By the end of the assessment period in 2050, discharge from all assessed sites is minimal, with approximately 12 ML/year discharged by Centennial-owned sites.

Current total discharges of salt to all assessed water sources are also dominated by discharges from Eraring Power Station and Vales Point Power Station. Current total discharges are estimated to be approximately 236 Mtpa on average with salinity of approximately 55,000 µS/cm. This is predicted to decrease to approximately 88 Mtpa with salinity of approximately 55,000 µS/cm after 2030, when Eraring Power Station is expected to cease discharging with decommissioning of the power station.

Not considering discharges from Eraring Power Station and Vales Point Power Station, current total discharges of salt to all water sources are estimated to be approximately 154,200 t/year with salinity of 15,300 µS/cm. This is substantially higher than the salt load generated by the natural catchment. Of this, approximately 59,800 t/year of salt with salinity of 13,200 µS/cm is discharged by Centennial-owned sites. Salt discharged from all sites is predicted to peak in 2015 at a rate of approximately 160,600 t/year with salinity of approximately 13,800 µS/cm. Salt associated with Centennial-owned sites is predicted to peak in 2023 at approximately 66,900 t/year with salinity of approximately 11,100 µS/cm. By the end of the assessment period in 2050, discharges of salt to all water sources by Centennial-owned sites is expected to have decrease significantly to a rate of 11 t/year with salinity of approximately 1,400 µS/cm. Considering the salt associated with groundwater extractions entering water management systems at Centennial-owned sites, the results of the salt balance for discharges of salt into surface water sources indicate that Centennial-owned sites act as a net store of salt in the Study Area.

The cumulative impact on each surface water source varies according to the mining operations discharging into each water source. The licensed discharge from each water source is predicted to peak at different times throughout the assessment period. However, discharges to all water sources are predicted to significantly decrease by the end of the assessment period.

The peak discharges estimated for each water source enabled a comparison of the current and predicted LDP volumetric discharge limits for each Centennial-owned site based on future predicted groundwater extraction rates. It is recommended that the adequacy of LDP volumetric discharges is completed on a site-by-site basis to include the interaction of site-specific water cycles and catchment runoff.

Extractions from Lake Macquarie do not require licensing. Both surface water extractions from and discharges to Lake Macquarie are dominated by transfers associated with the operation of Eraring Power Station and Vales Point Power Station. As a result, discharges from Centennial-owned sites form up to approximately 0.4% of the total discharges to the lake. The salt associated with discharges form up to approximately 0.08% of the total.

The results of the water balance modelling were used to provide a recommended WAL requirement for surface water transfers at Centennial-owned sites. WALs will be required as a result of water reuse strategies that extract water from the water management system at each site that would otherwise be discharged into receiving waterways. The recommended WAL requirement for Mandalong Mine within the Dora Creek water source is 150 ML/year and for Newstan Colliery within the North Lake Macquarie water source is 1,900 ML/year. No other Centennial-owned sites within the Study Area require a WAL.

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Appendices

Appendix A – Water Sharing Plan Rules

Table A-1 Hunter Unregulated and Alluvial Water Sources Rules: Dora Creek Water Source

Dora Creek water source	
1. Access Rules	
Dora Creek	
1.1 Cease to pump	All licence holders must cease to pump when: a) There is no visible flow immediately downstream of their pump site or into and out of the pumping pool, and b) When there is no visible flow at the reference point. *N.B. From year six of the plan the cease to pump condition will apply to aquifer access licences extracting from all alluvial aquifers within 40 m of an unregulated river, except for existing domestic and stock access licences and local water utilities access licences.*
1.2 Reference point	The weir downstream of road bridge on Freemans Drive, Cooranbong.
1.3 Amendment provisions	N/A
Stockton Creek, Jigadee Creek, all other tributaries	
1.1 Cease to pump	Existing licence conditions apply for the first five years of the plan. From year six, all licence holders must cease to pump when there is no inflow to, or outflow from, the pumping pool. *N.B. From year six of the plan the cease to pump condition will apply to aquifer access licences extracting from all alluvial aquifers within 40 m of an unregulated river, except for existing domestic and stock access licences and local water utilities access licences.*
1.2 Reference point	Riffles upstream and downstream of the pump.
1.3 Amendment provision	N/A
2. Trading Rules	
2.1 Trading INTO the water source	Not permitted.
2.2 Trading WITHIN the water source	Permitted, subject to assessment.
2.3 Conversion to High Flow Access Licence	Not permitted.
2.4 Conversion to Aquifer Access Licence	Not Permitted.

Dora Creek water source	
3. Managing Alluvial Groundwater Bores	
3.1 To minimise interference between neighbouring bores *These rules apply to **new** bores.* *These rules do not apply to **replacement** bores.* *These rules do not apply to bores nominated solely for domestic and stock, town water supply or local water utility access licences.*	New bores are not to be located within the following distances of existing bores: • 400 m from an access licence bore. • 200 m from a BLR bore. • 50 m from the boundary (unless negotiated with neighbour). • 500 m from a local or major utility bore (or as otherwise assessed). • 400 m from departmental monitoring bore (unless negotiated with the department). These distances may be varied by the Minister if the applicant undertakes a hydrogeological study, assessed as adequate by the Minister, which demonstrates minimal potential for adverse impacts on existing authorised extraction. These specified distances may also be varied after year five of the plan by the Minister.
3.2 Management of bores near contaminated sites. *These rules apply to **new** bores.* *These rules do not apply to **replacement** bores.*	New bores are not to be located within the 100 m of contaminated sites as identified within the plan. The distance may be varied for an applicant if the applicant can demonstrate no more than minimal harm to the groundwater source and there is no impact on the environment or threat to public health. New bores located within 100 m to 500 m of contaminated sites as identified within the plan will require ministerial approval and have evidence that no drawdown of groundwater within 100 m of the contamination source will occur. These rules do not apply to works for monitoring, environmental management purposes or remedial work. These rules may also be applied to contaminated sources not identified within the plan, based on the results of a site inspection or other relevant information provided to the Minister. Contaminated sites identified within the plan may be added or removed by the Minister based on results of a site inspection or other relevant information provide to the Minister on that contamination source.

<table>
<tr><th colspan="2">Dora Creek water source</th></tr>
<tr><td>3.3 Granting of bores near groundwater dependent ecosystems

These rules apply to new and replacement bores.

These rules do not apply to replacement bores that are part of a local or major water utility or town water supply bore field or network.</td><td>Bores are not be located within the following distance of high priority GDEs (non-karst) as identified within the plan:
• 100 m for bores used for extracting for BLR.
• 200 m for bores used for all other aquifer access licences.
• Where there is likely to be drawdown at the outside edge of the buffer zones referred to above.

Bores are not to be located within the following distances from these identified features:
• 500 m of karsts.
• In the bed of the river, unless assessment indicates that the work will have minimal harm on the river environment or stability.

These rules do not apply to works for monitoring, environmental management purposes or remedial work.

The distances from the GDEs may be varied for an applicant if a hydrogeological study is undertaken which demonstrates no drawdown of the groundwater at the outside edge of the GDE listed in the plan.

These specified distances may be amended or high priority GDEs identified within the plan may be added or removed, based on further studies of groundwater ecosystem dependency undertaken by the Minister.</td></tr>
<tr><td>3.4 Temporary local impact area rules for managing water quality and maintaining groundwater levels

These rules apply to all bores.</td><td>In order to protect water quality and maintain groundwater levels within this groundwater source, local restrictions may be applied.</td></tr>
</table>

Table A-2 Hunter Unregulated and Alluvial Water Sources Rules: North Lake Macquarie Water Source

North Lake Macquarie water source	
1. Access Rules	
Cockle Creek	
1.1 Cease to pump	All licence holders must cease to pump when: a) There is no visible low immediately downstream of their pump site or into and out of the pumping pool, and b) When there is no visible flow at the reference point. *N.B. From year six of the plan the cease to pump condition will apply to aquifer access licences extracting from all alluvial aquifers within 40 m of an unregulated river, except or existing domestic and stock access licences and local water utilities access licences.*
1.2 Reference point	The causeway on the Weir Road, Barnsley.
All other tributaries	
1.1 Cease to pump	Existing licence conditions apply for the first five years. From year six of the plan all licence holders must cease to pump when there is no visible inflow to, or outflow from, the pumping pool. *N.B. From year six of the plan the cease to pump condition will apply to aquifer access licences extracting from all alluvial aquifers within 40 m of an unregulated river, except for existing domestic and stock access licences and local water utilities access licences.*
1.2 Reference point	Riffles upstream and downstream of the pump.
1.3 Amendment provisions	N/A
2. Trading Rules	
2.1 Trading INTO the water source	Permitted, subject to assessment, if the trade will not increase the total licensed entitlement for the water source (no net gain trade).
2.2 Trading WITHIN the water source	Permitted, subject to assessment.
2.3 Conversion to High Flow Access Licence	Not permitted.
2.4 Conversion to Aquifer Access Licence	Not permitted.

North Lake Macquarie water source	
3. Managing Alluvial Groundwater Bores	
3.1 To minimise interference between neighbouring bores *These rules apply to **new** bores.* *These rules do not apply to **replacement** bores.* *These rules do not apply to bores nominated solely for domestic and stock, town water supply or local water utility access licences.*	New bores are not to be located within the following distances of existing bores: • 400 m from an access licence bore. • 200 m from a BLR bore. • 50 m from the boundary (unless negotiated with neighbour). • 500 m from a local or major utility bore (or as otherwise assessed). • 400 m from departmental monitoring bore (unless negotiated with the department). These distances may be varied by the Minister if the applicant undertakes a hydrogeological study, assessed as adequate by the Minister, which demonstrates minimal potential for adverse impacts on existing authorised extraction. These specified distances may also be varied after year five of the plan by the Minister.
3.2 Management of bores near contaminated sites *These rules apply to **new** bores.* *These rules do not apply to **replacement** bores.*	New bores are not to be located within the 100 m of contaminated sites as identified within the plan. The distance may be varied for an applicant if the applicant can demonstrate no more than minimal harm to the groundwater source and there is no impact on the environment or threat to public health. New bores located within 100 m to 500 m of contaminated sites as identified within the plan will require Ministerial approval and have evidence that no drawdown of groundwater within 100 m of the contamination source will occur. These rules do not apply to works for monitoring, environmental management purposes or remedial work. These rules may also be applied to contaminated sources not identified within the plan, based on the results of a site inspection or other relevant information provided to the Minister. Contaminated sites identified within the plan may be added or removed by the Minister based on results of a site inspection or other relevant information provide to the Minister on that contamination source.

North Lake Macquarie water source	
3.3 Granting of bores near groundwater dependent ecosystems *These rules apply to* ***new and replacement*** *bores.* *These rules do not apply to* ***replacement*** *bores that are part of a local or major water utility or town water supply bore field or network.*	Bores are not be located within the following distance of high priority GDEs (non-karst) as identified within the plan: • 100 m for bores used for extracting for BLR. • 200 m for bores used for all other aquifer access licences. • Where there is likely to be drawdown at the outside edge of the buffer zones referred to above. Bores are not to be located within the following distances from these identified features: • 500 m of karsts. • In the bed of the river, unless assessment indicates that the work will have minimal harm on the river environment or stability. These rules do not apply to works for monitoring, environmental management purposes or remedial work. The distances from the GDEs may be varied for an applicant if a hydrogeological study is undertaken which demonstrates no drawdown of the groundwater at the outside edge of the GDE listed in the plan. These specified distances may be amended or high priority GDEs identified within the plan may be added or removed, based on further studies of groundwater ecosystem dependency undertaken by the Minister.
3.4 Temporary local impact area rules for managing water quality and maintaining groundwater levels *These rules apply to* ***all*** *bores.*	In order to protect water quality and maintain groundwater levels within this groundwater source, local restrictions may be applied.

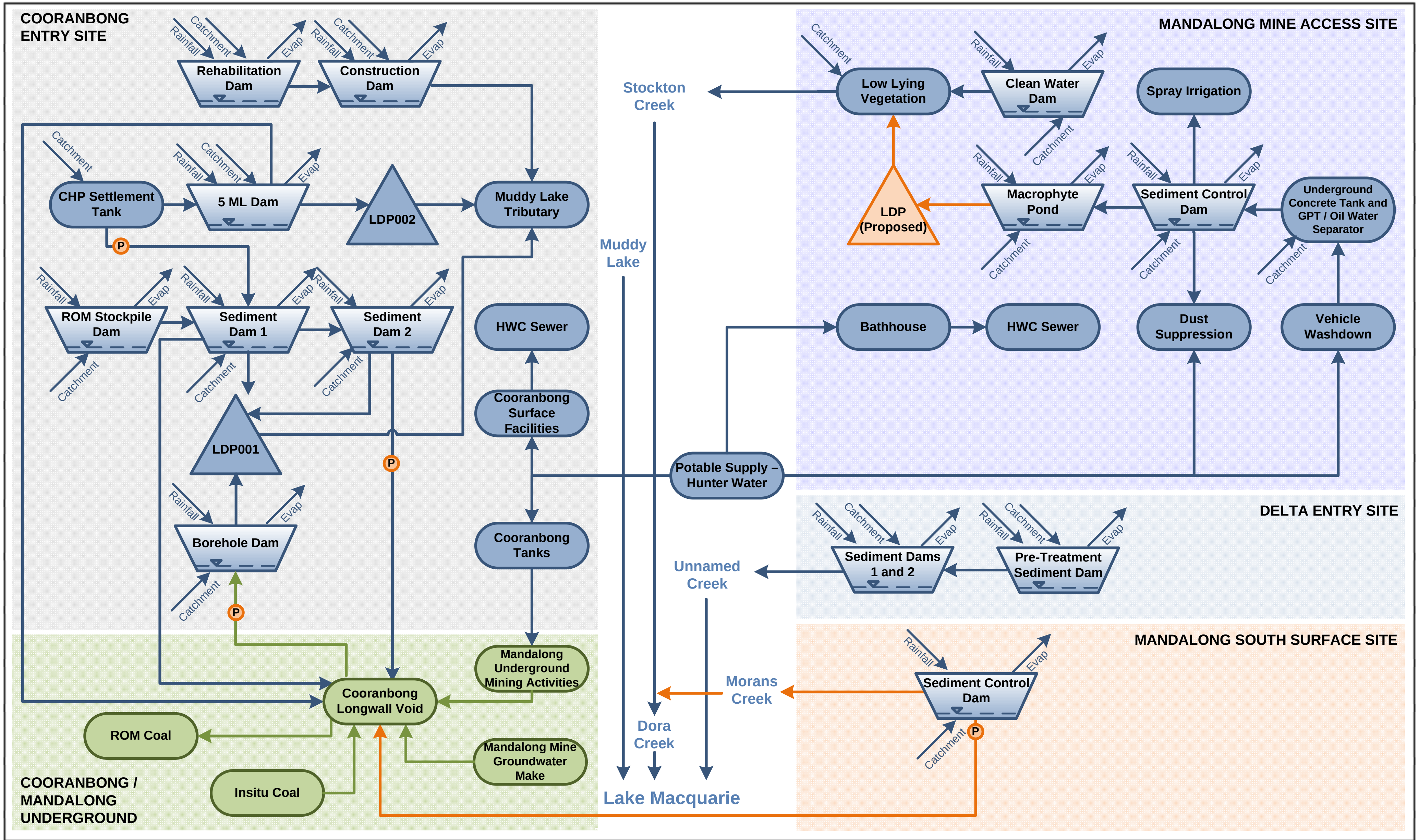
Table A-3 Hunter Unregulated and Alluvial Water Sources Rules: South Lake Macquarie Water Source

South Lake Macquarie water source	
1. Access Rules	
1.1 Cease to pump	Existing licence conditions remain for the first five years. From year six of the plan, cease to pump is when there is either no visible inflow to, or outflow from, the pumping pool. *N.B. From year six of the plan the cease to pump condition will apply to aquifer access licences extracting from all alluvial aquifers within 40 m of an unregulated river, except for existing domestic and stock access licences and local water access licences.*
1.2 Reference point	Riffles upstream and downstream of the pump.
2. Trading Rules	
2.1 Trading INTO the water source	Not permitted.
2.2 Trading WITHIN the water source	Permitted, subject to assessment.
2.3 Conversion to High Flow Access Licence	Not permitted.
2.4 Conversion to Aquifer Access Licence	Not Permitted.
3. Managing Alluvial Groundwater Bores	
3.1 To minimise interference between neighbouring bores *These rules apply to **new** bores.* *These rules do not apply to **replacement** bores.* *These rules do not apply to bores nominated solely for domestic and stock, town water supply or local water utility access licences.*	New bores are not to be located within the following distances of existing bores: • 400 m from an access licence bore. • 200 m from a BLR bore. • 50 m from the boundary (unless negotiated with neighbour). • 500 m from a local or major utility bore (or as otherwise assessed). • 400 m from departmental monitoring bore (unless negotiated with the department). These distances may be varied by the Minister if the applicant undertakes a hydrogeological study, assessed as adequate by the Minister, which demonstrates minimal potential for adverse impacts on existing authorised extraction. These specified distances may also be varied after year five of the plan by the Minister.

South Lake Macquarie water source	
3.2 Management of bores near contaminated sites. *These rules apply to **new** bores.* *These rules do not apply to **replacement** bores.*	New bores are not to be located within the 100 m of contaminated sites as identified within the plan. The distance may be varied for an applicant if the applicant can demonstrate no more than minimal harm to the groundwater source and there is no impact on the environment or threat to public health New bores located within 100 m to 500 m of contaminated sites as identified within the plan will require ministerial approval and have evidence that no drawdown of groundwater within 100 m of the contamination source will occur. These rules do not apply to works for monitoring, environmental management purposes or remedial work. These rules may also be applied to contaminated sources not identified within the plan, based on the results of a site inspection or other relevant information provided to the Minister. Contaminated sites identified within the plan may be added or removed by the Minister based on results of a site inspection or other relevant information provide to the Minister on that contamination source.
3.3 Granting of bores near groundwater dependent ecosystems *These rules apply to **new and replacement** bores.* *These rules do not apply to **replacement** bores that are part of a local or major water utility or town water supply bore field or network.*	Bores are not be located within the following distance of high priority GDEs (non-karst) as identified within the plan: • 100 m for bores used for extracting for BLR. • 200 m for bores used for all other aquifer access licences. • Where there is likely to be drawdown at the outside edge of the buffer zones referred to above. Bores are not to be located within the following distances from these identified features: • 500 m of karsts. • In the bed of the river, unless assessment indicates that the work will have minimal harm on the river environment or stability. These rules do not apply to works for monitoring, environmental management purposes or remedial work. The distances from the GDEs may be varied for an applicant if a hydrogeological study is undertaken which demonstrates no drawdown of the groundwater at the outside edge of the GDE listed in the plan. These specified distances may be amended or high priority GDEs identified within the plan may be added or removed, based on further studies of groundwater ecosystem dependency undertaken by the Minister.

South Lake Macquarie water source	
3.4 Temporary local impact area rules for managing water quality and maintaining groundwater levels *These rules apply to **all** bores.*	In order to protect water quality and maintain groundwater levels within this groundwater source, local restrictions may be applied.

Appendix B – Site Schematics



- Surface Transfers
- Underground Transfers
- Proposed Transfers
- (P) Pump

LOCATION	Mandalong
SEAM	Fassifern
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

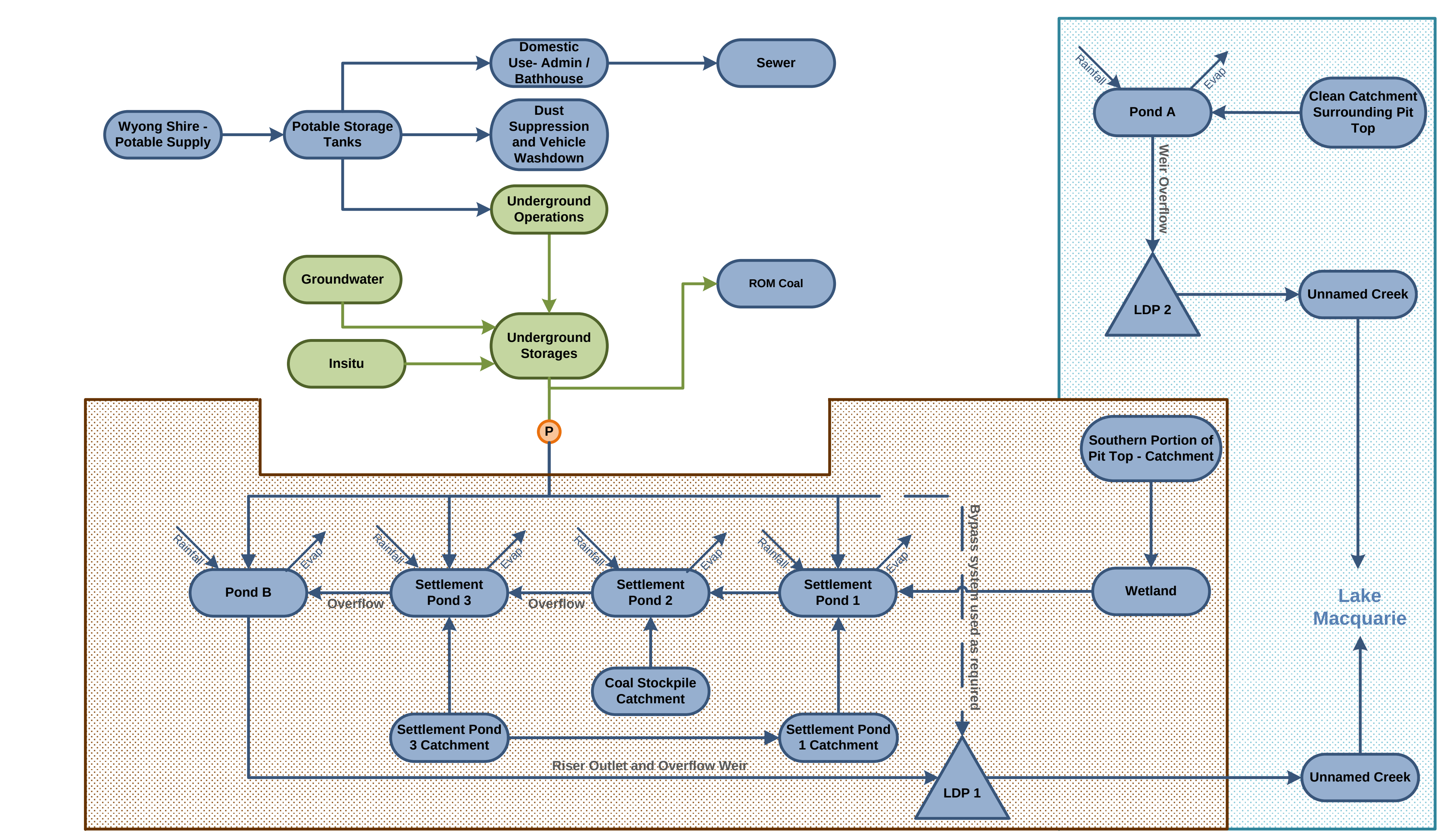
Northern Operations Water and Salt Balance

Mandalong Mine Water Cycle Schematic

Centennial Mandalong

DATE Mar 2014

Figure B-1



Note: All sediment ponds are able to be dewatered as required through the use of portable pumps

Surface Transfers
Underground Transfers
P Pump
Mine and Dirty Water Management
Clean Water Management

LOCATION	Mannering
SEAM	Fassifern
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

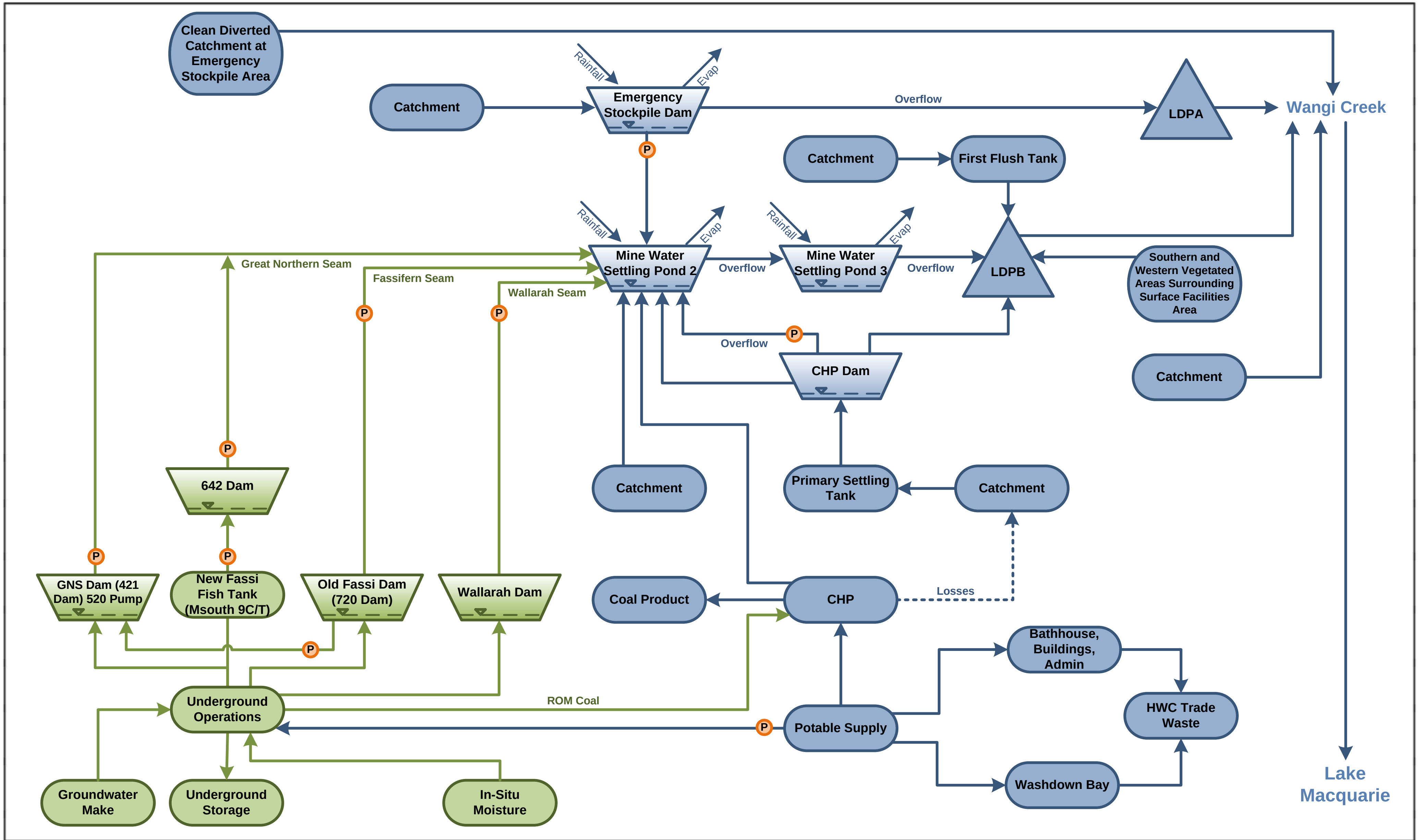
Northern Operations Water and Salt Balance

Mannering Colliery
Water Cycle Schematic

Centennial Mannering

DATE Mar 2014

Figure B-2



GHD

Surface Transfers

Underground Transfers

P Pump

LOCATION	Myuna
SEAM	Wall., G.N., Gt Nrth
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

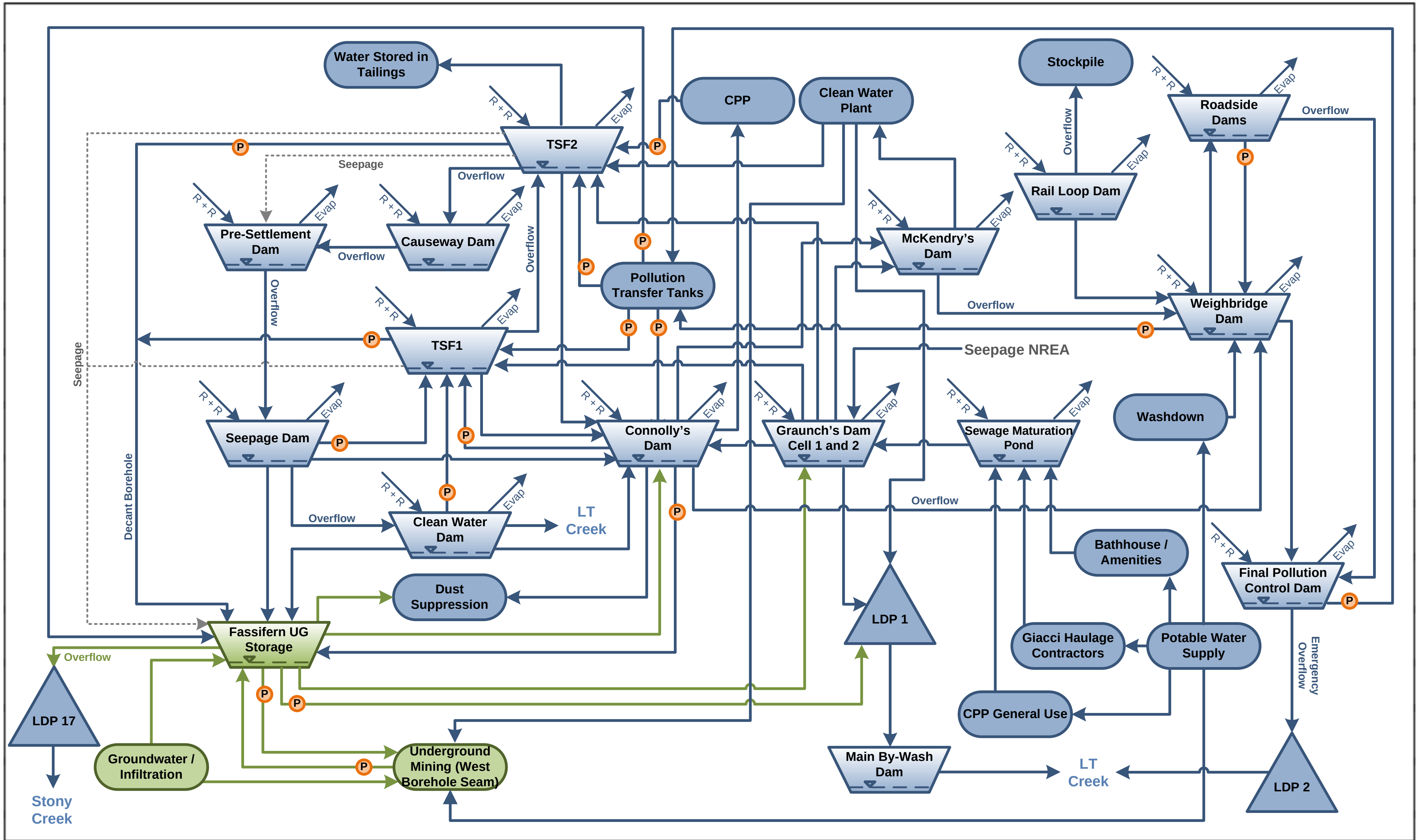
Northern Operations Water and Salt Balance

Myuna Colliery Water Cycle Schematic

Centennial Coal

DATE Mar 2014

Figure B-3



Surface Transfers

Underground Transfers

P Pump

LOCATION	Myuna
SEAM	Wall., G.N., Gt Nrth
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

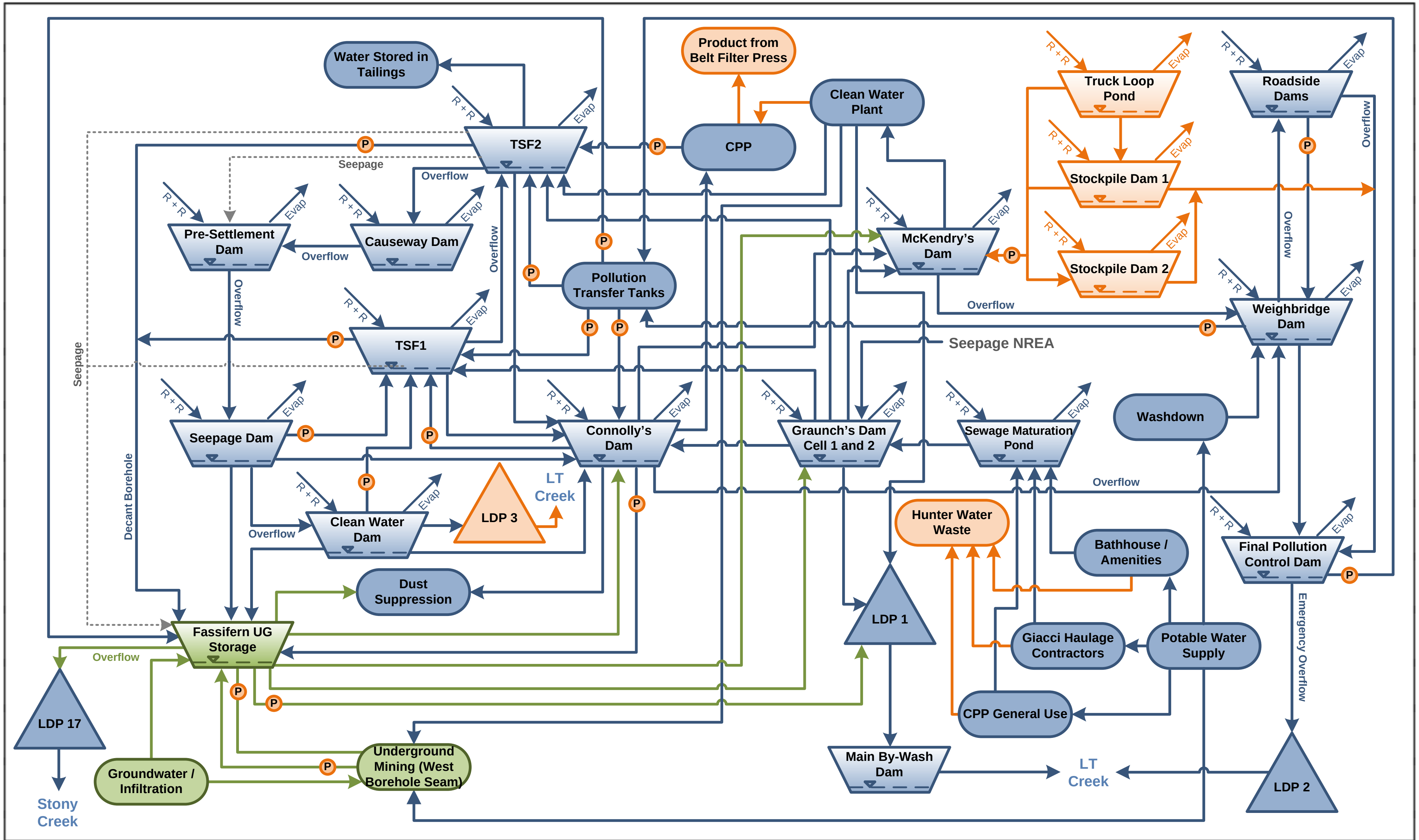
Northern Operations Water and Salt Balance

Newstan Colliery
Water Cycle Schematic
Existing Conditions

Centennial Coal

DATE Mar 2014

Figure B-4



Surface Transfers

Underground Transfers

Proposed Transfers

P Pump

LOCATION	Myuna
SEAM	Wall., G.N., Gt Nrth
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

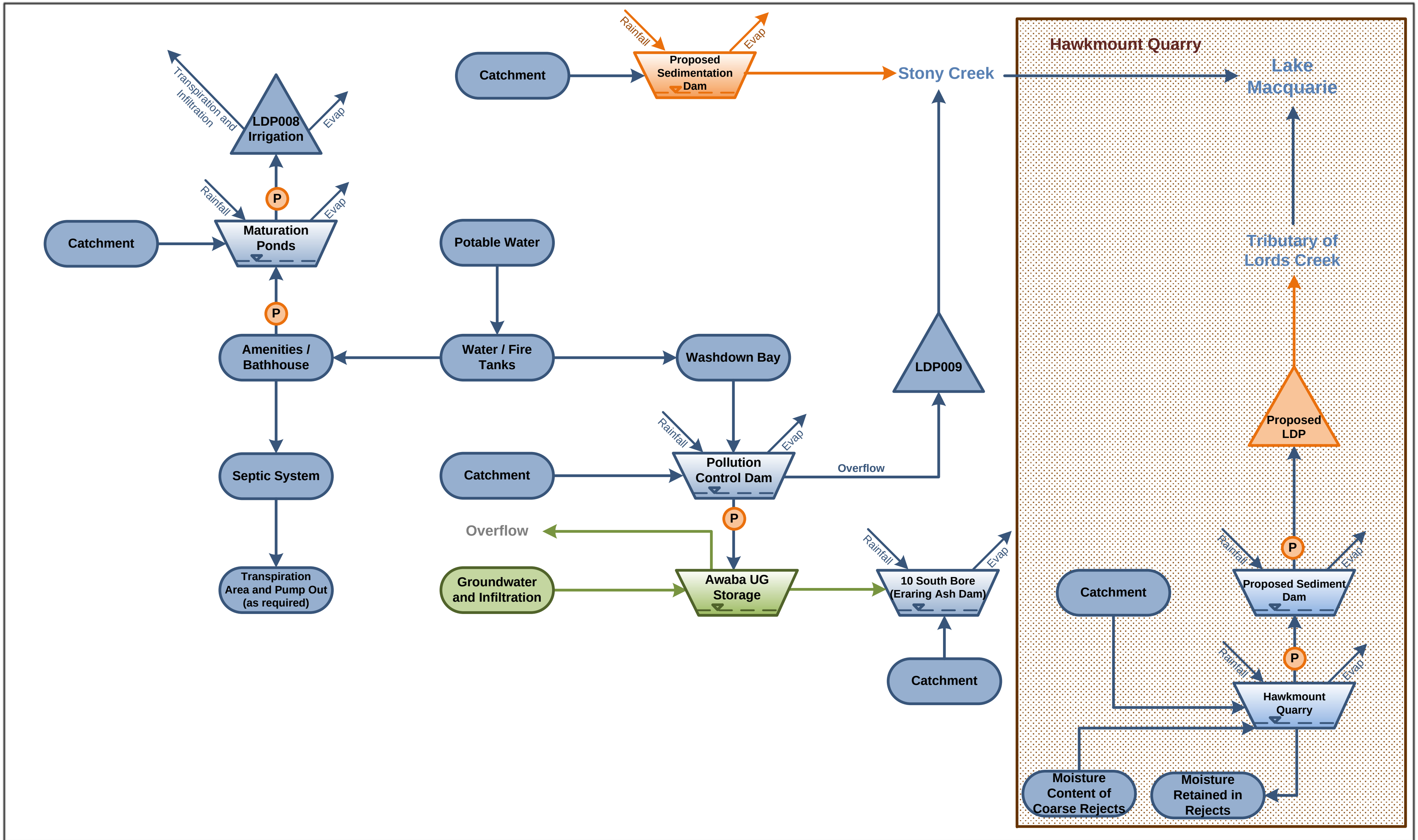
Northern Operations Water and Salt Balance

Newstan Colliery
Proposed Water Cycle Schematic

Centennial Coal

DATE Mar 2014

Figure B-5



- Surface Transfers
- Underground Transfers
- Proposed Transfers
- P — Pump

LOCATION	Awaba
SEAM	Fassifern
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

Northern Operations Water and Salt Balance

Awaba Colliery and Hawkmount Quarry Water Cycle Schematic

Centennial Coal

DATE Mar 2014

Figure B-6

Appendix C – Sub-Catchment Data

Table C-1 Sub-Catchment Data – Dora Creek Water Source

Sub-catchment	Area (ha)
Dora Creek	11,417.1
Jigadee Creek	3,948.4
Lords Creek	2,091.4
Morans Creek	2,384.3
Stockton Creek	3,220.6

Table C-2 Sub-Catchment Data – North Lake Macquarie Water Source

Sub-catchment	Area (ha)
Brush Creek	457.4
Burkes Creek	1,510.9
Cocked Hat Creek	868.0
Cockle Creek	3,040.8
Crokers Creek	4,062.1
Crooked Creek	578.9
Diega Creek	1,044.5
Hely Creek	133.7
Kilaben Creek	336.5
LT Creek	519.2
Marmong Creek	646.7
Mills Gully	270.1
North Creek	552.6
North Creek	41.0
Palmers Creek	2,028.6
Puntei Creek	1,010.3
Sawmill Creek	139.2
Sheppards Creek	571.0
Slatey Creek	1,891.2
South Creek	567.2
Stockyard Creek	435.4
Stony Creek	1,761.0
Unnamed tributary of Lake Macquarie	1,035.0

Table C-3 Sub-Catchment Data – South Lake Macquarie Water Source

Sub-catchment	Area (ha)
Bonny Boy Gully	125.8
Cobra Creek	344.9
Crangan Creek	120.5
Freshwater Creek	87.2
Fullers Creek	104.2
Galgabbah Gully	423.6
Galgabree Creek	578.0
Karigan Creek	515.7
Mangrove Creek	371.2
Middle Camp Gully	566.4
Plains Gully	583.0
Post Mistress Creek	75.2
Pourmalong Creek	1,586.1
Stranger Gully	54.4
Tiembula Creek	360.6
Wyee Creek	5,041.6
Yallawali Creek	78.7
Unnamed tributary of Lake Macquarie	2,835.4
Unnamed tributary to ocean	1,143.4

Table C-4 Sub-Catchment Data – Development Footprint Areas

Water source	Development	Area (ha)
Dora Creek	Aquabait	1.1
	Cooranbong Entry Site	23.9
	Eraring Power Station and Eraring Ash Dam	106.4
	Hawkmount Quarry	22.1
	Mandalong Mine Access Site	8.4
	Proposed Mandalong South Surface Site	3.3
North Lake Macquarie	Awaba Colliery	36.5
	Eraring Power Station and Ash Dam	150.5

Water source	Development	Area (ha)
North Lake Macquarie	Macquarie Preparation Plant (part of West Wallsend Colliery)	146.7
	Myuna Colliery	23.3
	Newstan Colliery	236.0
	Pasminco and Incitec Consolidated Remediation Project	157.3
	Teralba Quarry	45.1
	West Wallsend Colliery	14.7
	Westside Mine	66.5
South Lake Macquarie	Chain Valley Colliery	12.0
	Delta Entry Site	4.1
	Mannering Colliery	17.5
	Vales Point Power Station and Ash Dam	185.7

Appendix D – Australian Water Balance Model Parameter Sensitivity Analysis

D.1 Introduction

The AWBM parameters that determine the volume of runoff generated by a catchment are the three surface storage capacities (C_1, C_2 and C_3) and the partial areas of the catchment represented by each capacity (A_1, A_2 and A_3). Boughton and Chiew (2003) recommend the use of an average surface storage capacity (Ave) such that:

$$A_1 = 0.134$$

$$A_2 = 0.433$$

$$A_3 = 0.433$$

$$C_1 = 0.01 \times \frac{Ave}{A_1}$$

$$C_2 = 0.33 \times \frac{Ave}{A_2}$$

$$C_1 = 0.66 \times \frac{Ave}{A_3}$$

The relationship between the average surface storage capacity and the three surface storage capacities were based on calibrated parameters on 19 catchments with high quality rainfall and runoff data (Boughton and Chiew, 2003). The use of these relationships requires only one parameter required to be calibrated and has been found to be applicable on a wide range of catchments in Australia (Boughton and Chiew, 2003).

Application of the AWBM to determine runoff from rainfall over a catchment requires observed streamflow data to calibrate model parameters. Boughton and Chiew (2003) provide AWBM parameter values and catchment characteristics for 221 Australian catchments calibrated against runoff data. The calibrated parameter values are intended to be used in the AWBM to estimate runoff from ungauged catchments. The selection of parameter values is based on spatial proximity to nearby gauged catchments for which parameters have been calibrated.

The parameter values for bushland or vegetated areas for the regional water and salt balance were selected for the most appropriate location for which AWBM parameters had been determined by Boughton and Chiew (2003). The only gauging station within the Study Area with calibrated AWBM parameters was determined to be Jigadee Creek, located approximately 30 km south-west of Newcastle.

A sensitivity analysis of the AWBM parameters that determine runoff from rainfall on bushland or vegetated areas, represented by the parameter for average surface storage capacity, was undertaken to ensure that the results of the water and salt balance model were not significantly affected by uncertainty in the adopted AWBM parameters.

D.2 Methodology

A value of 50 mm was selected for the average surface storage capacity based on the results of a calibration of Jigadee Creek at Avondale (NOW gauge 211008) presented by Boughton and Chiew (2003). Streamflow data from the Wyee Creek gauging station (NOW gauge 211003) from January 1960 to January 1965 was used to compare with the catchment runoff predicted by the model.

The sensitivity analysis was performed by varying the average surface storage capacity by 10 mm and observing the changes in the Nash-Sutcliffe efficiency coefficient and the estimated discharge values output by the model. Other parameters within the model were held constant.

The Nash-Sutcliffe efficiency coefficient was used to measure the performance of the model in fitting the observed discharge. The Nash-Sutcliffe efficiency coefficient (R^2), given by the following equation:

$$R^2 = 1 - \frac{\sum(Q_i - Q_i')^2}{\sum(Q_i - Q'')^2}$$

where

Q_i = observed discharge

Q'_i = modelled discharge

Q'' = average observed discharge

The Nash-Sutcliffe efficiency coefficient considers the ratio of the variance of the observed data set and the variance of the model and provides a measure of the ability of the model to reproduce gauged flows. An efficiency coefficient of one indicates that all modelled discharges are equal to observed discharges, while an efficiency of zero indicates that the average observed discharge is as accurate as the model estimate of streamflow. An efficiency coefficient less than zero indicates that the average observed discharge is more accurate at predicting streamflow than the model.

D.3 Results and Discussion

The Nash-Sutcliffe efficiency coefficients determined by the model for the varied values of the average surface storage capacity parameter are presented in Table D-1. Figure D-1, Figure D-2 and Figure D-3 present the modelled and observed discharge from the catchment along with observed rainfall for the varied values of the parameter.

Table D-1 Results of Sensitivity Analysis

Value of Ave (mm)	Change in parameter	Nash-Sutcliffe efficiency coefficient	Total discharge (ML)
40	– 10 mm	0.539	29,003
50	No change	0.537	30,890
60	+ 10 mm	0.577	29,376

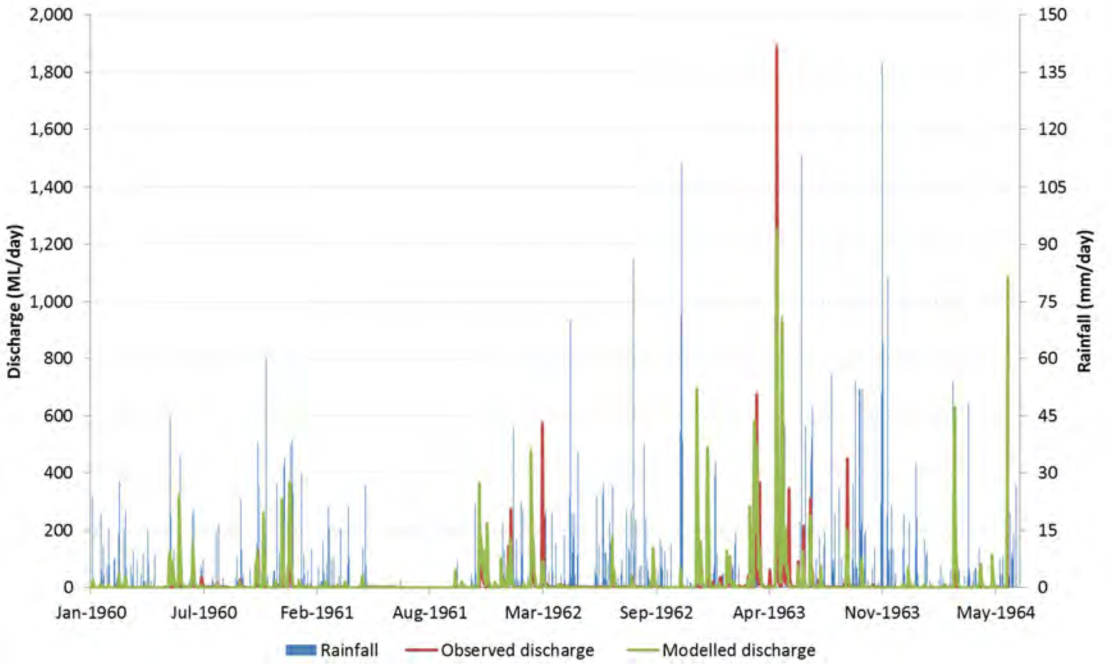


Figure D-1 Predicted Daily Discharge for Ave = 40 mm (– 10 mm change)

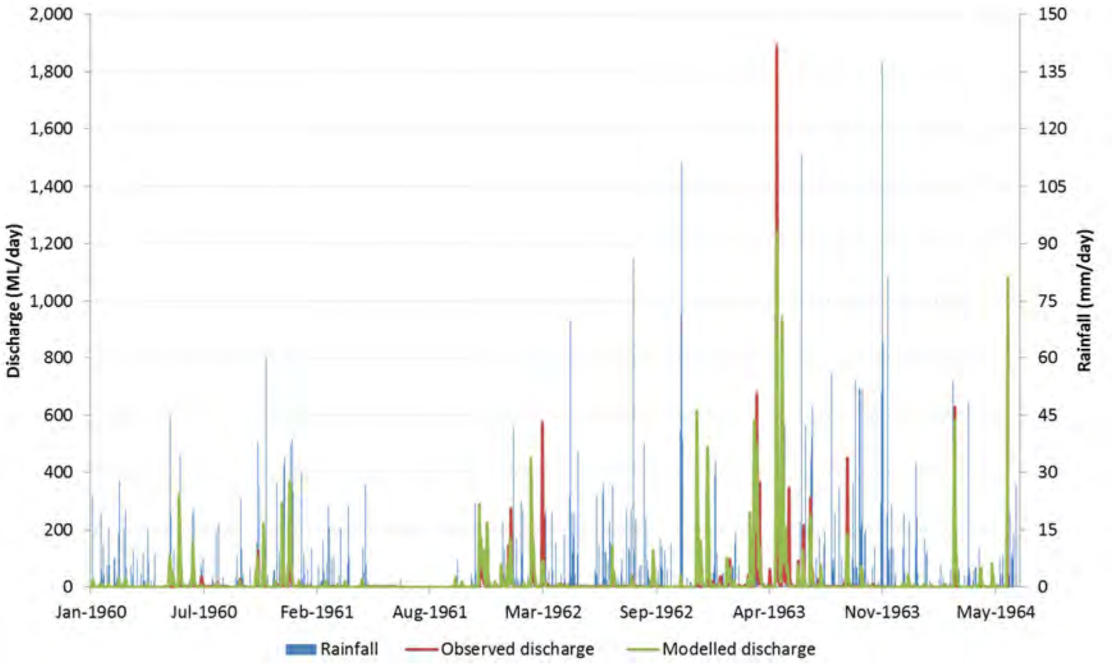


Figure D-2 Predicted Daily Discharge for Ave = 50 mm

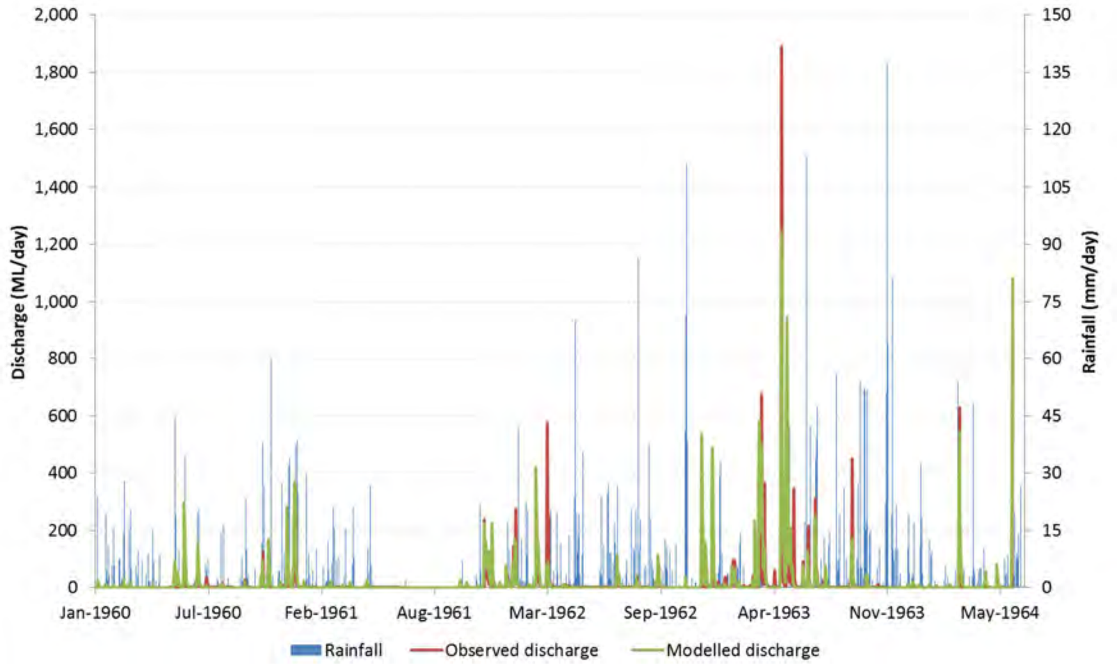


Figure D-3 Predicted Daily Discharge for Ave = 60 mm (+ 10 mm change)

From an analysis of the results, the Nash-Sutcliffe efficiency coefficient was found to range between 0.537 and 0.577, indicating that the model performed well in predicting the runoff generated by the catchment. The total discharge observed at the gauge over the simulation period was 19,365 ML, which was overestimated by the model by approximately 37%. Varying the average surface storage capacity by 10 mm was found to result in the total discharge estimated by the model varying by less than 10%. Overall, the results of the sensitivity analysis indicate that the parameter selection for the average surface storage capacity, based on a calibration of a nearby catchment by Boughton and Chiew (2003), is relatively robust, with little change in the estimated discharge predicted by the model resulting from the variation in parameter value.

Appendix E – Salinity Data

Site	Parameter	Source	Statistic	Value (µS/cm)
All sites	Rainfall	Department of Natural Resources and Water, Queensland Government (DNRW, 2007)	Typical value	30
Centennial-owned sites				
Mandalong Mine	Clean catchment runoff	Water quality monitoring of point upstream of surface facility operations	Typical value	450
	Coal-contact catchment runoff	Water quality monitoring of catchment runoff from Centennial surface facility operations	Estimated composite value	895
	Groundwater inflow to underground workings	Water quality monitoring of the Borehole Dam at Cooranbong Entry Site	95th percentile	5,882
	Potable water	Centennial Newstan water quality monitoring data and Hunter Water Corporation supply information	Typical value	235
Mannering Colliery	Clean catchment runoff	Water quality monitoring of point upstream of surface facility operations	Typical value	450
	Coal-contact catchment runoff	Water quality monitoring of catchment runoff from Centennial surface facility operations	Estimated composite value	895
	Groundwater inflow to underground workings	Water quality monitoring of groundwater in underground workings	95th percentile	25,000
	Potable water	Centennial Newstan water quality monitoring data and Hunter Water Corporation supply information	Typical value	235
Myuna Colliery	Coal-contact catchment runoff	Water quality monitoring of catchment runoff from Centennial surface facility operations	Estimated composite value	895
	Groundwater inflow to underground workings	Water quality monitoring of groundwater in underground workings	95th percentile	40,100

Site	Parameter	Source	Statistic	Value (µS/cm)
	Potable water	Centennial Newstan water quality monitoring data and Hunter Water Corporation supply information	Typical value	235
Newstan Colliery	Clean catchment runoff	Water quality monitoring of point upstream of surface facility operations	Typical value	450
	Coal-contact catchment runoff	Water quality monitoring of catchment runoff from Centennial surface facility operations	Estimated composite value	895
	Groundwater inflow and infiltration into Fassifern Underground Storage	Water quality monitoring of Fassifern Underground Storage	95th percentile	1,500
	Groundwater inflow to West Borehole Seam	Water quality monitoring of groundwater in underground workings	95th percentile	3,500
	Potable water	Centennial Newstan water quality monitoring data and Hunter Water Corporation supply information	Typical value	235
Non-Centennial sites				
Aquabait	Surface water extraction	Water quality monitoring by Eraring Power Station	Average	55,000
	LDP discharge	Water quality monitoring by Eraring Power Station	Average	55,000
Chain Valley Colliery	Groundwater inflow into underground workings	Water quality monitoring of groundwater	Maximum	35,600
	LDP discharge	Water quality monitoring of LDP discahrges	Average	33,000
Eraring Power Station	Surface water extraction	Water quality monitoring by Eraring Power Station	Average	55,000
	LDP discharge	Water quality monitoring by Eraring Power Station	Average	55,000

Site	Parameter	Source	Statistic	Value (µS/cm)
Pasminco and Incitec Consolidated Remediation Project	Groundwater extraction	Water quality monitoring by Incitec Pivot	Average	1,688
	LDP discharge	Water quality monitoring by Incitec Pivot	Average	1,688
Tasman Underground Mine	Groundwater inflow into underground workings	Water quality monitoring of groundwater	Upper value of range	1,260
Teralba Quarry	Groundwater extraction	Water quality monitoring of LDP discharges	Lower value of range	2,300
	LDP discharge	Water quality monitoring of LDP discharges	Lower value of range	2,300
Vales Point Power Station	Surface water extraction	Water quality monitoring by Vales Point Power Station	Average	55,000
	Point 1 discharge	Water quality monitoring by Vales Point Power Station	Average	55,000
	Point 2 discharge	Laucht, 2011	Median	403
	Point 3 discharge	Laucht, 2011	Median	403
Wallarah 2 Coal Project	Groundwater inflow into underground workings	Water quality monitoring of groundwater	Upper value of range	11,940
West Wallsend Colliery	Groundwater inflow into underground workings	Water quality monitoring of LDP discharges at Point 4 of Westside Mine	Average	5,200
	Point 1 discharge	Water quality monitoring of LDP discharges	Average	665
	Point 2 discharge	Water quality monitoring of LDP discharges	Average	271

Site	Parameter	Source	Statistic	Value (µS/cm)
	Point 3 discharge	Water quality monitoring of LDP discharges	Average	446
Westside Mine	Groundwater inflow into void	Water quality monitoring of groundwater	Average	6,700
	Point 2 discharge	Water quality monitoring of LDP discharges	Average	202
	Point 3 discharge	Water quality monitoring of LDP discharges	Average	1,070
	Point 4 discharge	Water quality monitoring of LDP discharges	Average	5,200
	Point 5 discharge	Water quality monitoring of LDP discharges	Average	134
	Point 6 discharge	Water quality monitoring of LDP discharges	Average	131

Appendix F – Data Sources and Confidence

Table F-1 Mandalong Mine – Data Sources

Parameter	Data source
General operational data	Provided by Centennial Mandalong
Surface areas of water storages	Derived from aerial photography provided by Centennial Mandalong
Topographical data	Department of Lands contours
Catchment areas	Provided by Centennial Mandalong and derived from topographic information
Maximum water transfer rates	Provided by Centennial Mandalong
Storage capacities	Provided by Centennial Mandalong
Potable water usage	Provided by Centennial Mandalong
Dust suppression usage	Provided by Centennial Mandalong
Washdown usage	Provided by Centennial Mandalong
Drainage infrastructure information	Provided by Centennial Mandalong
Pumping rules and rates	Provided by Centennial Mandalong

Table F-2 Mannering Colliery – Data Sources

Parameter	Data source
General operational data	Provided by Centennial Mannering
Surface areas of water storages	Derived from aerial photography provided by Centennial Mannering
Topographical data	Department of Lands contours
Catchment areas	Provided by Centennial Mannering and derived from topographic information
Maximum water transfer rates	Provided by Centennial Mannering
Dust suppression usage	Provided by Centennial Mannering
Washdown usage	Provided by Centennial Mannering
Storage capacities	Provided by Centennial Mannering
Underground water usage	Provided by Centennial Mannering
Coal production data	Provided by Centennial Mannering
Potable water demand	Provided by Centennial Mannering
Pumping rules and rates	Provided by Centennial Mannering

Table F-3 Myuna Colliery – Data Sources

Parameter	Data source
General operational data	Provided by Centennial Myuna
Surface areas of water storages	Derived from aerial photography provided by Centennial Myuna
Topographical data	Department of Lands contours
Catchment areas	Provided by Centennial Myuna and derived from topographic information
Maximum water transfer rates	Provided by Centennial Myuna
CHP water usage	Provided by Centennial Myuna
Storage capacities	Provided by Centennial Myuna
Underground water usage	Provided by Centennial Myuna
Coal production data	Provided by Centennial Myuna
Potable water demand	Provided by Centennial Myuna
Washdown usage	Provided by Centennial Myuna
Drainage infrastructure information	Provided by Centennial Myuna
Pumping rules and rates	Provided by Centennial Myuna

Table F-4 Newstan Colliery – Data Sources

Parameter	Data source
Water storage operations and management rules	Provided by Centennial Newstan
Topographic information	Provided by Centennial Newstan
Maximum water transfer rates	Provided by Centennial Newstan
Storage capacities	Provided by Centennial Newstan
Underground water usage	Derived from information provided by Centennial Newstan
CPP water usage	Derived from information provided by Centennial Newstan
Haulage contractor’s water usage	Derived from information provided by Centennial Newstan
Amenities and bathhouse water usage	Derived from information provided by Centennial Newstan

Parameter	Data source
Washdown usage	Derived from information provided by Centennial Newstan
Dust suppression usage	Derived from information provided by Centennial Newstan
Surface areas of water storages	Derived from information provided by Centennial Newstan
Catchment areas	Derived from information provided by Centennial Newstan
Groundwater make into Fassifern Underground Storage	Calibrated to data provided by Centennial Newstan
Proportion of rainfall infiltrating into the underground storages	Calibrated to data provided by Centennial Newstan
Seepage from TSF to the Fassifern Underground Storage	Calibrated to data provided by Centennial Newstan
Fassifern and Awaba Underground Storages stage storage relationship	Calibrated to data provided by Centennial Newstan

Table F-5 Limitations and Data Confidence

Site	Limitations	Data confidence level
Centennial-owned sites		
Mandalong Mine	Standard Centennial site-specific water balance modelling limitations apply.	High
Mannering Colliery	Standard Centennial site-specific water balance modelling limitations apply. Future operating conditions unknown.	Medium
Myuna Colliery	Standard Centennial site-specific water balance modelling limitations apply. Preliminary hydrogeological modelling outcomes considered.	Medium
Newstan Colliery	Standard Centennial site-specific water balance modelling limitations apply. Draft water balance and hydrogeological modelling outcomes considered.	Medium
Non-Centennial sites		
Aquabait	Limited publicly available information. Volumetric inflow and outflow data estimated.	Low
Chain Valley Colliery	Site-specific water balance modelling outcomes considered. However, only average values could be used, which limits the consideration of rainfall variability.	Medium
Eraring Power Station	Limited publicly available information. Volumetric inflow and outflow data estimated. Discharges from Ash Dam not considered due to limited publicly available information.	Low
Pasminco and Incitec Consolidated Remediation Project	Limited publicly available recent information. Remediation works are ongoing, however are drawing to a close.	Low

Site	Limitations	Data confidence level
Tasman Underground Mine	Site-specific hydrogeological modelling outcomes considered.	Medium
Teralba Quarry	Site-specific water balance modelling outcomes considered. However, only average values could be used, which limits the consideration of rainfall variability.	Medium
Vales Point Power Station	Limited publicly available information. Volumetric inflow and outflow data estimated.	Low
Wallarah 2 Coal Project	Site-specific hydrogeological modelling outcomes considered.	Medium
West Wallsend Colliery	No site-specific water balance modelling outcomes to be considered. Monitoring data was considered in modelling. Future operating conditions unknown.	Low
Westside Mine	No site-specific water balance modelling outcomes to be considered. Monitoring data was considered in modelling. Future operating conditions unknown.	Medium

Appendix G – Individual Site Water Balance Results

Centennial-Owned Sites

Mandalong Mine

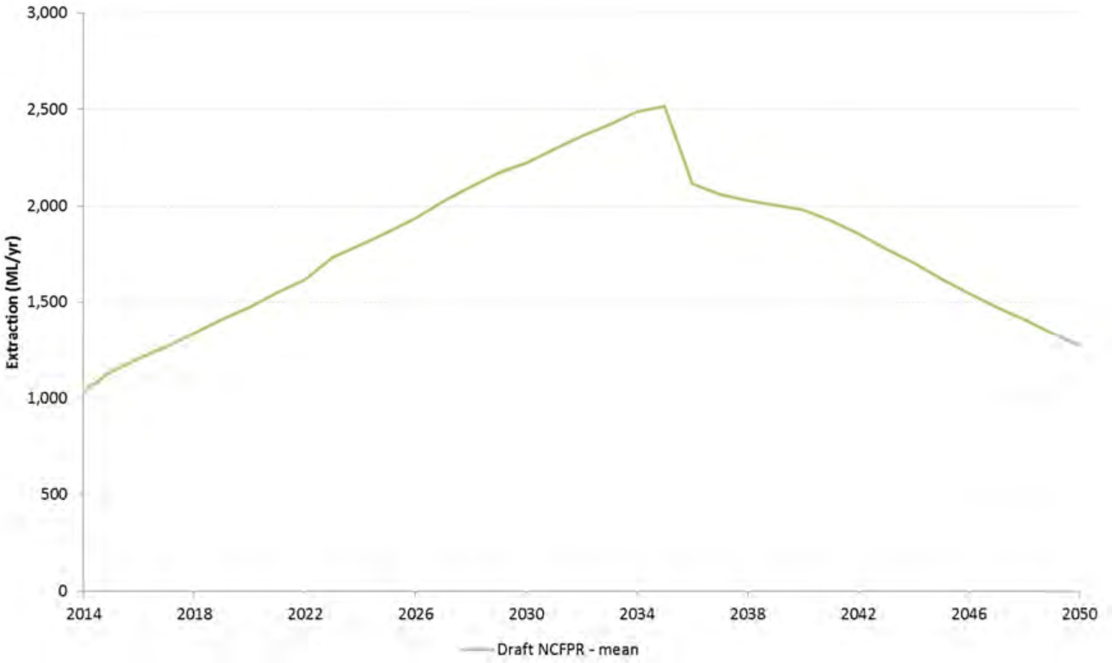


Figure G–1 Mandalong Mine – Groundwater Extraction

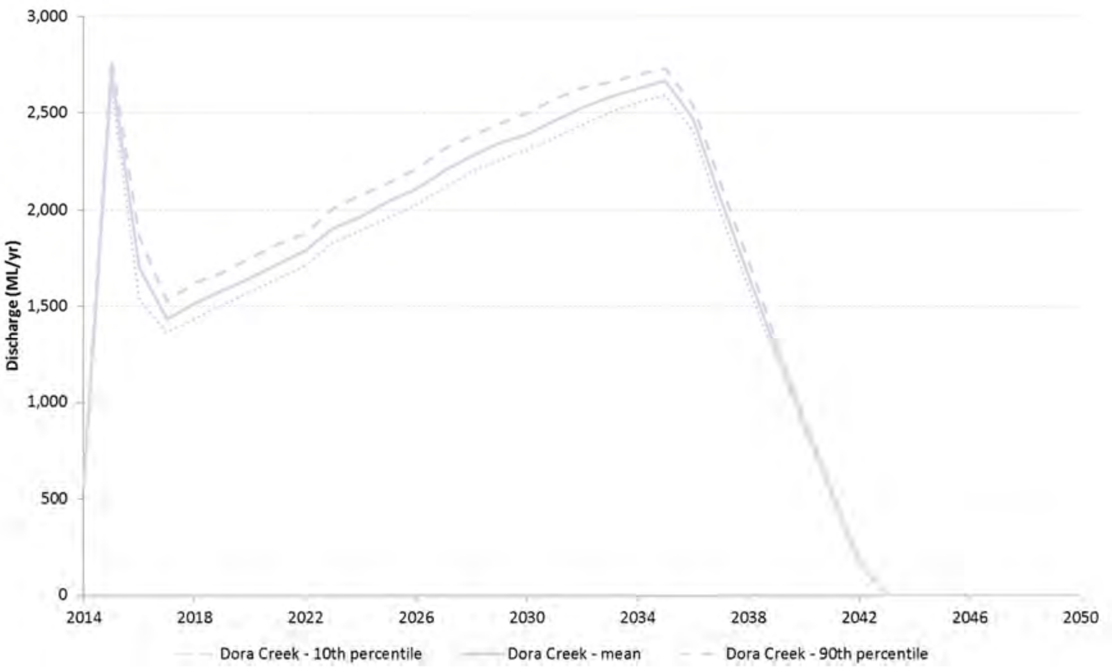


Figure G–2 Mandalong Mine – Surface Water Discharge

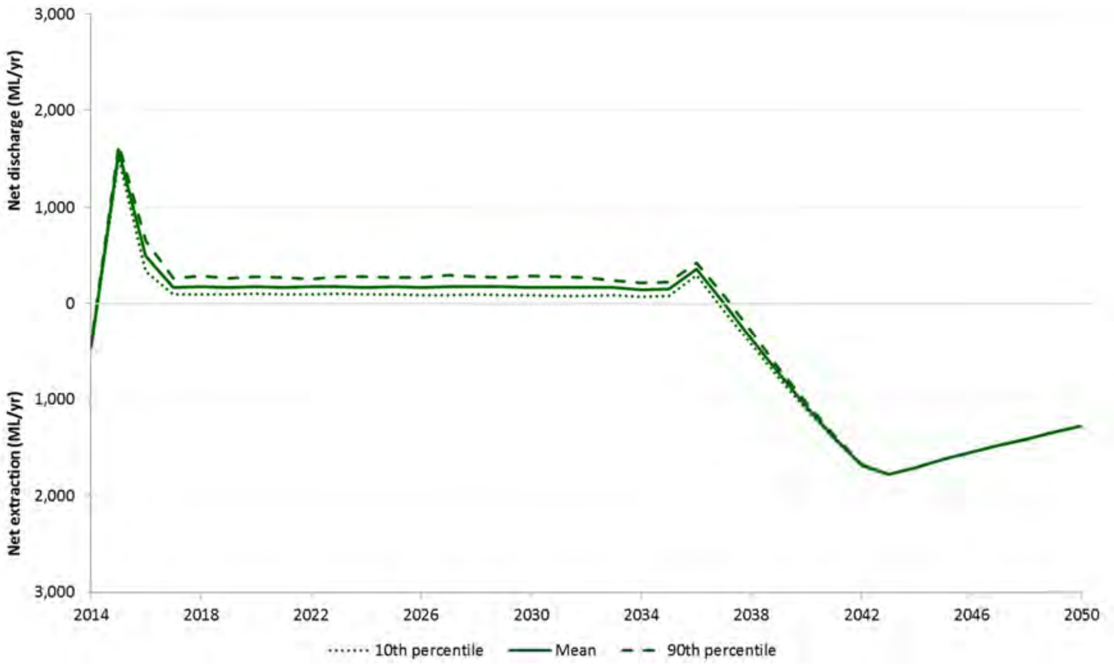


Figure G–3 Mandalong Mine – Net Extraction/Discharge

Mannering Colliery

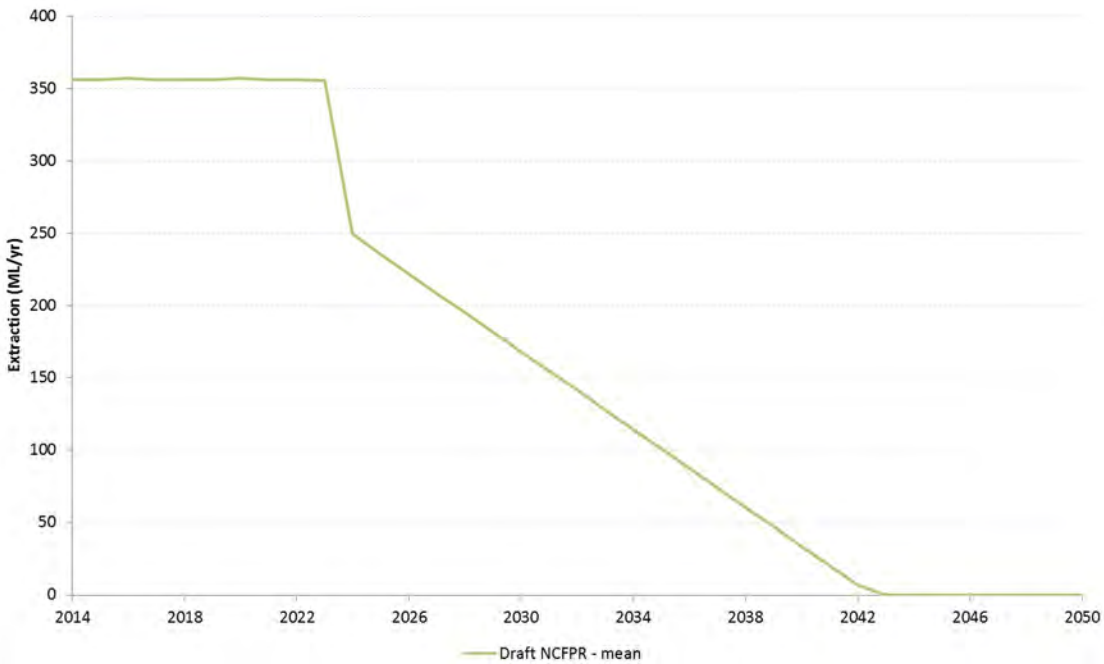


Figure G-4 Mannering Colliery – Groundwater Extraction

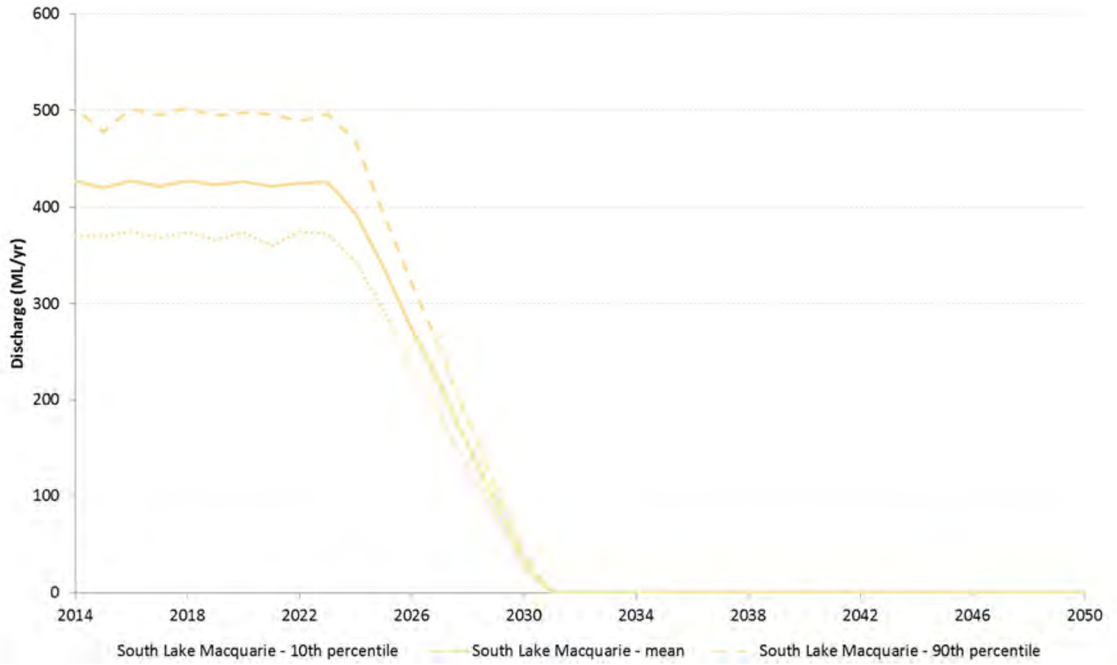


Figure G-5 Mannering Colliery – Surface Water Discharge

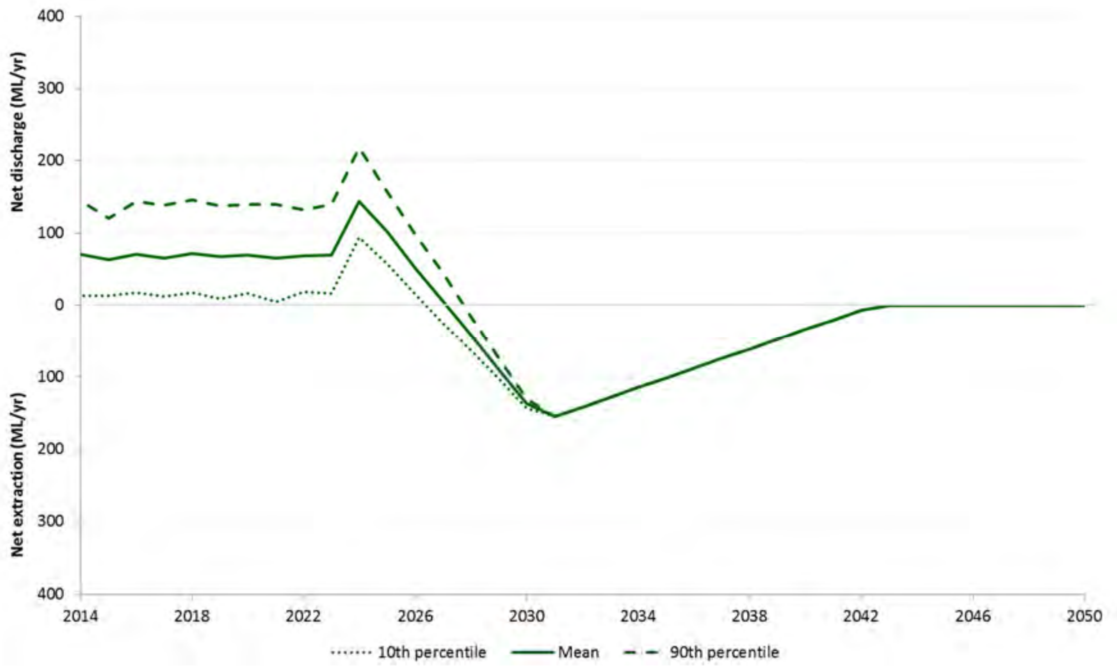


Figure G-6 Mannering Colliery – Net Extraction/Discharge

Myuna Colliery

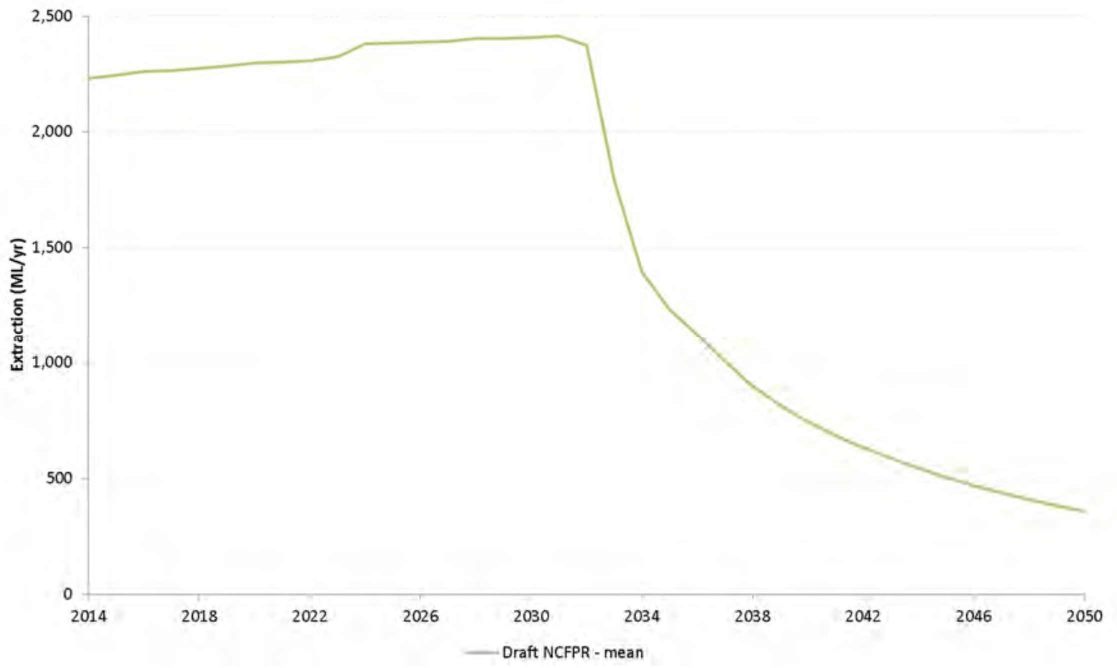


Figure G-7 Myuna Colliery – Groundwater Extraction

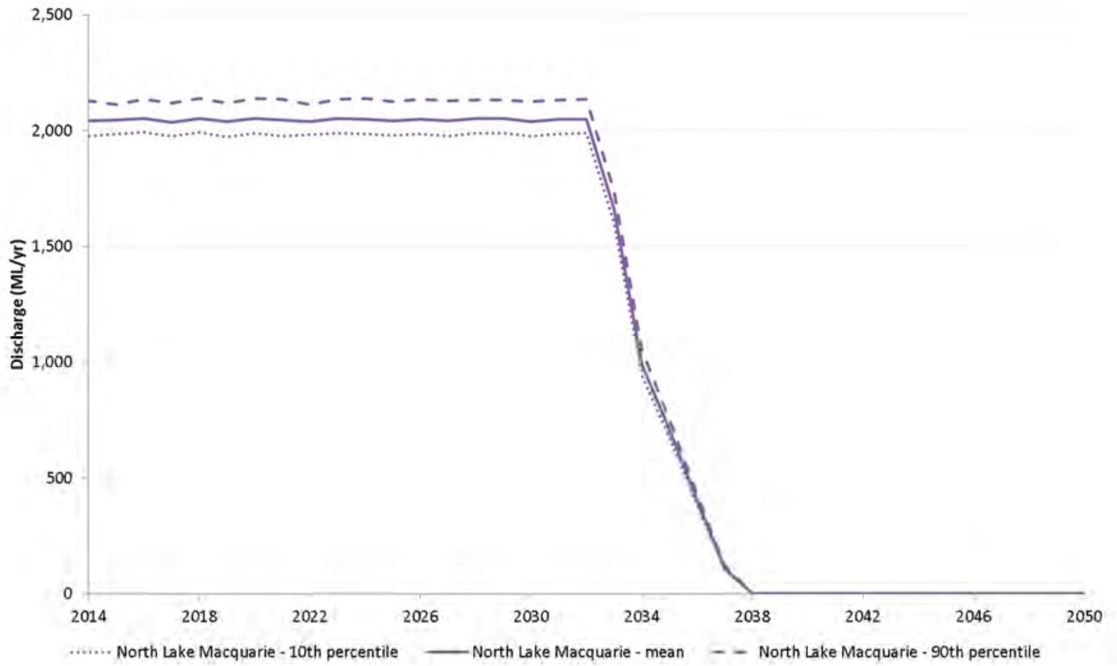


Figure G-8 Myuna Colliery – Surface Water Discharge

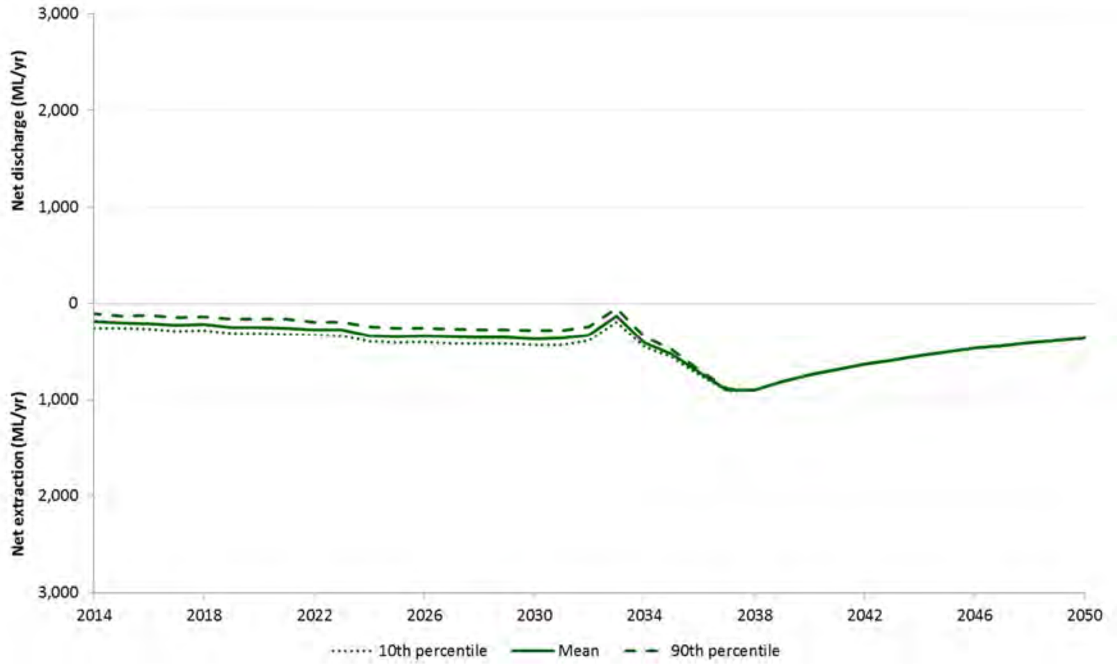


Figure G-9 Myuna Colliery – Net Extraction/Discharge

Newstan Colliery

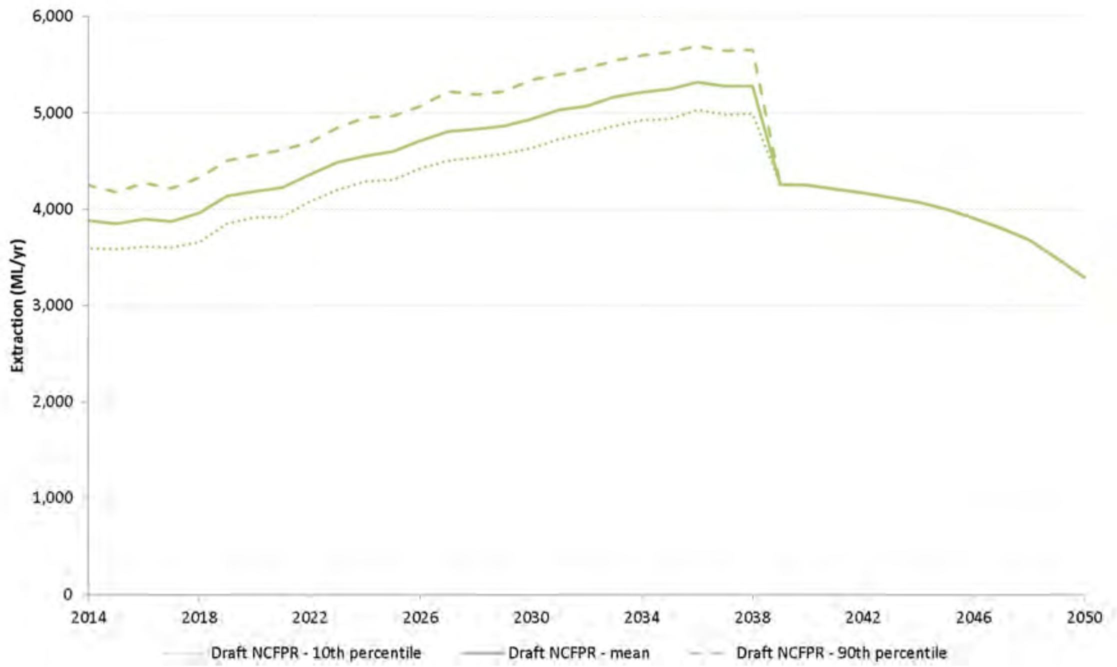


Figure G-10 Newstan Colliery – Groundwater Extraction

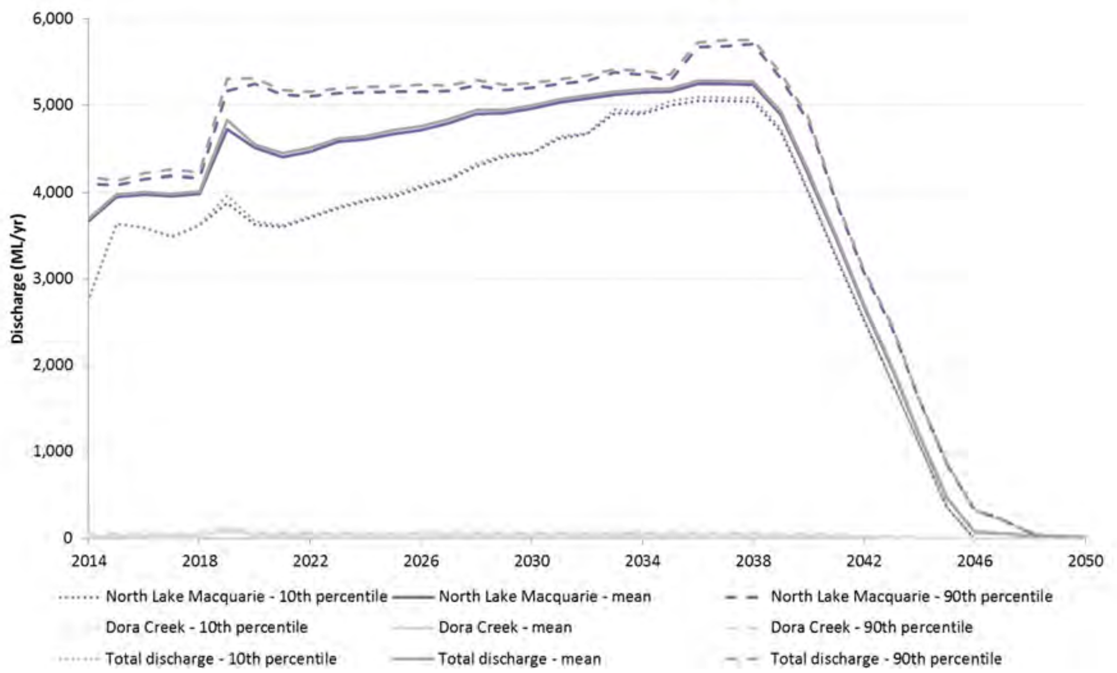


Figure G-11 Newstan Colliery – Surface Water Discharge

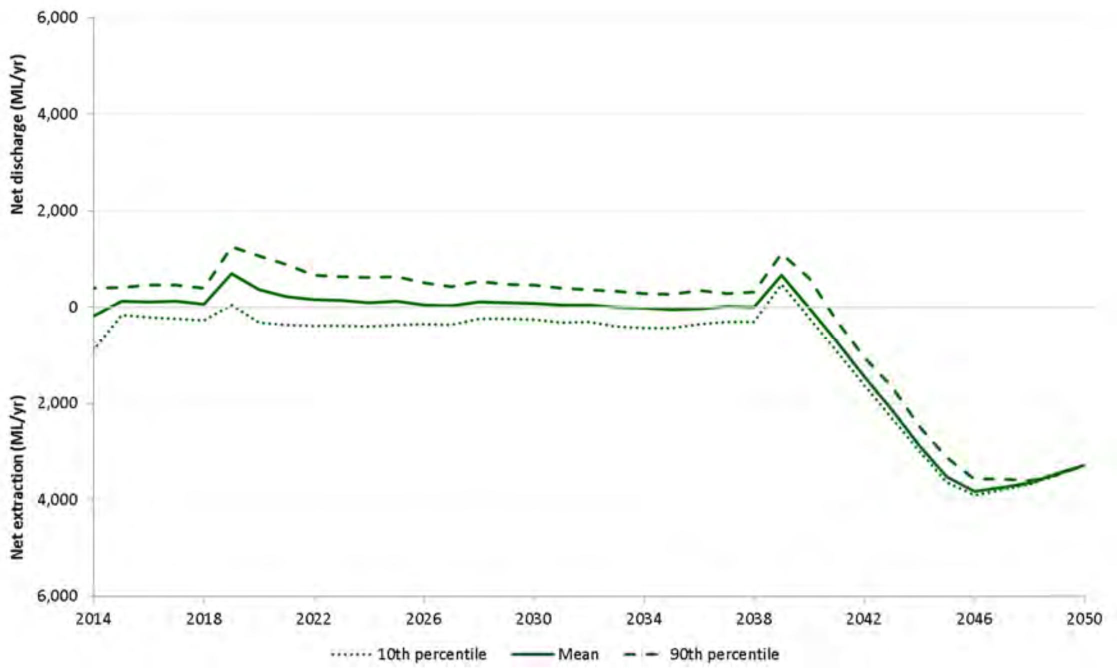


Figure G-12 Newstan Colliery – Net Extraction/Discharge

Non-Centennial Sites

Aquabait

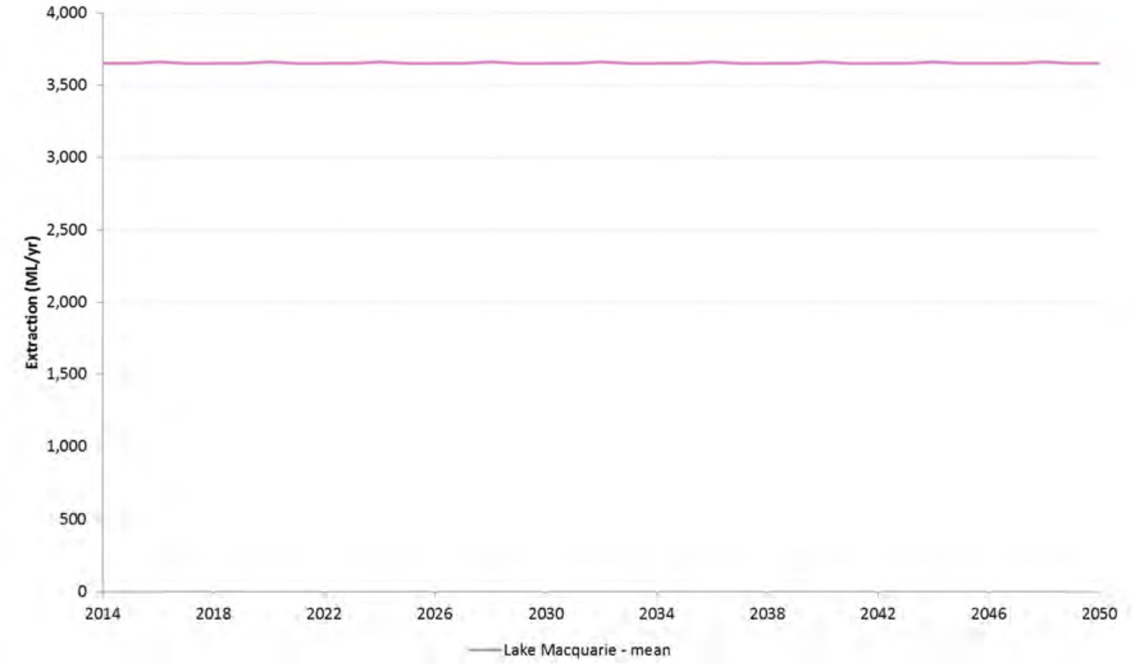


Figure G-13 Aquabait – Surface Water Extraction

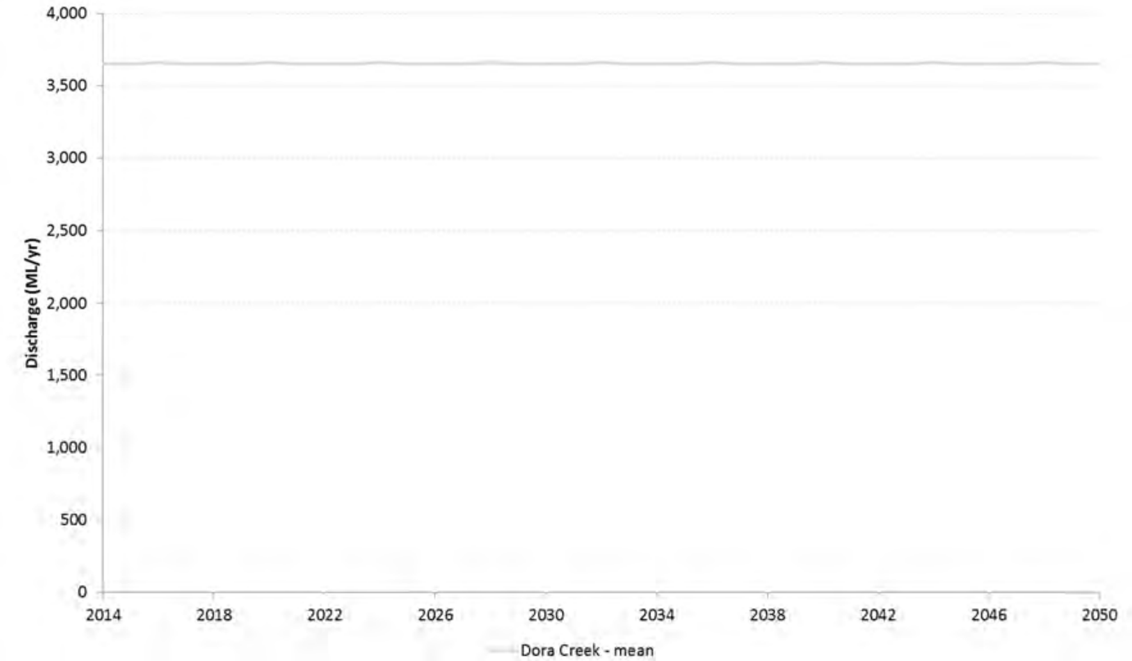


Figure G-14 Aquabait – Surface Water Discharge

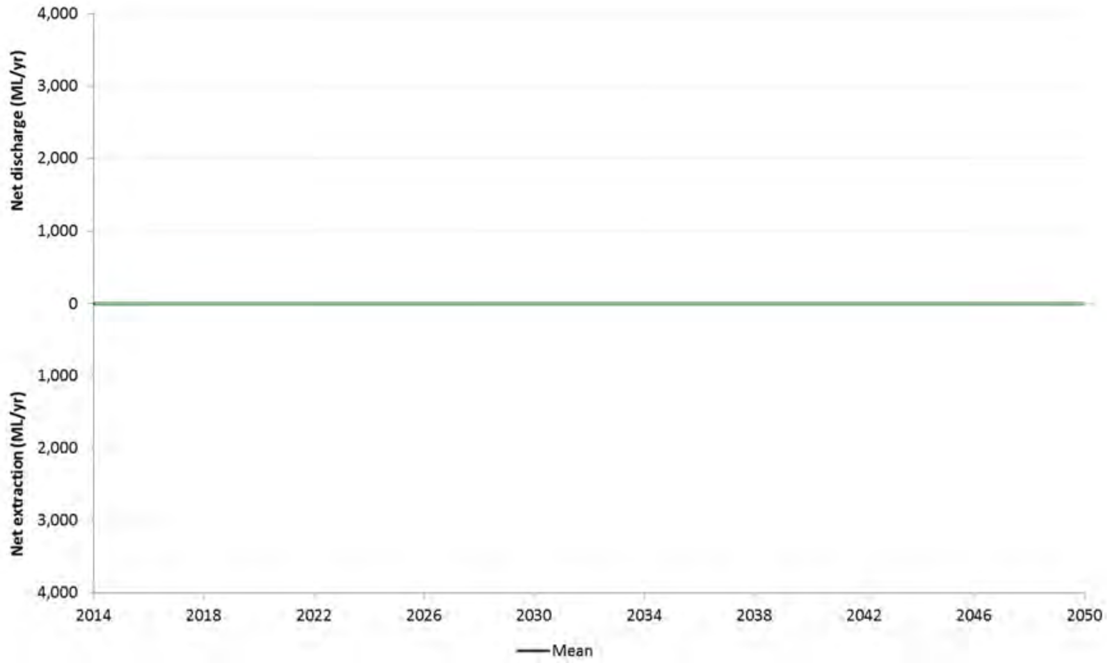


Figure G-15 Aquabait – Net Extraction/Discharge

Chain Valley Colliery

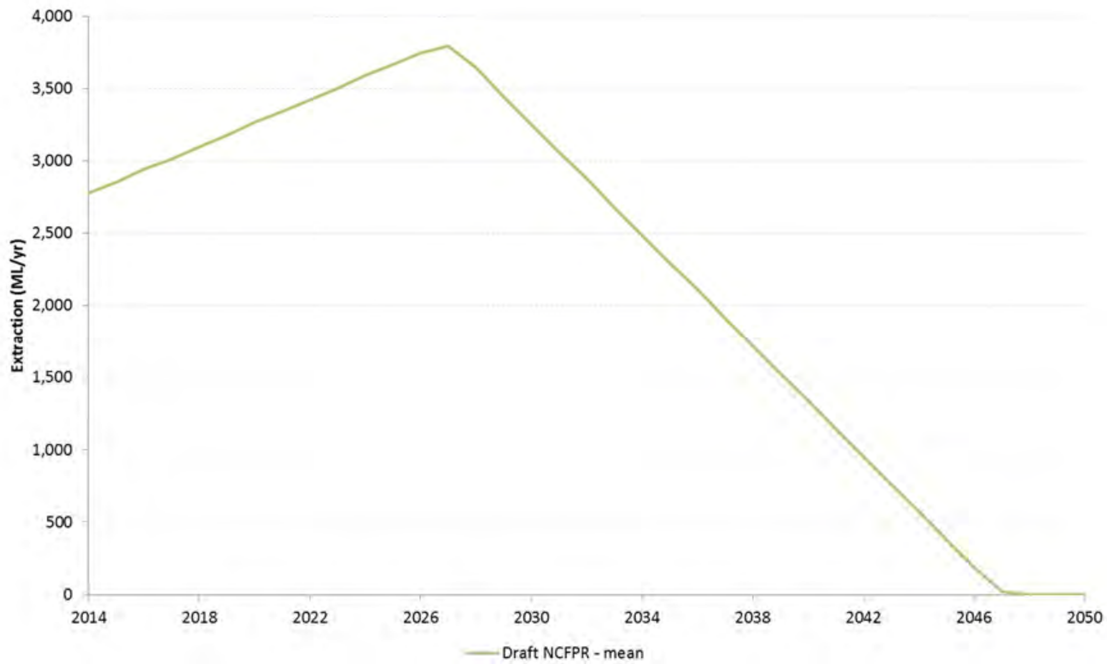


Figure G-16 Chain Valley Colliery – Groundwater Extraction

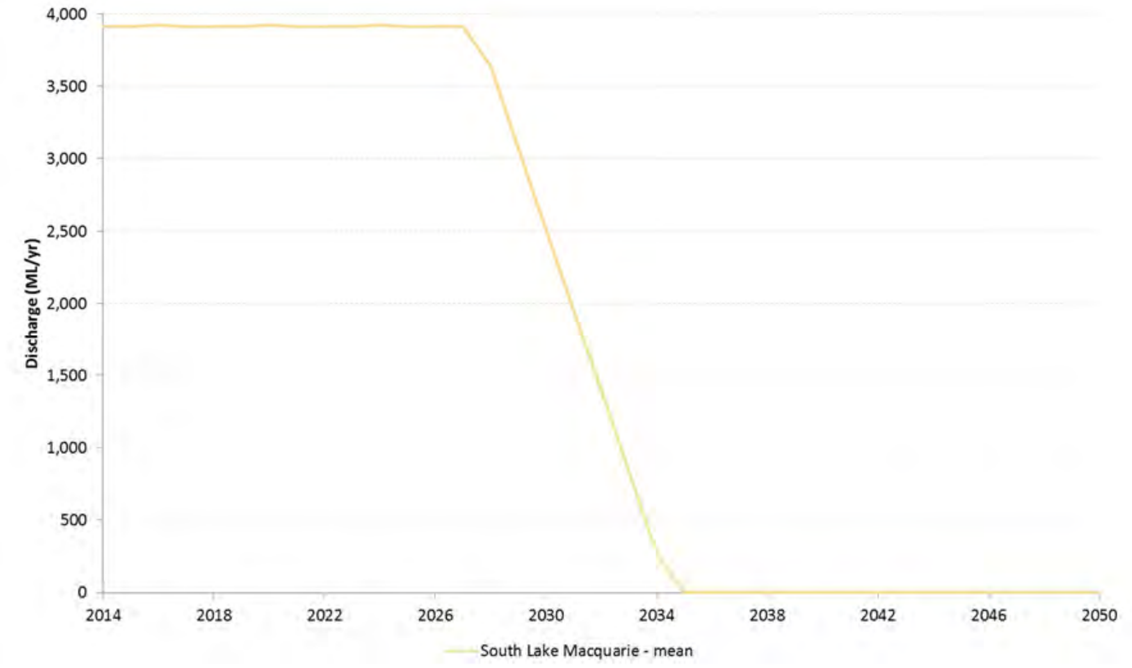


Figure G-17 Chain Valley Colliery – Surface Water Discharge

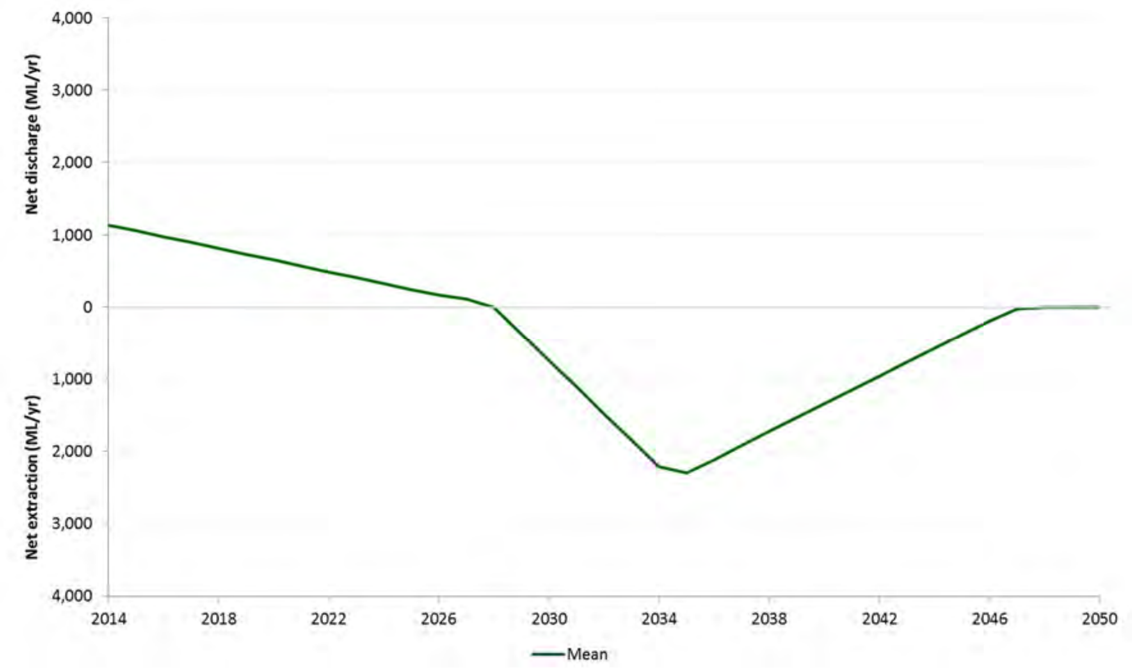


Figure G-18 Chain Valley Colliery – Net Extraction/Discharge

Eraring Power Station

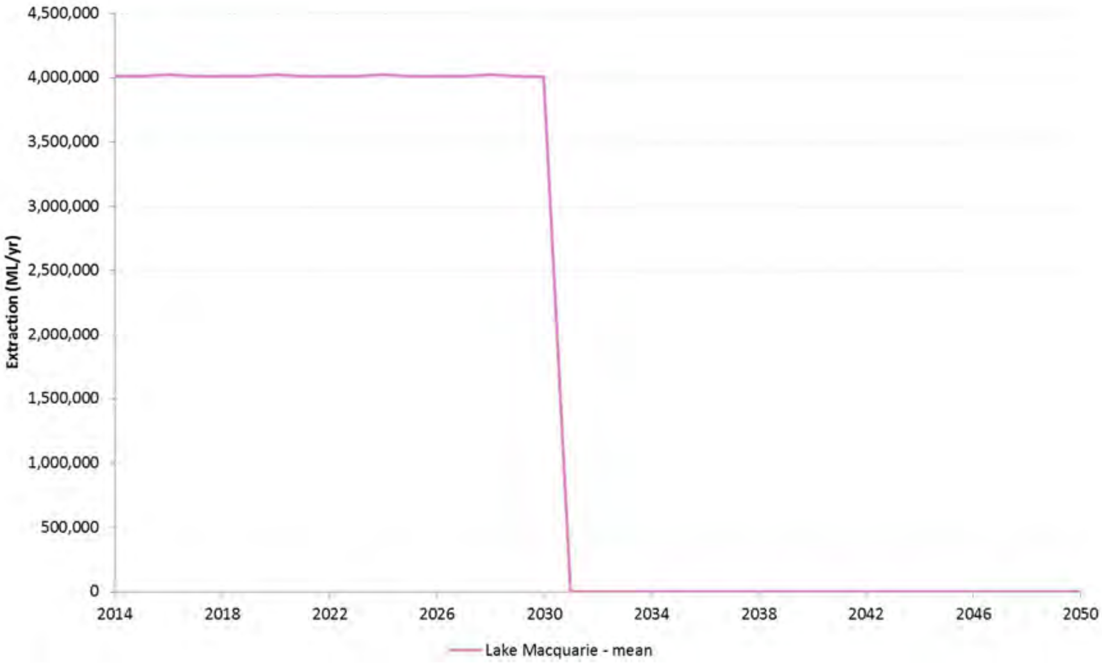


Figure G-19 Eraring Power Station – Surface Water Extraction

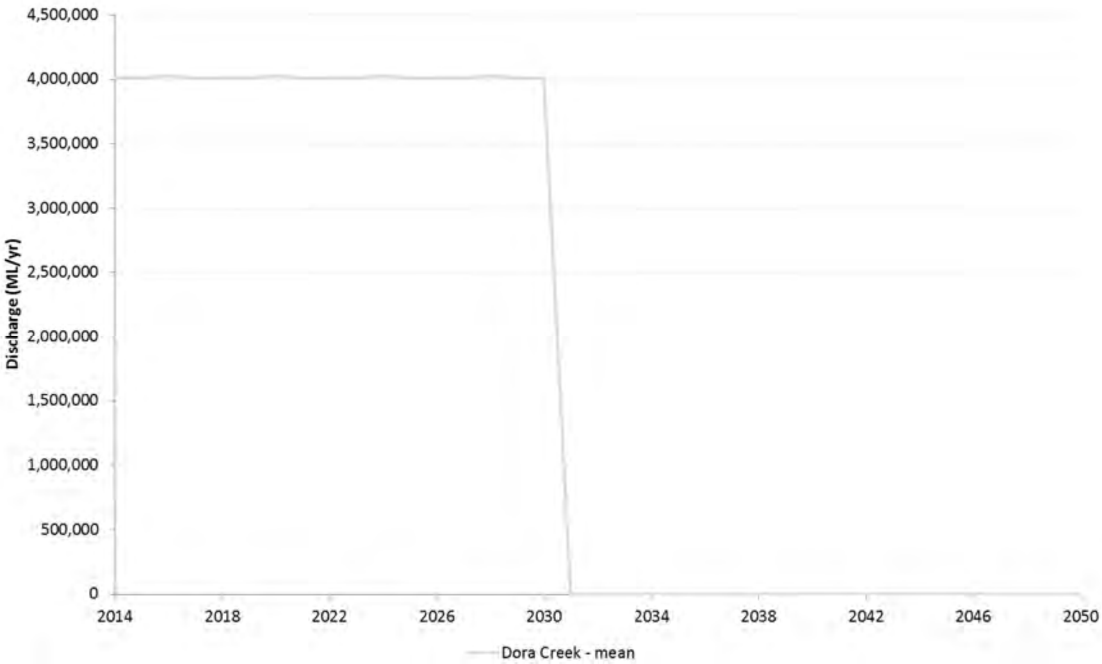


Figure G-20 Eraring Power Station – Surface Water Discharge

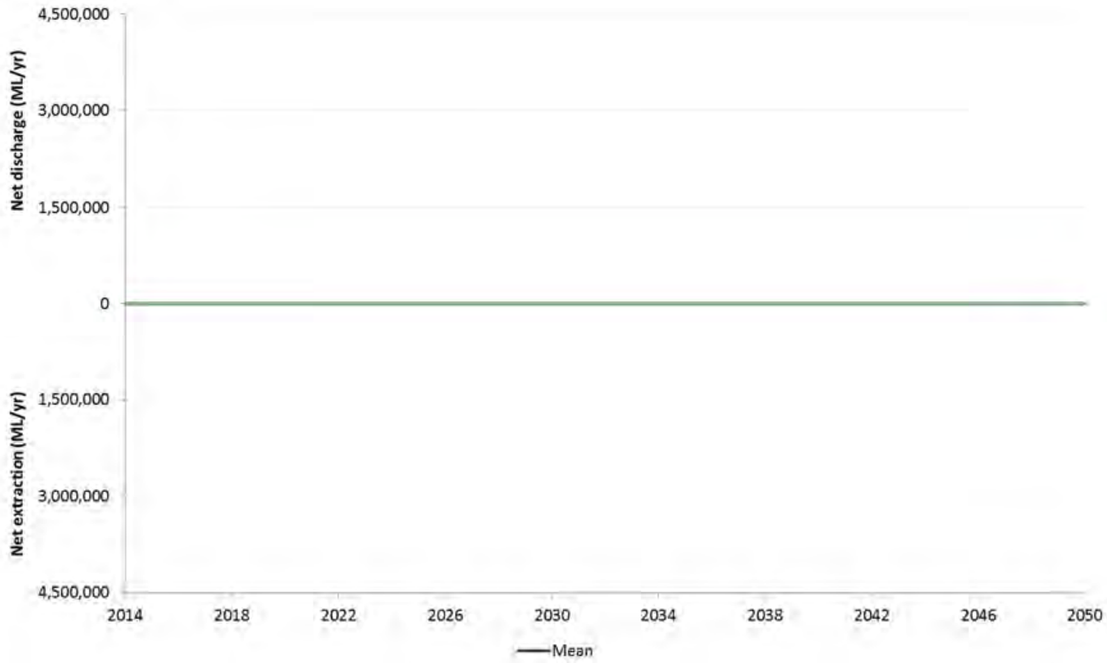


Figure G-21 Eraring Power Station – Net Extraction/Discharge

Pasminco and Incitec Consolidated Remediation Project

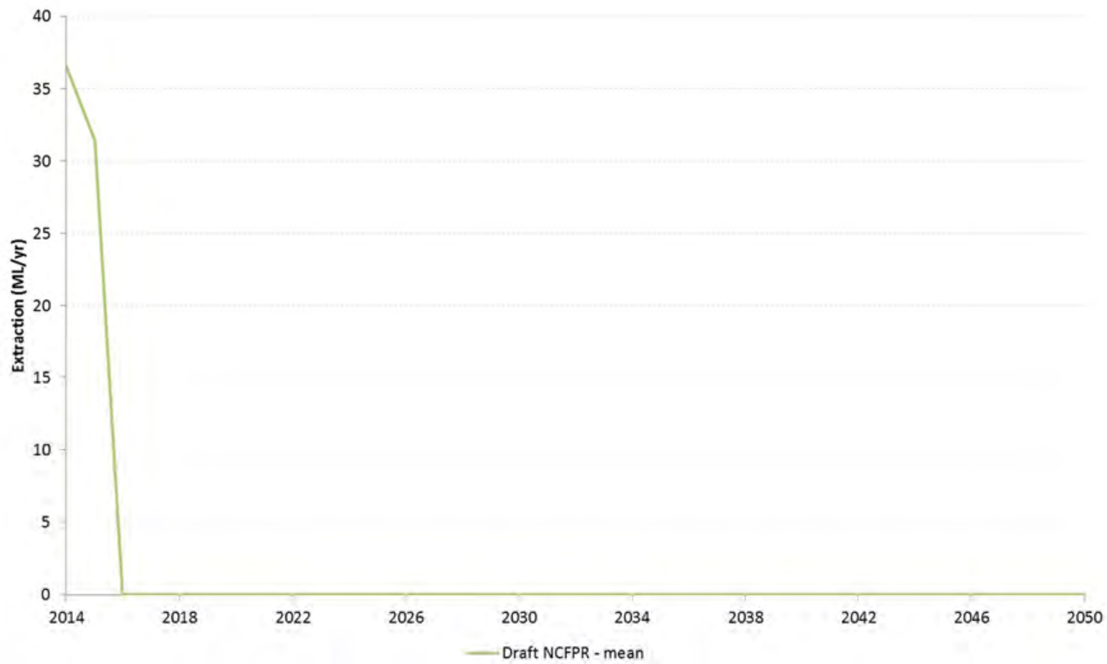


Figure G-22 Pasminco and Incitec Consolidated Remediation Project – Groundwater Extraction

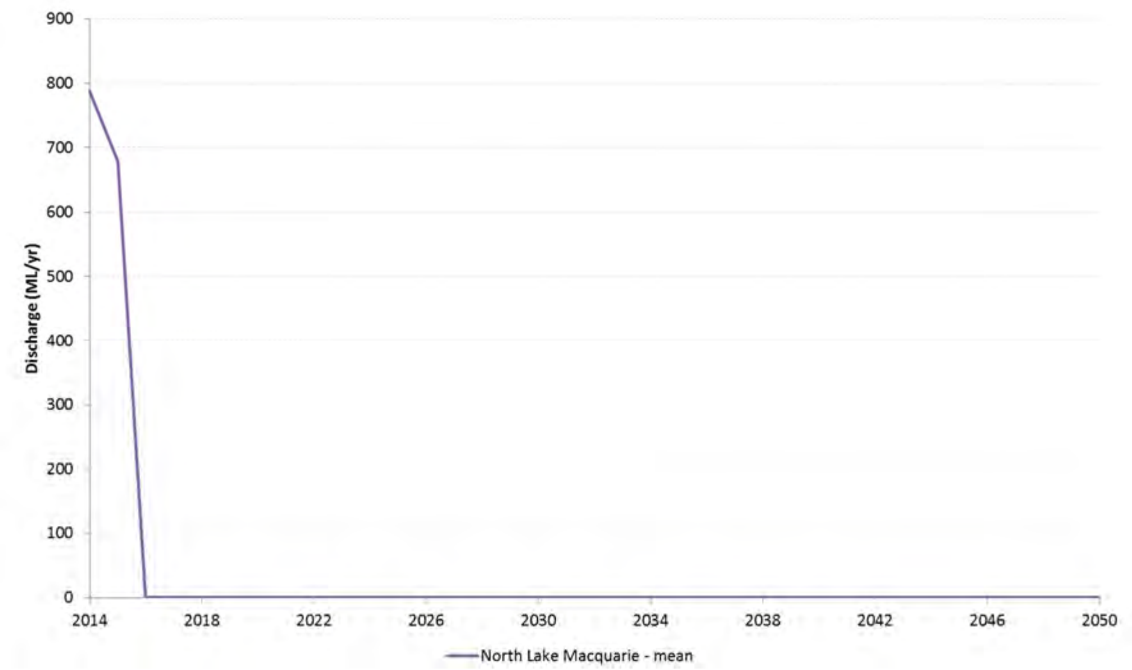


Figure G-23 Pasminco and Incitec Consolidated Remediation Project – Surface Water Discharge

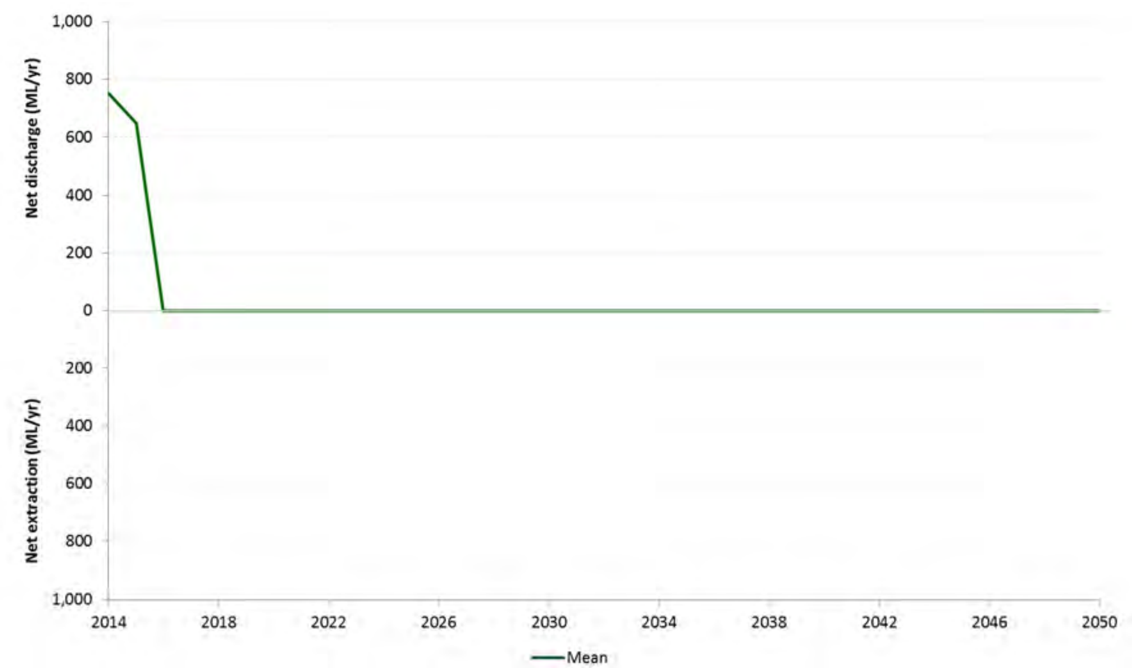


Figure G-24 Pasminco and Incitec Consolidated Remediation Project – Net Extraction/Discharge

Tasman Underground Mine

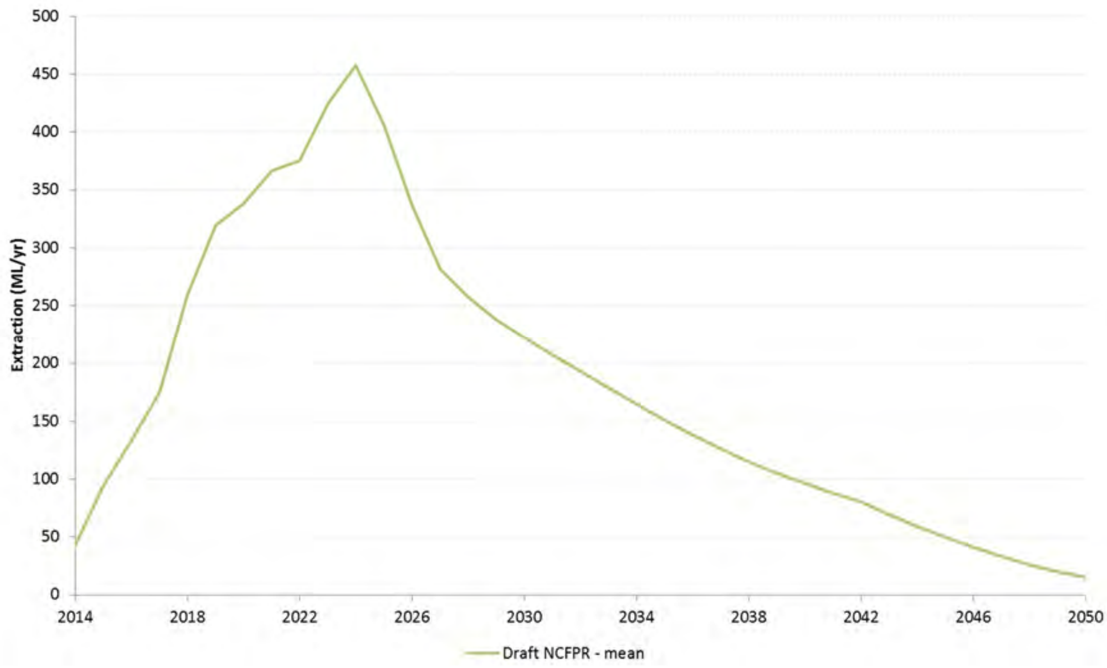


Figure G-25 Tasman Underground Mine – Groundwater Extraction

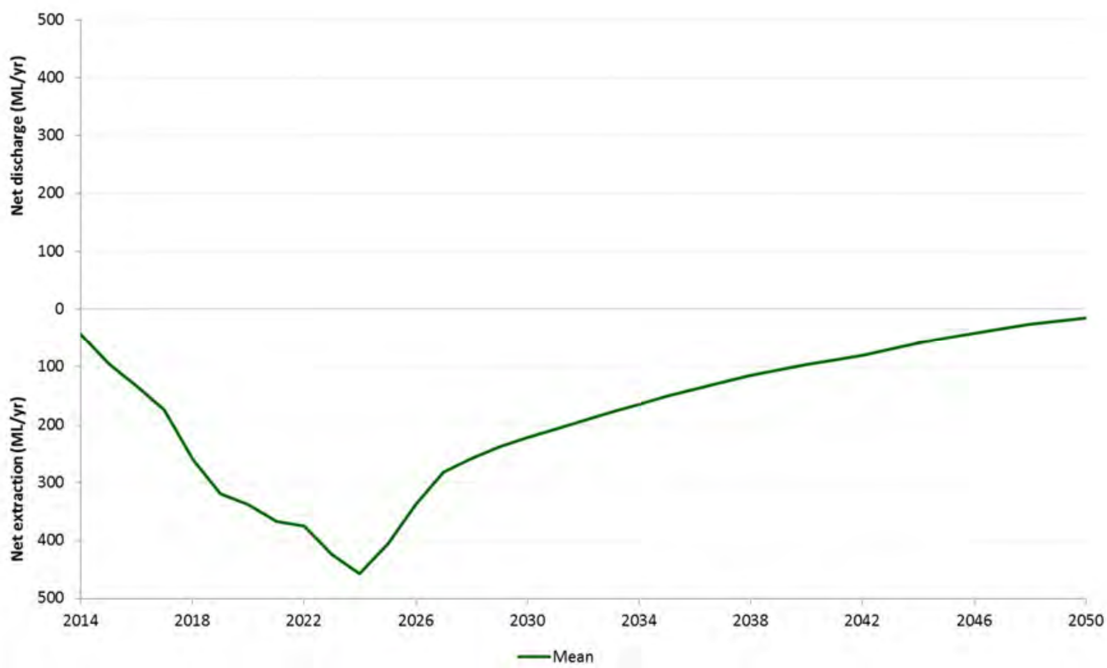


Figure G-26 Tasman Underground Mine – Net Extraction/Discharge

Teralba Quarry

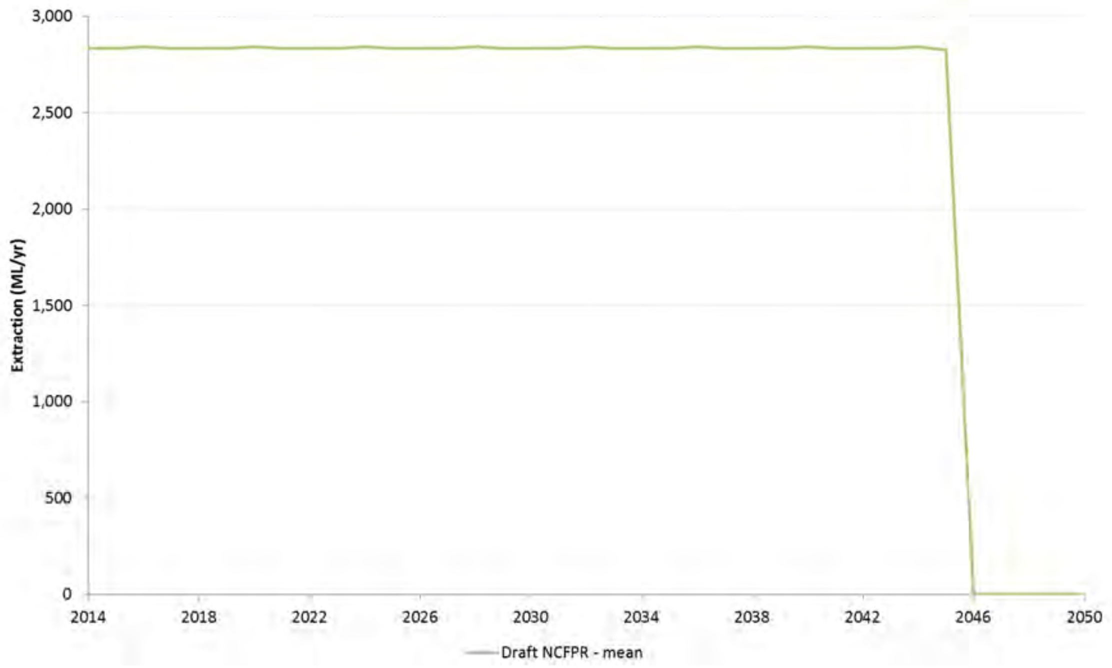


Figure G-27 Teralba Quarry – Groundwater Extraction

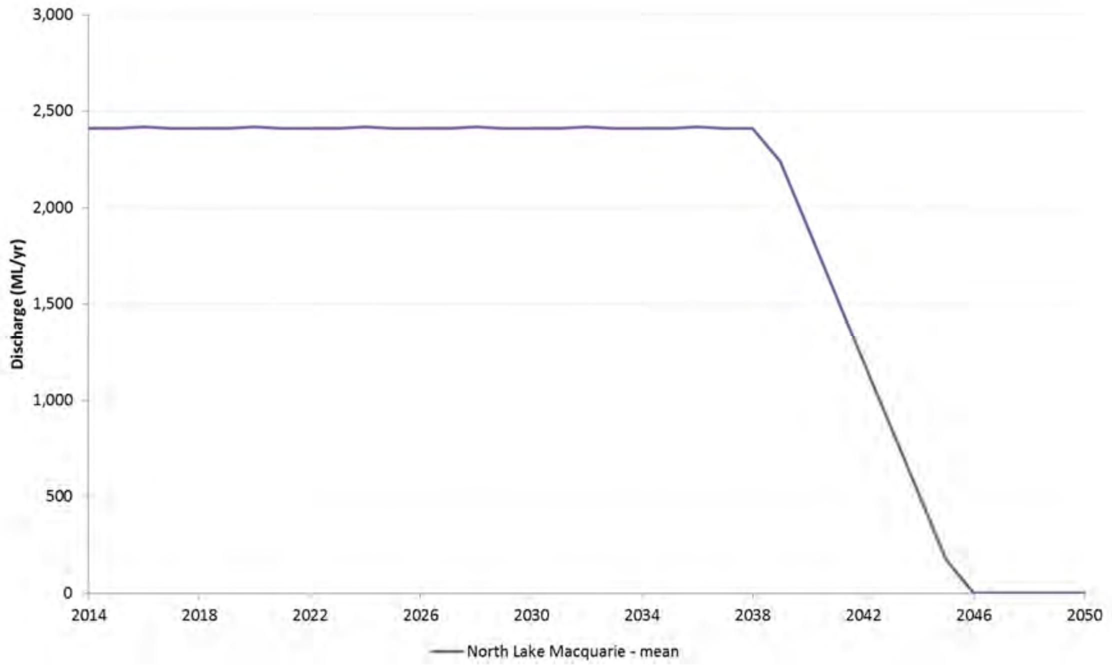


Figure G-28 Teralba Quarry – Surface Water Discharge

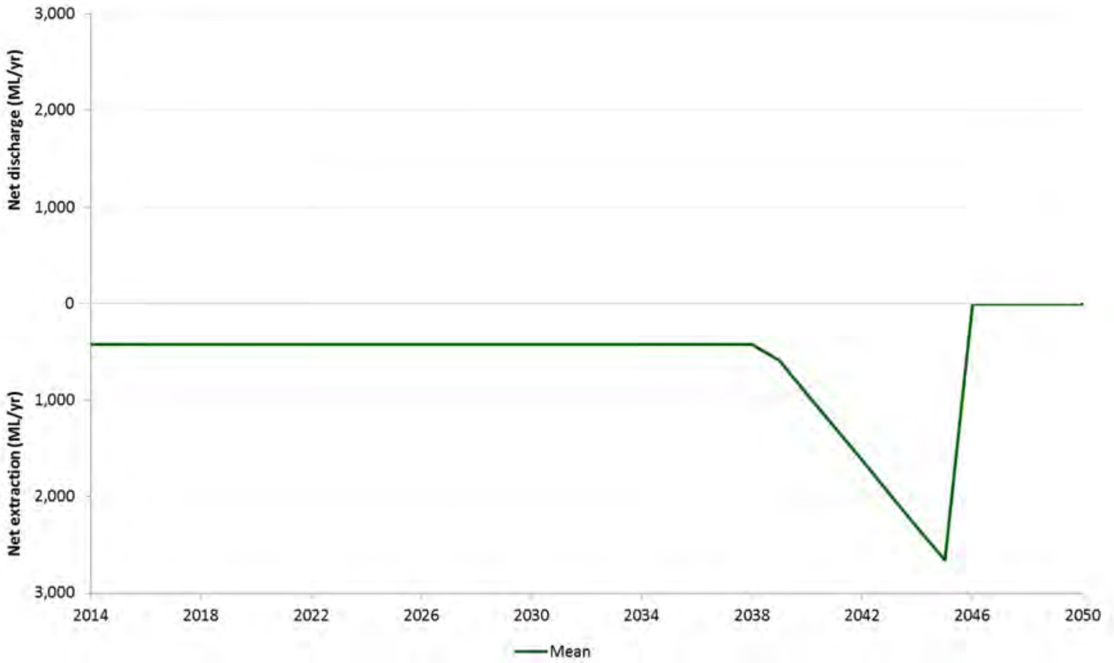


Figure G-29 Teralba Quarry – Net Extraction/Discharge

Vales Point Power Station

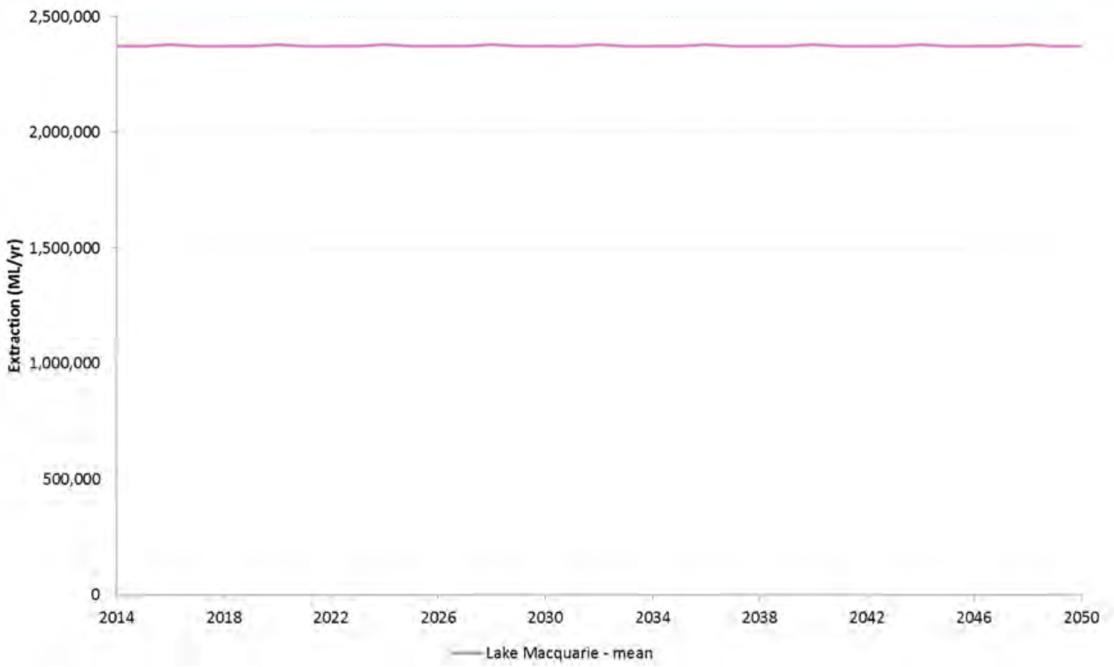


Figure G-30 Vales Point Power Station – Surface Water Extraction

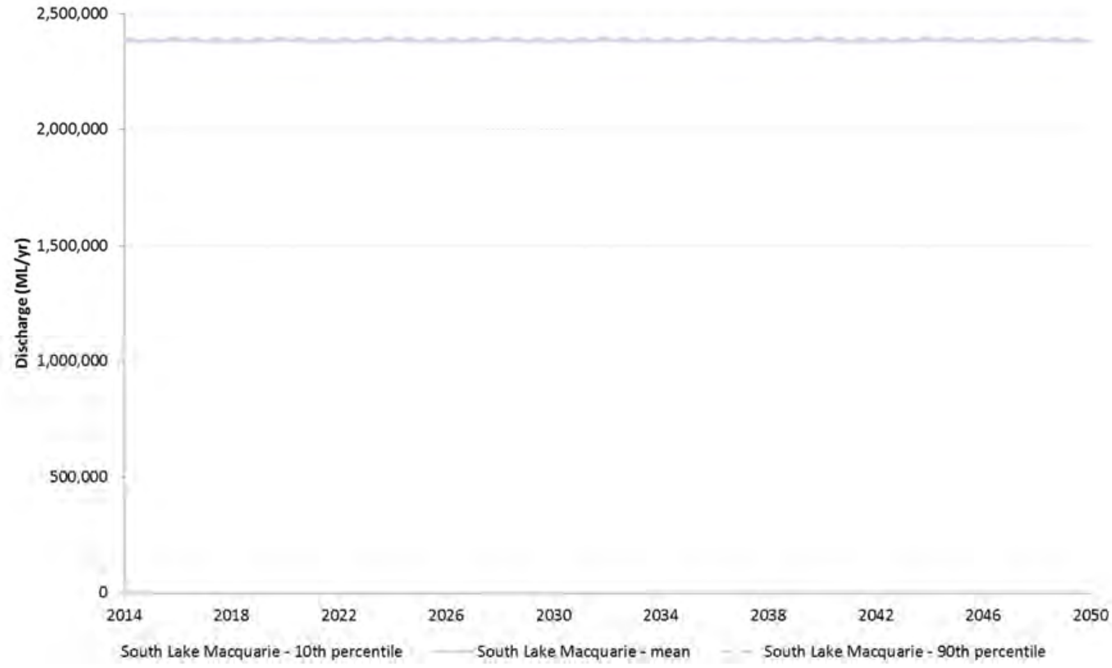


Figure G-31 Vales Point Power Station – Surface Water Discharge

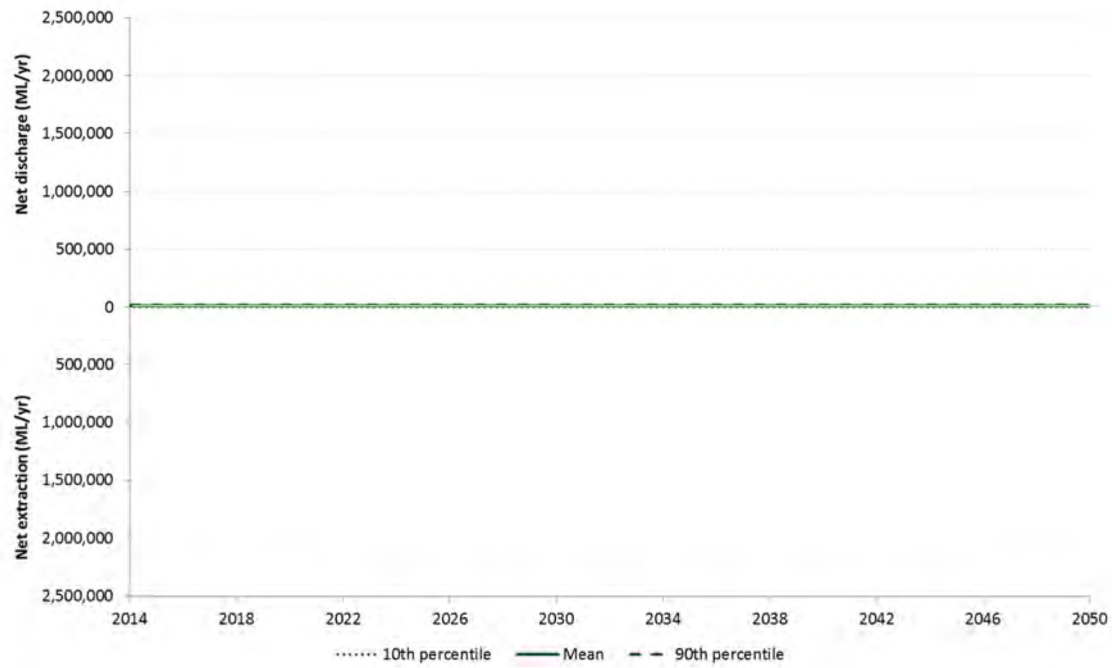


Figure G-32 Vales Point Power Station – Net Extraction/Discharge

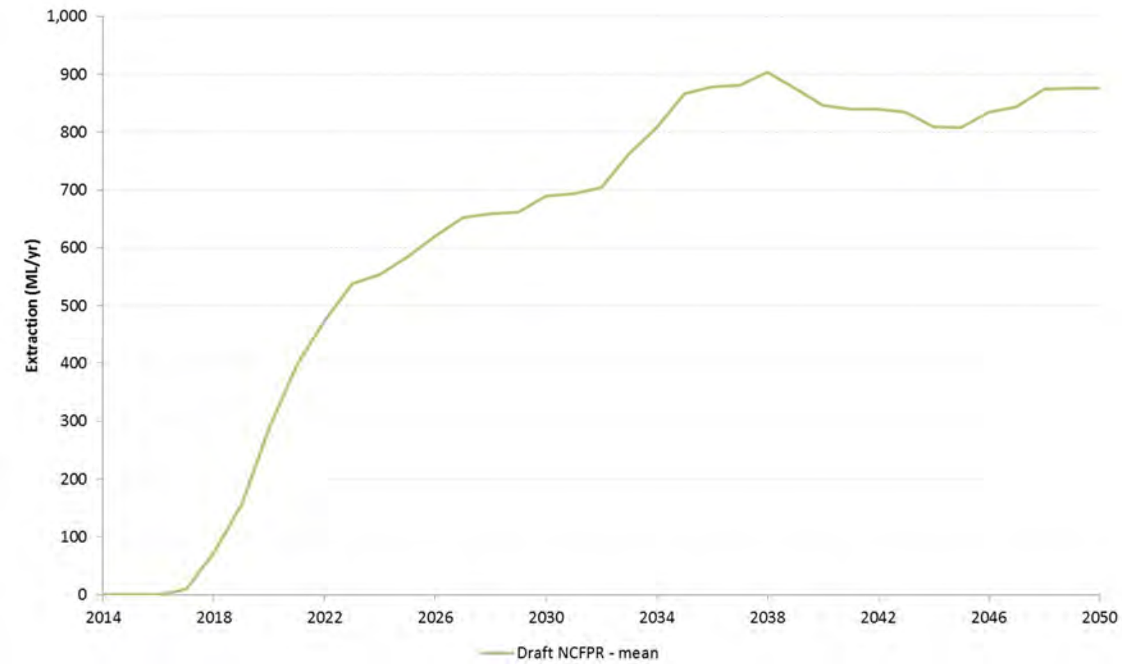


Figure G-33 Wallarah 2 Coal Project – Groundwater Extraction

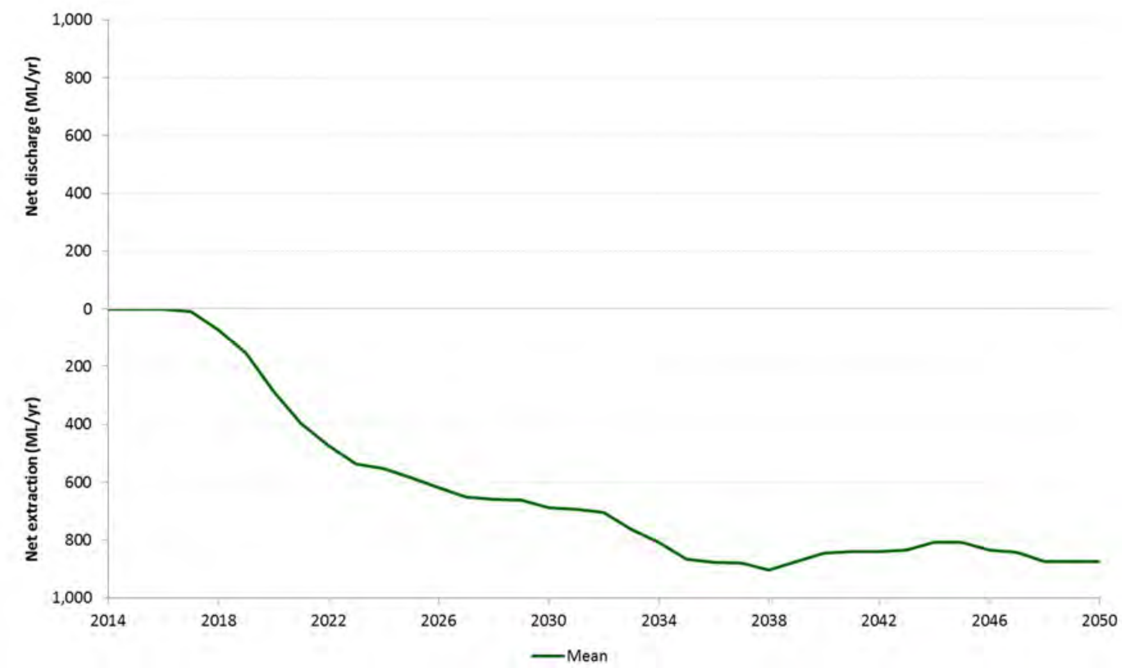


Figure G-34 Wallarah 2 Coal Project – Net Extraction/Discharge

West Wallsend Colliery

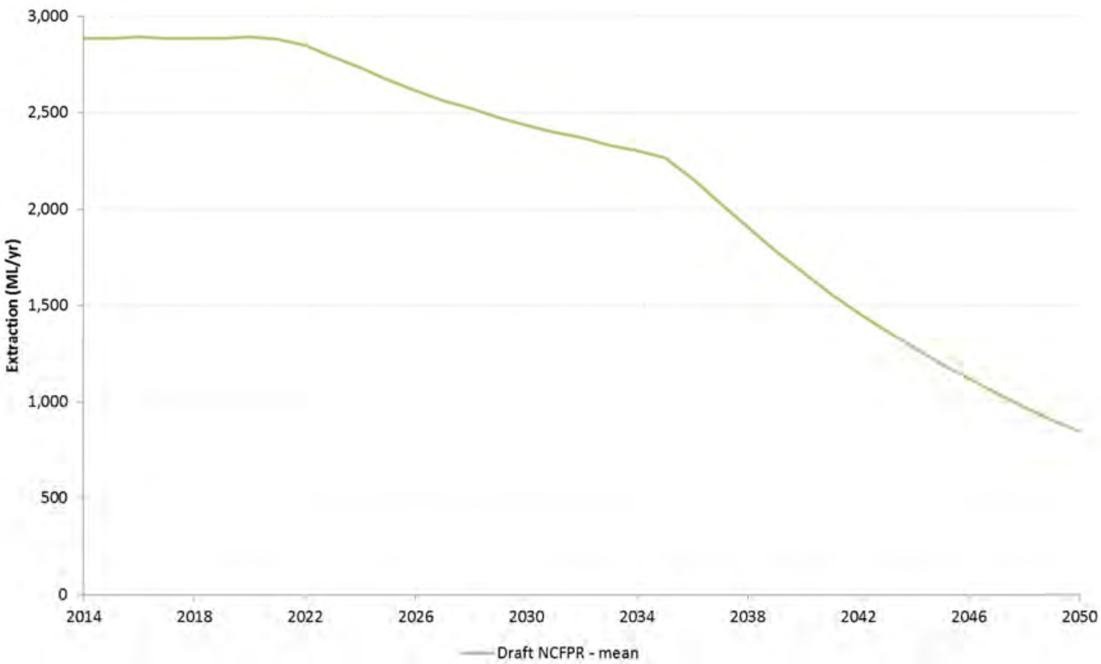


Figure G-35 West Wallsend Colliery – Groundwater Extraction

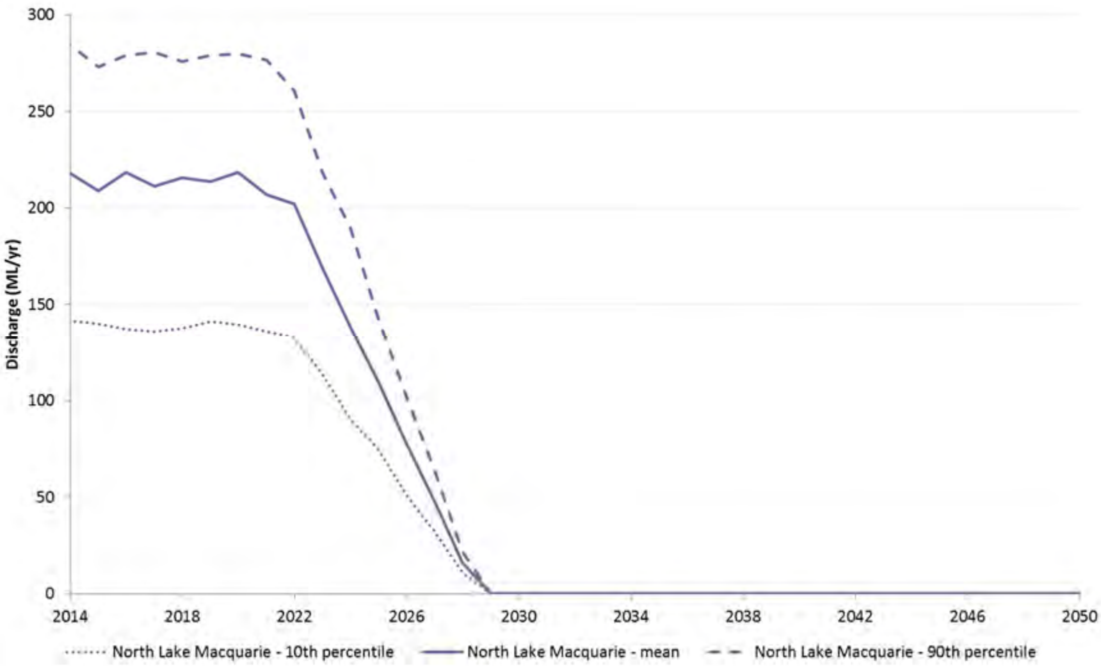


Figure G-36 West Wallsend Colliery – Surface Water Discharge

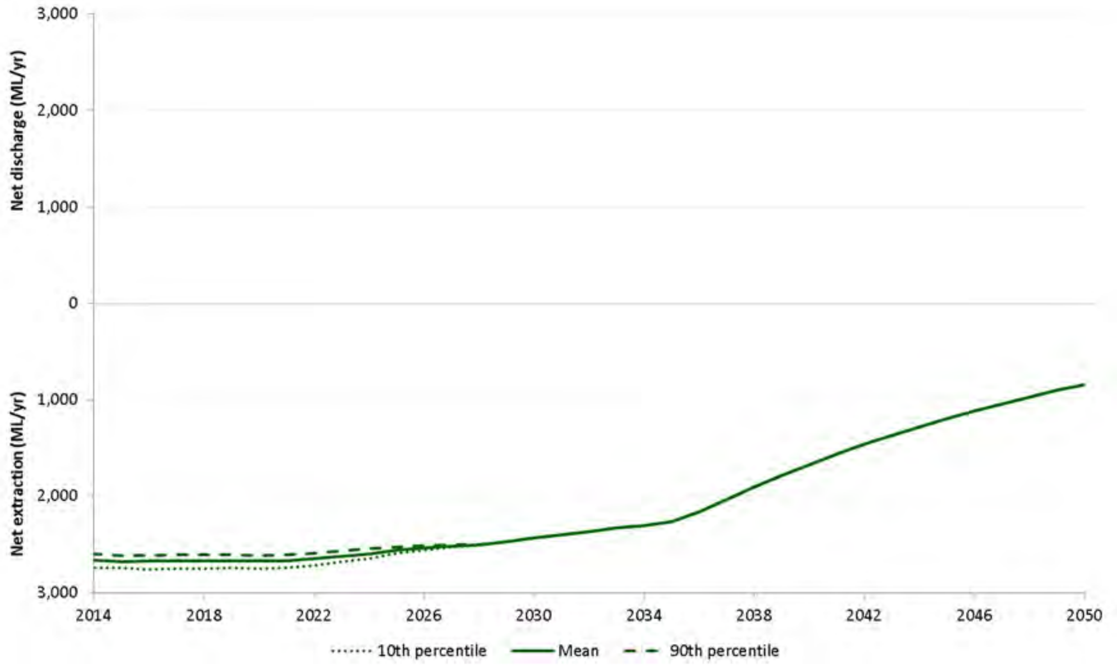


Figure G-37 West Wallsend Colliery – Net Extraction/Discharge

Westside Mine

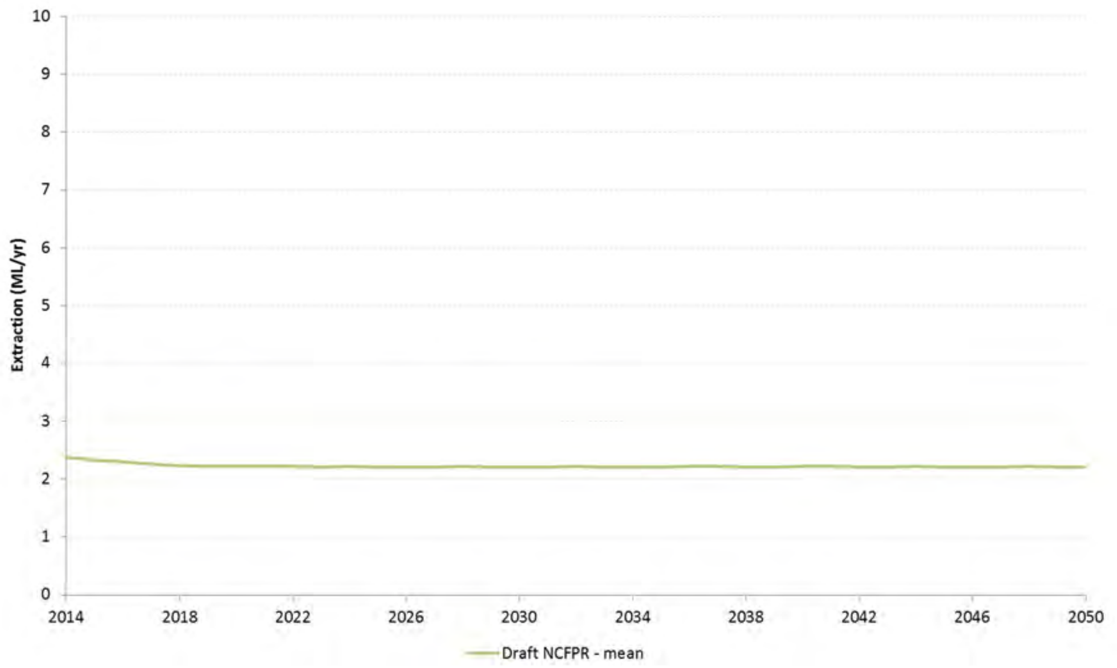


Figure G-38 Westside Mine – Groundwater Extraction

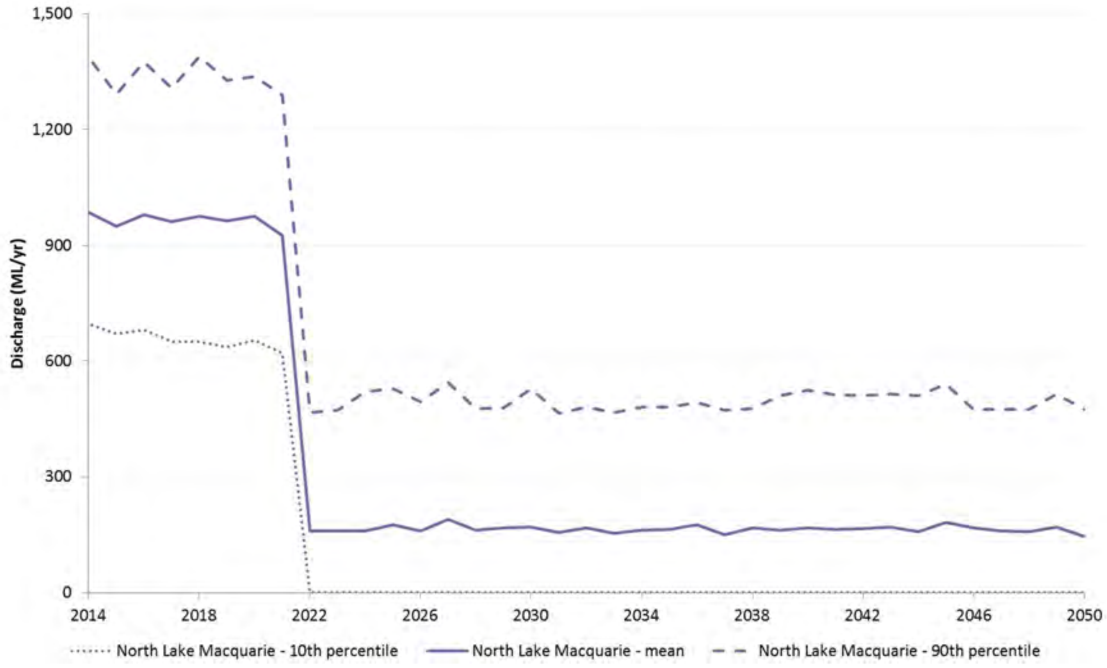


Figure G-39 Westside Mine – Surface Water Discharge

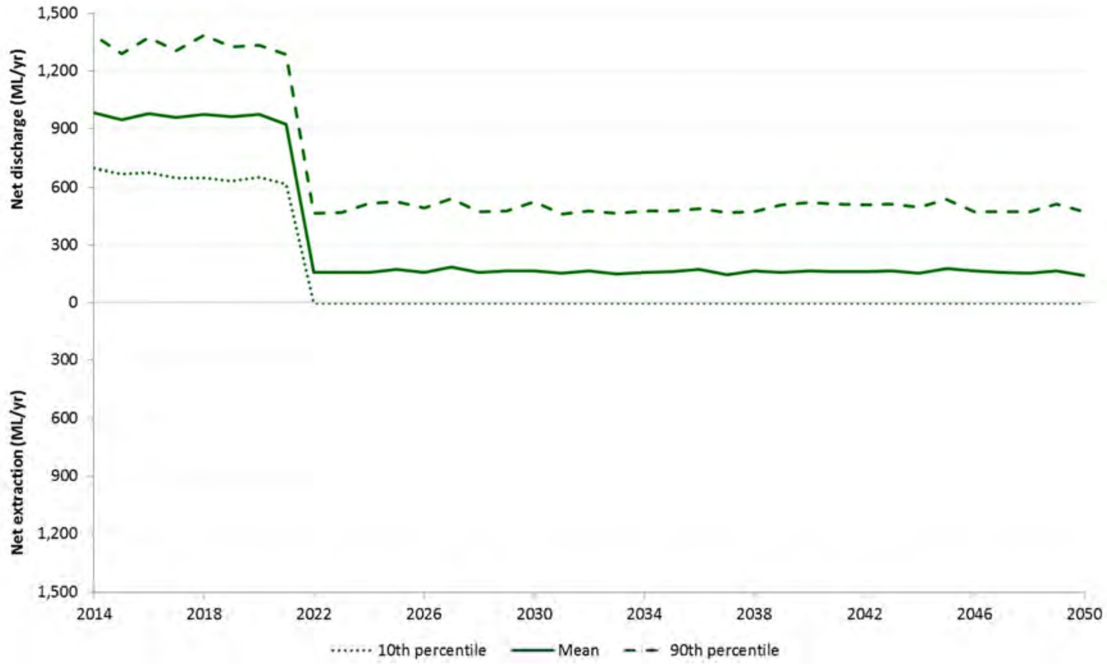


Figure G-40 Westside Mine – Net Extraction/Discharge

Appendix H – Individual Site Salt Balance Results

Centennial-Owned Sites

Mandalong Mine

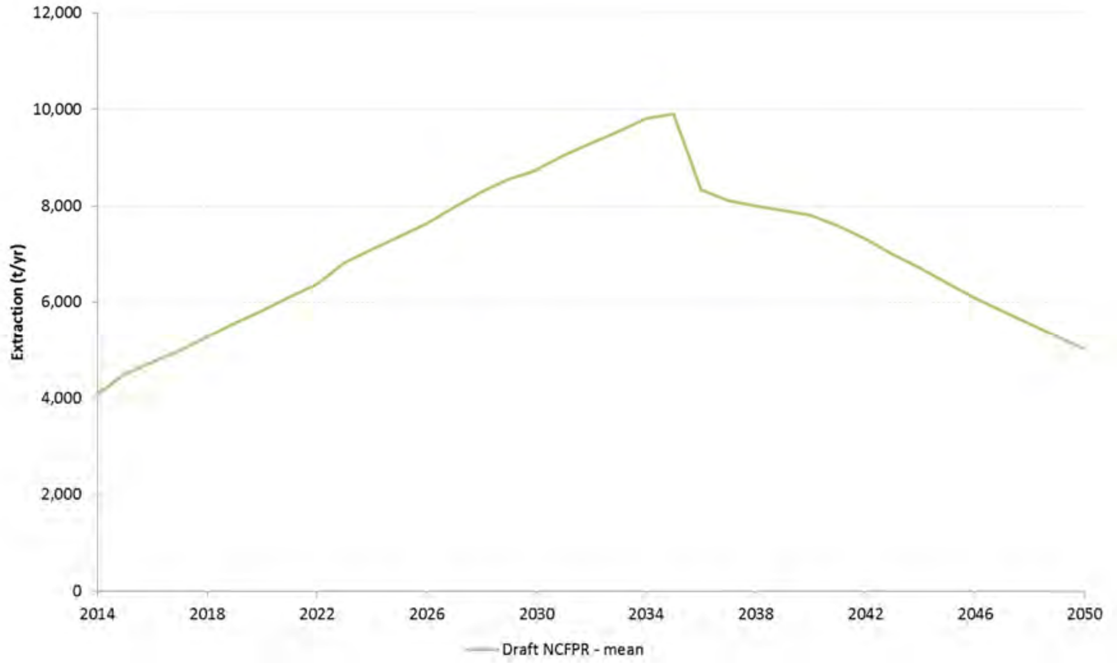


Figure H–1 Mandalong Mine – Groundwater Extraction Salt Mass

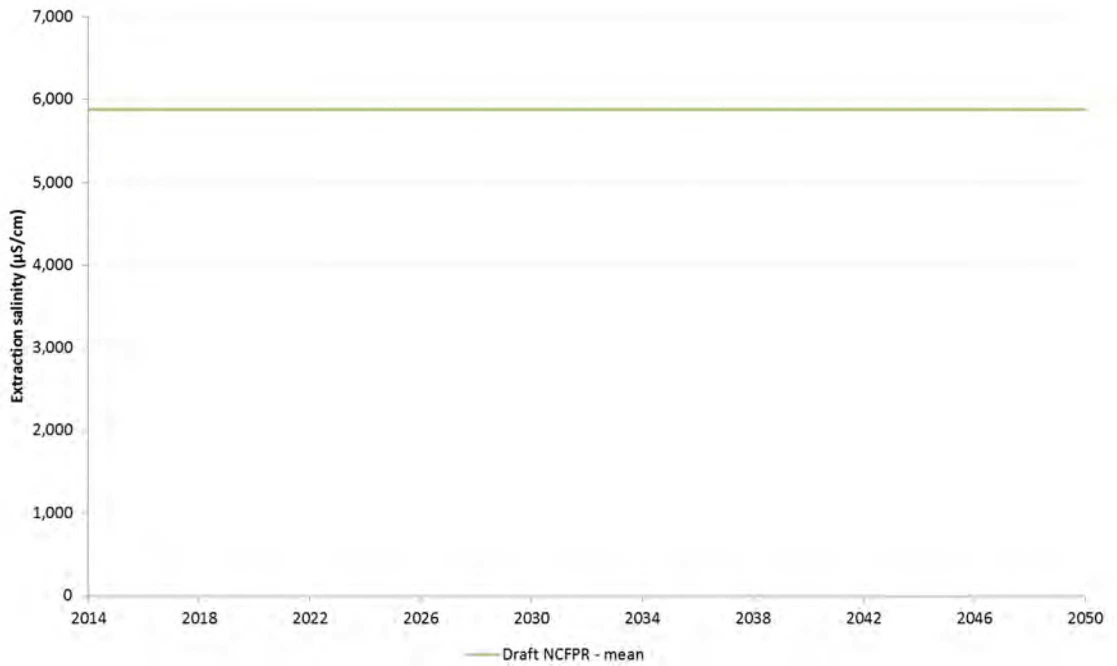


Figure H–2 Mandalong Mine – Groundwater Extraction Salinity

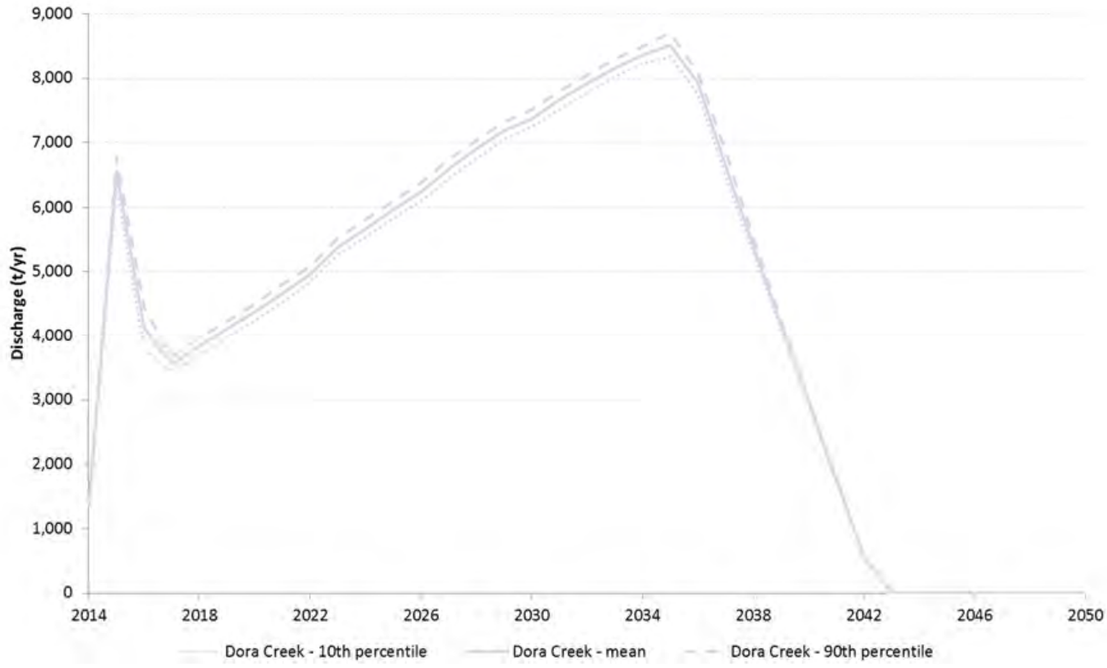


Figure H–3 Mandalong Mine – Surface Water Discharge Salt Mass

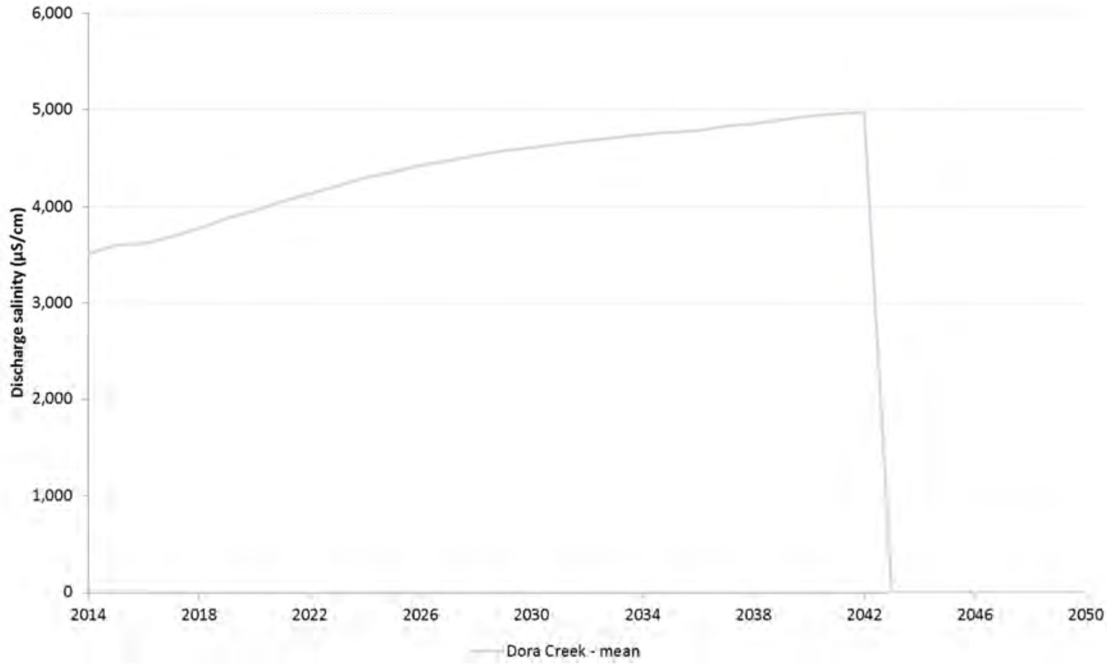


Figure H–4 Mandalong Mine – Surface Water Discharge Salinity

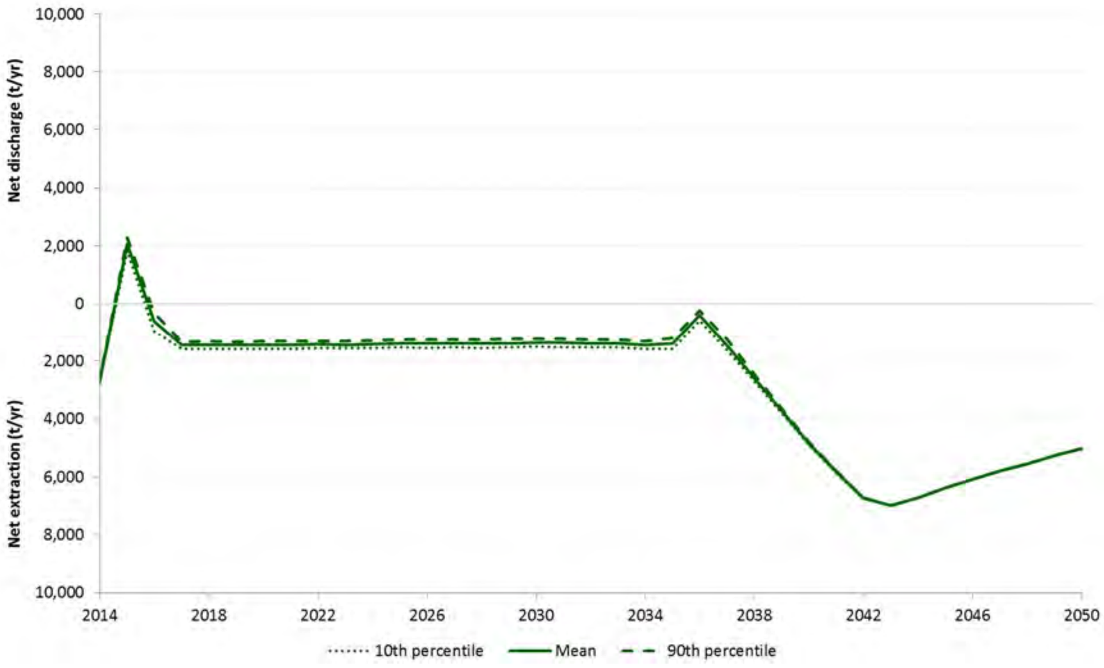


Figure H–5 Mandalong Mine – Net Extraction/Discharge Salt Mass

Mannering Colliery

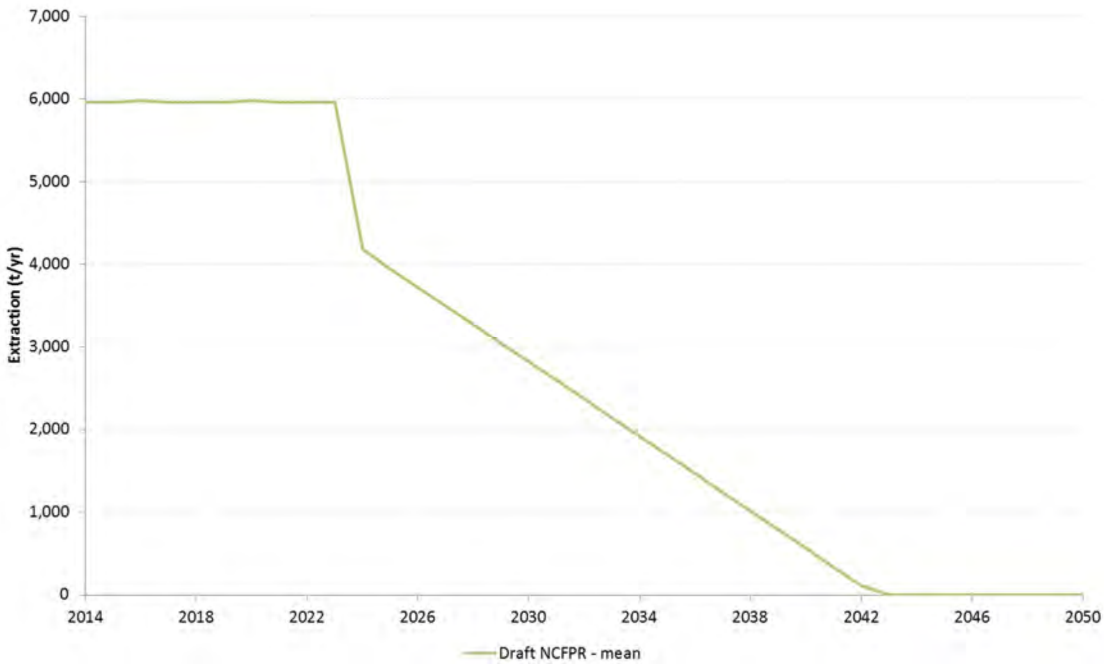


Figure H-6 Mannering Colliery – Groundwater Extraction Salt Mass

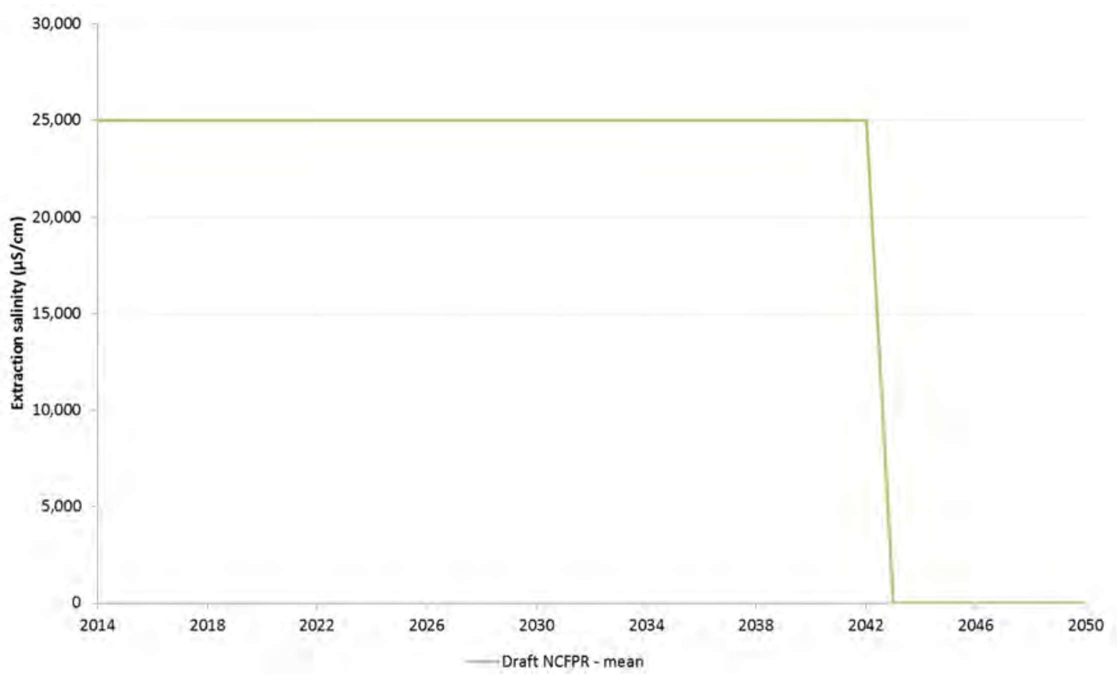


Figure H-7 Mannering Colliery – Groundwater Extraction Salinity

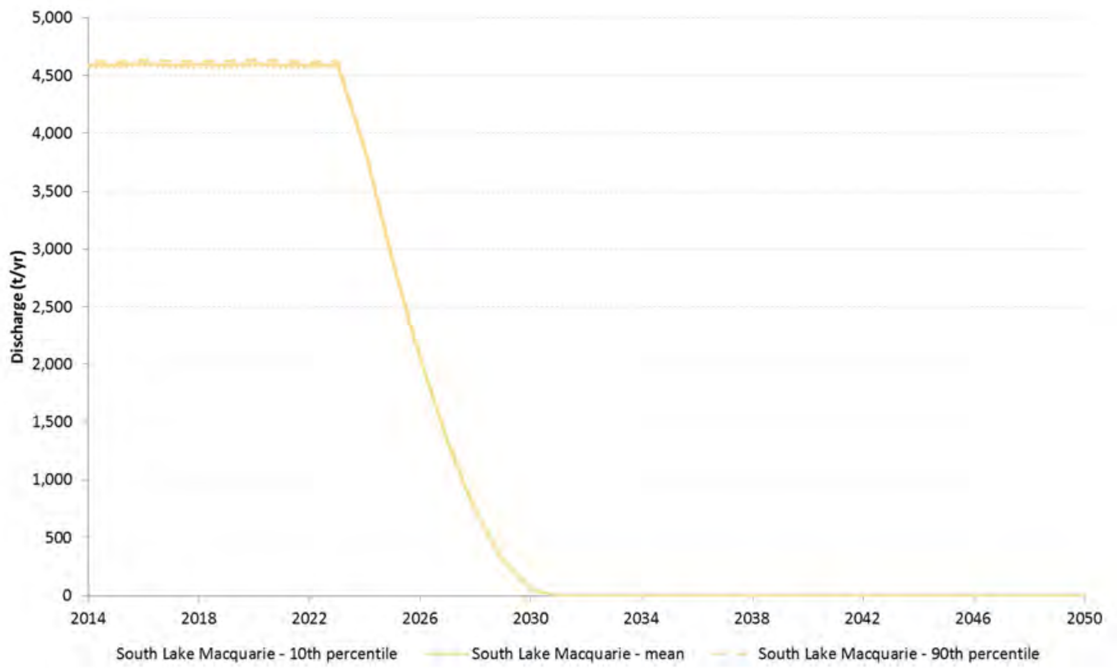


Figure H-8 Mannering Colliery – Surface Water Discharge Salt Mass

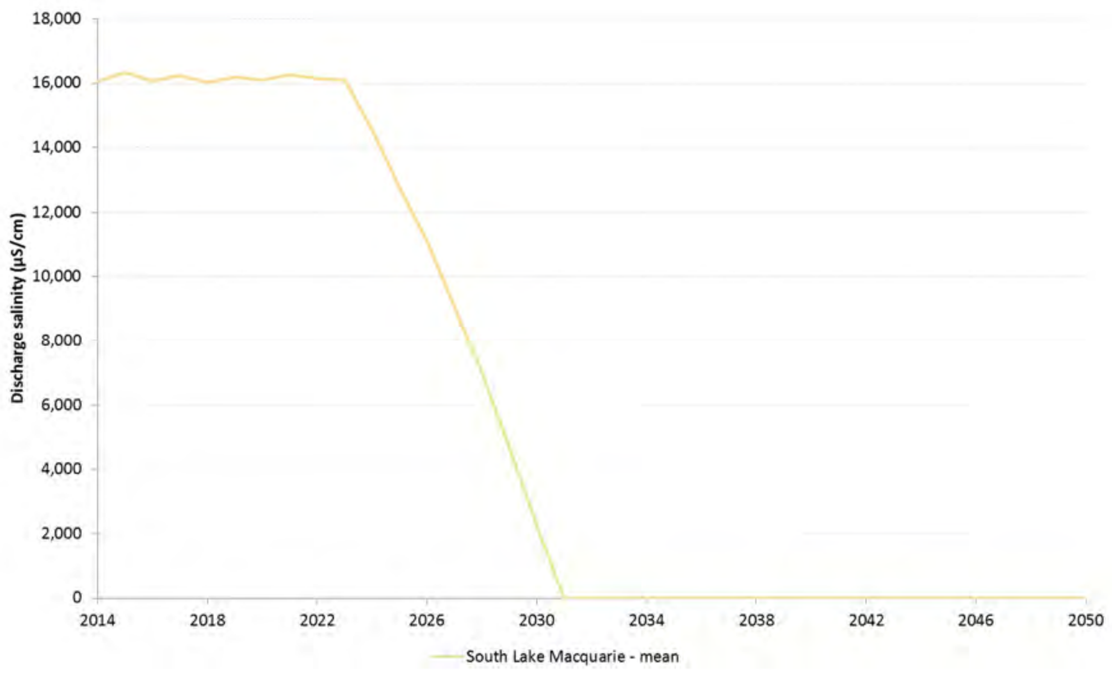


Figure H-9 Mannering Colliery – Surface Water Discharge Salinity

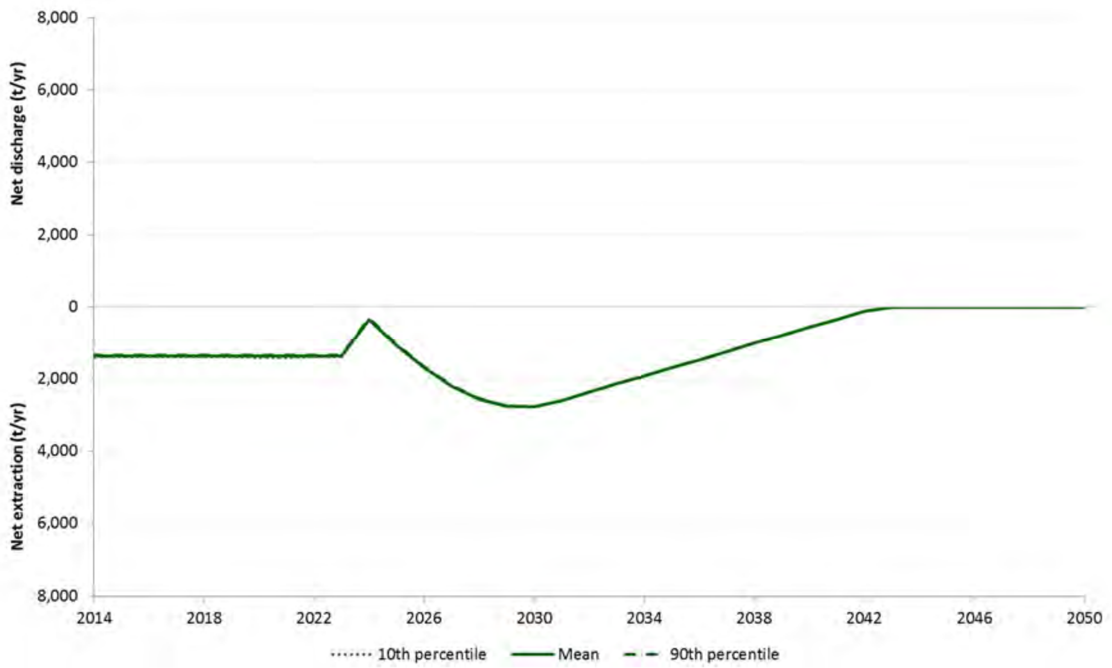


Figure H-10 Mannering Colliery – Net Extraction/Discharge Salt Mass

Myuna Colliery

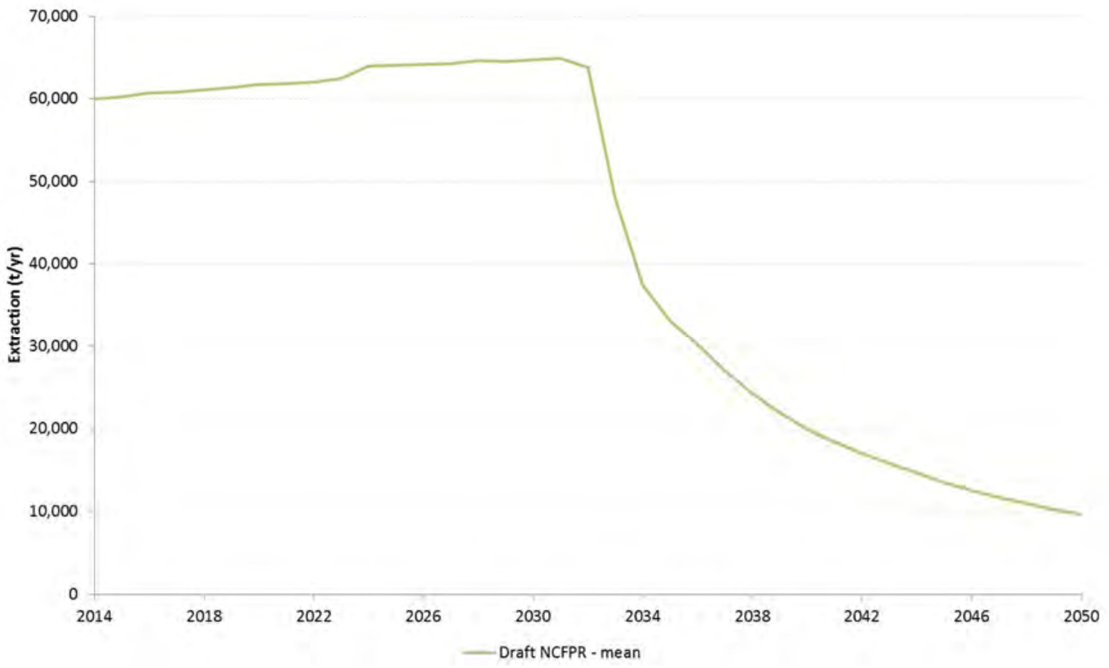


Figure H-11 Myuna Colliery – Groundwater Extraction Salt Mass

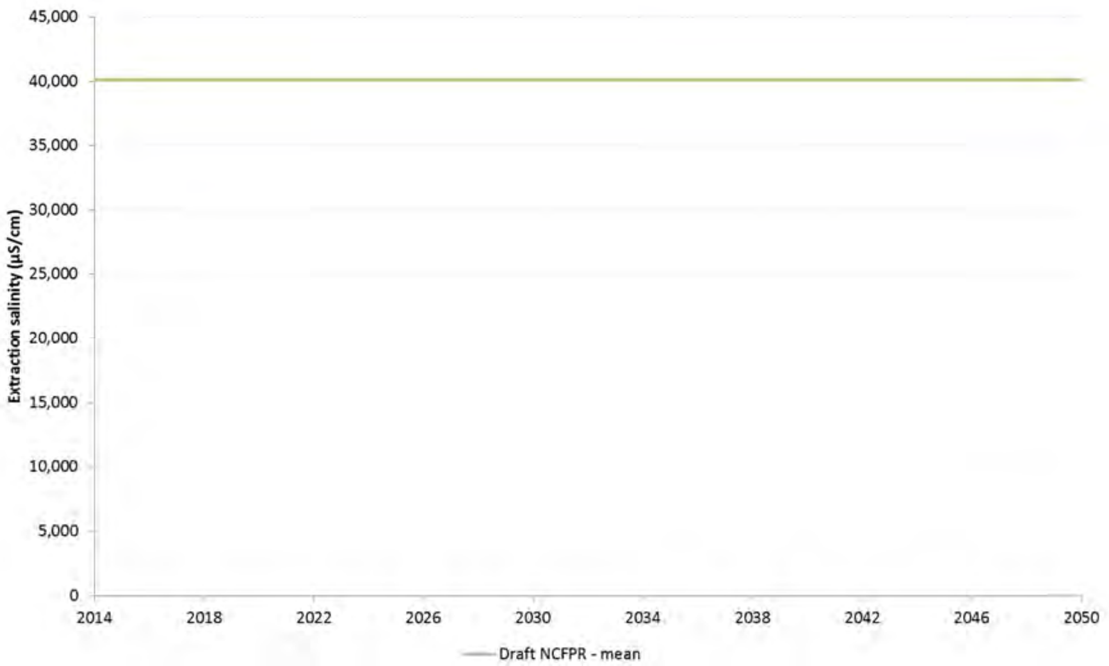


Figure H-12 Myuna Colliery – Groundwater Extraction Salinity

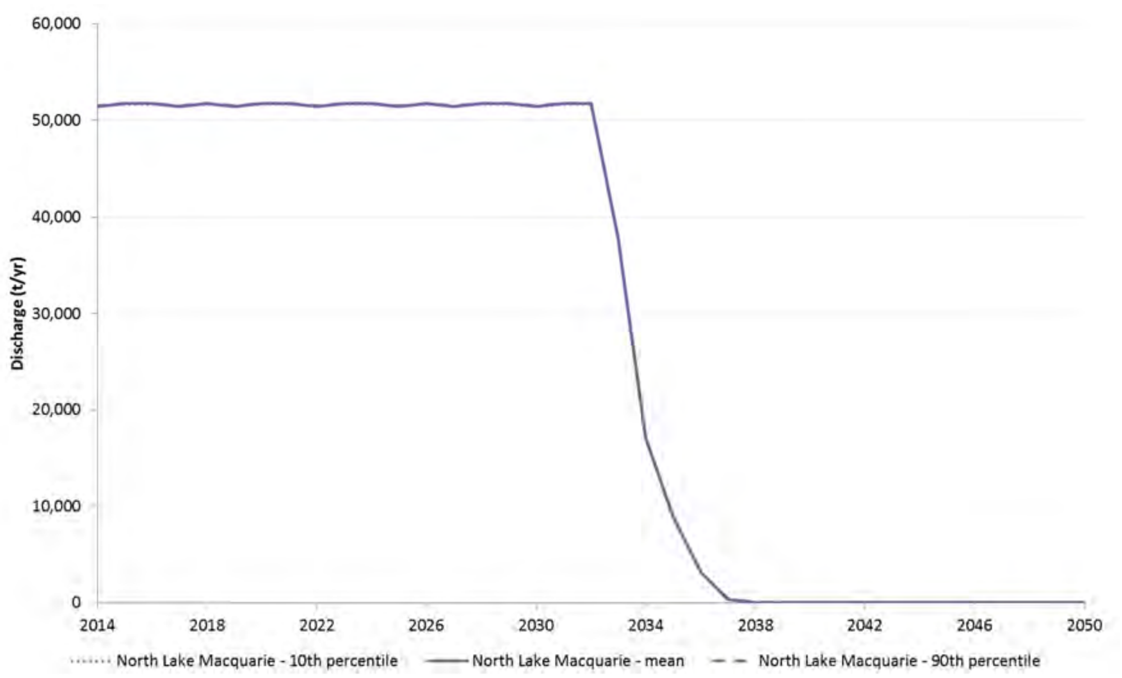


Figure H-13 Myuna Colliery – Surface Water Discharge Salt Mass

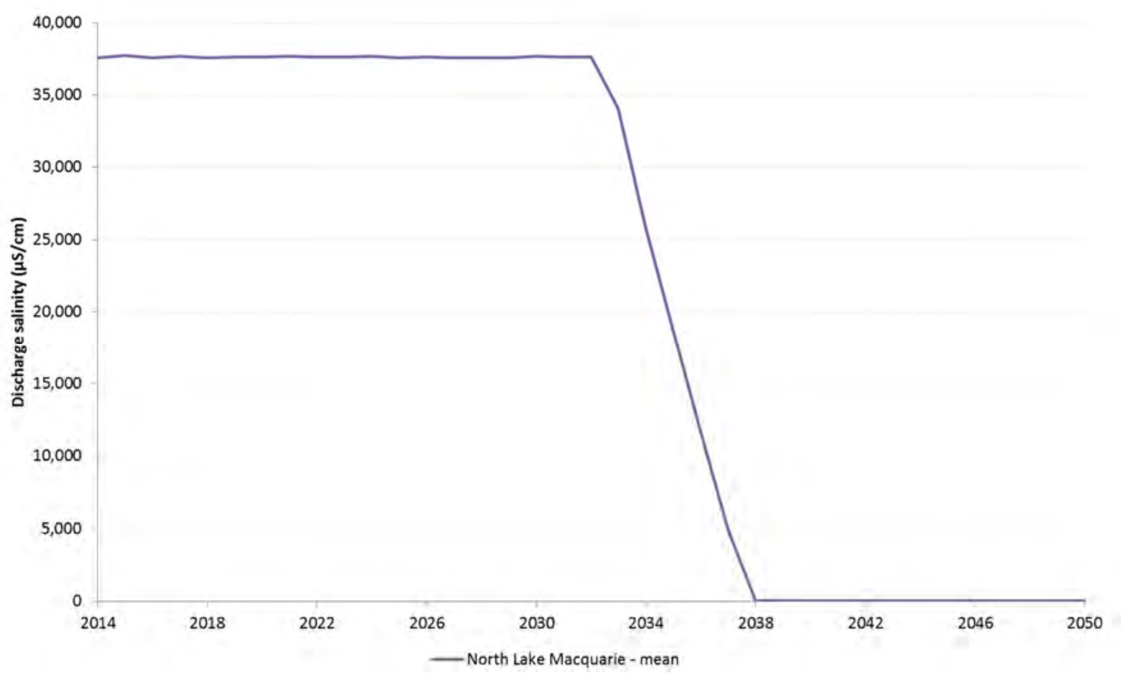


Figure H-14 Myuna Colliery – Surface Water Discharge Salinity

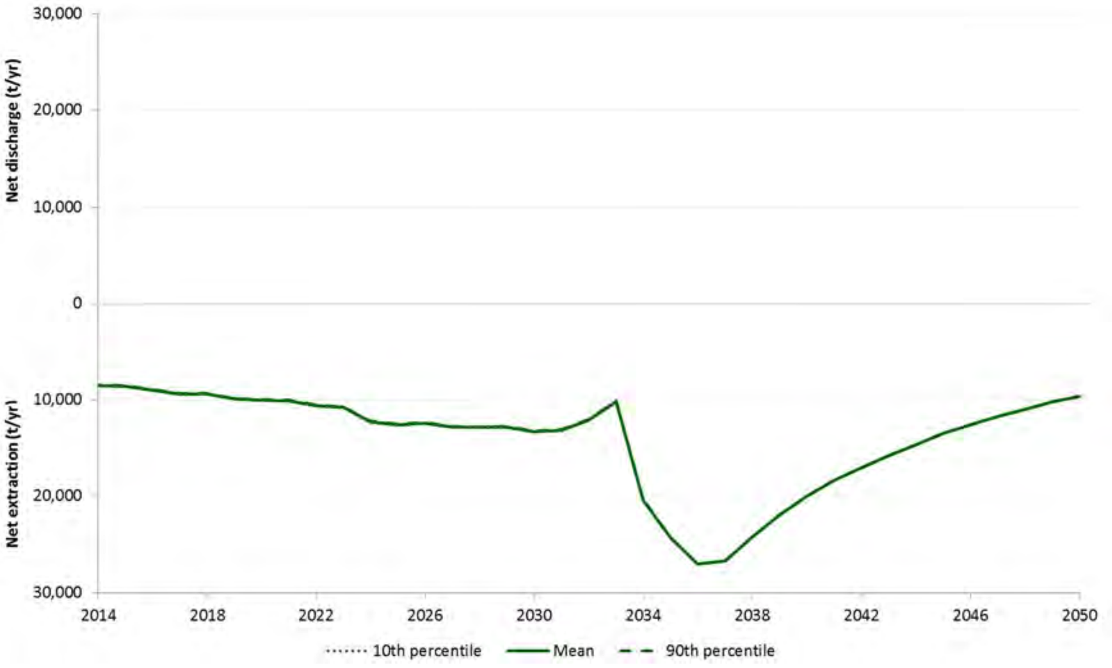


Figure H-15 Myuna Colliery – Net Extraction/Discharge Salt Mass

Newstan Colliery

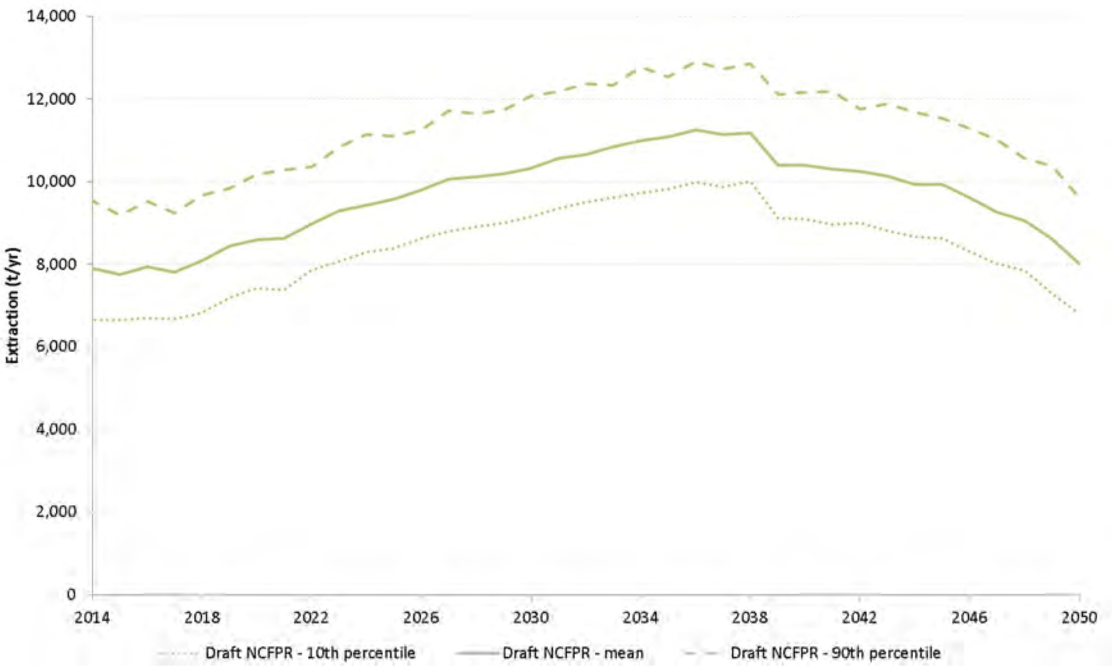


Figure H-16 Newstan Colliery – Groundwater Extraction Salt Mass

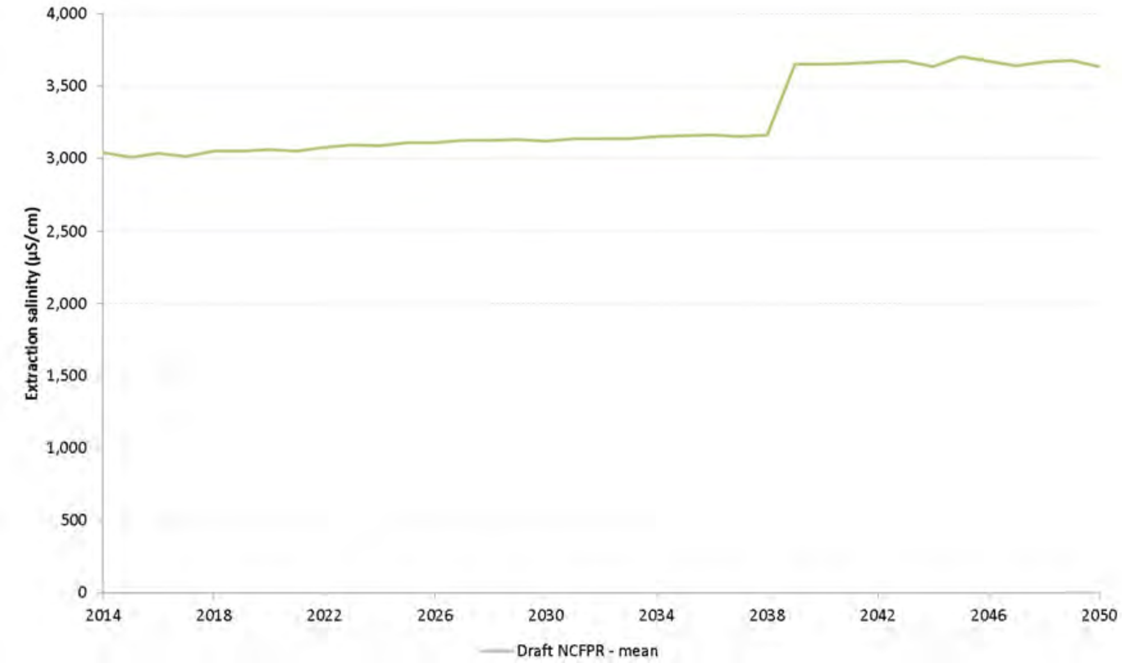


Figure H-17 Newstan Colliery – Groundwater Extraction Salinity

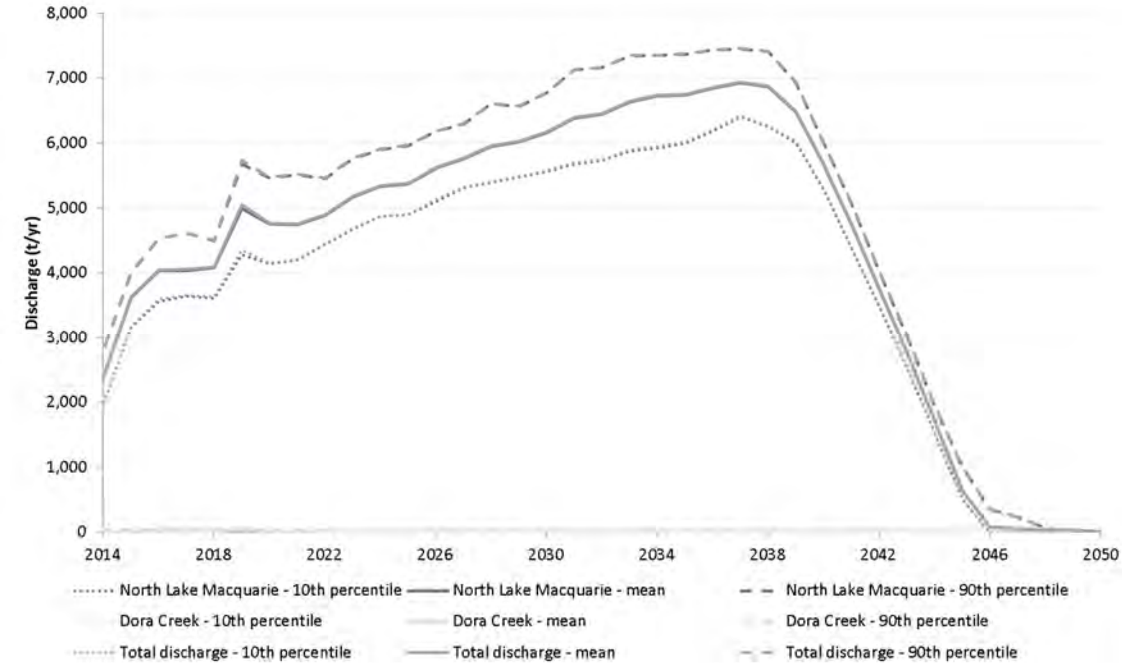


Figure H-18 Newstan Colliery – Surface Water Discharge Salt Mass

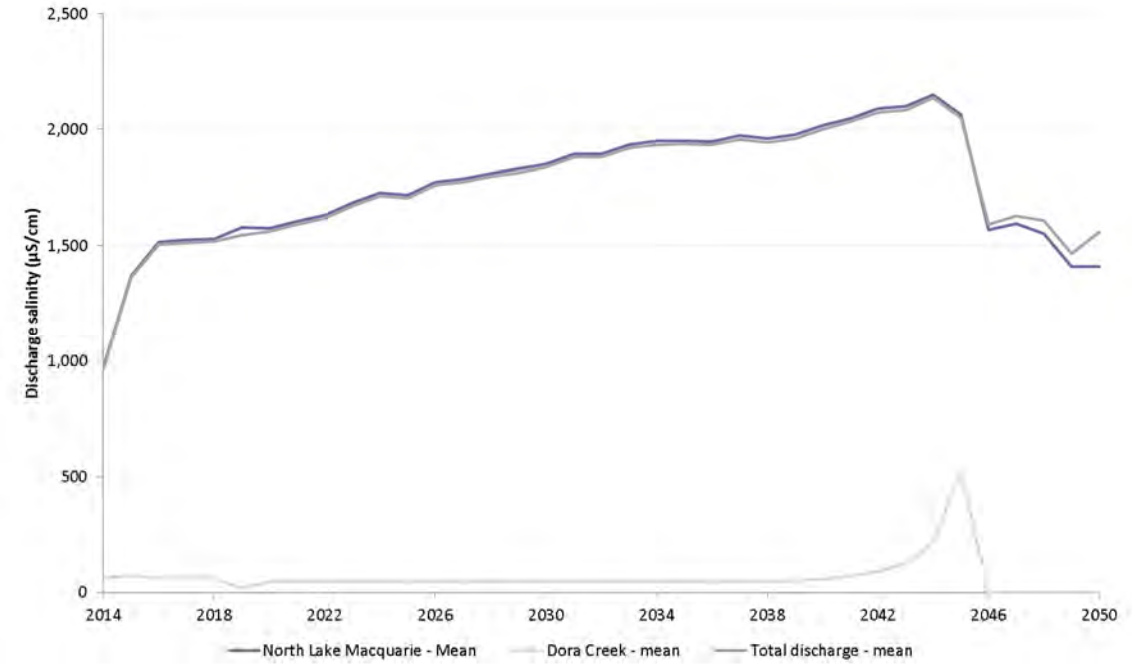


Figure H-19 Newstan Colliery – Surface Water Discharge Salinity

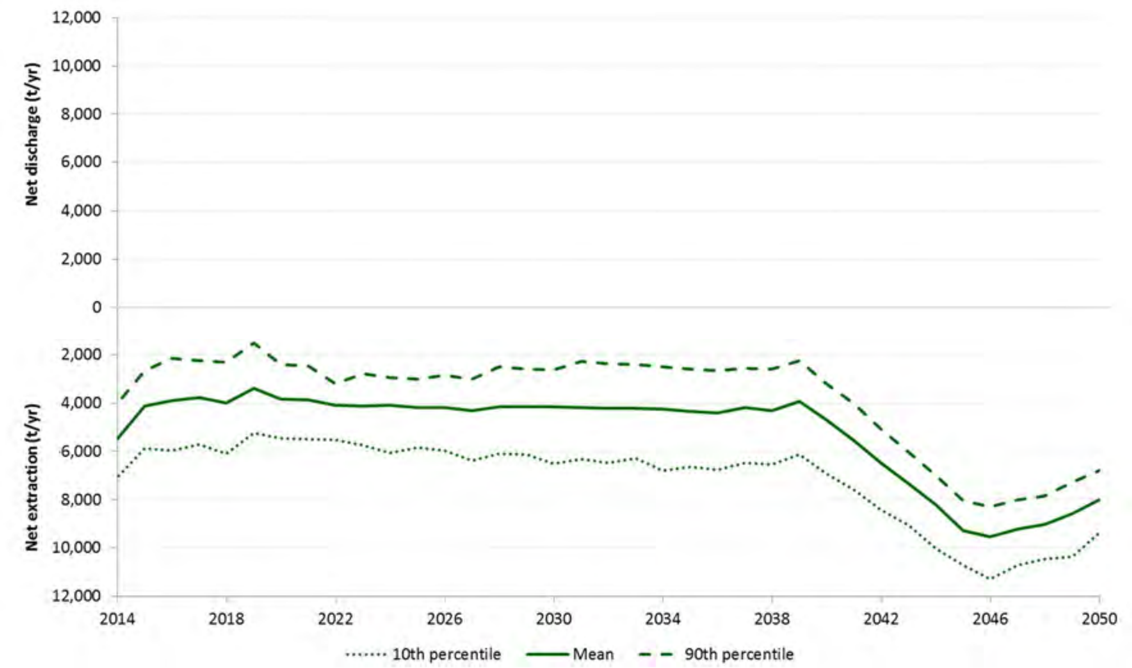


Figure H-20 Newstan Colliery – Net Extraction/Discharge Salt Mass

Non-Centennial Sites

Aquabait

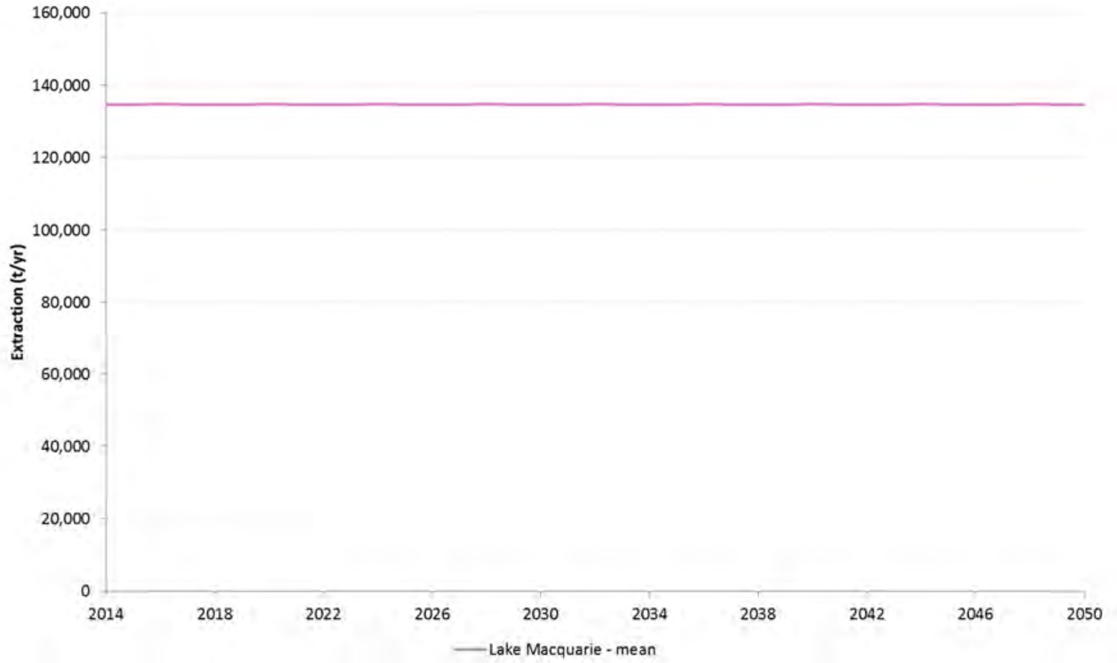


Figure H-21 Aquabait – Surface Water Extraction Salt Mass

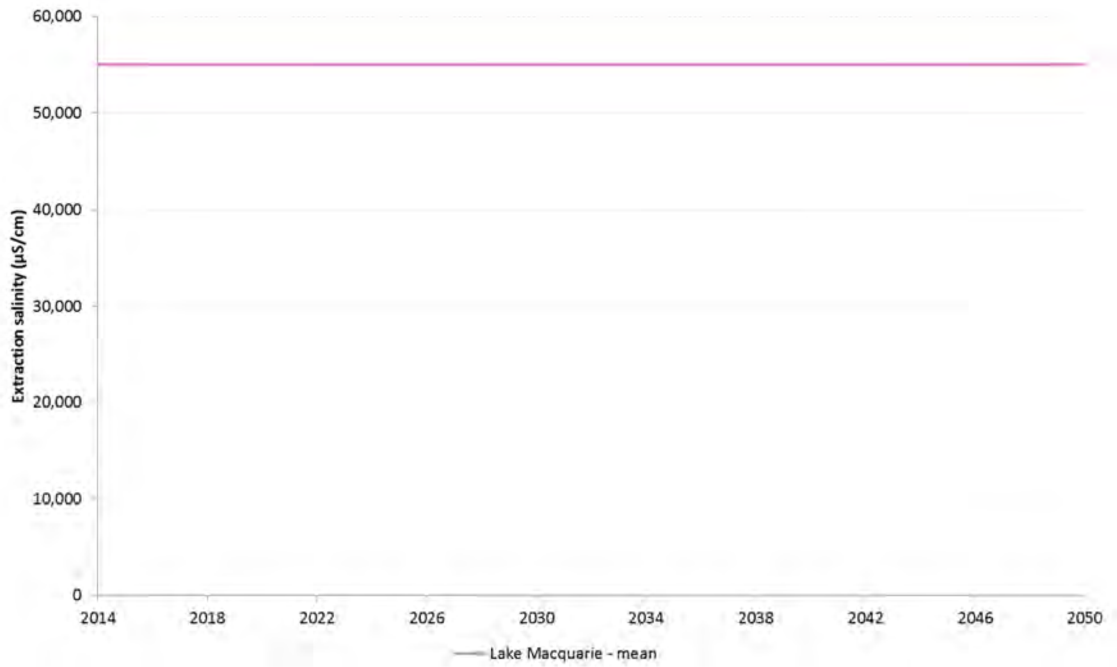


Figure H-22 Aquabait – Surface Water Extraction Salinity

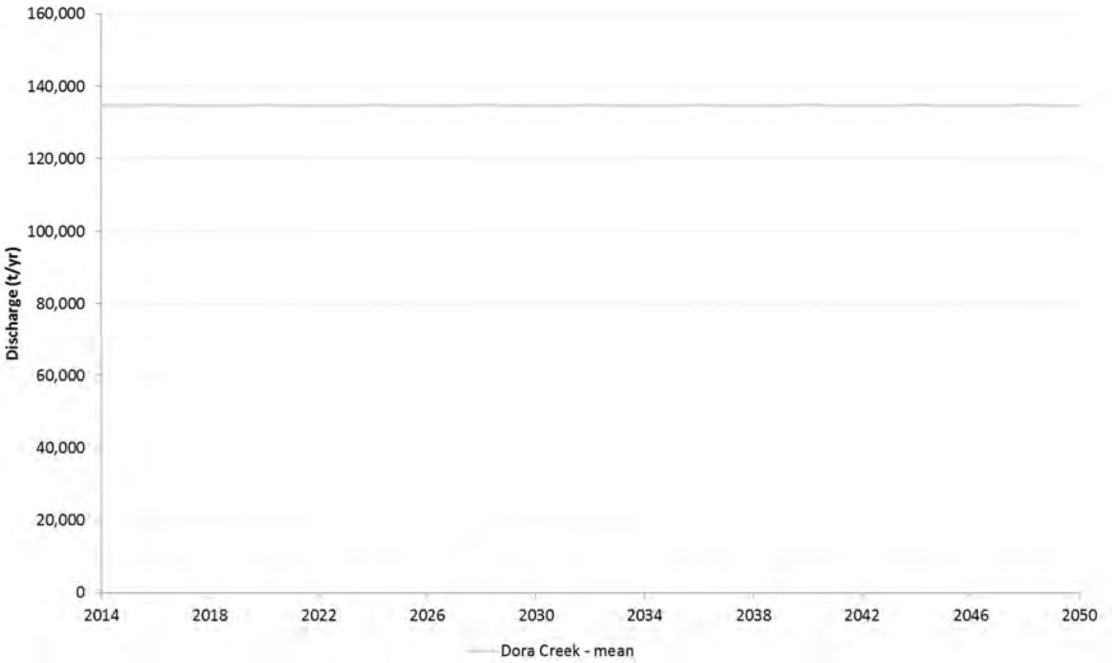


Figure H-23 Aquabait – Surface Water Discharge Salt Mass

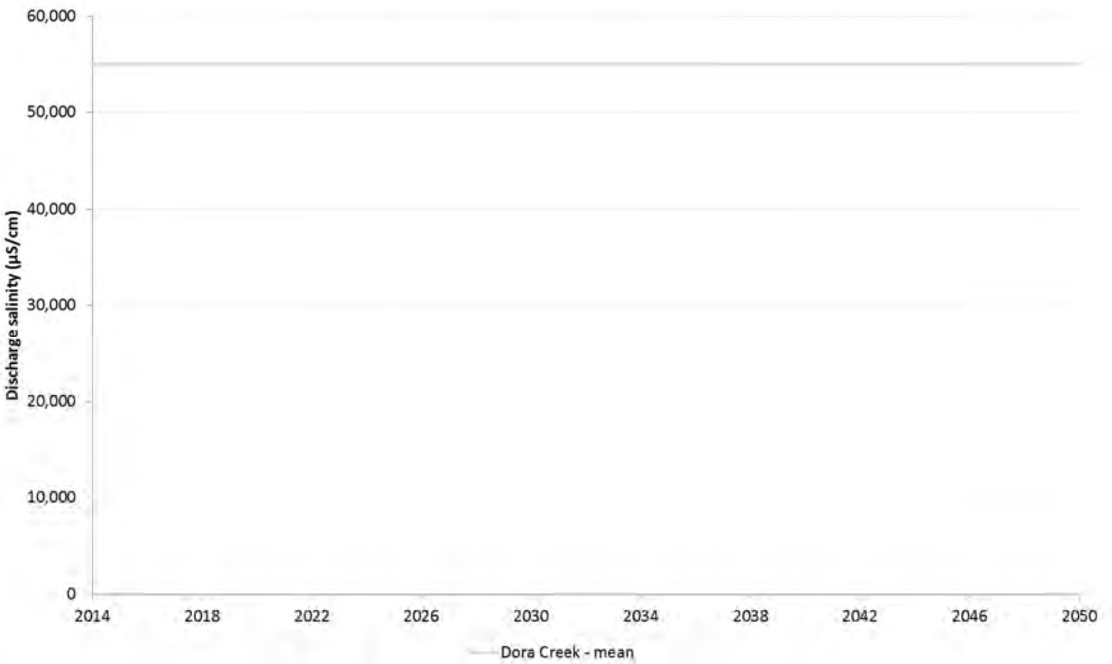


Figure H-24 Aquabait – Surface Water Discharge Salinity

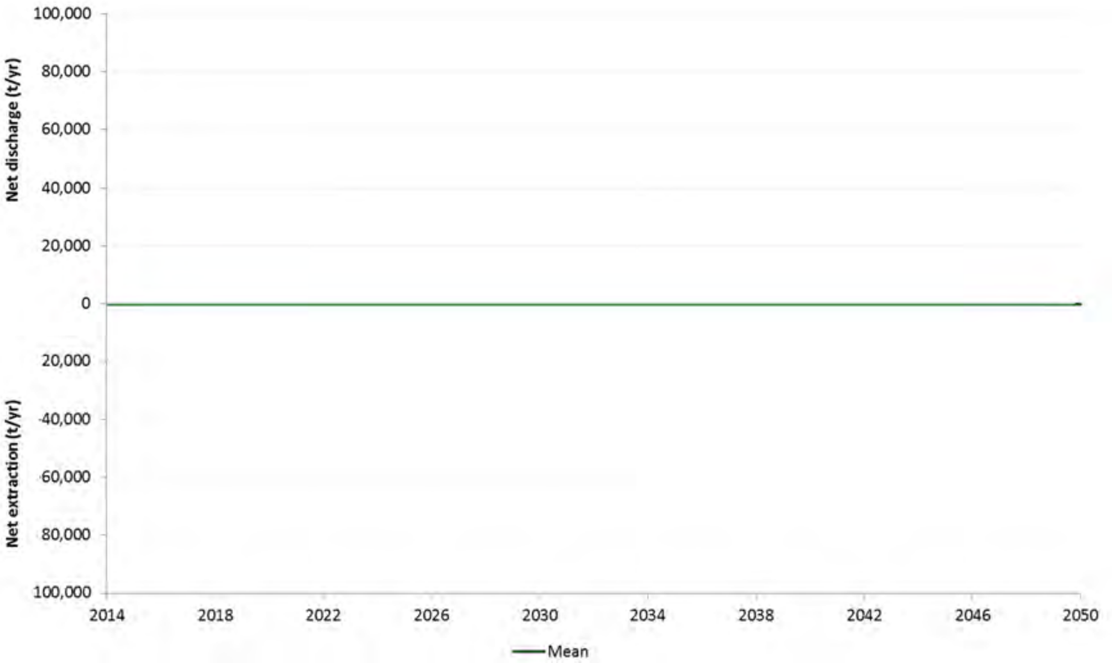


Figure H-25 Aquabait – Net Extraction/Discharge Salt Mass

Chain Valley Colliery

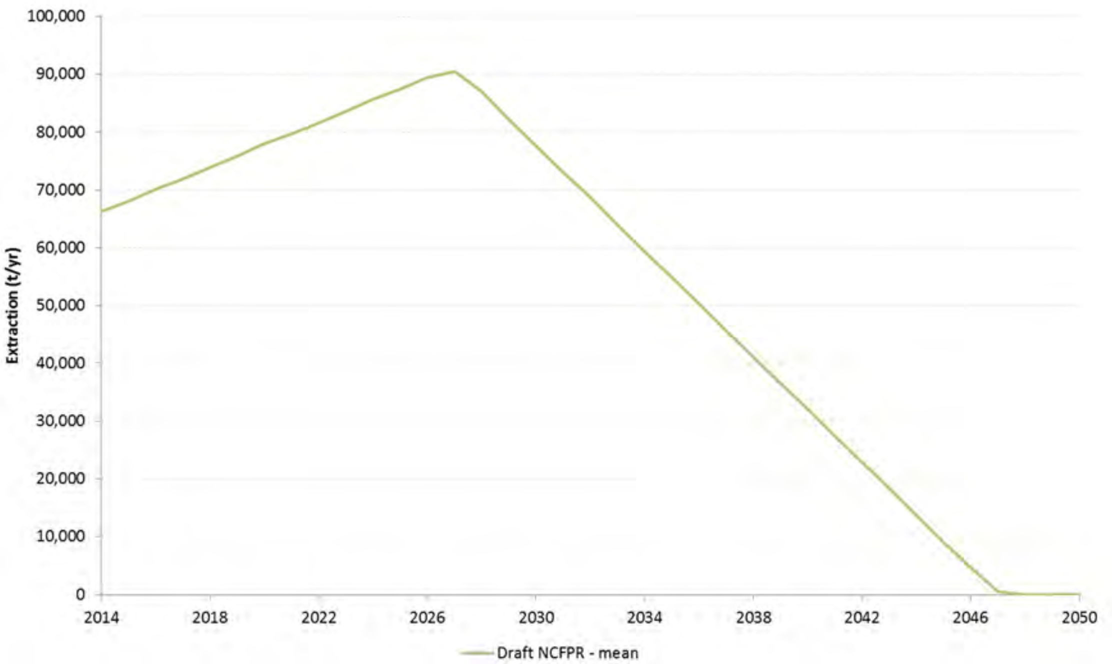


Figure H-26 Chain Valley Colliery – Groundwater Extraction Salt Mass

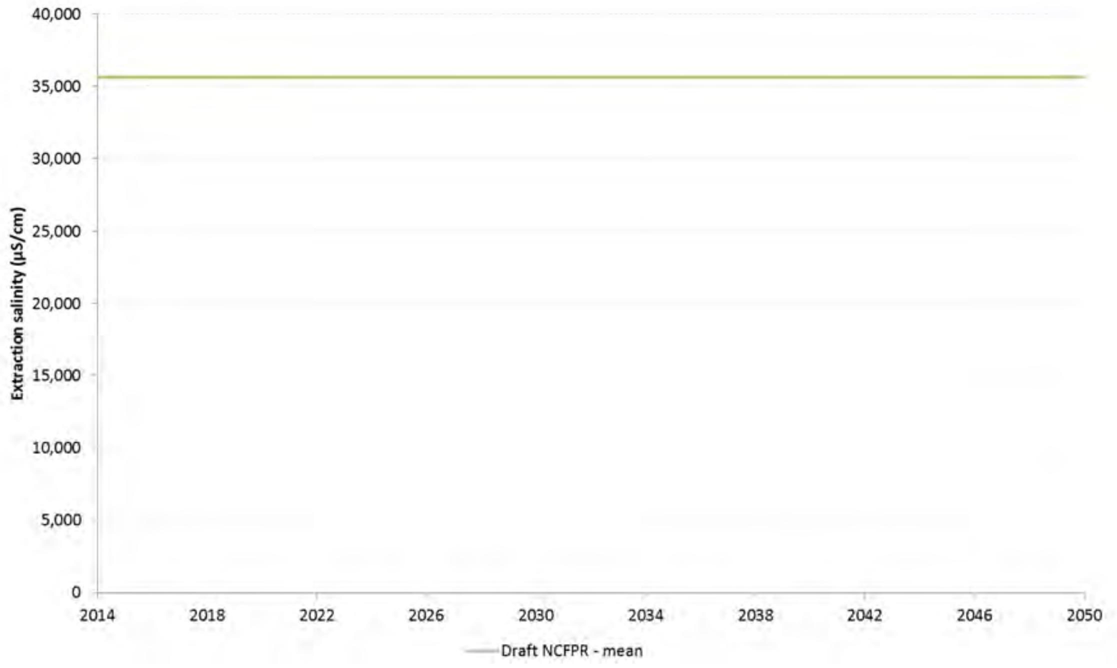


Figure H-27 Chain Valley Colliery – Groundwater Extraction Salinity

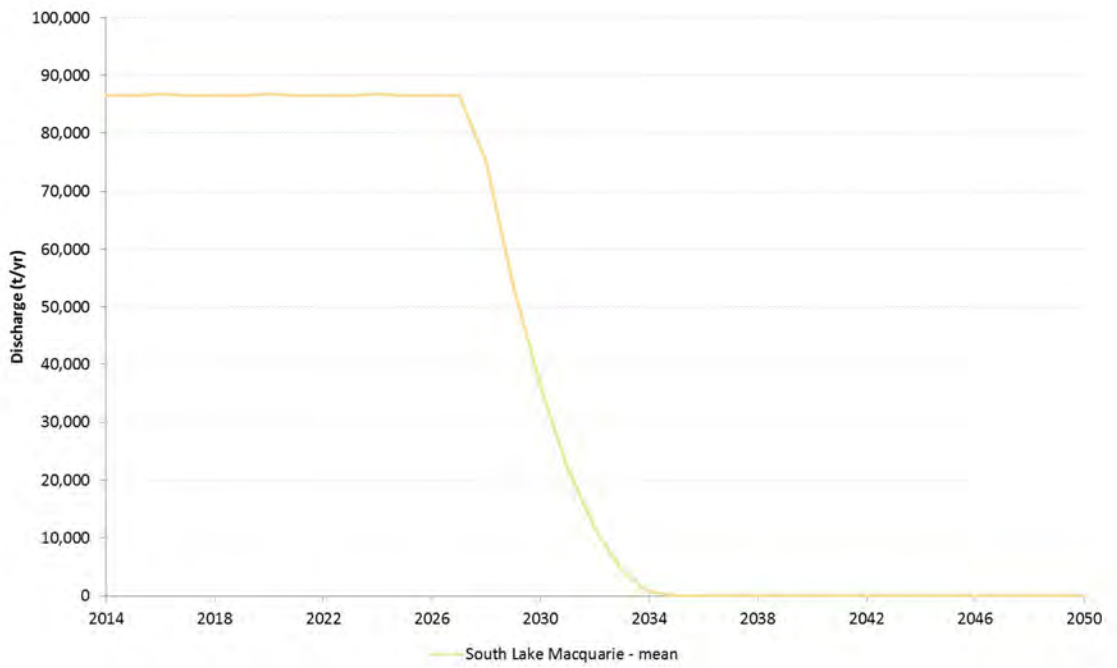


Figure H-28 Chain Valley Colliery – Surface Water Discharge Salt Mass

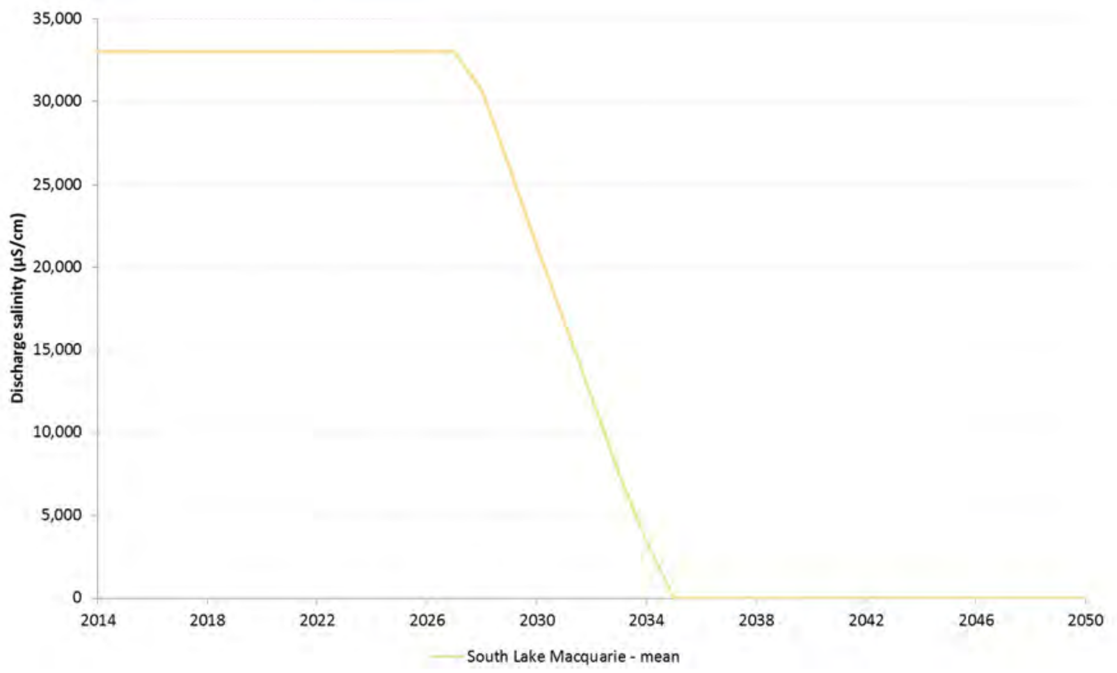


Figure H-29 Chain Valley Colliery – Surface Water Discharge Salinity

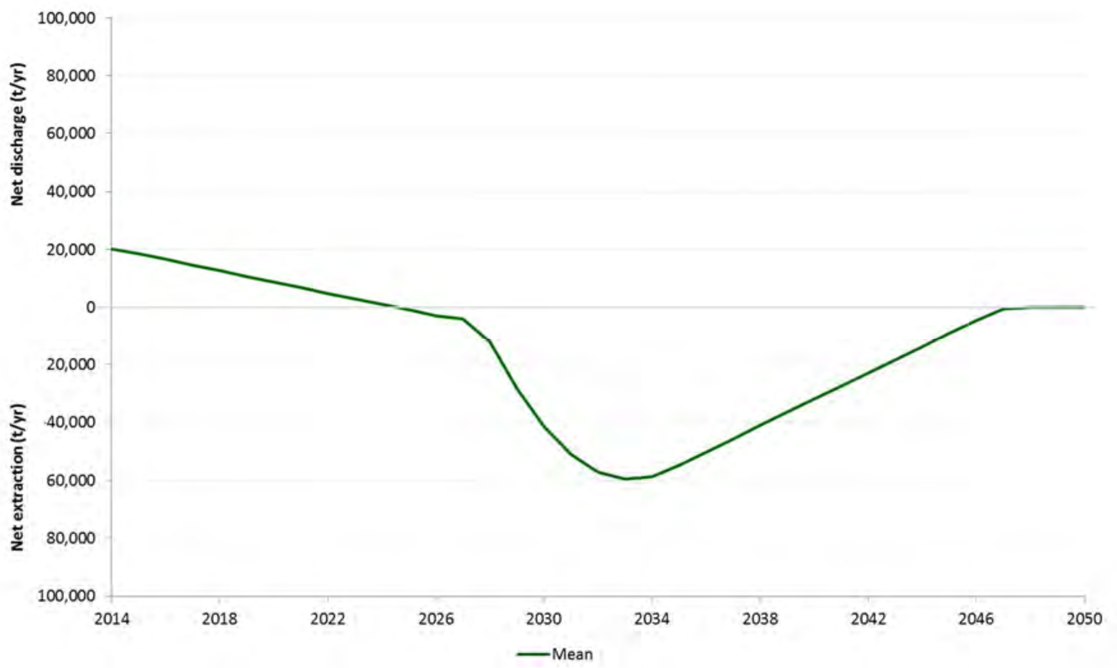


Figure H-30 Chain Valley Colliery – Net Extraction/Discharge Salt Mass

Eraring Power Station

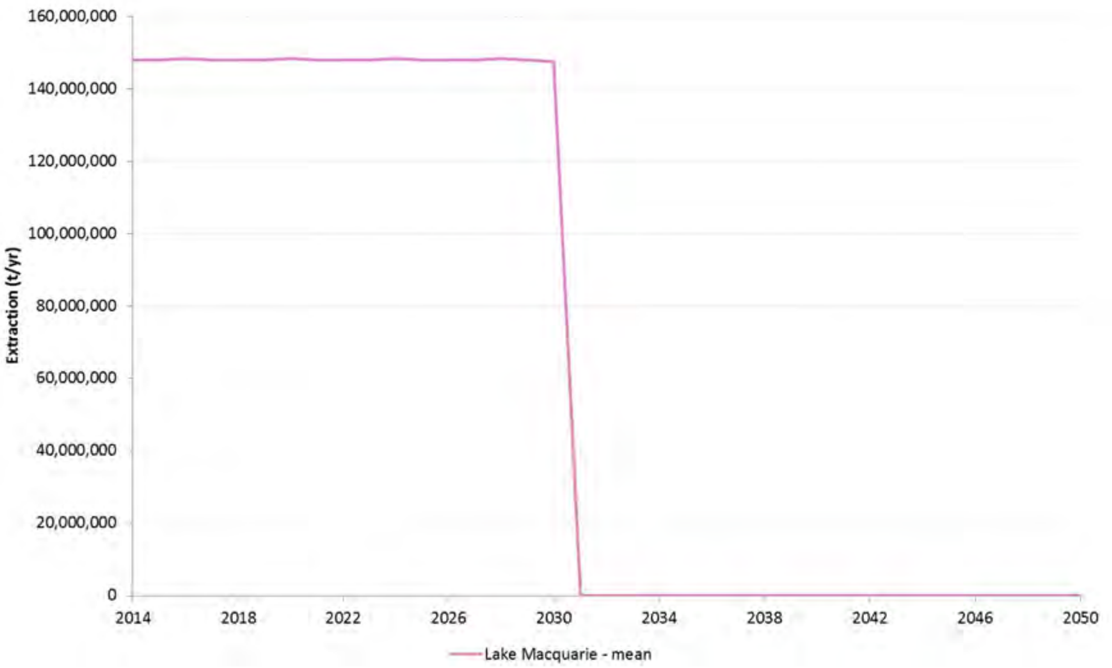


Figure H-30 Eraring Power Station – Surface Water Extraction Salt Mass

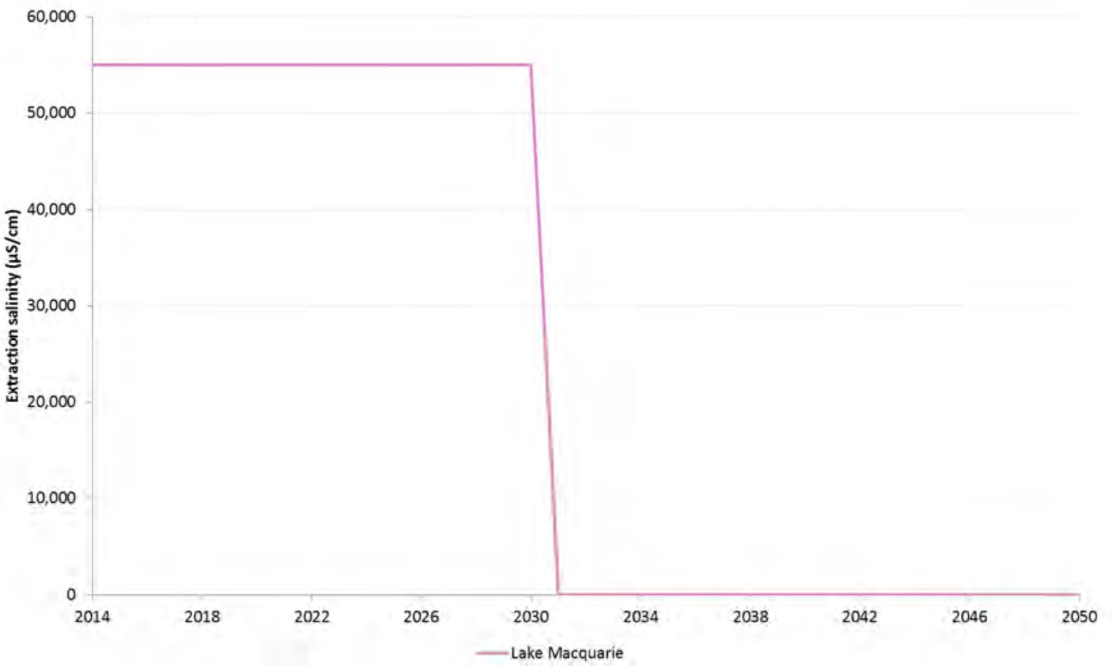


Figure H-31 Eraring Power Station – Surface Water Extraction Salinity

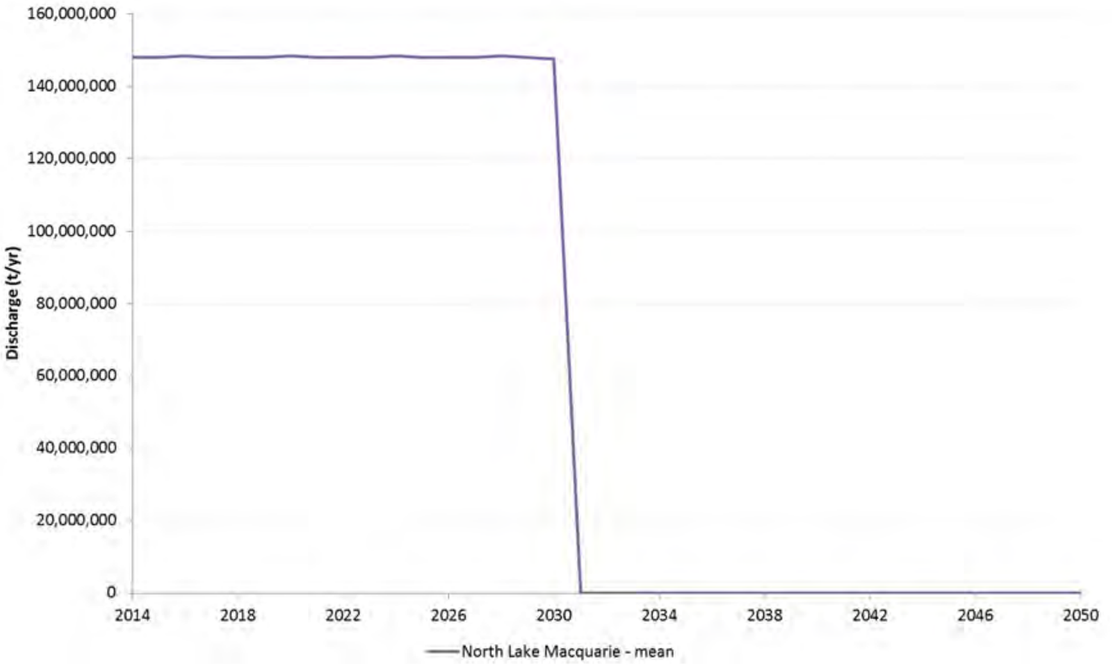


Figure H-32 Eraring Power Station – Surface Water Discharge Salt Mass

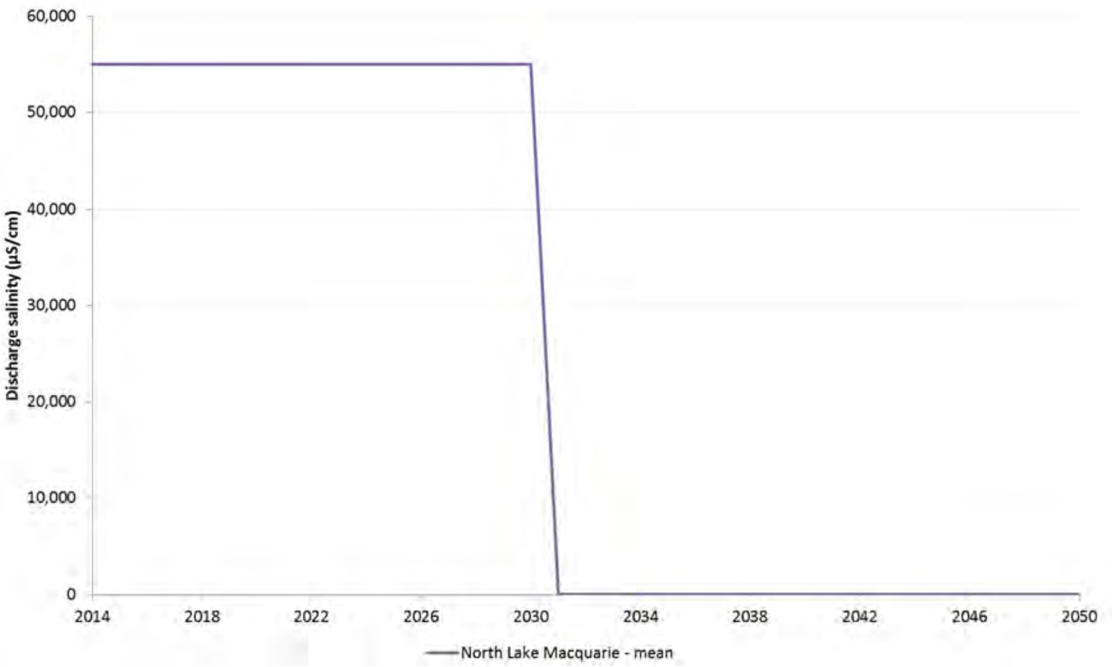


Figure H-33 Eraring Power Station – Surface Water Discharge Salinity

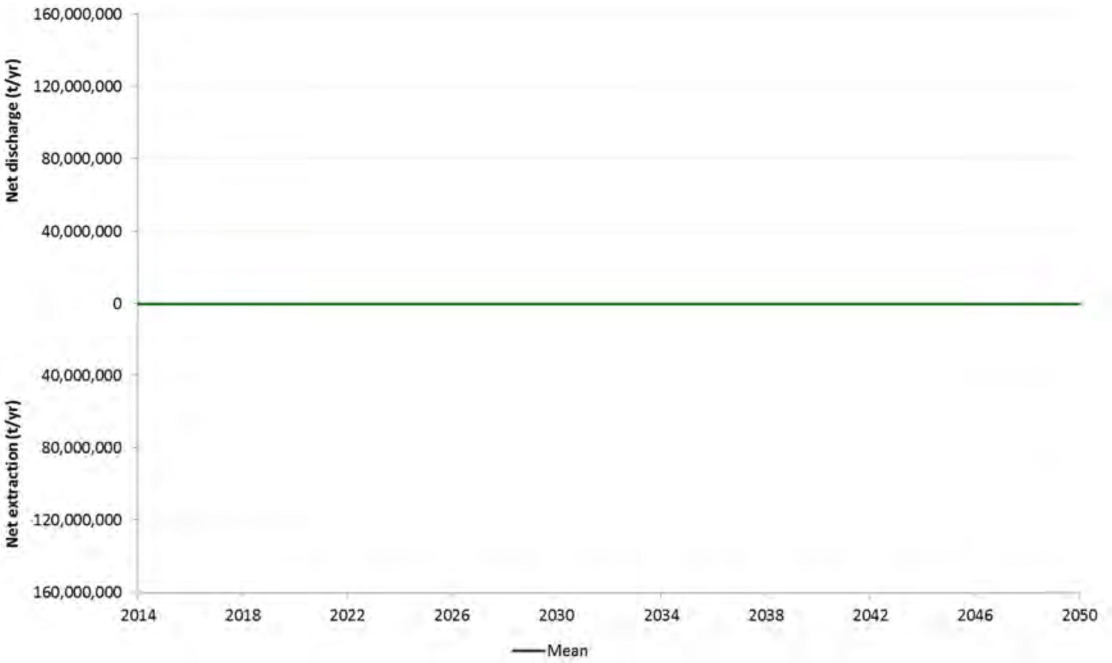


Figure H-34 Eraring Power Station – Net Extraction/Discharge Salt Mass

Pasminco and Incitec Consolidated Remediation Project

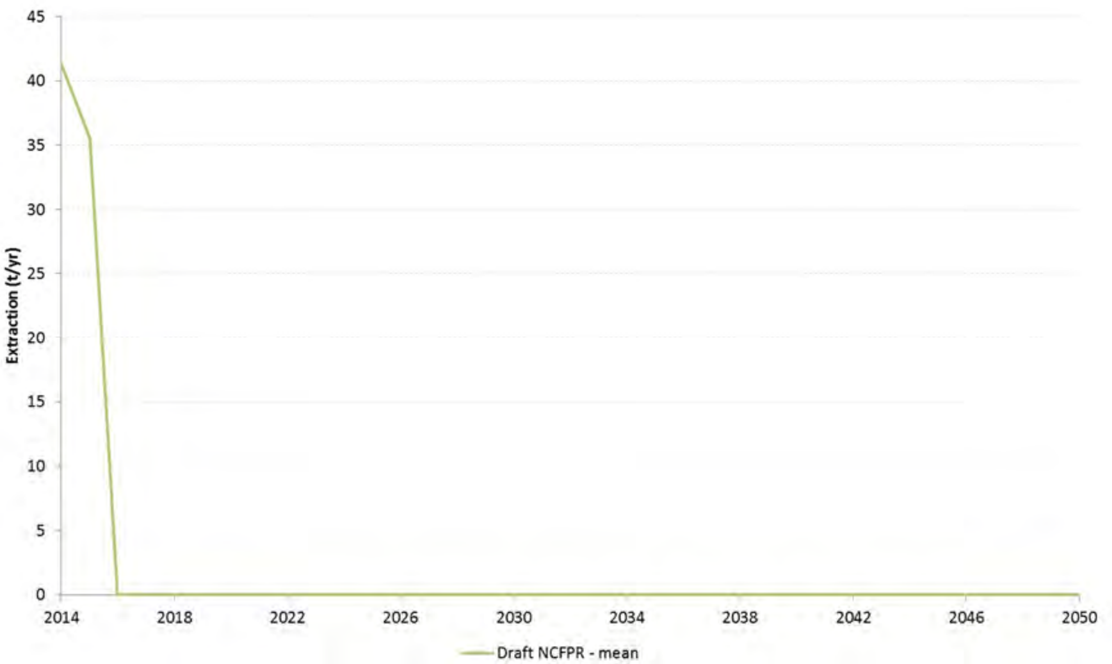


Figure H-35 Pasminco and Incitec Consolidated Remediation Project – Groundwater Extraction Salt Mass

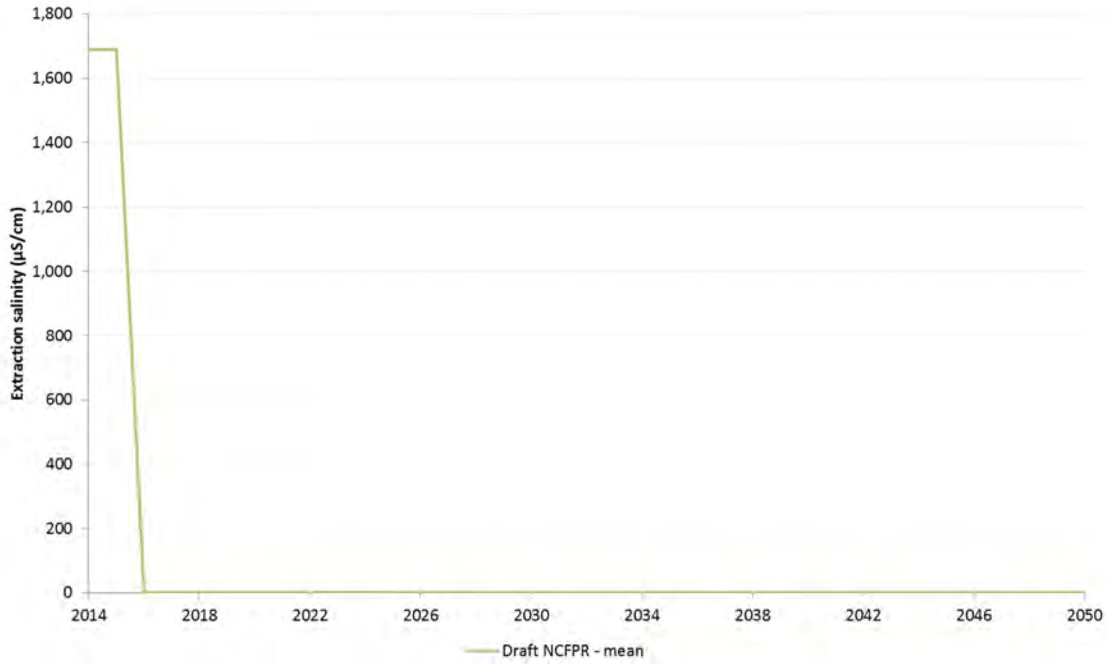


Figure H-36 Pasminco and Incitec Consolidated Remediation Project – Groundwater Extraction Salinity

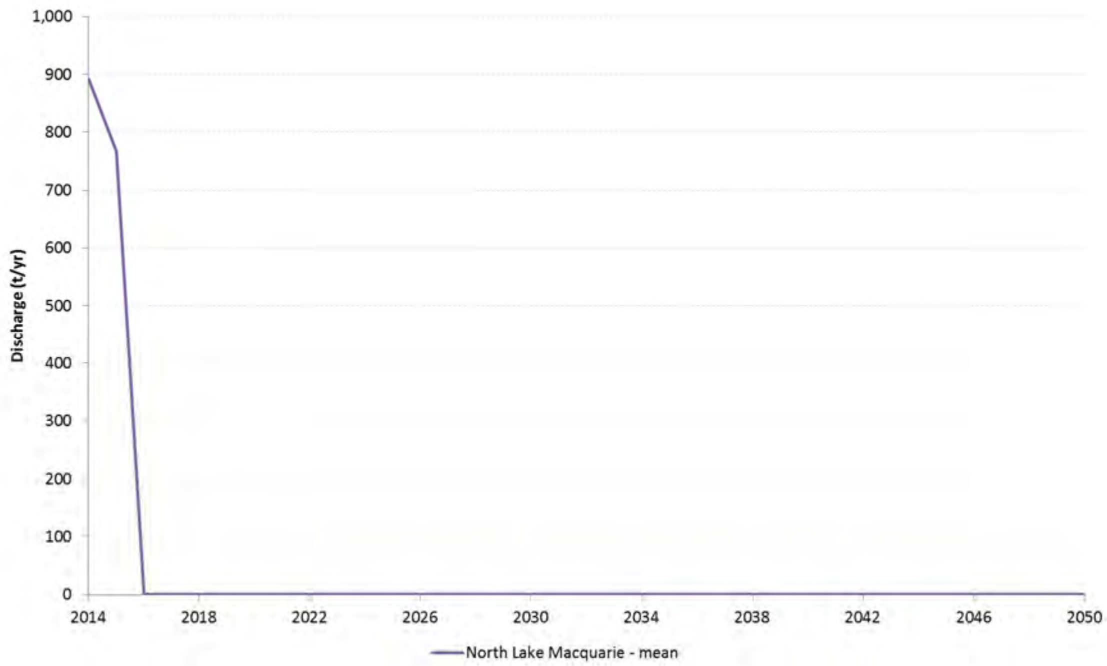


Figure H-37 Pasminco and Incitec Consolidated Remediation Project – Surface Water Discharge Salt Mass

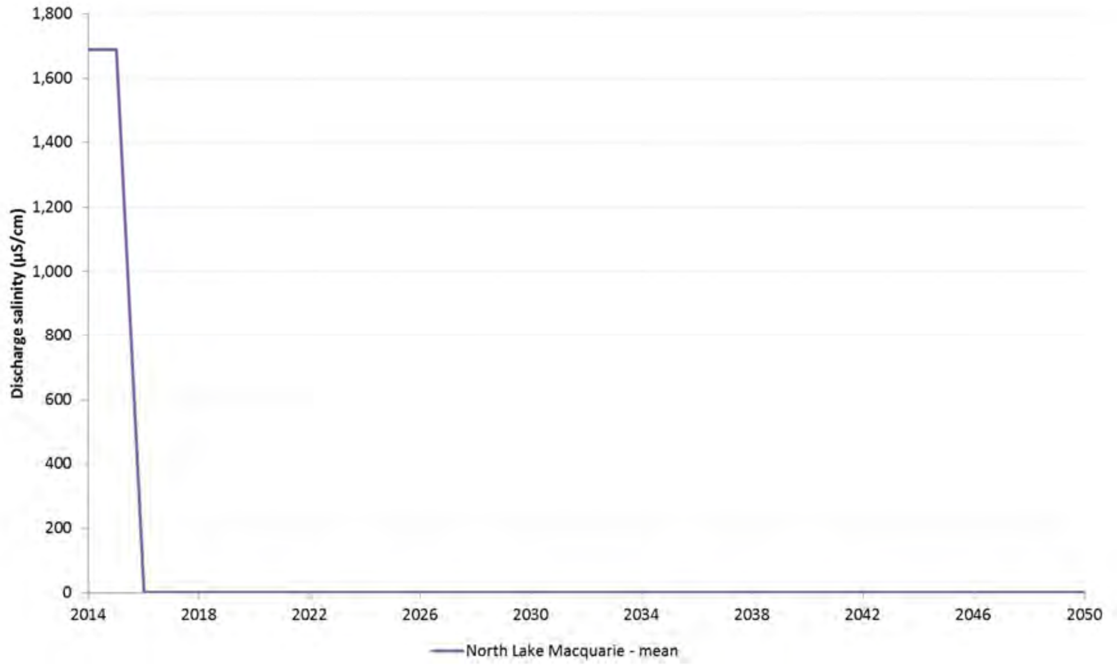


Figure H-38 Pasminco and Incitec Consolidated Remediation Project – Surface Water Discharge Salinity

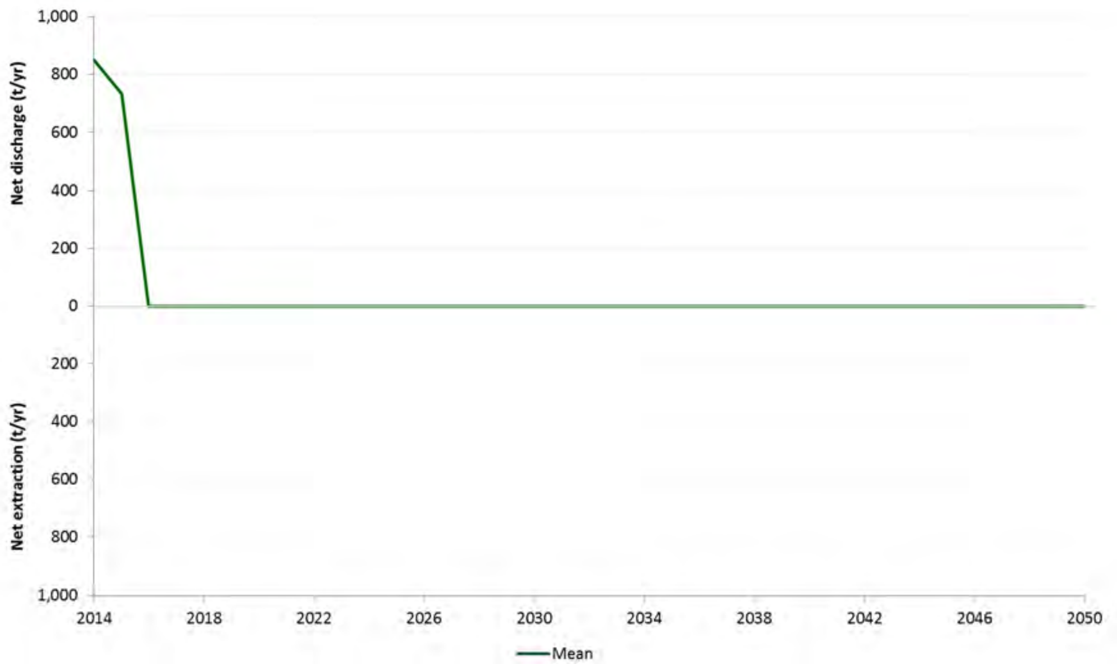


Figure H-39 Pasminco and Incitec Consolidated Remediation Project – Net Extraction/Discharge Salt Mass

Tasman Underground Mine

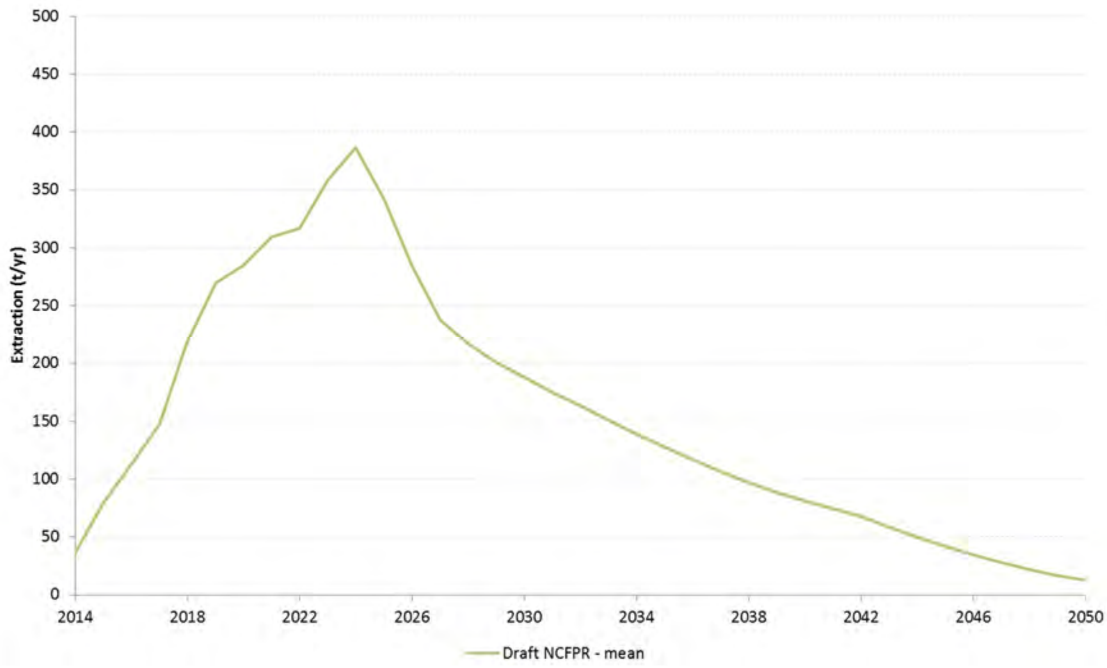


Figure H-40 Tasman Underground Mine – Groundwater Extraction Salt Mass

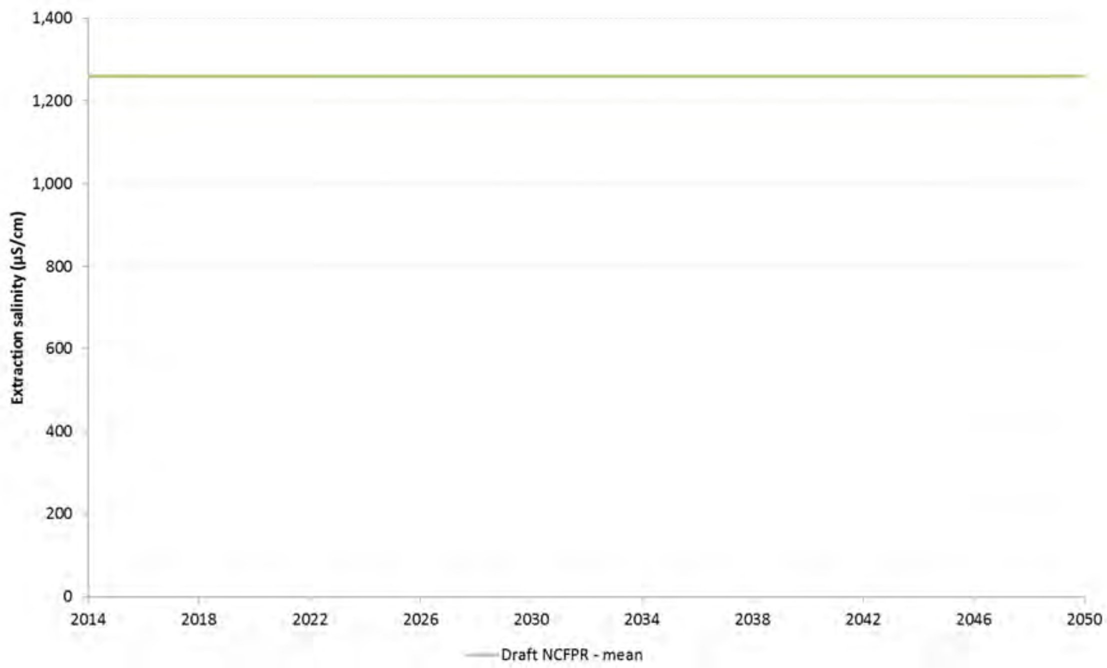


Figure H-41 Tasman Underground Mine – Groundwater Extraction Salinity

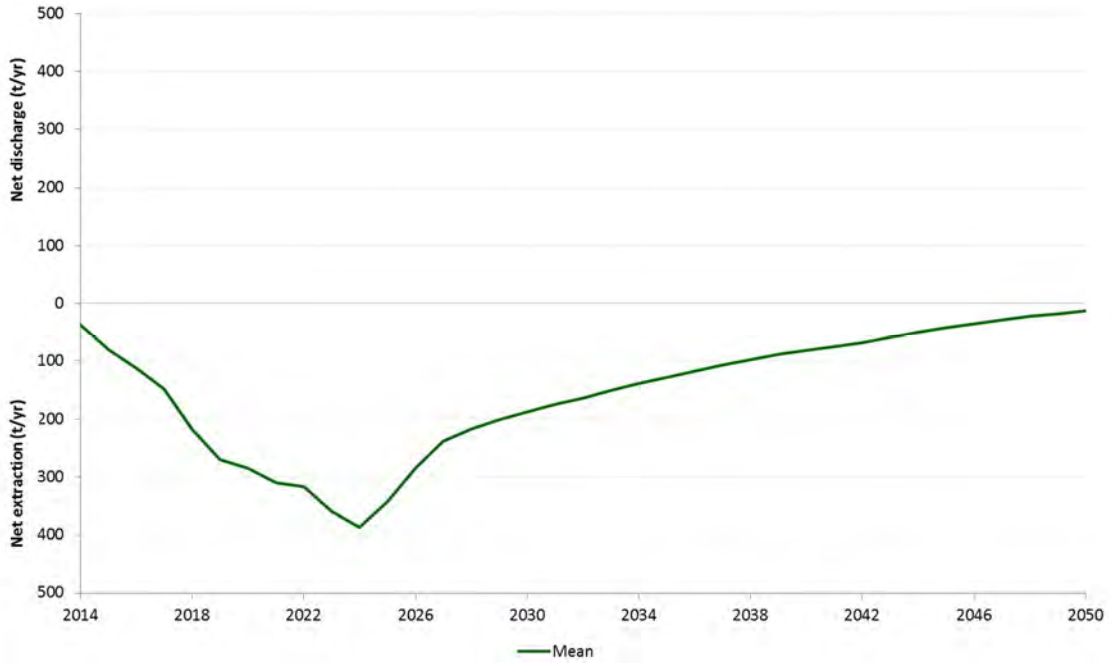


Figure H-42 Tasman Underground Mine – Net Extraction/Discharge Salt Mass

Teralba Quarry

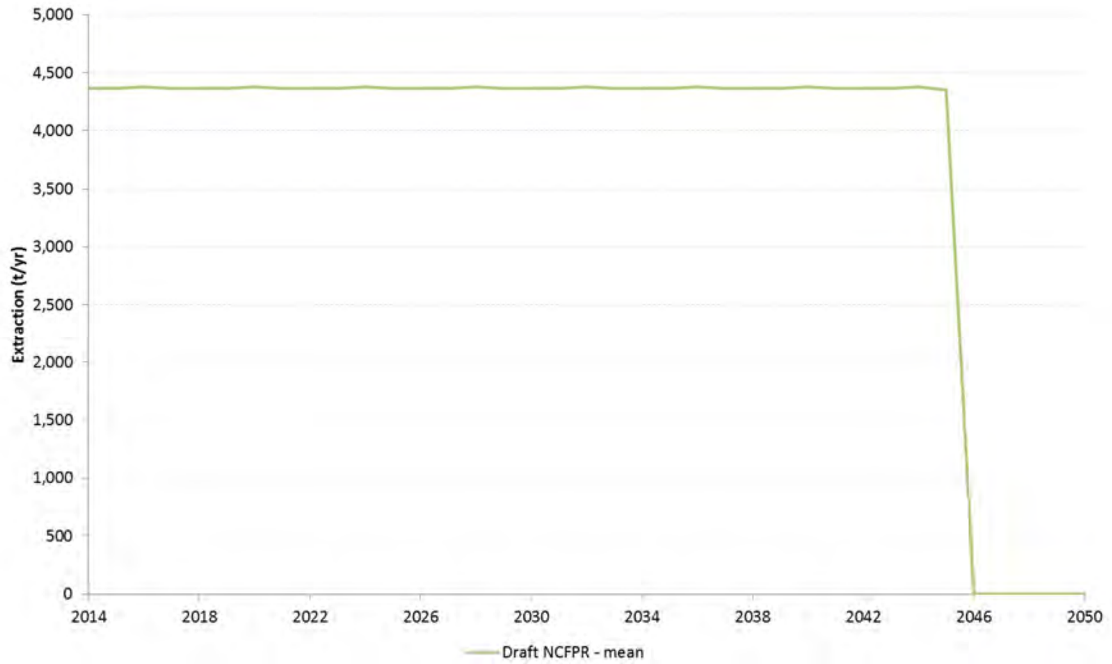


Figure H-43 Teralba Quarry – Groundwater Extraction Salt Mass

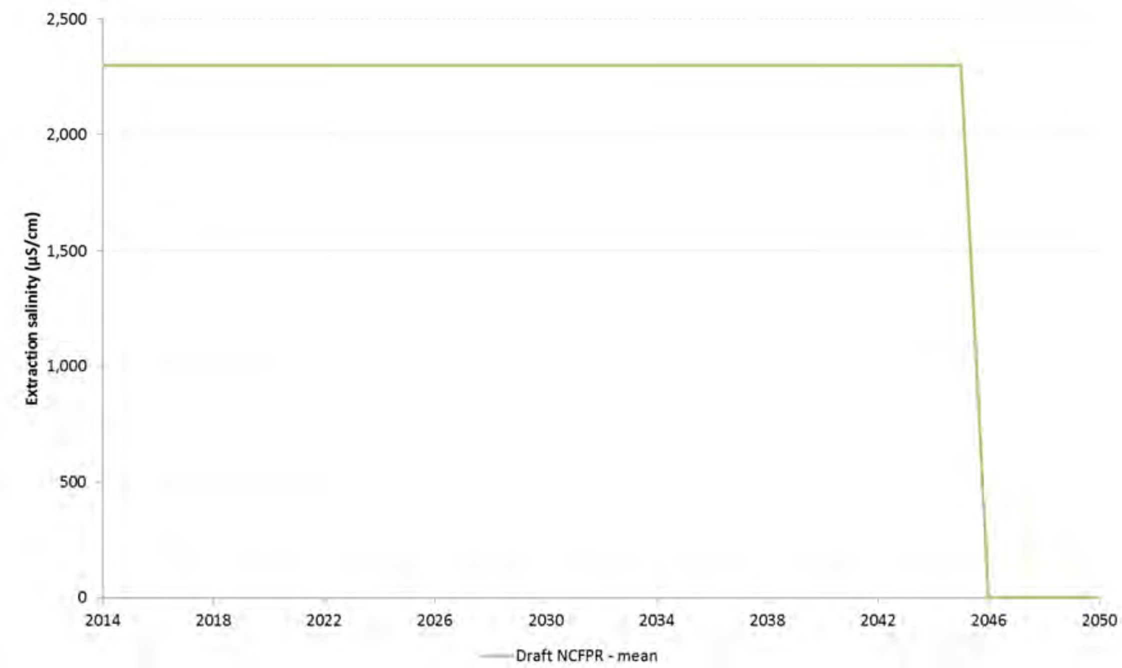


Figure H-44 Teralba Quarry – Groundwater Extraction Salinity

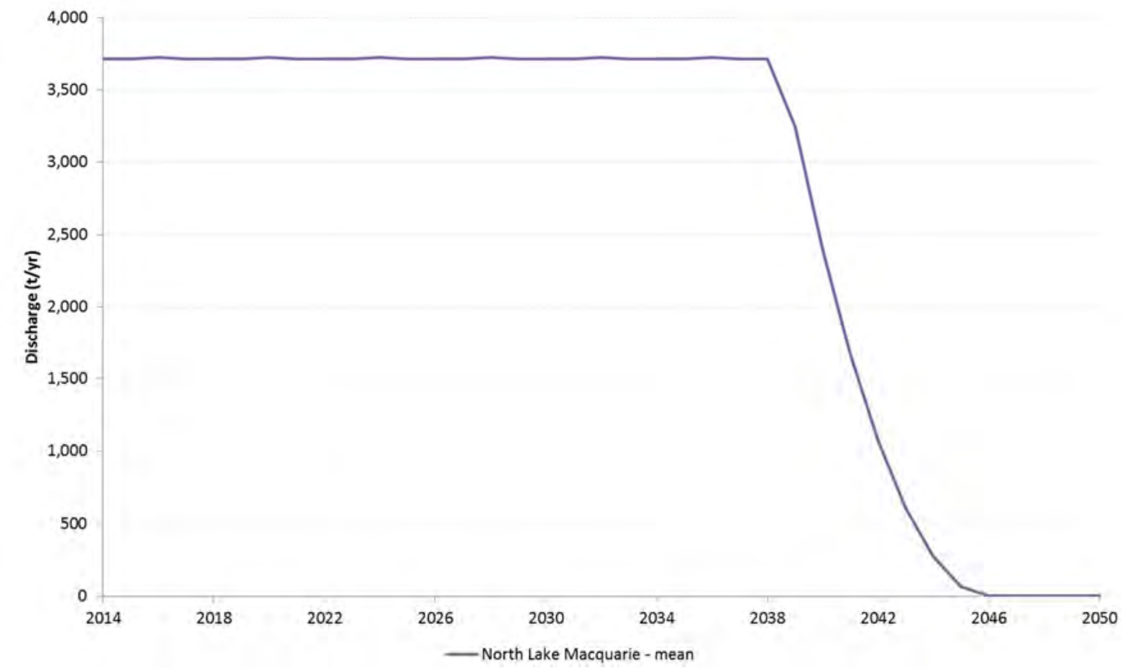


Figure H-45 Teralba Quarry – Surface Water Discharge Salt Mass

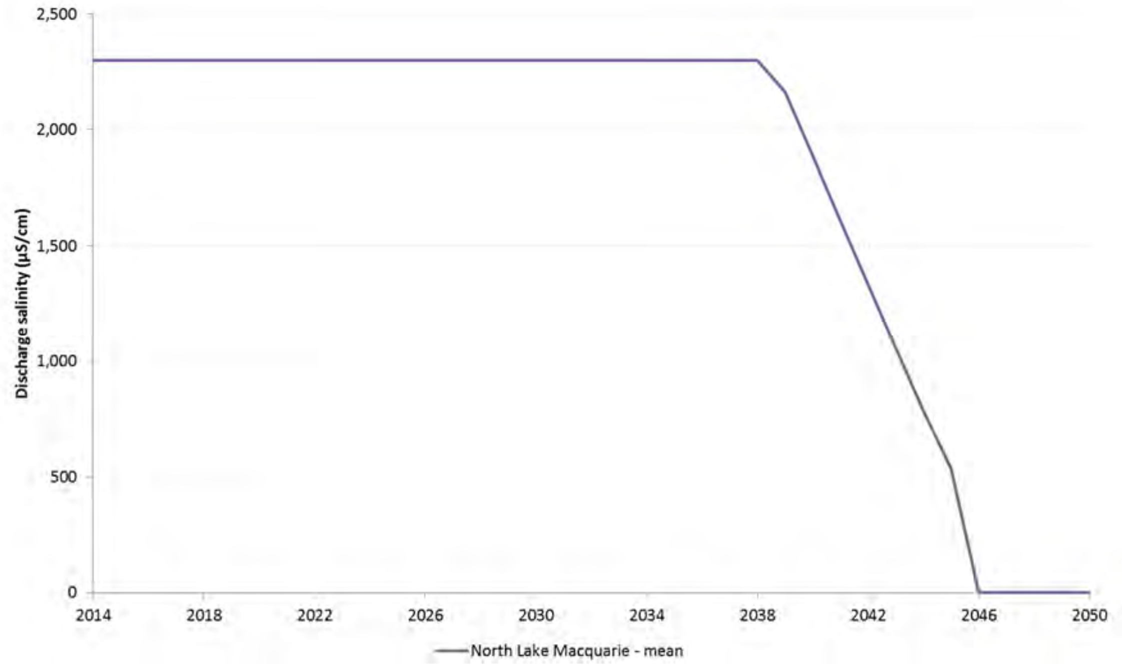


Figure H-46 Teralba Quarry – Surface Water Discharge Salinity

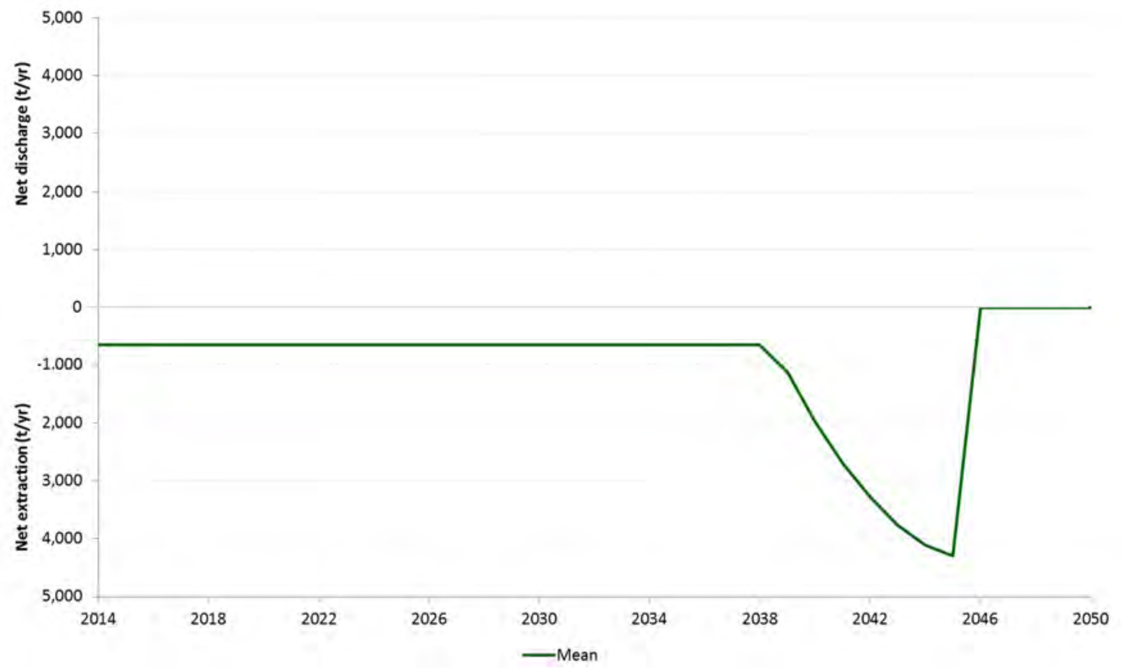


Figure H-47 Teralba Quarry – Net Extraction/Discharge Salt Mass

Vales Point Power Station

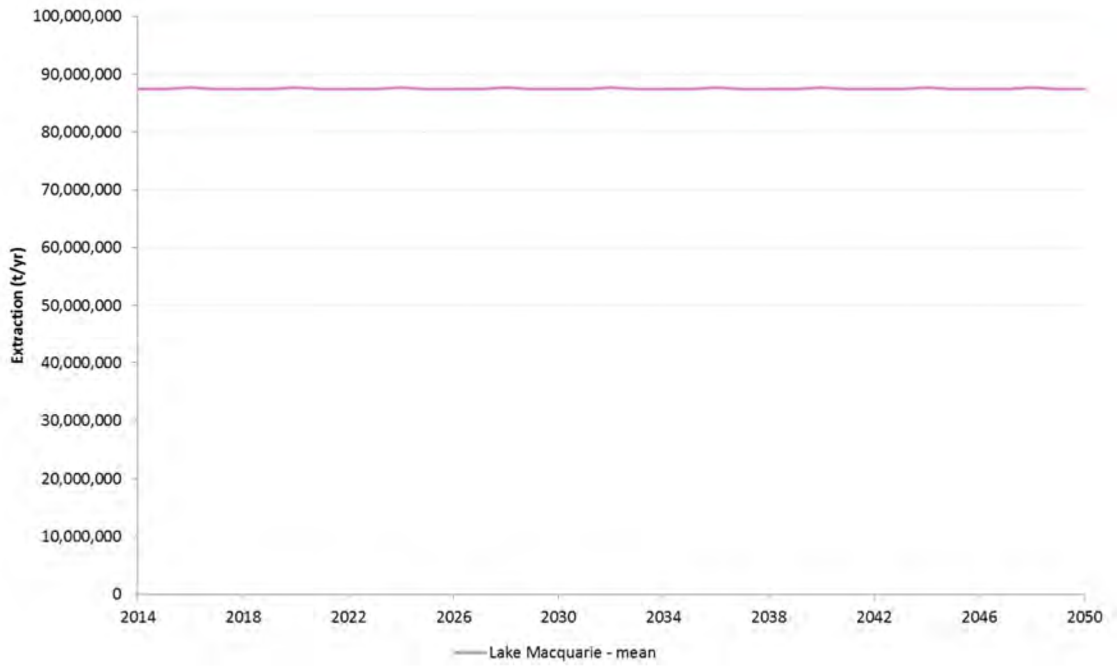


Figure H-48 Vales Point Power Station – Surface Water Extraction Salt Mass

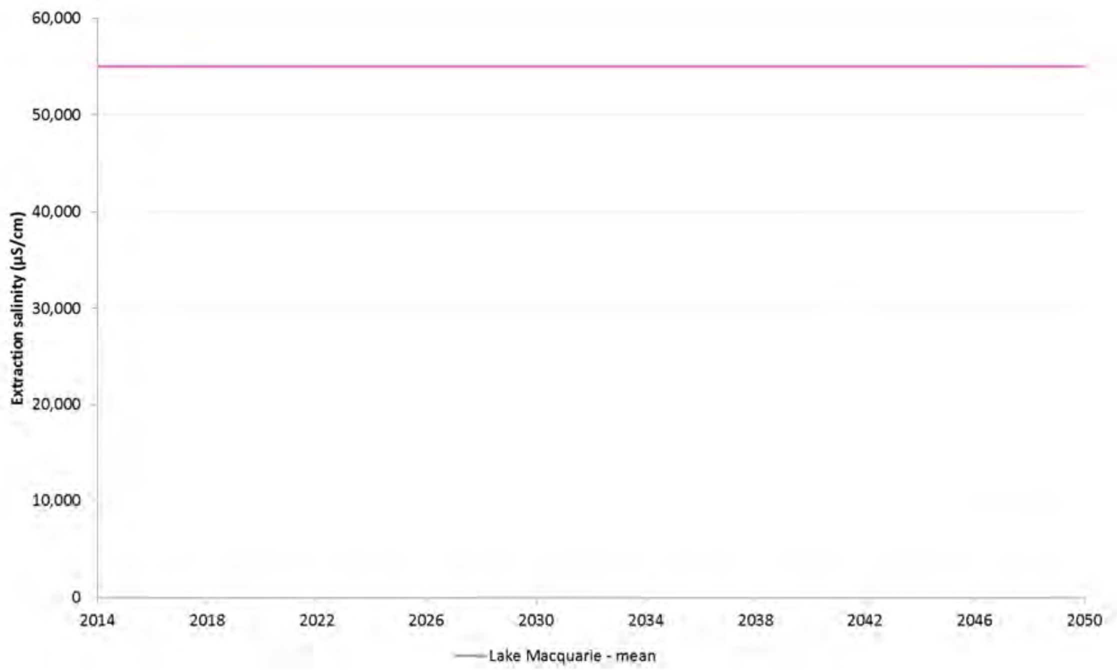


Figure H-49 Vales Point Power Station – Surface Water Extraction Salinity

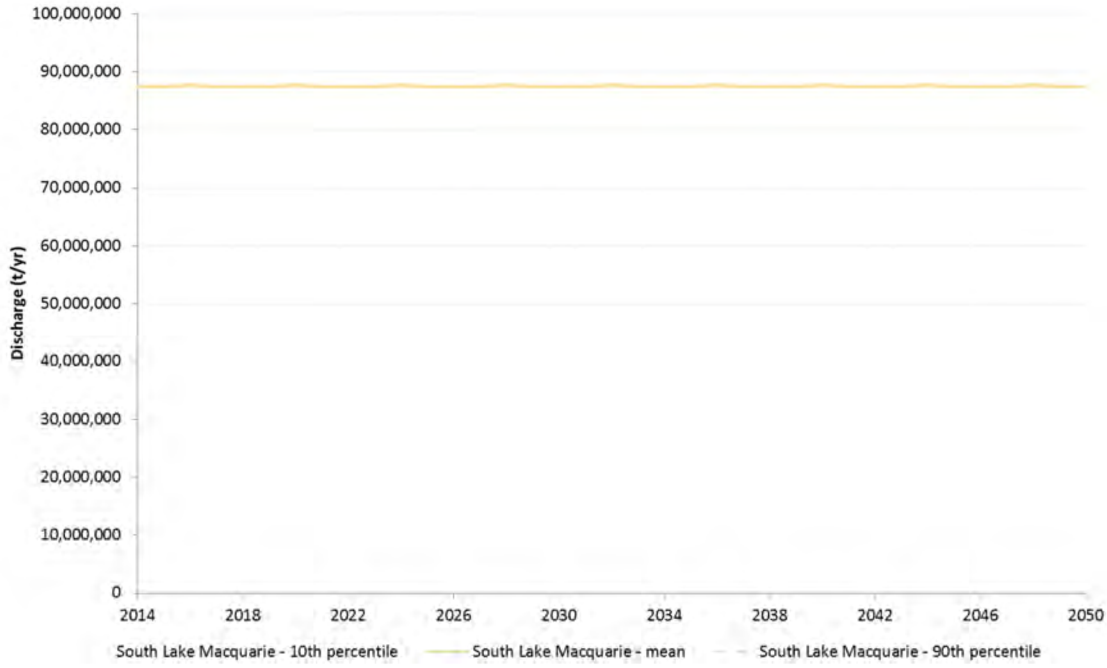


Figure H-50 Vales Point Power Station – Surface Water Discharge Salt Mass

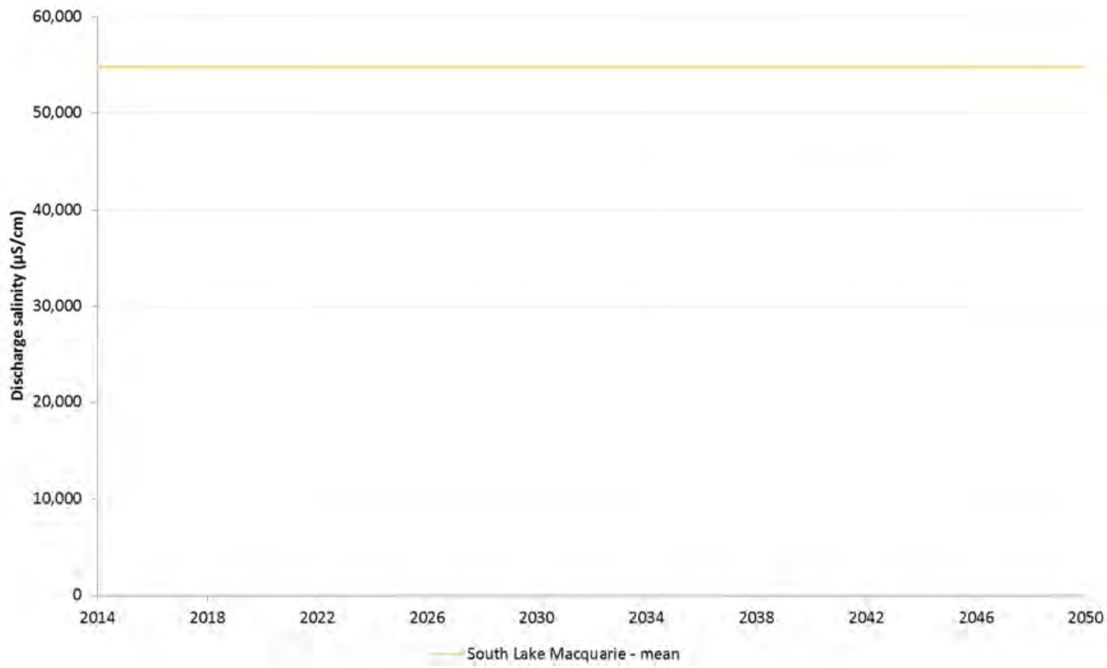


Figure H-51 Vales Point Power Station – Surface Water Discharge Salinity

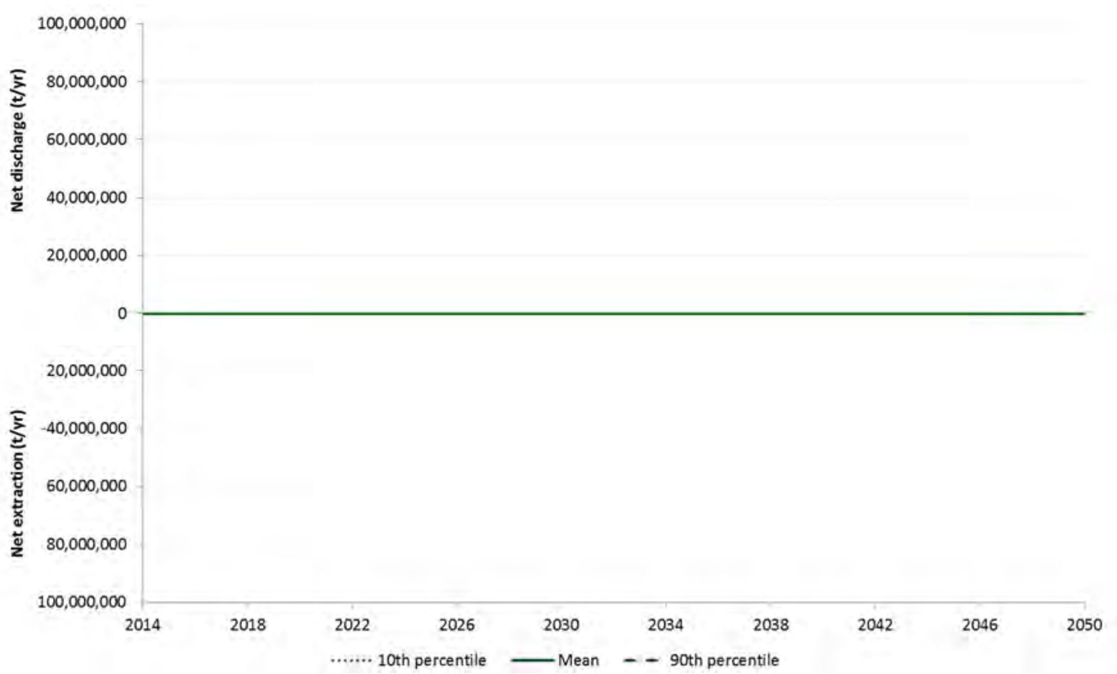


Figure H-52 Vales Point Power Station – Net Extraction/Discharge Salt Mass

Wallarah 2 Coal Project

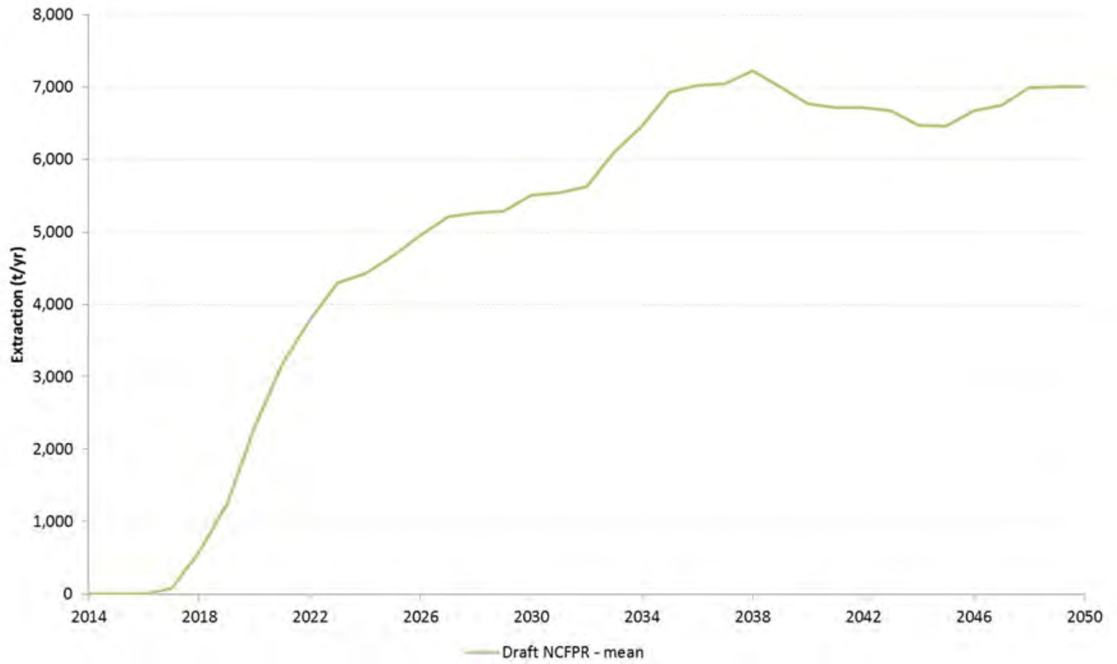


Figure H-53 Wallarah 2 Coal Project – Groundwater Extraction Salt Mass

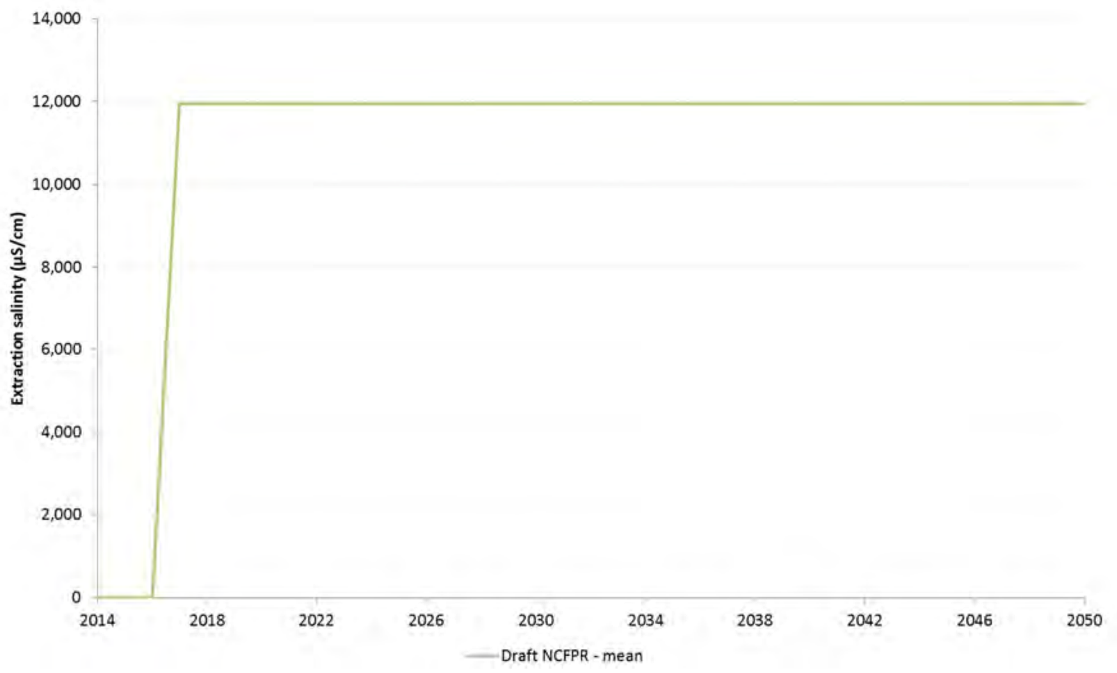


Figure H-54 Wallarah 2 Coal Project – Groundwater Extraction Salinity

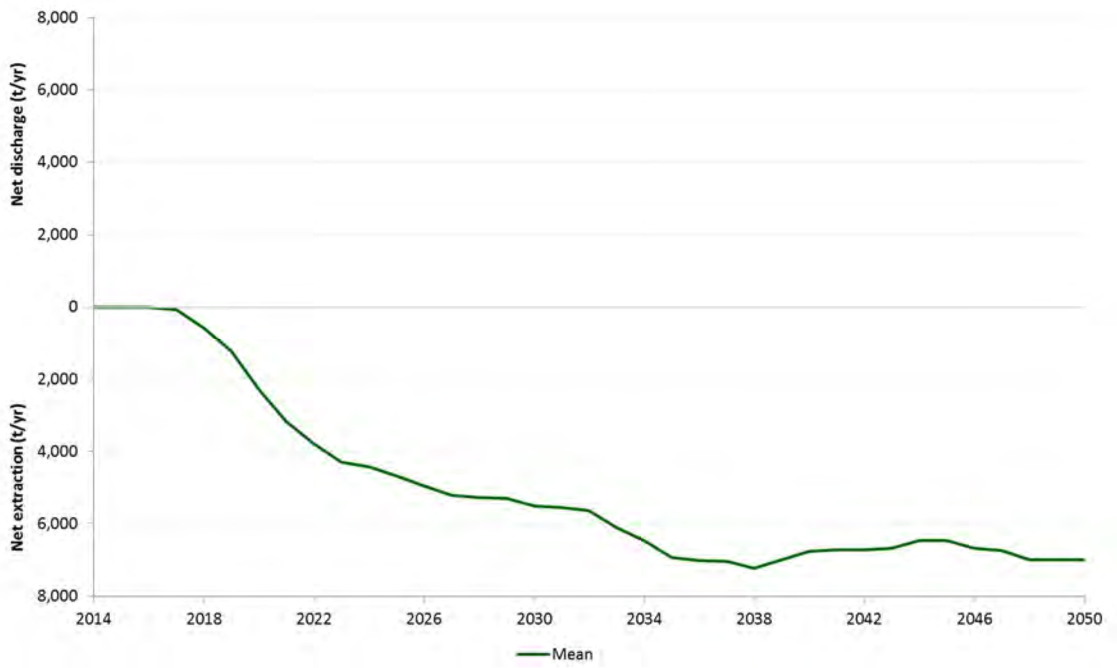


Figure H-55 Wallarah 2 Coal Project – Net Extraction/Discharge Salt Mass

West Wallsend Colliery

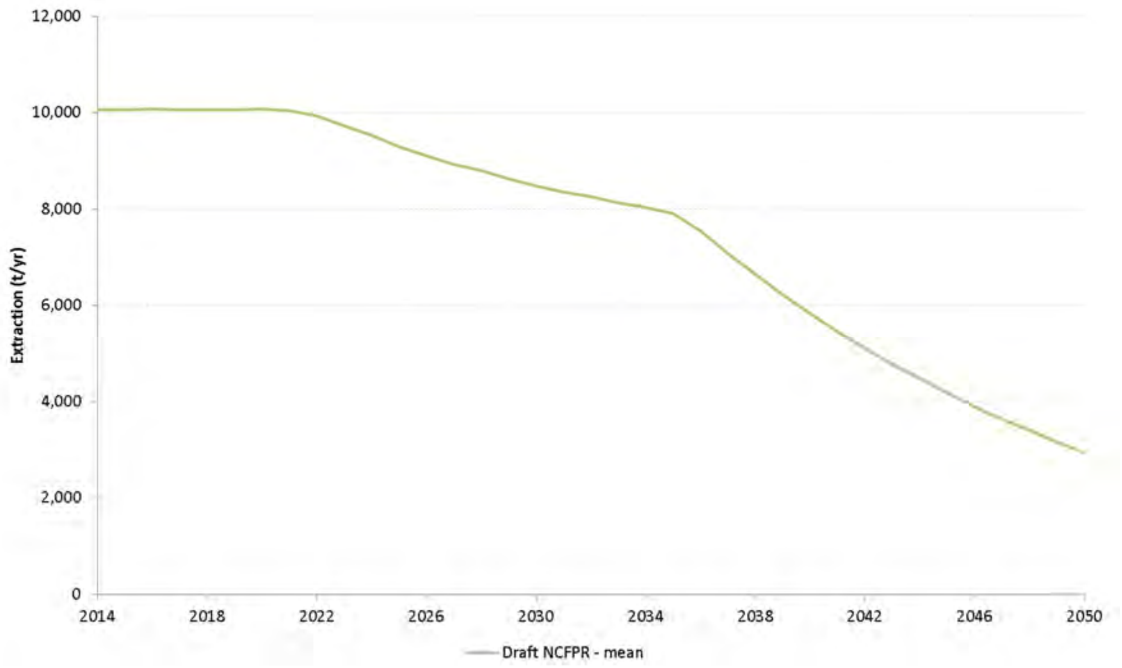


Figure H-56 West Wallsend Colliery – Groundwater Extraction Salt Mass

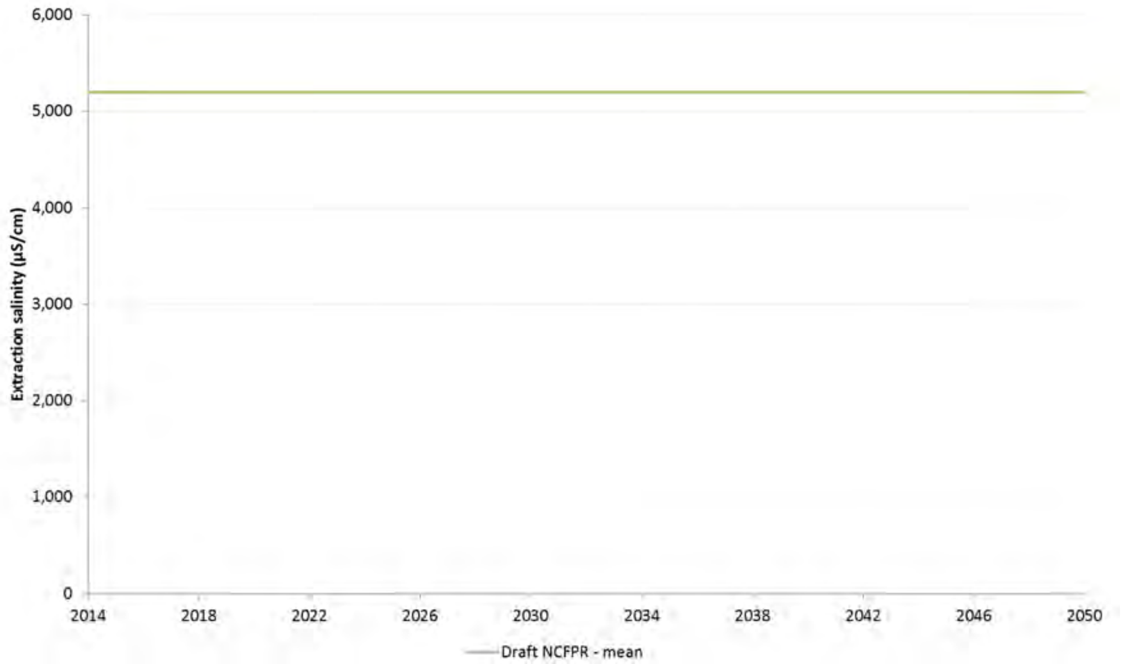


Figure H-57 West Wallsend Colliery – Groundwater Extraction Salinity

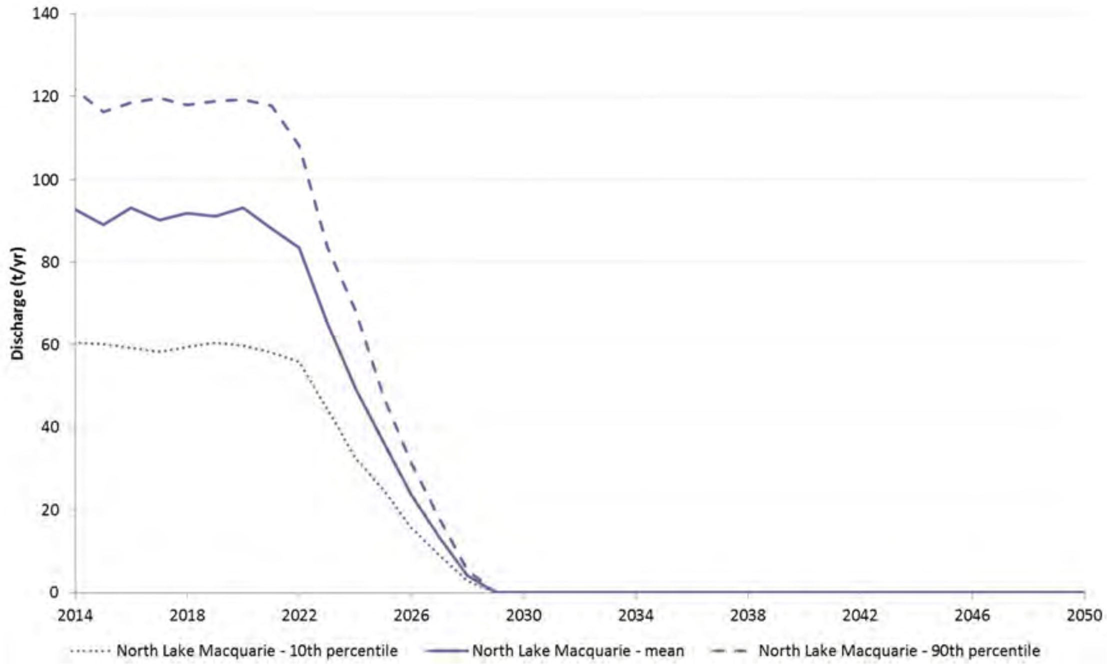


Figure H-58 West Wallsend Colliery – Surface Water Discharge Salt Mass

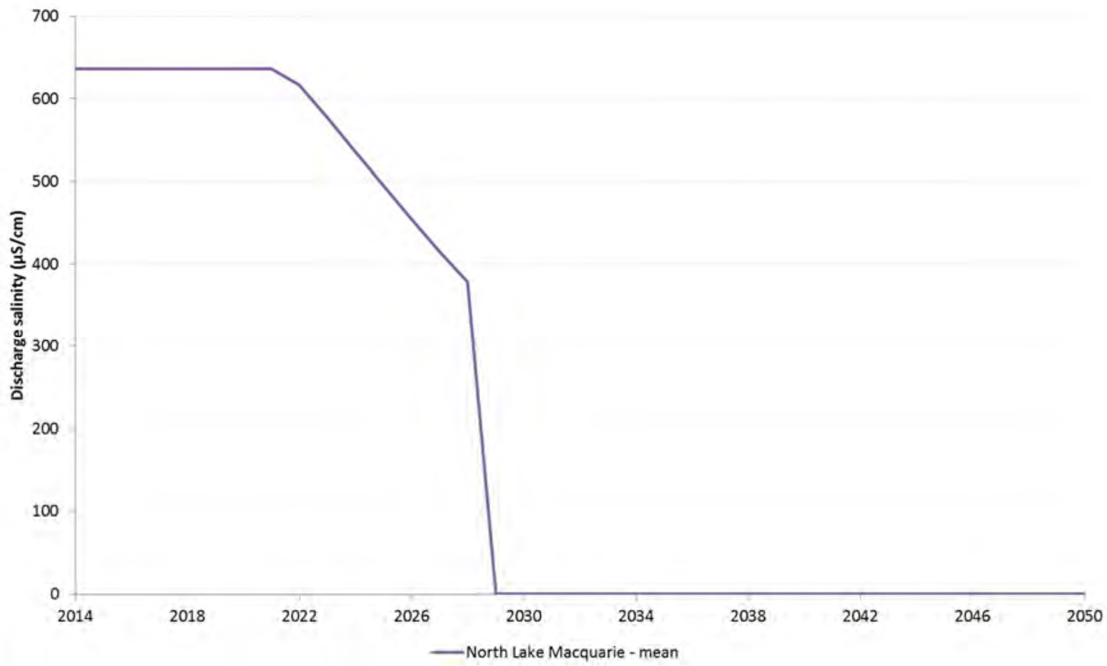


Figure H-59 West Wallsend Colliery – Surface Water Discharge Salinity

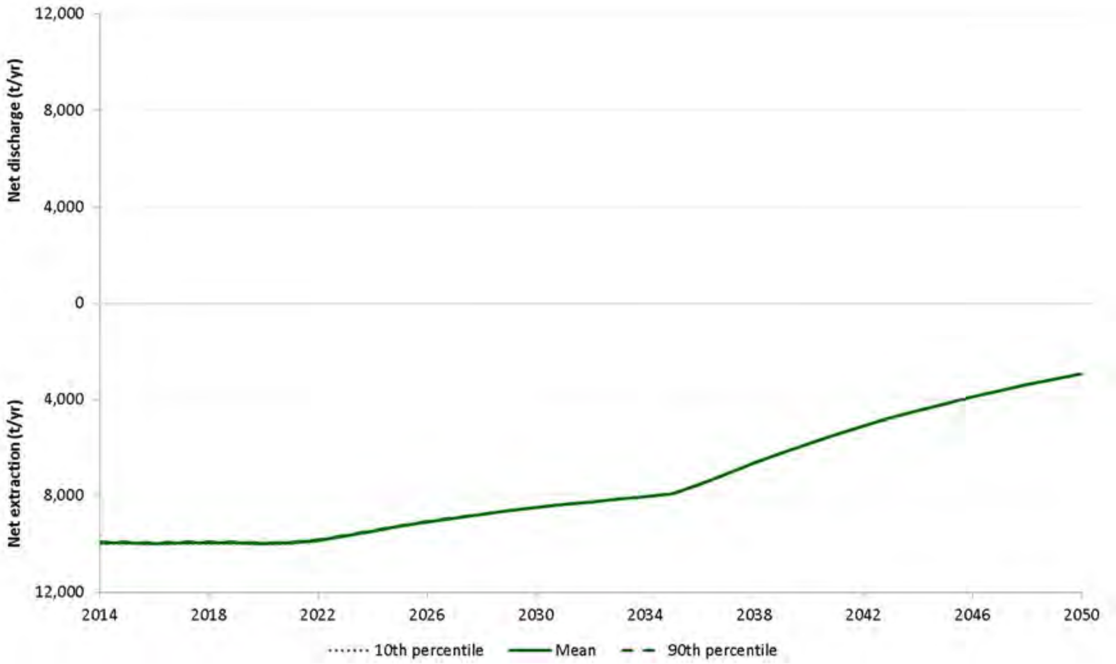


Figure H-60 West Wallsend Colliery – Net Extraction/Discharge Salt Mass

Westside Mine

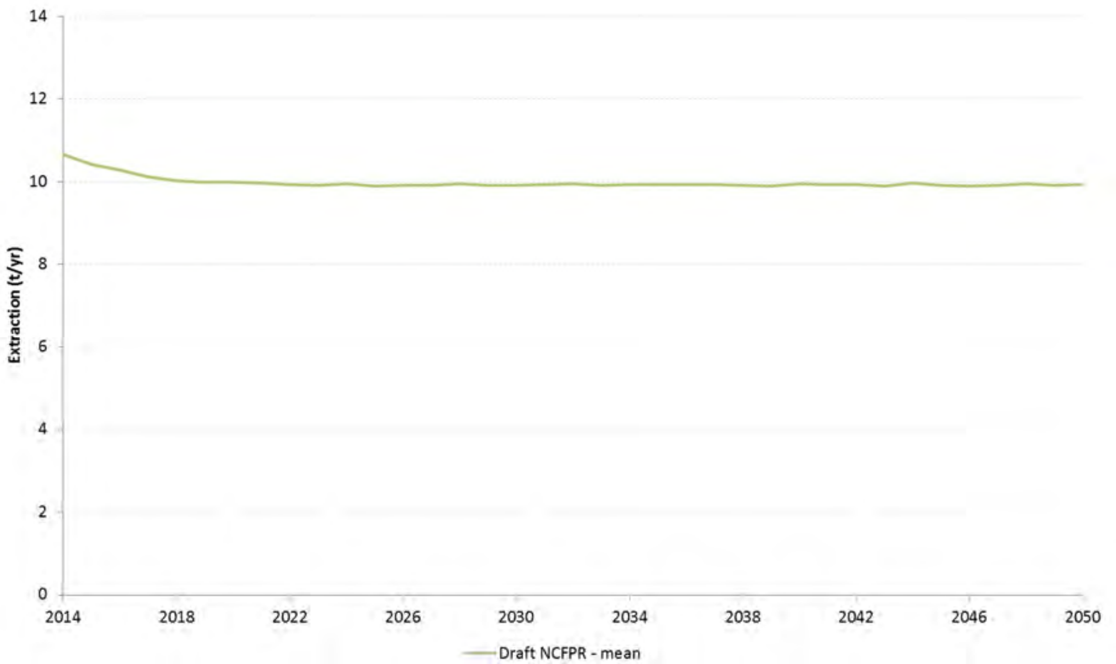


Figure H-61 Westside Mine – Groundwater Extraction Salt Mass

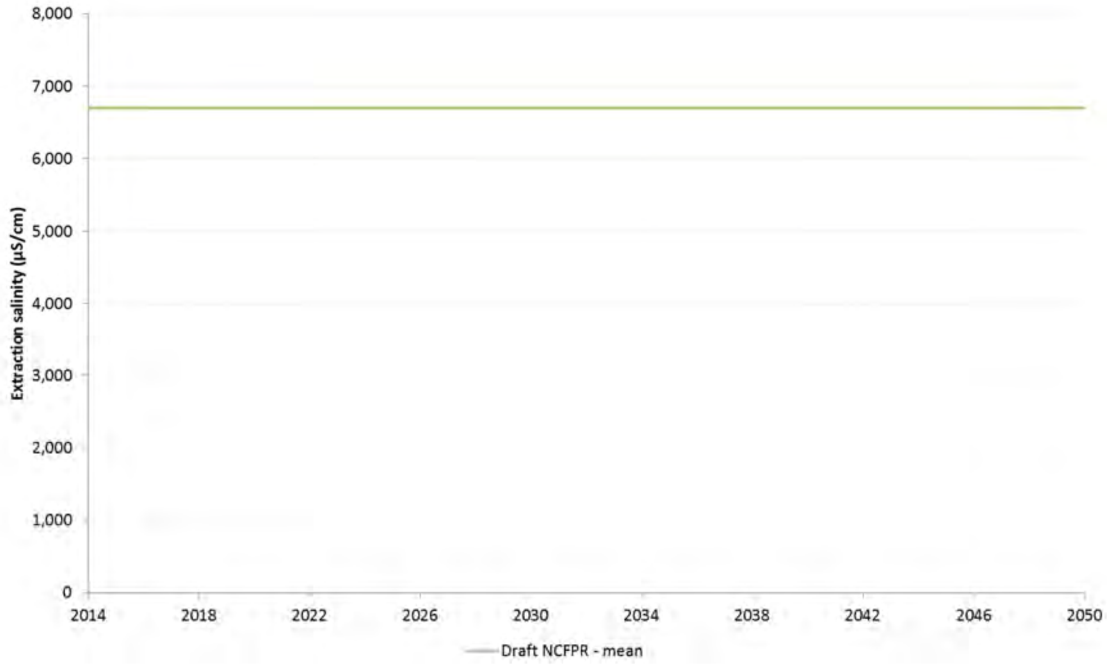


Figure H-62 Westside Mine – Groundwater Extraction Salinity

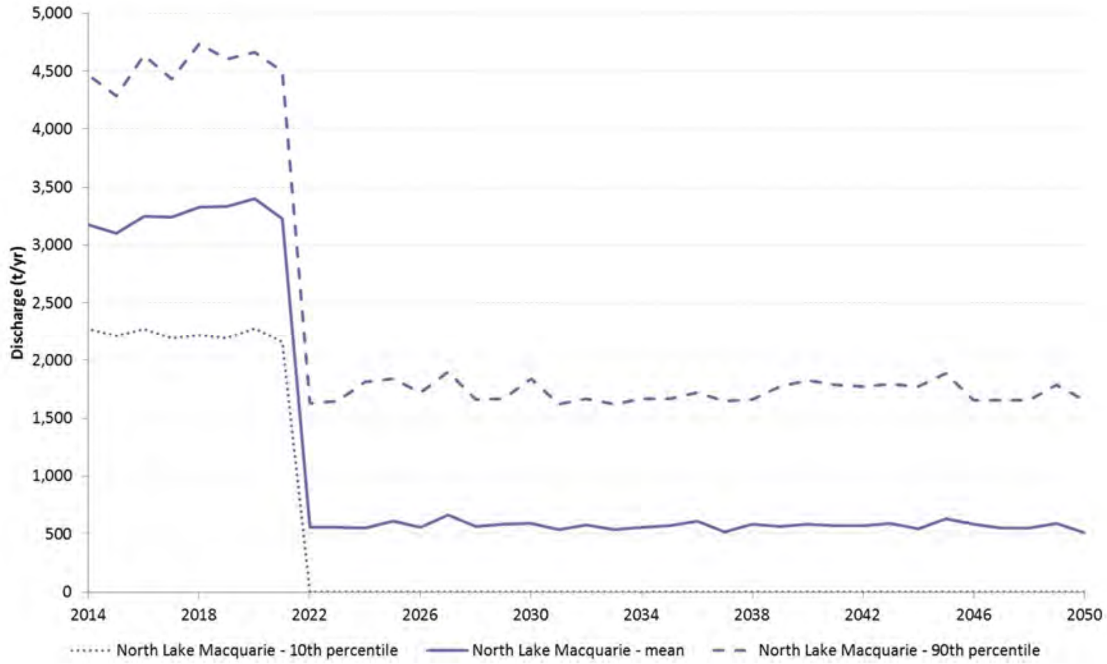


Figure H-63 Westside Mine – Surface Water Discharge Salt Mass

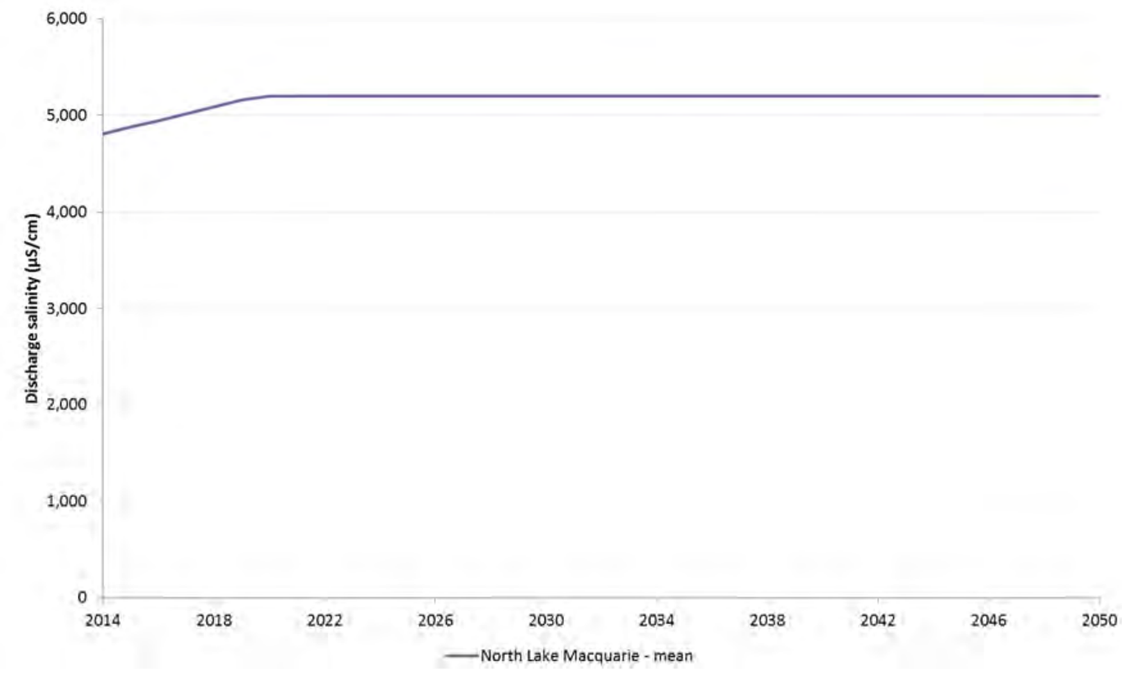


Figure H-64 Westside Mine – Surface Water Discharge Salinity

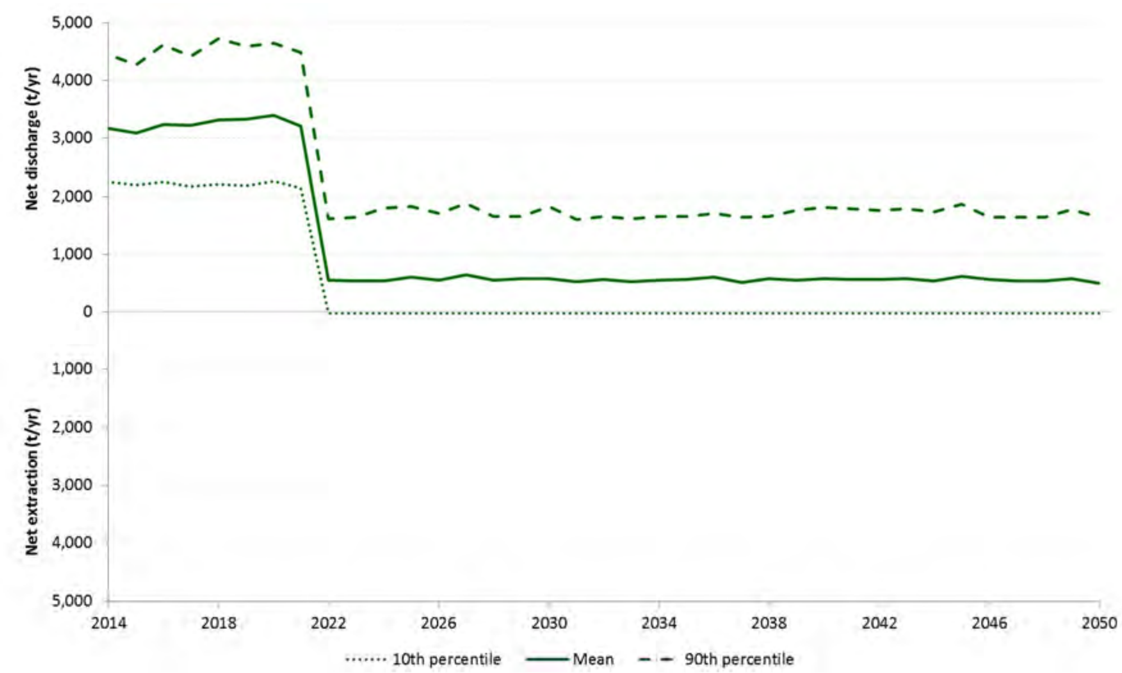


Figure H-65 Westside Mine – Net Extraction/Discharge Salt Mass

GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999   F: (02) 4979 9988   E: ntlmail@ghd.com.au

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		Name	Signature	Name	Signature	Date
0	T Davies	S Gray	[signature]	S Gray	[signature]	25/03/13

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Appendix C – Water Management Options Assessment

C.1 Introduction

C.1.1 Background

For the existing sites of Newstan Colliery and Mandalong Mine, there are key water management challenges including the management of excess water, interaction of water with the local environment, maximising water reuse and providing a safe workplace. To address these challenges, water management across the Centennial Coal's northern operations in recent years has relied on the transfer of water to old underground mine workings for storage (goaf storage areas). Assessment of water levels in these underground water storages indicate that they are approaching capacity and therefore water management strategies across the region require revision.

Currently, the water management at each of the assessed operations operate largely independently of one another. Surface water and groundwater features are managed by each site's water management system, including the collection of runoff, water treatment, distribution for reuse, storage and discharge.

There are numerous underground storages formed by historical mine workings throughout Centennial Coal's northern operations and also operations external to Centennial Coal. Water from the surface is transferred to the underground storages following rain and water is drawn from the underground storages for reuse for site operations. Each of the underground storages is affected by different groundwater and infiltration processes. Some storages are affected by relatively large constant groundwater inflows and minimal direct infiltration due to rain, whilst others experience low groundwater inflows and high infiltration rates following rainfall. Rising water levels in the underground storages are managed by the transfer of water to the surface and discharge through LDPs, the majority of which discharge into tributaries of Lake Macquarie.

The current water management system relies on the available capacity of the underground storages to store excess water. Investigations indicated as part of a recent project that if current management practices continue the underground storages will reach capacity in the near future.

C.1.2 Objectives and Scope

The assessment of options to manage excess water at nominated sites throughout Centennial Coal's northern operations has been undertaken in parallel with the preparation of EISs for:

- Newstan Extension of Mining Project.
- Mandalong Southern Extension Project.
- Northern Coal Logistics Project.

The objective of the assessment was to identify preferred water management options that address both current water management issues as well as future requirements. Of the sites included in the northern operations, Newstan Colliery and Mandalong Mine were included in the assessment. Revised future assessments may include the incorporation of Myuna Colliery.

The assessment identified and evaluated management options for surface and underground storages at individual sites. With an integrated mine water management system, the maximisation of water recirculation and reuse and the minimisation of the need for environmental discharges could be achieved across the sites.

C.2 Identification of Options

The following items were highlighted by Centennial as feasible options to be assessed and potentially progressed into a phase of detailed design and assessment. This assessment was conducted with the purpose of developing one integrated option. These options are further discussed below.

C.2.1 Option 1 – Discharge at Newstan LDP001

EPL 395 conditions limit the discharge through Newstan LDP001 to 11 ML/day. Most scenarios will consider the discharge at Newstan LDP001 to be limited to 11 ML/day. However, some scenarios will assess the need for discharges greater than 11 ML/day where other transfer options from Newstan Colliery Surface Site are limited.

As of 2014, the Clean Water Plant, at the Newstan Colliery Surface Site, is expected to treat all water transferred from the Fassifern Underground Storage to Newstan LDP001. In the assessed scenarios where the maximum transfer from the Fassifern Underground Storage to Newstan LDP001 is 14.5 ML/day, the Clean Water Plant is proposed to treat up to 14.5 ML/day with 3 ML/day to be reused on the site. When the maximum transfer rate from the Fassifern Underground Storage to Newstan LDP001 is greater than 14.5 ML/day, the Clean Water Plant is assumed to treat to the capacity of the transfer.

C.2.2 Option 2 – West Borehole Seam to Fassifern Underground Storage

A transfer from the current mining area at the West Borehole Seam to the Fassifern Underground Storage was investigated. This transfer investigated the possibility of transferring water to the Fassifern Underground Storage and subsequent discharge through Newstan LDP001.

C.2.3 Option 3 – West Borehole Seam to Awaba Colliery

An aboveground transfer pipeline with a capacity of 4 ML/day has historically been in operation between Newstan Colliery and Awaba Colliery. The pipeline has historically transfered groundwater from the West Borehole Seam to the Awaba Underground Storage.

If required by the scenario that was investigated, the maximum transfer rate could be increased to mitigate discharge requirements to Stony Creek via the Newstan LDP017.

For all scenarios assessed, the transfer from the West Borehole Seam to Awaba Colliery was not considered any further.

C.2.4 Option 4 – Discharge to Eraring Ash Dam

Currently, water is transferred from the Awaba Underground Storage to the Eraring Ash Dam at a rate of 0.4 ML/day and Centennial currently has approval to discharge up to 1.2 ML/day. The options to maintain the current transfer rate as well as the option to increase the transfer rate to achieve the water management objectives were both incorporated into the assessment.

C.2.5 Option 5 – Discharge at Awaba LDP003 and LDP004

Awaba LDP003 and LDP004 are approved under Awaba Colliery's EPL 443 to discharge up to 2 ML/day each from the Awaba Underground Storage. The bores discharge into the catchments of Stony Creek and Lords Creek respectively which drain into Lake Macquarie. Currently the bores are not operating though Awaba LDP004 however these have the option of being recommissioned as part of the approval of the Newstan Extension of Mining Project (under development).

All scenarios have assumed that the combined maximum discharge through Awaba LDP003 and LDP004 from January 2013 is 4 ML/day, the current approved EPL limit.

C.2.6 Option 6 – Hawkmount Quarry

The disposal of coarse rejects at the Hawkmount Quarry is proposed as part of the Project. As a result, Northern Coal Services will be implementing a water management system at Hawkmount Quarry which includes the discharge of water collected in the Sediment Dam to an unnamed tributary of Lords Creek via a proposed LDP. This transfer of water was assessed in all scenarios as this is considered the most appropriate method of water management at the quarry.

C.2.7 Option 7 – Awaba Colliery to Cooranbong Entry Site

A transfer pipeline from the Awaba Underground Storage to the transfer tanks at Cooranbong Entry Site was considered as part of an integration option. The pipeline was assumed to extract water from the 301 Panel Bore located in the south western extent of the Awaba Underground Storage and transfer water to aboveground tanks at Cooranbong Entry Site. The tanks would then supply water to the underground for mining activities and dispose of the remaining water to the Cooranbong Underground Storage.

The Awaba Colliery to Cooranbong Entry Site transfer option was investigated, with a maximum pumping rate of 20 ML/day investigated. This option was deemed unsuitable due to the limited capacity of water in the Awaba Colliery underground workings and uncertainty in water quality. Therefore, an upper limit transfer rate equal to 4 ML/day was determined appropriate to prevent exceeding the capacity of the Awaba Underground Storage.

C.2.8 Option 8 – Discharge at Cooranbong LDP001

Although the current average daily discharge through Cooranbong LDP001 is 1.6 ML/day, under the current EPL 365 for Mandalong Mine the approved discharge is limited to 5 ML/day. As increasing the discharge at this location requires relatively less approvals requirements, an option of discharging 25 ML/day at Cooranbong LDP001 was considered. A discharge volume of 8 ML/day was determined appropriate as part of the Mandalong Southern Extension Project and has been included as part of its proposed water management.

C.2.9 Option 9 – Discharge at Mandalong Mine

Investigations have been undertaken to create additional surface water discharge locations within the operations of Mandalong Mine. The options provided by Northern Coal Services included:

- Discharge into Dora Creek – This option proposes to utilise underground water staging areas to store the water transported from the workings of the Cooranbong Underground Storage before discharging via a borehole into Dora Creek.
- Discharge into Eraring Energy's new discharge water diversion dam – Underground water would be transferred from the Cooranbong Entry Site to Eraring Energy's facilities via a 3.5 km pipeline.
- Discharge into Lake Macquarie north of Dora Creek – Underground water would be transferred from Cooranbong Entry Site to a discharge location on Lake Macquarie. The pipeline would follow either power line and rail easements to the discharge location or an existing watercourse.
- Discharge into Lake Macquarie from the Delta Entry Site – Underground water would be extracted at the Delta Entry Site and piped to Lake Macquarie following existing watercourses.
- Discharge into Vales Point Power Station Ash Dam – Underground water would be extracted at the Delta Entry Site and Vales Point Power Station Ash Dam along the existing conveyor easement.

The consideration of licences, approvals, cost and negotiations with respective stakeholders was not accounted for in assessing the above options. Therefore, this one option considered all the above points as sub-components as one discharge option.

C.3 Assessment of Options

Assessment of options was undertaken primarily through the development of a regional water balance model including all sites. This model was calibrated where possible against existing data and used to predict water transfer and discharge volumes for each water management options identified.

C.3.1 Water Management Objectives

Newstan Colliery, Awaba Colliery and Mandalong Mine each have site-specific criteria to be met in order to satisfy various licence and operational conditions. If these criteria are not achieved by the water management systems, the operation of the sites is put at risk.

The following water management objectives were formulated to mitigate the risk to mining operations:

- Maintenance of the water level in Fassifern Underground Storagebelow 16.6 m below ground level (spill level as advised by Northern Coal Services) once the maintenance level was achieved for all modelled runs.
- Maintenance of the West Borehole Seam at Newstan Colliery in dry conditions for all modelled runs.
- Maintenance of the water level in Cooranbong Underground Storage below -50 m AHD (spill level) for all modelled runs.

C.3.2 General Challenges

A recent assessment of water levels in the Fasssifern Underground Storage and Cooranbong Underground Storage indicate that water in these storages may achieve capacity within six months to three years if they continue to be managed under existing systems and strategies, which has been supported from site observations during 2014. Traditionally, more water has been deposited into the underground storages than the volume that is withdrawn due to licensing requirements and surface constraints.

The underground storages at Newstan are directly influenced by rainfall where as Cooranbong Entry Site does not experience much in the way of surface infiltration. Surface cracks and sinkholes above the underground storages provide ingress routes for rainfall to enter the storages and thereby raise water levels in the storages. Due to the large surface catchment areas of the underground storages, rainfall can have a dramatic impact on underground storage levels over both short-term event based rainfall and long-term wet cycles. Water management systems need to consider these influxes in order to develop a system that can effectively manage water levels such that overflows from underground storages are minimised and discharges only occur under controlled conditions.

The criteria placed on surface water discharges from existing site water management systems are becoming increasingly stringent, thereby limiting the possible volumes able to be discharged from sites. In obtaining new or upgraded EPLs from the EPA, a focus is placed on reducing salt and metal loads into coastal creeks and limiting volumetric discharges. Salinity concentrations of groundwater inflows to underground storages and mining areas range from slightly brackish to saline and water quality limits restrict the load that is able to be discharged via LDPs.

C.3.3 Stakeholder Engagement

Stakeholder engagement during the development of the options was a fundamental step of determining the most likely option for the Projects water management. Stakeholders included:

- EPA.
- NOW.
- Centennial Awaba.
- Centennial Mandalong.
- Centennial Newstan.
- Northern Coal Services.

Consultation amongst all Centennial parties was undertaken in the form of a number of technical workshops were the results of the water balance were discussed and deliberated. The outcomes of the workshops provided the direction for the assessment to take. The direction for each site was based upon the following factors:

- Requirements for environmental and planning licensing and approvals.
- Appropriate timeframes for options compared with expansion projects.
- Reliance of third party arrangements and agreements.
- Further requirements for supporting technical studies.

These components of the decisions made on the options by the Centennial team are further discussed in the sections below.

C.3.4 Environmental and Planning Licensing and Approvals

In order for the successful implementation of a number of the options discussed in Section C.2, environmental and planning licensing and approvals would be required. This would have involved the use of such projects including reviews of environmental effects.

The approval process would also be required to address land ownership constraints. The wider regional area under consideration as part of the integration of water management options assessment has a number of various industries, commercial and residential developments and pipeline options would require significant negotiations.

C.3.5 Time Frames of Integration Options

The assessment of options has to also consider an understanding of lead time and time for assessments to be completed in order to satisfy environmental and planning approvals. The drivers for integrating water management across the sites have always been due to the proposed consequences of projects long-term.

The following section discusses the aspects of both short- and long-term integration options and how the issues were addressed and resolved.

Short Term

The primary concern in the short-term of water management is the filling the Fassifern Underground Storage and Cooranbong Underground Storage. These issues are primarily related to their rainfall influenced underground workings, poor underground water quality and constraints present at the surface.

Fassifern Underground Storage

The Fassifern Underground Storage is an underground storage area in the Great Northern and Fassifern seams which was formed from previous mining activities. Water is transferred from the surface storages to the Fassifern Underground Storage and this water is drawn from, during dry periods, to supply the CPP. The storage also receives inflows as a result of infiltration from the surface catchment and groundwater inflows from the West Borehole Seam, Great Northern and Fassifern Seams. Water levels in the storage are managed by discharging water into the north arm of LT Creek via Newstan LDP001.

As the water level in the storage rises above the spill level, the storage discharges through two 600 mm diameter pipes via Newstan LDP017 into Stony Creek. Fractures above the Great Northern Seam connect the underground storage to the surface enabling water to infiltrate from the surface catchment to the Fassifern Underground Storage. Site investigations also indicate the Fassifern Underground Storage is connected to the TSFs via fractures in the overlying strata causing seepage to occur from the TSFs.

The capacity of the Fassifern Underground Storage is linked to the discharge location of Newstan LDP017, the Stony Creek pipeline. When the storage capacity reaches the spill level, discharges through Newstan LDP017 are minimised by pumping water to Newstan LDP001. This discharge has been identified as an environmental risk and to mitigate the risk the management of the underground storage needs to be kept to a much lower level. As indicated in Figure C–1, the storage exceeded capacity between the period of February 2012 and July 2012.

When the Fassifern Underground Storage has reached capacity its purpose as a point of dewatering the current area of mining, the West Borehole Seam, is compromised through operational and safety risks.

Figure C–1 Recent Water Volume within Fassifern Underground Storage

<u>Cooranbong Underground Storage</u>

Underground water levels in the Cooranbong Underground Storage have been monitored by Centennial Mandalong since December 2011. The measured water levels (corrected to mAHD) between December 2011 and June 2012 are shown in Figure C–3. Over this period the underground water level rose by approximately 4 m, which represents an increase in storage of approximately 280 ML. This estimate of storage is based on a void height of 3 m and void ratio of 0.4.

The inputs into the Cooranbong Underground Storage consist of:

- Groundwater seepage from the coal seam and adjacent strata.
- Supply of potable water to mining equipment (approximately 1 ML/day).
- Transfer of surface water from Sediment Dams 1 and 2 (estimated to be 40 ML/year).

- Transfers from the active workings.

The output from the Cooranbong Underground Storage is the extraction of underground water via a dewatering bore and transfer to the surface at Cooranbong Entry Site (currently approximately 1.6 ML/day).

Based on known inputs and outputs and the measured increase in underground water level between December 2011 and June 2012, the average groundwater seepage over this period is estimated to be approximately 1.9 ML/day.

The approximately spill level for the storage has been identified from underground seam floor information to be -50 m AHD as indicated in Figure C–3.

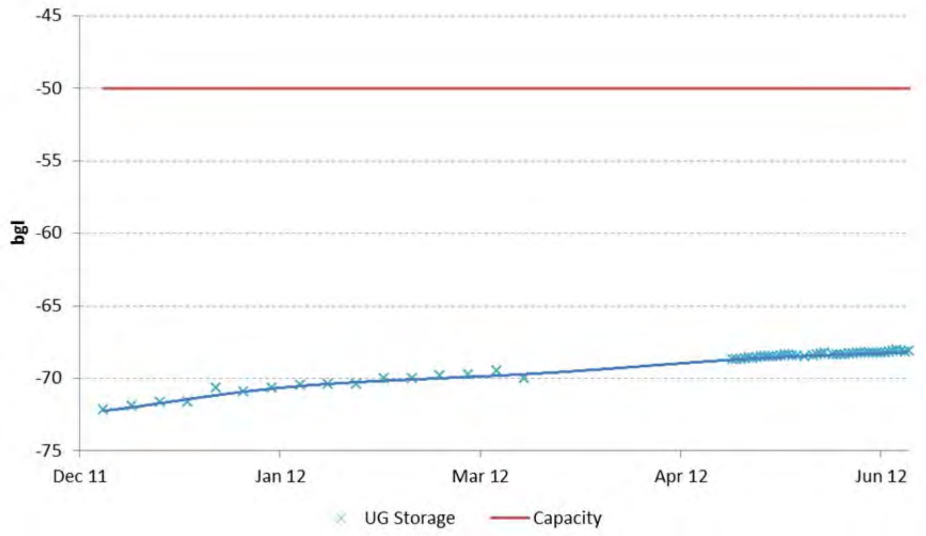


Figure C–3 Recent water levels within the Cooranbong Underground Storage

Though the spill level of -50 m AHD is determined approximately from seam floor contour information the actual confirmed spill level of the storage is unconfirmed. In the event of a spill the water would spill to the south back towards the active Mandalong Mine workings and essentially pose an operational safety concern.

Long Term

Disposal options for excess water have been considered during the undertaking of all northern operation Projects though many revolve around third party arrangements. Therefore Centennial is still in consultation with the relevant stakeholders regarding long-term water management options and solutions.

Generally this water management options assessment determined that a long-term option needs to be implemented by approximately 2025. A key long-term strategy was identified to distribute excess water to local demands that may include stakeholders such as:

- Hunter Water Corporation.
- Eraring Energy.
- Lake Macquarie City Council and Wyong Shire Council.

To assist in the distribution of excess water the identification of treatment options was required in addition to the function provided by the Clean Water Plant, which has been constructed and is in operation as of 2014, at the Newstan Colliery Surface Site. Underground water can be of variable quality and this uncertainty requires the need for a number of treatment options. For example, some uncertainty regarding water quality under varying rainfall conditions exists for the underground workings of Newstan Colliery, Awaba Colliery and Mandalong Mine.

Connection pipelines, transfer pumps and balancing tank arrangements would be required to get any transfer system operational to the wider Lake Macquarie water supply network. This is dependent upon regulation such as the *Water Industry Competition Act 2006,* to assist in the facilitation of a long-term strategy to supply water for reuse. Internally within Centennial's current sites such an integrated reuse supply system would be a more achievable goal where controls and environmental and planning approvals could be managed more effectively.

Centennial Newstan currently has a supply arrangement with Eraring Energy through transfers from the Awaba 10 South Bore. During the project it was established that this agreement had the potential to increase to between 4 ML/day and 10 ML/day.

Eraring Energy had in the meantime established a reuse arrangement for cooling water with another supplier which has put any potential increase of discharges to the Ash Dam in question. This led to the certainty regarding any water supply arrangements had moving into the future. The result of the internal discussions was to remove any dependencies on third party arrangements as the risk of them not working in the future was a risk not worth having. The risk was identified not only in the certainty of third parties, but also the potential effect third parties could have on the project time frames.

Within all of the Centennial's northern operations, surface sites are very dependent upon potable water supply. The progression to move surface sites to a more sustainable water reuse strategy has not eventuated in the past and this is primarily due to problems with water quality. The egress of groundwater into the underground workings is highly saline and with the addition of total suspended solids, water reuse within the mining infrastructure is very difficult.

Opportunities exist within many of the sites to reuse water through the underground storages present at each of the sites. Newstan Colliery will be taking advantage of their reuse opportunities as part of the process improvements around the site, and the installation of the new Clean Water Plant which will on average supply approximately 3 ML/day of treated water to the redeveloped and upgraded coal handling and preparation infrastructure proposed as part of the Northern Coal Logistics Project.

The new Mandalong South Surface Site, proposed as part of the Mandalong Southern Extension Project, was identified as an opportunity for being serviced by reused water stored in the Cooranbong Underground Storage or Awaba Underground Storage. The opportunity was identified due to Mandalong Mine's need for a non-potable, low security water supply. However, a reuse system was not deemed appropriate at this stage considering the ongoing uncertainty around water quality in the Awaba Underground Storage and the degree of treatment required for water sourced from Cooranbong Underground Storage. Despite this, when an integrated water management system can be achieved, the site has been configured so a reuse system can be retrofitted at the new proposed surface site. This flexibility was written into the water management of the site and is an example of what can be achieved at other Centennial sites with the right and suitable infrastructure.

C.3.6 Reliance on Third Party Agreements and Arrangements

The reliance of third party agreements and arrangements arose as a constraint when the long-term options were being developed. Long term options were being developed which identified stakeholders such as Hunter Water Corporation, Eraring Energy and surrounding local councils as a potential for disposal of water.

Certainty could not be placed on those parties identified for collaboration and hence other options were chosen for the Project though opportunities still exist with some stakeholders for involvement.

C.3.7 Further Technical Studies

Increased understanding of the aquatic ecology and ecotoxicology within the surrounding environments has been achieved in the assessments undertaken for Centennial's three northern operations.

Further technical studies are also required to investigate potential new LDPs, however these would be expected to be undertaken as part of the Projects detailed design phase. These new LDPs were largely discounted in this study due to limited data available and the timeframes involved in such studies which would extend beyond the timeframe of this Project.

C.4 Outcomes of Water Management Options Assessment

To assess and determine the appropriateness of proposed integration options to both the environment and operations, the Centennial project team members held a series of workshops and risk assessments. These workshops and risk assessments were specific to the appropriate management of surface and underground water as a result of the Project.

From the initial workshop held on 29 October 2012 the following outcomes were gained:

- The introduction of a number of integrated water management options between the Awaba Colliery, Mandalong Mine and Newstan Colliery.
- The development of a short- and long-term water management perspective. Long-term water volumes require an integrated water management option to be in place by 2025.
- Environmental and planning approvals have to be achieved prior to implementation of any options.
- Further options for assessment were proposed. These included:
  - Combining all site discharges into one pipe with a direct pipe outfall into Lake Macquarie.
  - Transfer of all site discharges to Myuna Colliery for discharge to Lake Macquarie.
  - Transfers to new underground storages within the future Newstan Colliery underground workings.
- Risk based assessment criteria needed to be confirmed.

A further workshop was held on 19 December 2012 at which the following outcomes were determined:

- Further results from integration options provided all with positive and negative aspects.
- Further studies into the integration options risks needed to be confirmed.
- Proposed water management requirements for each site independently.
- Any proposed increase in LDP discharge volumes are to be supported with adequate water quality data and assessment criteria and if required additional supporting environmental studies to identify potential impacts.
- Risk assessment to be undertaken on increased and new surface mine water discharges at Newstan Colliery Surface Site and Cooranbong Entry Site.

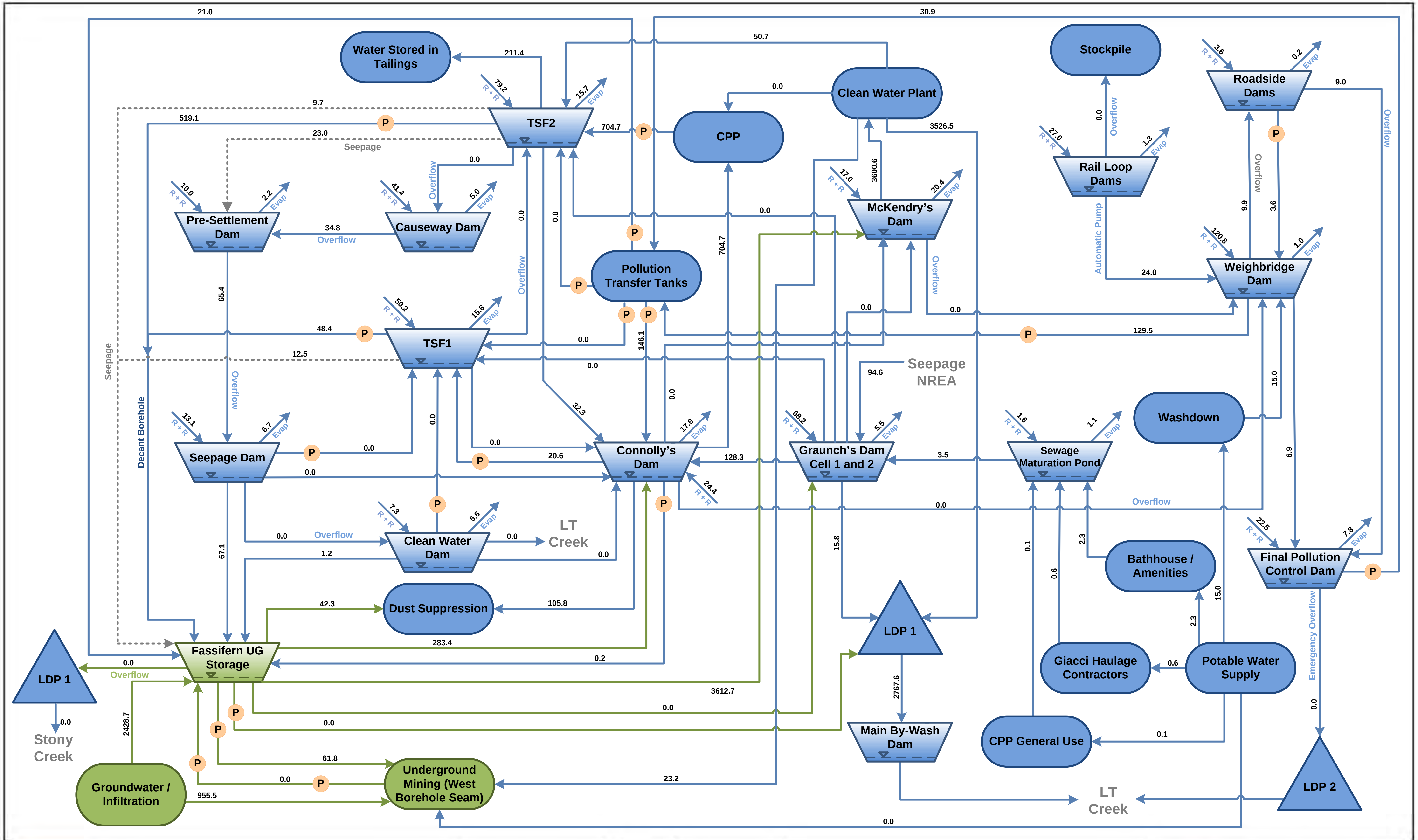
C.4.1 Preferred Option

A final Project risk assessment was undertaken on the 14 February 2013 at which the environmental and operational risks of a number of discharge options were worked through for the Newstan Extension of Mining Project, Mandalong Southern Extension Project and Northern Coal Logistics Project. These options were associated with the appropriate requirements to manage underground storages present at Newstan Colliery Surface Site and Cooranbong Entry Site.

As a result of the Newstan Extension of Mining Project, Newstan Colliery will require an increase from their current volumetric limit of 11 ML/day through LDP001 to approximately 14.5 ML/day to appropriately manage both operational and safety risks of the current and proposed workings in the West Borehole Seam and the potential environmental risks of discharges occurring to Newstan LDP017.

As a result of the Mandalong Southern Extension Project, Cooranbong LDP001 at the Cooranbong Entry Site will require an increase to current volumetric discharge limit from 5 ML/day to 8 ML/day. This has been proposed to manage the operational and safety risks of the current workings in Mandalong Mine.

Appendix D – Additional Water and Salt Balance Results



Surface Transfer
Underground Transfer
Seepage
Storages
P Pump
XX **Mean (ML/yr)**
Catchment Runoff and Direct Rainfall
Evaporation from Storage

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

10th Percentile Annual Water Transfers
Newstan Colliery Surface Site
Existing Conditions

Centennial Northern Coal Services

DATE April 2014 Figure D-1

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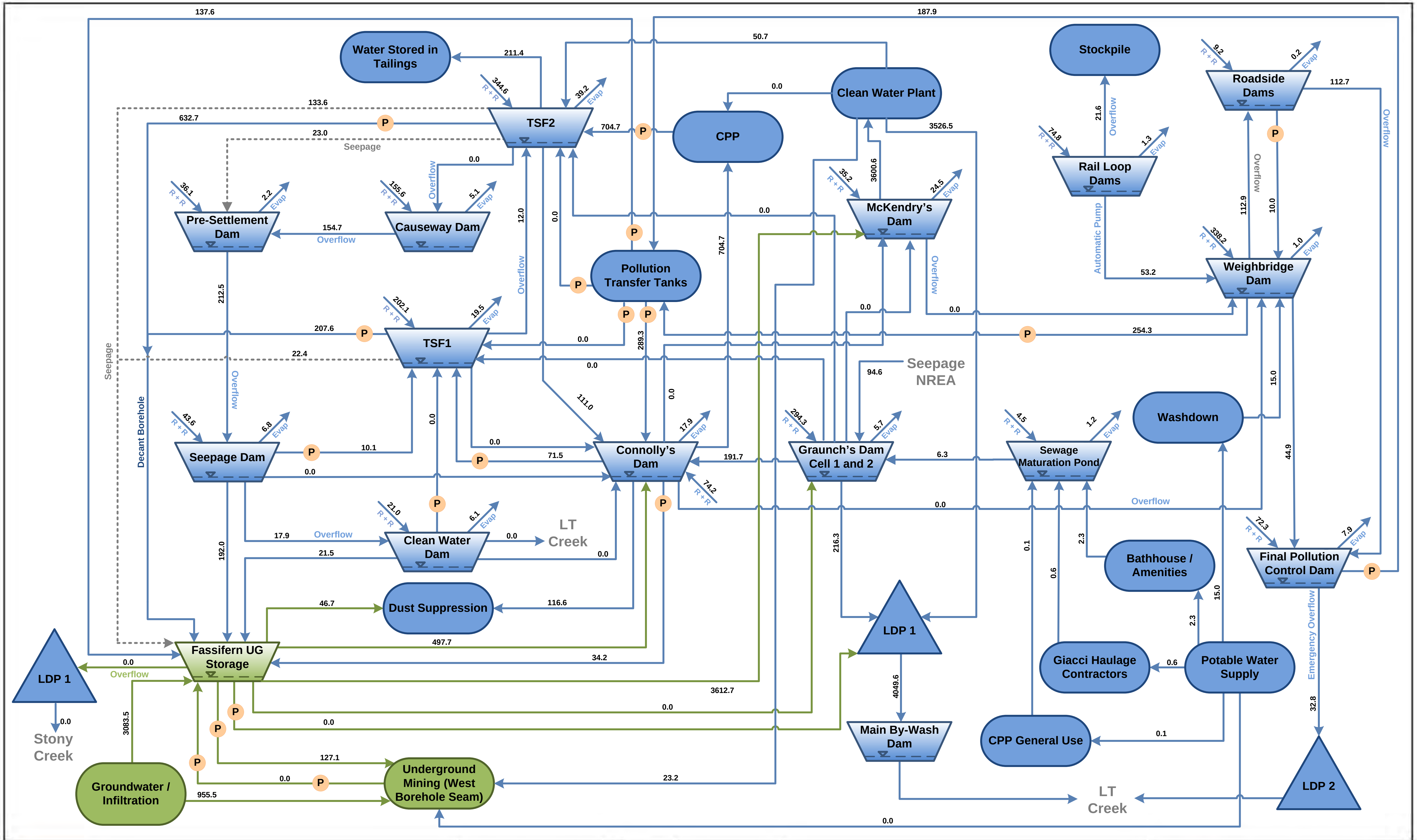


Surface Transfer | P Pump
Underground Transfer | XX **Mean (ML/yr)**
Seepage | Catchment Runoff and Direct Rainfall
Storages | Evaporation from Storage

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

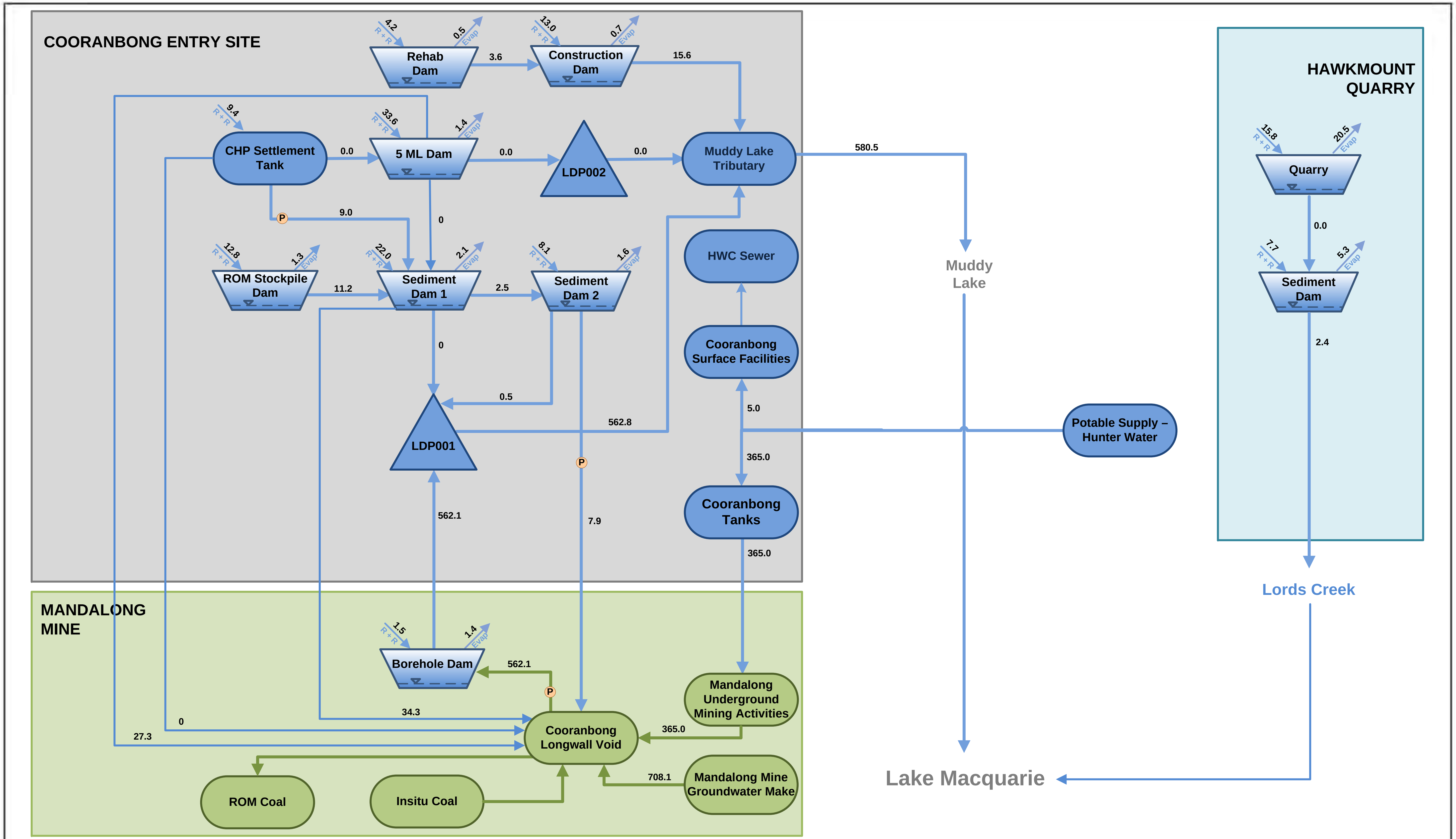
Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Water Transfers
Newstan Colliery Surface Site
Existing Conditions

Centennial Northern Coal Services

DATE April 2014 | Figure D-2

G:\22\16167\Visio\Coal Logistics\Appendix_10th_90th\Figure D-2_MeanAnnualWaterTransfer_Existing_NewstanSurfaceSite_90th.vsd



Surface Transfers
Underground Transfers
XX (ML/yr)
P Pumping Transfers
R+R Rainfall and Runoff
Storages

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SW
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

10th Percentile Annual Water Transfers
Cooranbong Entry Site and Hawkmount Quarry
Existing Conditions

Centennial Northern Coal Services

DATE April 2014

Figure D-3

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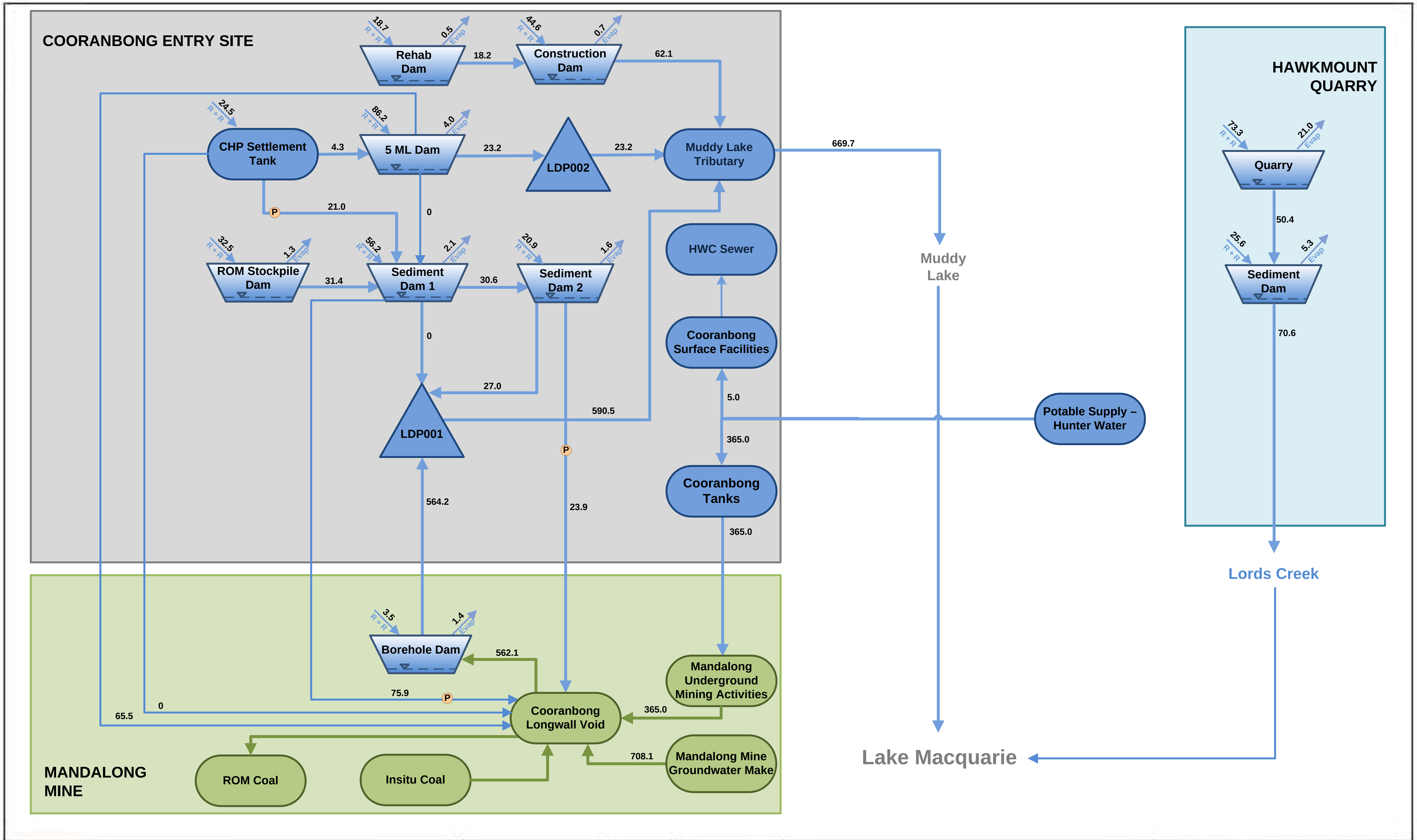

Surface Transfers			
Underground Transfers	XX	(ML/yr)	
P Pumping Transfers	R+R	Rainfall and Runoff	
Storages			

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SW
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Water Transfers
Cooranbong Entry Site and Hawkmount Quarry
Existing Conditions

Centennial Northern Coal Services

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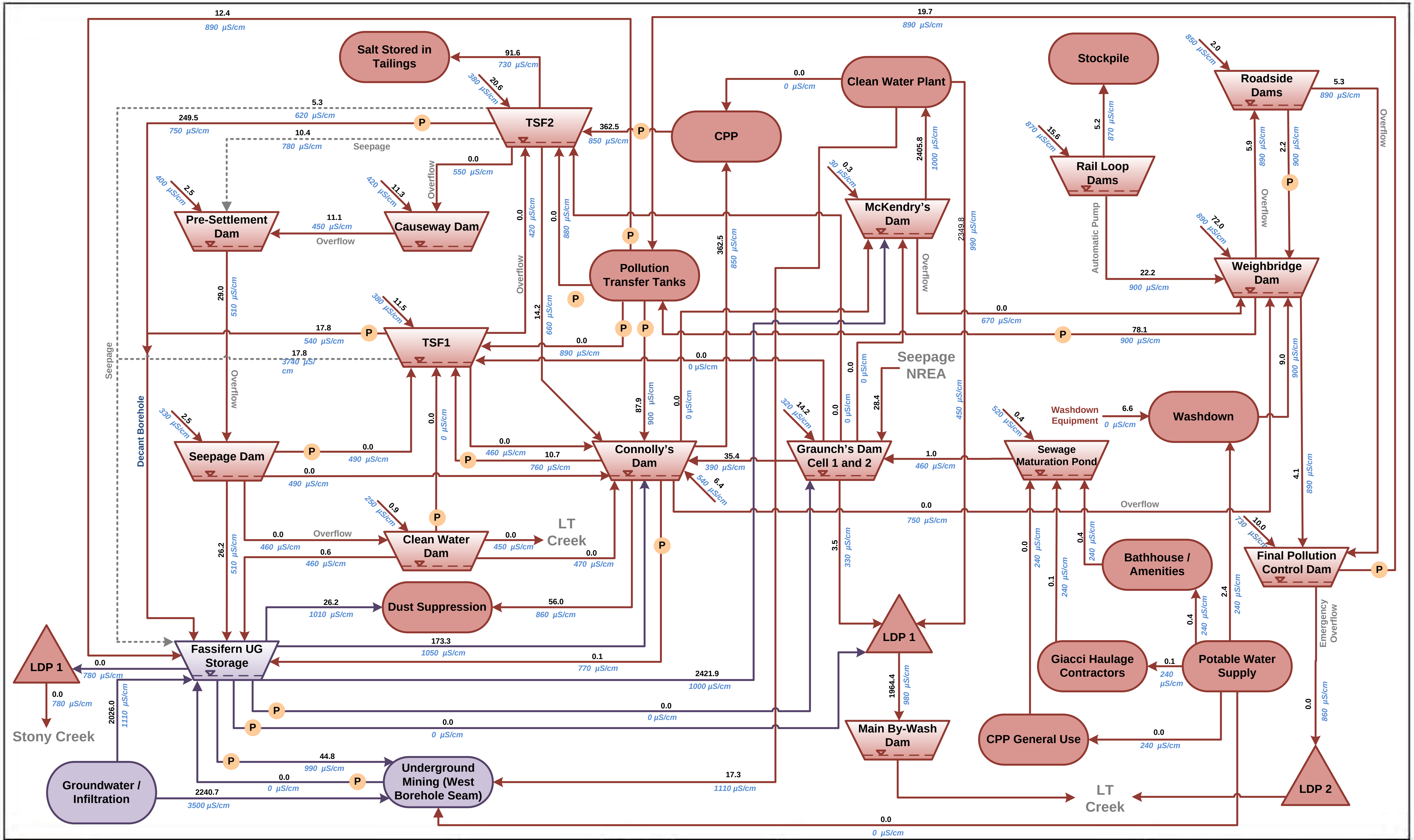

Surface Transfer	P Pump
Underground Transfer	XX **Mean (t/yr)**
Seepage	*XX* ***Mean Salinity***
Storages	Catchment Runoff and Direct Rainfall

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

10th Percentile Annual Salt Transfers
Newstan Colliery Surface Site
Existing Conditions

Centennial Northern Coal Services

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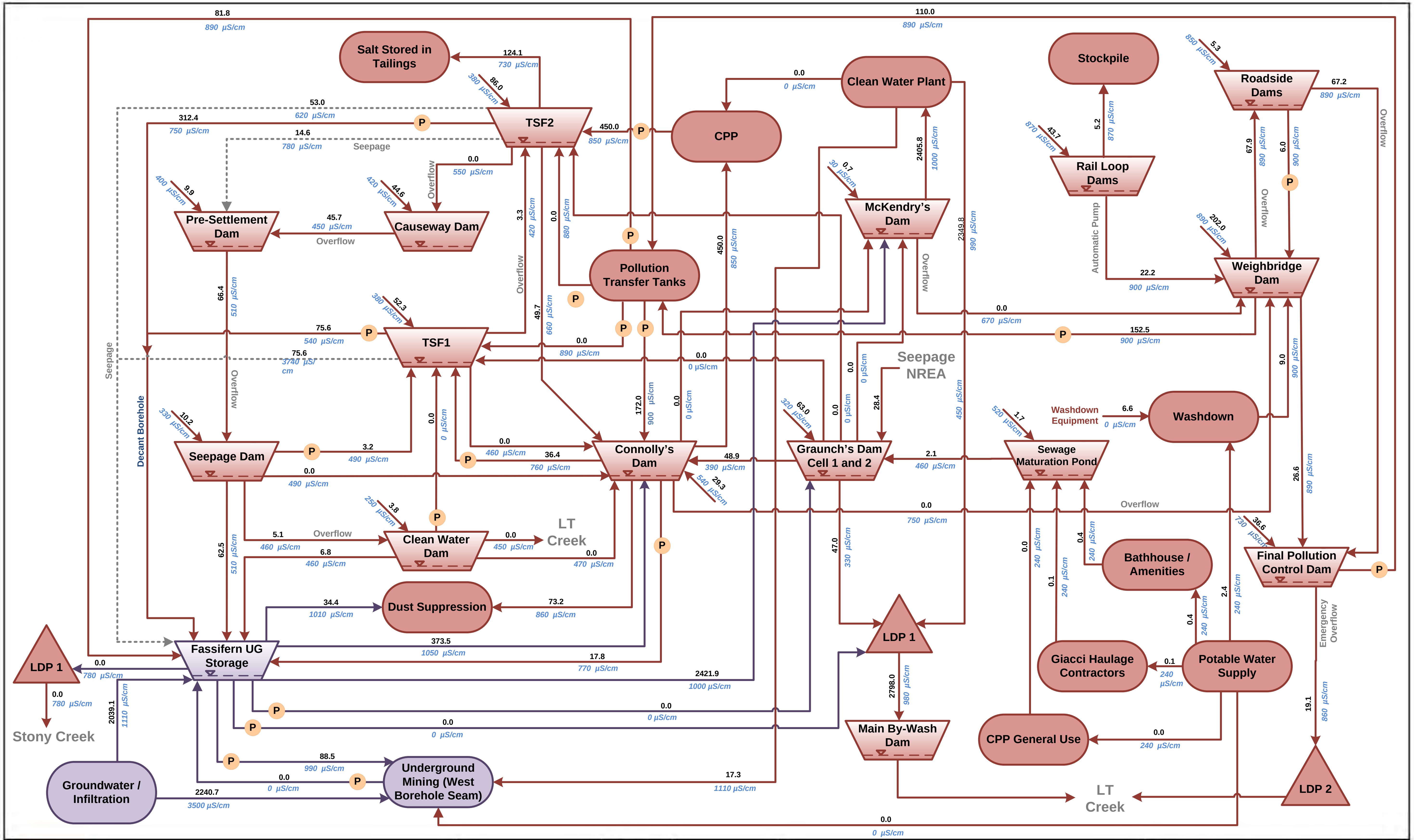

Surface Transfer
Underground Transfer
Seepage
Storages
P Pump
XX **Mean (t/yr)**
XX ***Mean Salinity***
Catchment Runoff and Direct Rainfall

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Salt Transfers
Newstan Colliery Surface Site
Existing Conditions

Centennial Northern Coal Services

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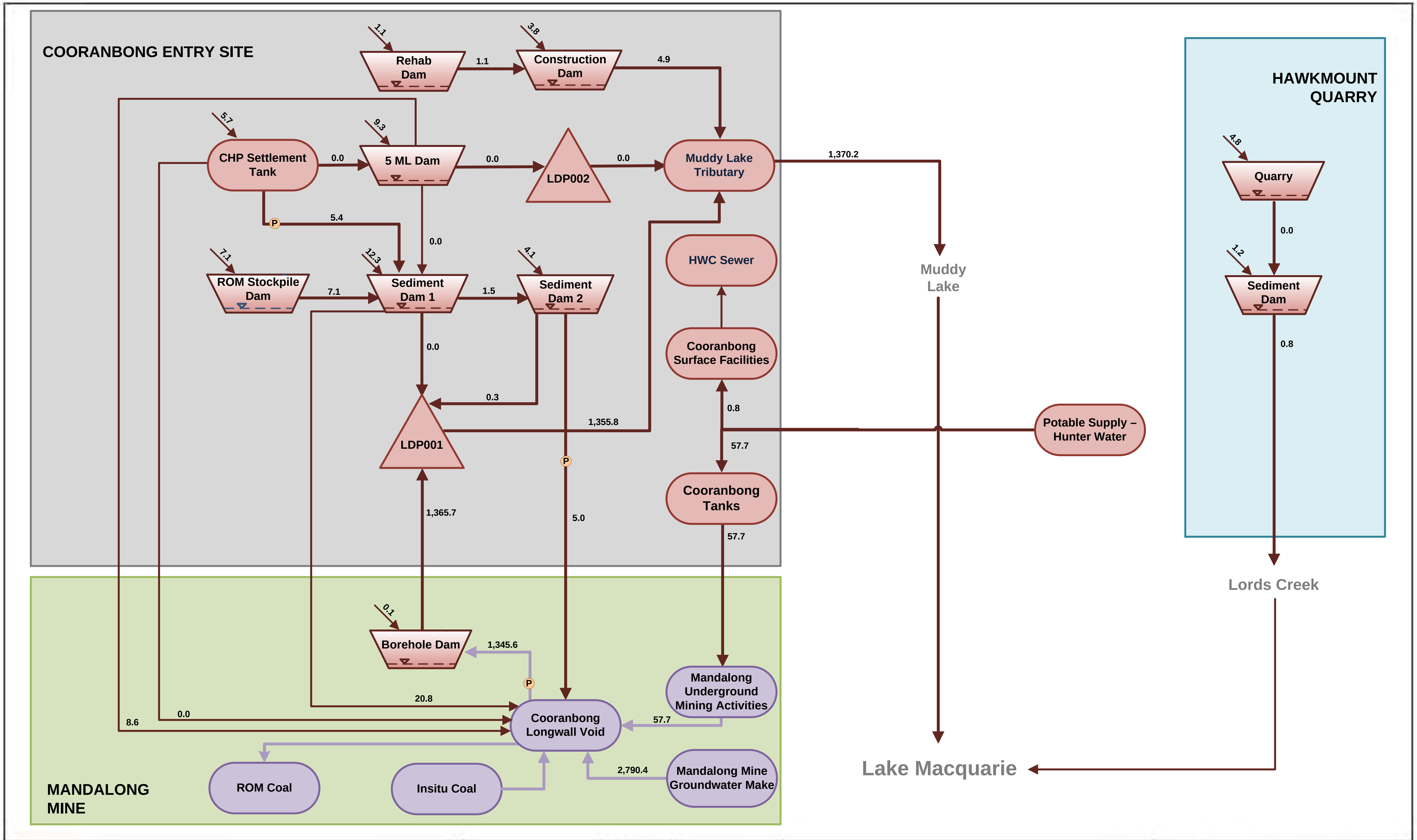

Surface Transfers
Underground Transfers
Pumping Transfers
Storages
XX Mean (t/yr)
Rainfall Runoff

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SC
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

10th Percentile Annual Salt Transfers
Cooranbong Entry Site and Hawkmount Quarry
Existing Conditions

Centennial Northern Coal Services

DATE April 2014

Figure D-7

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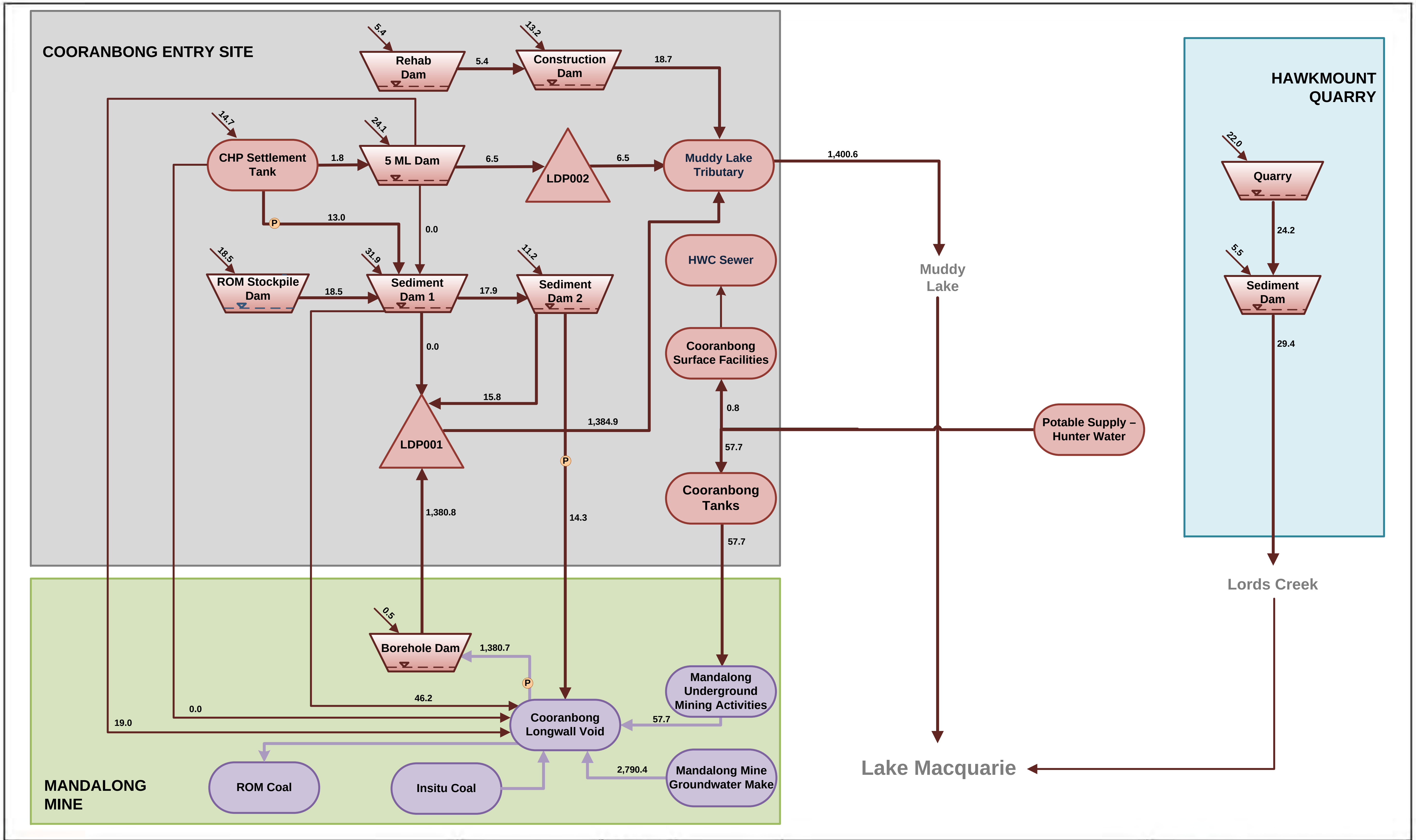

Surface Transfers

Underground Transfers — XX **Mean (t/yr)**

(P) Pumping Transfers

Storages — Rainfall Runoff

GHD

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SC
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Salt Transfers
Cooranbong Entry Site and Hawkmount Quarry
Existing Conditions

Centennial Northern Coal Services

DATE April 2014 — Figure D-8

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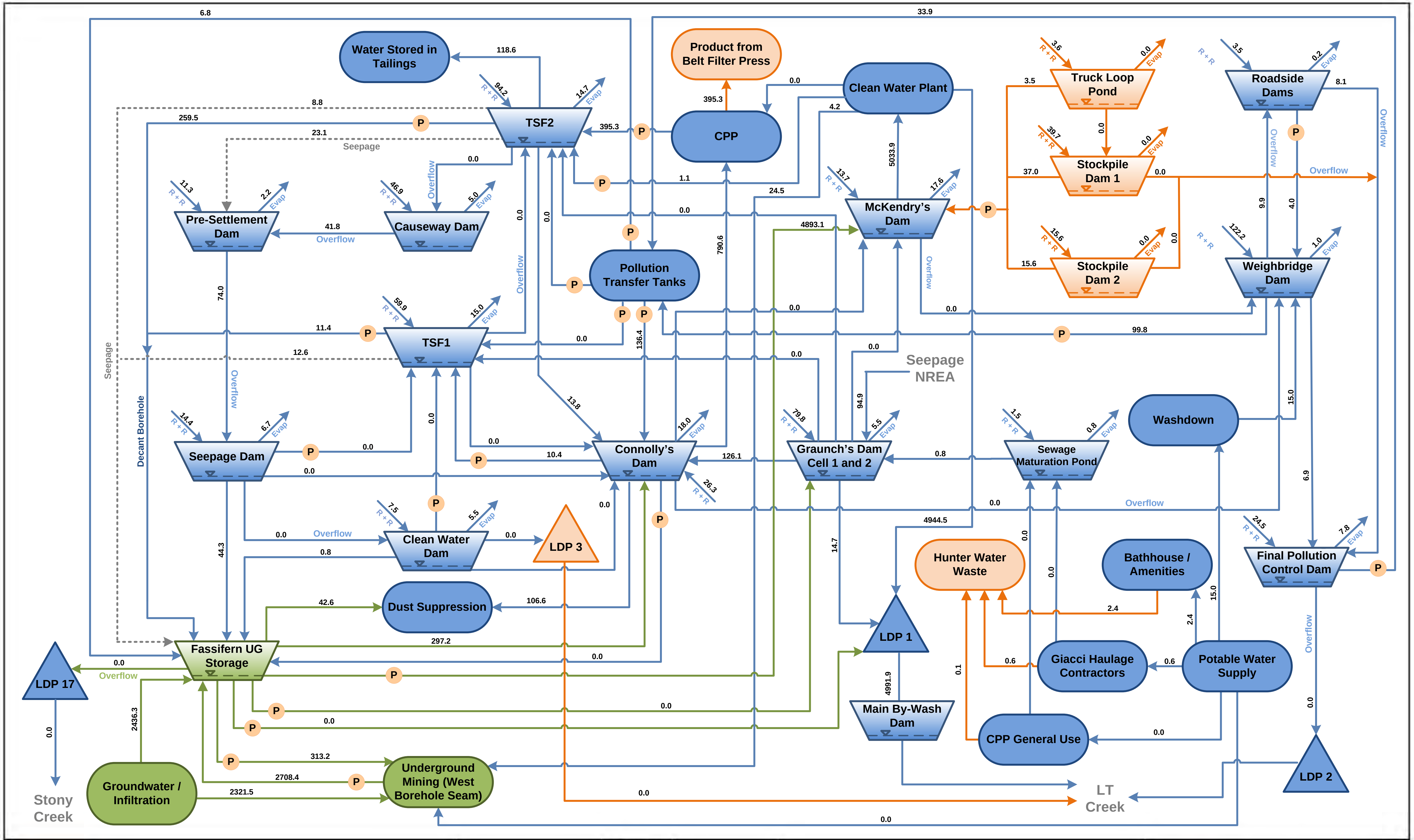

→	Surface Transfer
→	Underground Transfer
→	Proposed Transfer
- - →	Seepage
Storages	
XX	Mean (ML/yr)
R + R	Catchment Runoff and Direct Rainfall
Evap	Evaporation from Storage

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

10th Percentile Annual Water Transfers
Newstan Colliery Surface Site
Proposed Conditions

Centennial Northern Coal Services

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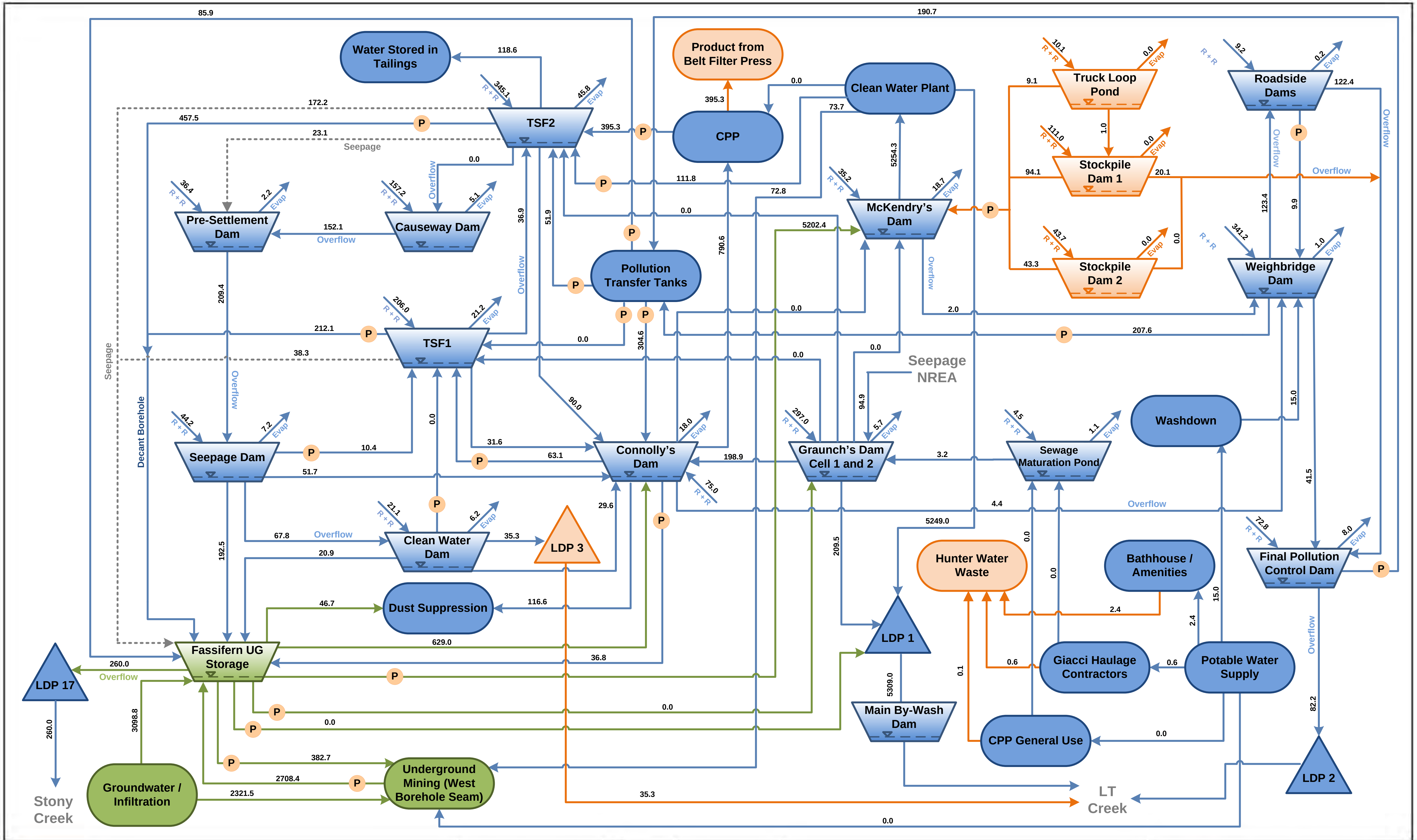

Surface Transfer	
Underground Transfer	
Proposed Transfer	
Seepage	

Storages

XX Mean (ML/yr)

R + R Catchment Runoff and Direct Rainfall

Evap Evaporation from Storage

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Water Transfers
Newstan Colliery Surface Site
Proposed Conditions

Centennial Northern Coal Services

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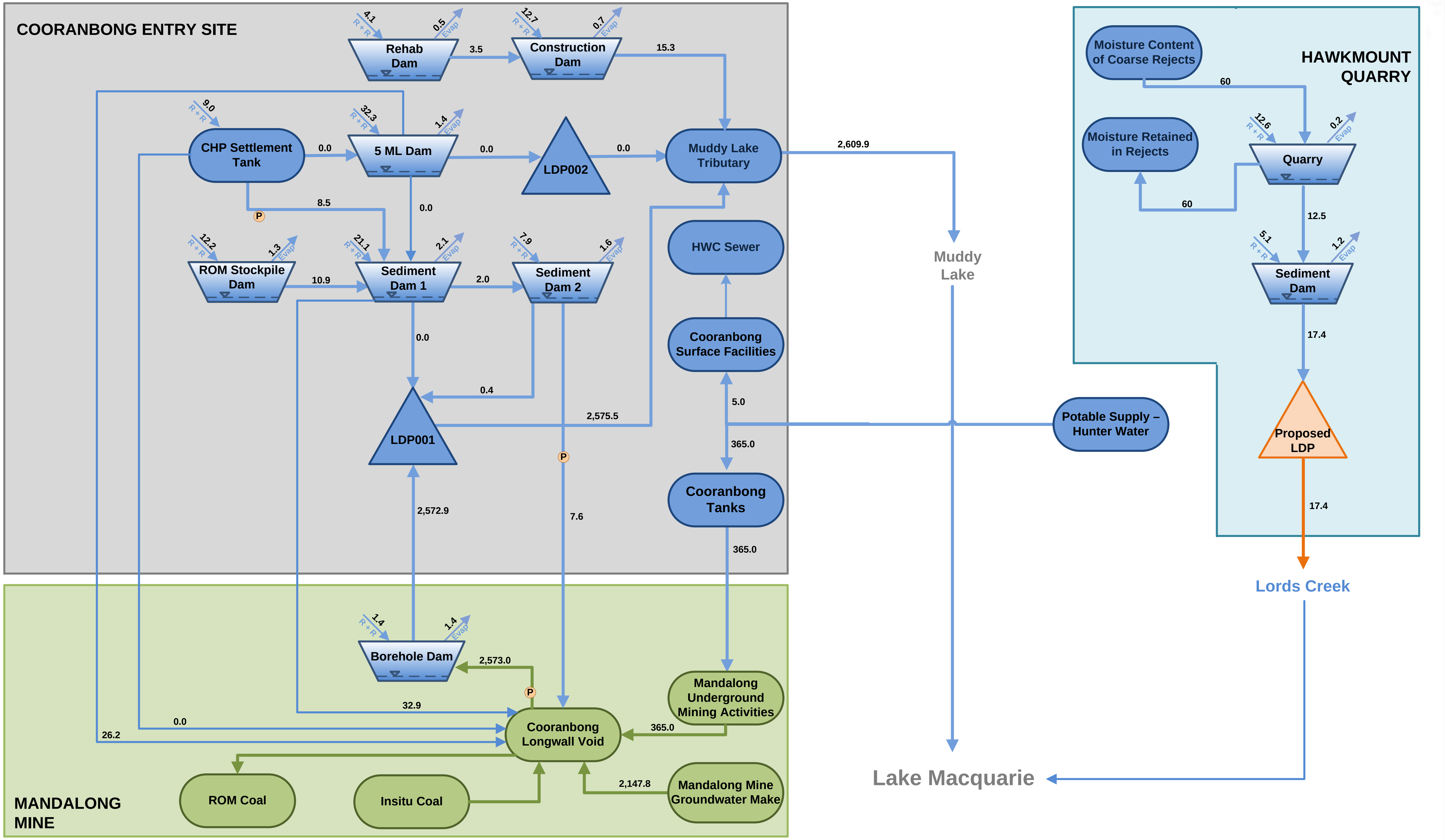

Surface Transfers
Underground Transfers
Proposed Transfers
Pumping Transfers
Storages

XX (ML/yr)

R+R Rainfall and Runoff

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SC
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

10th Percentile Annual Water Transfers
Cooranbong Entry Site and Hawkmount Quarry
Proposed Conditions

Centennial Northern Coal Services

DATE April 2014 Figure D-11

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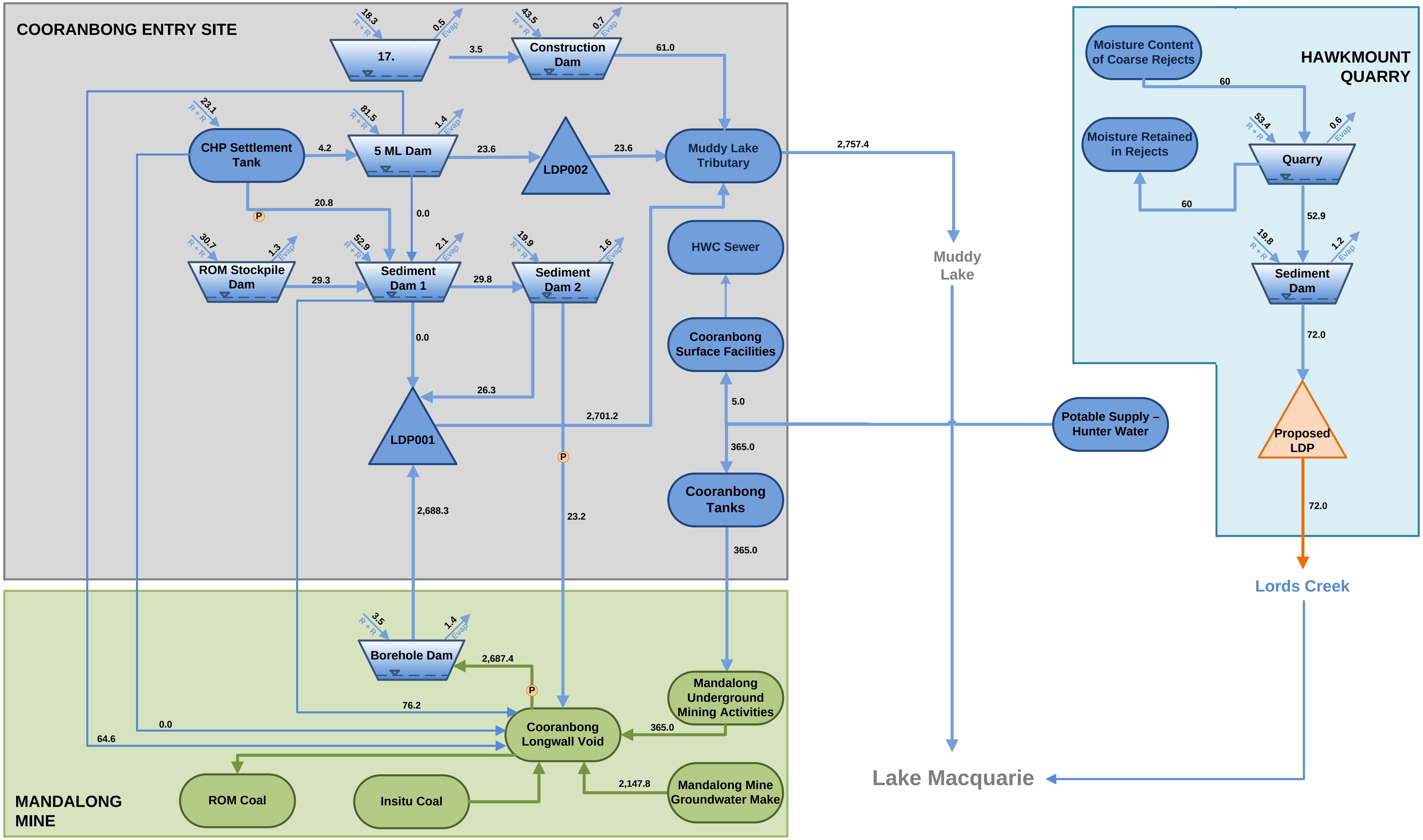

Surface Transfers	
Underground Transfers	XX (ML/yr)
Proposed Transfers	
P Pumping Transfers	R + R Rainfall and Runoff
Storages	

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SC
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Water Transfers
Cooranbong Entry Site and Hawkmount Quarry
Proposed Conditions

Centennial Northern Coal Services

DATE April 2014 | Figure D-12

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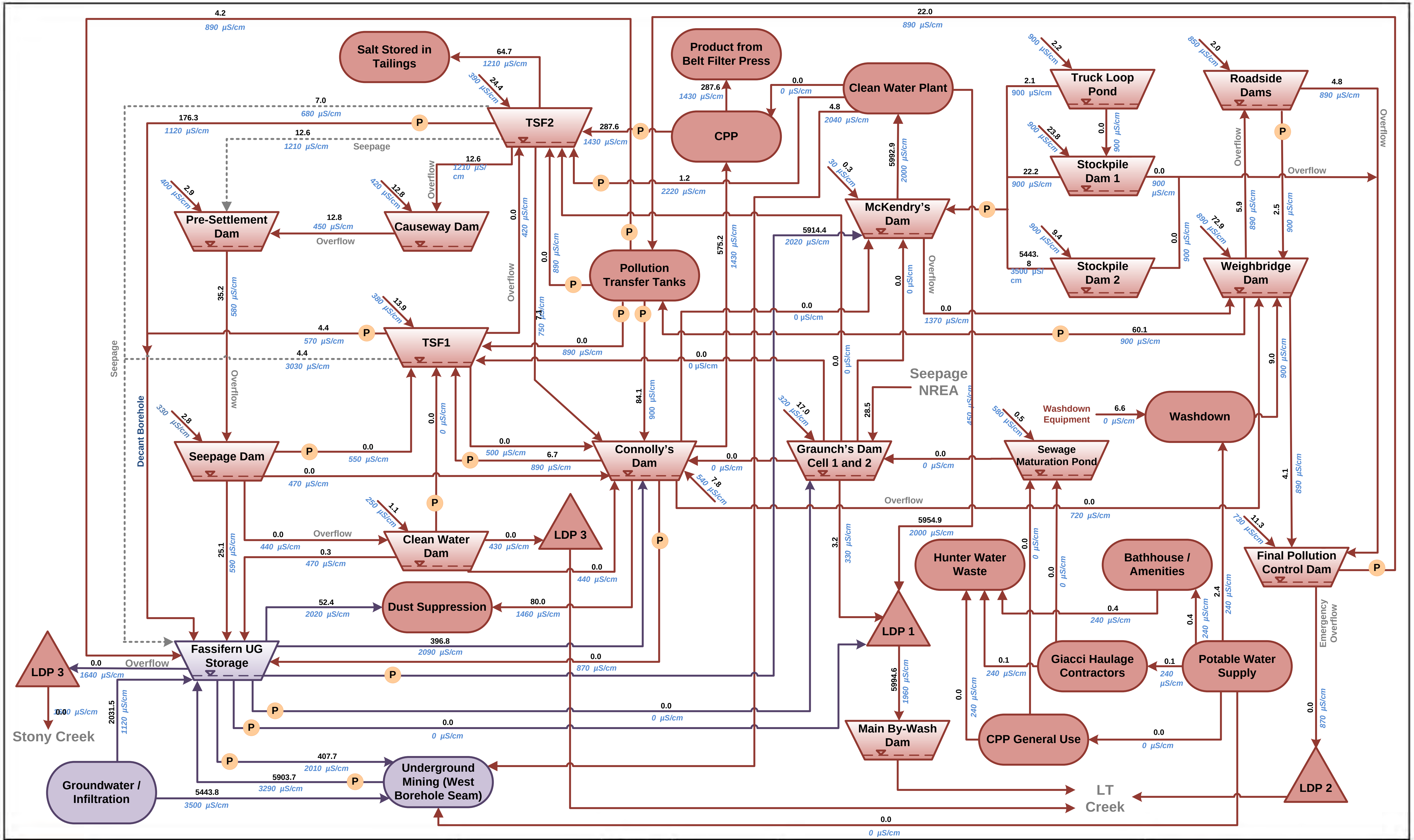


Surface Transfer
Underground Transfer
Seepage
Storages
P Pump
XX Mean (t/yr)
XX Mean Salinity
Catchment Runoff and Direct Rainfall

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

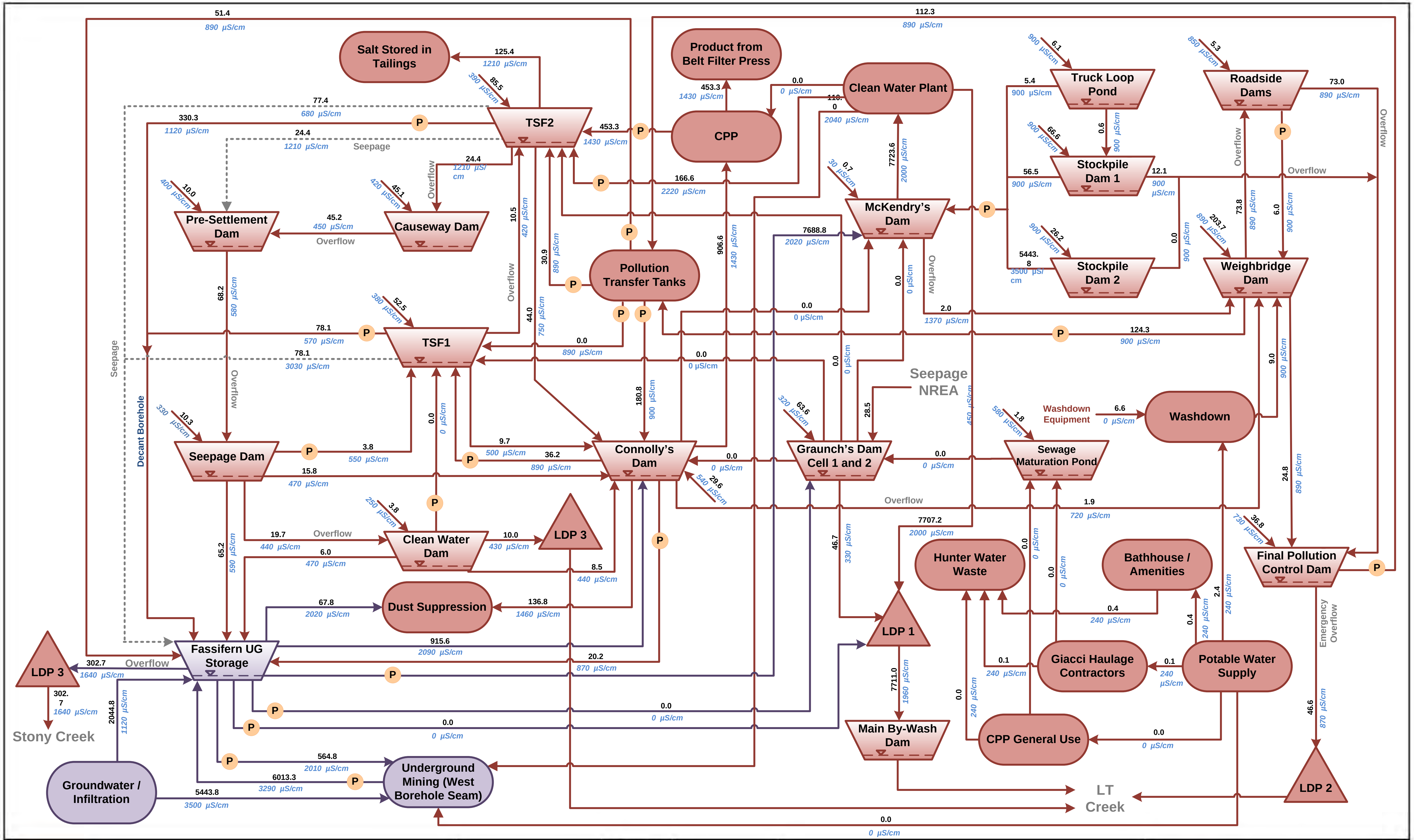
10th Percentile Annual Salt Transfers
Newstan Colliery Surface Site
Proposed Conditions

Centennial Northern Coal Services

DATE April 2014

Figure D-13

G:\22\16167\Visio\Coal Logistics\Appendix_10th_90th\Figure D-13_MeanAnnualSaltTransfer_Proposed_NewstanSurfaceSite_10th.vsd



Surface Transfer	P Pump
Underground Transfer	XX Mean (t/yr)
Seepage	*XX* *Mean Salinity*
Storages	Catchment Runoff and Direct Rainfall

LOCATION	Newstan
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Salt Transfers
Newstan Colliery Surface Site
Proposed Conditions

Centennial Northern Coal Services

DATE April 2014 Figure D-14

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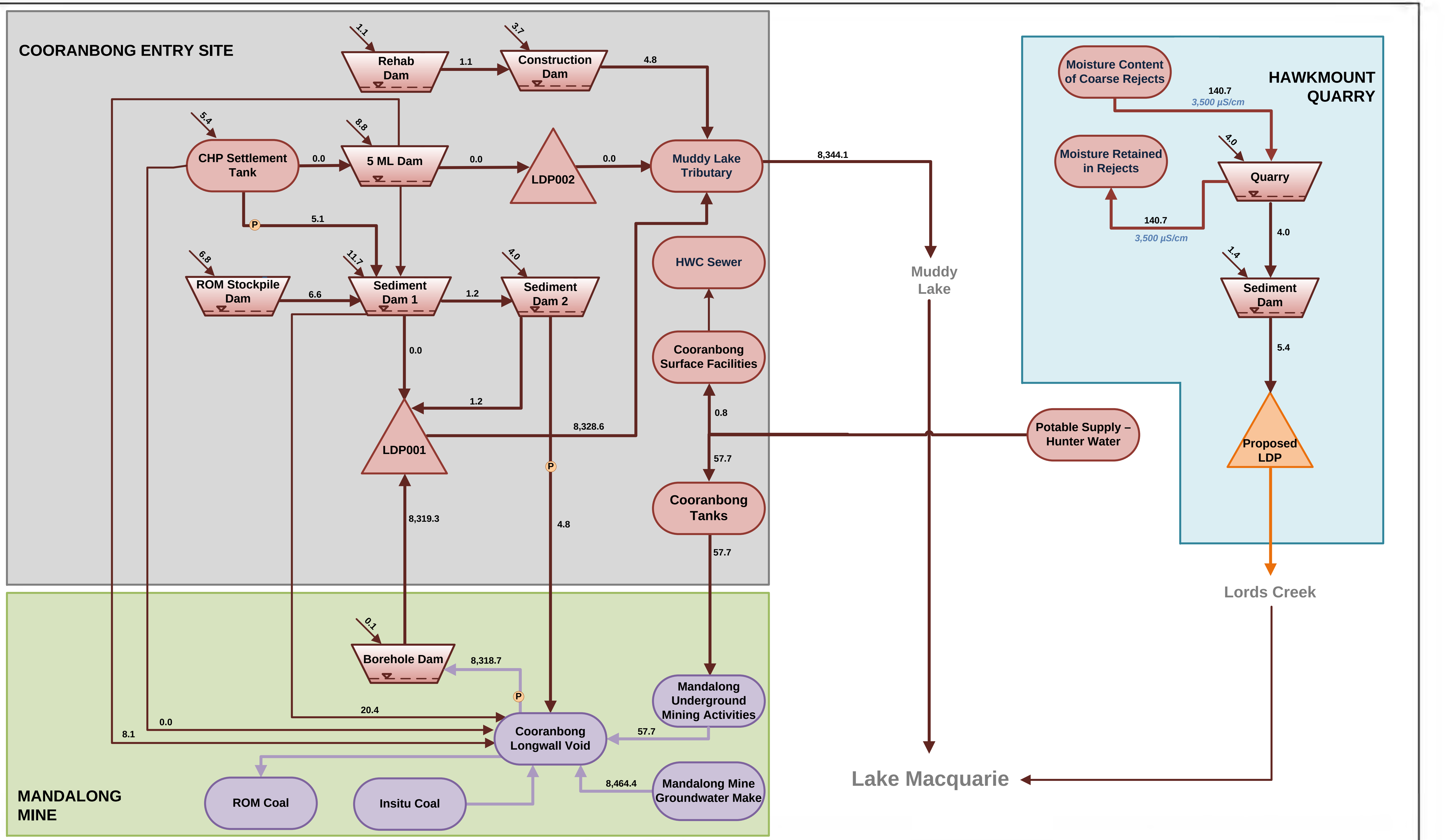


Surface Transfers
Underground Transfers
Proposed Transfers
Pumping Transfers
Storages

XX Mean (t/yr)

Rainfall Runoff

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SW
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

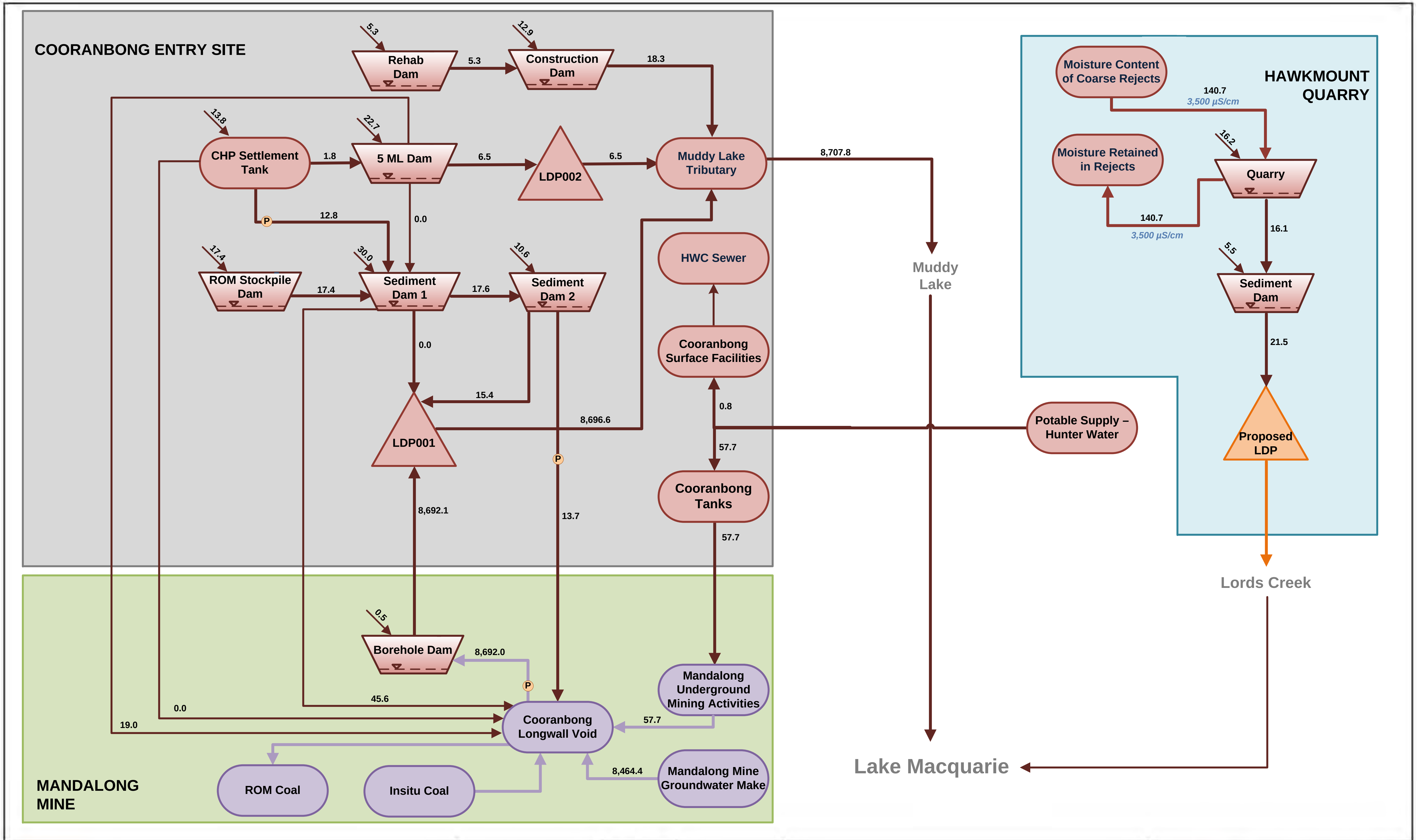
10th Percentile Annual Salt Transfers
Cooranbong Entry Site and Hawkmount Quarry
Proposed Conditions

Centennial Northern Coal Services

DATE April 2014

Figure D-15

G:\22\16167\Visio\Coal Logistics\Appendix_10th_90th\Figure D-15_MeanAnnualSaltTransfer_Proposed_CooranbongEntrySite_10th.vsd



Surface Transfers
Underground Transfers
Proposed Transfers
Pumping Transfers
Storages
XX Mean (t/yr)
Rainfall Runoff

LOCATION	Cooranbong
SEAM	N/A
DRAWN	SM
CHECKED	SW
APPROVED	GM
SCALE	NTS

Northern Coal Logistics Project
Water Impact Assessment

90th Percentile Annual Salt Transfers
Cooranbong Entry Site and Hawkmount Quarry
Proposed Conditions

Centennial Northern Coal Services

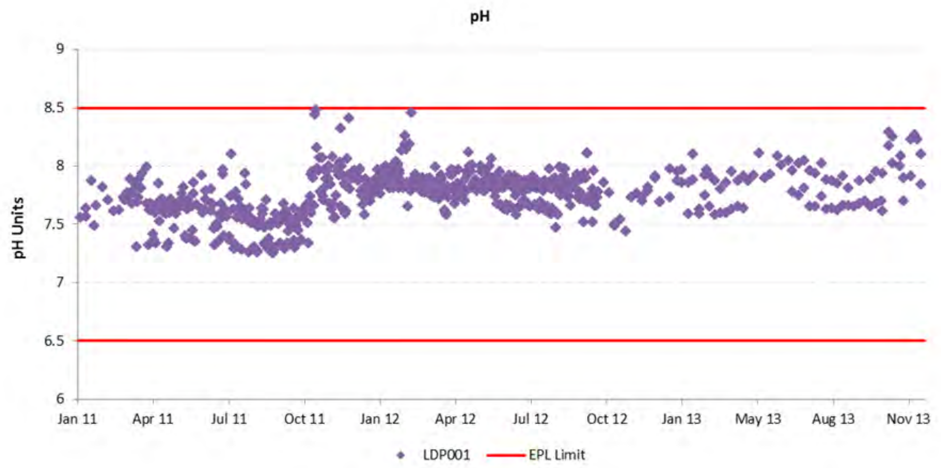
DATE April 2014 Figure D-16

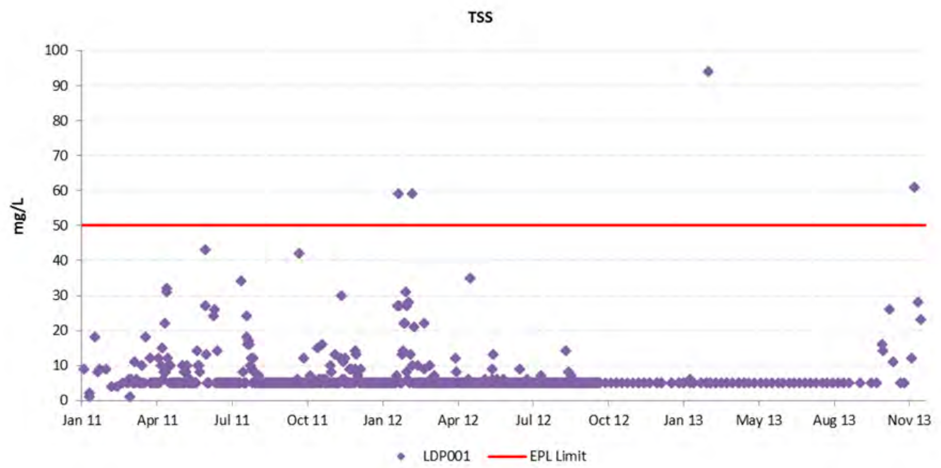
G:\22\16167\Visio\Coal Logistics\Appendix_10th_90th\Figure D-16_MeanAnnualSaltTransfer_Proposed_CooranbongEntrySite_90th.vsd

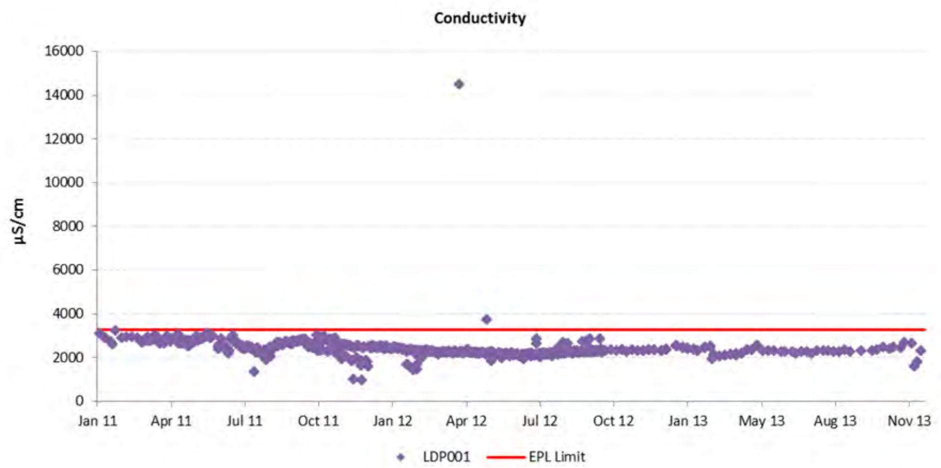
Appendix E – Water Quality Monitoring Data

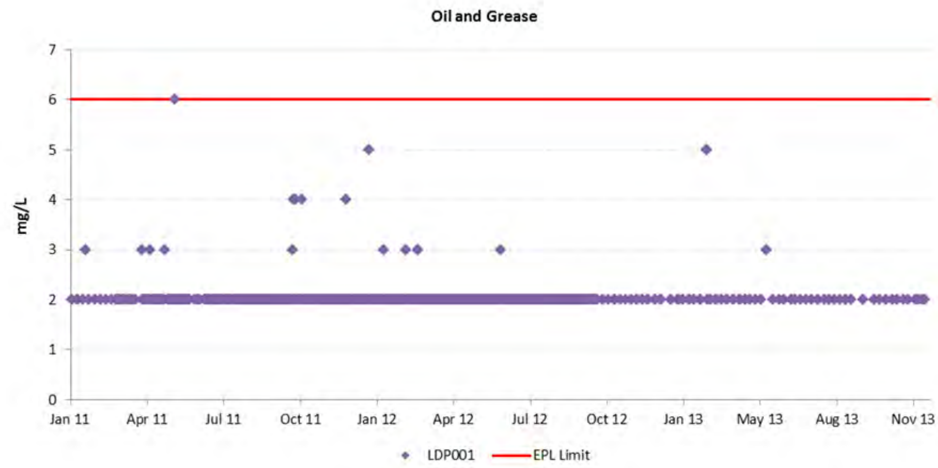
Newstan Colliery

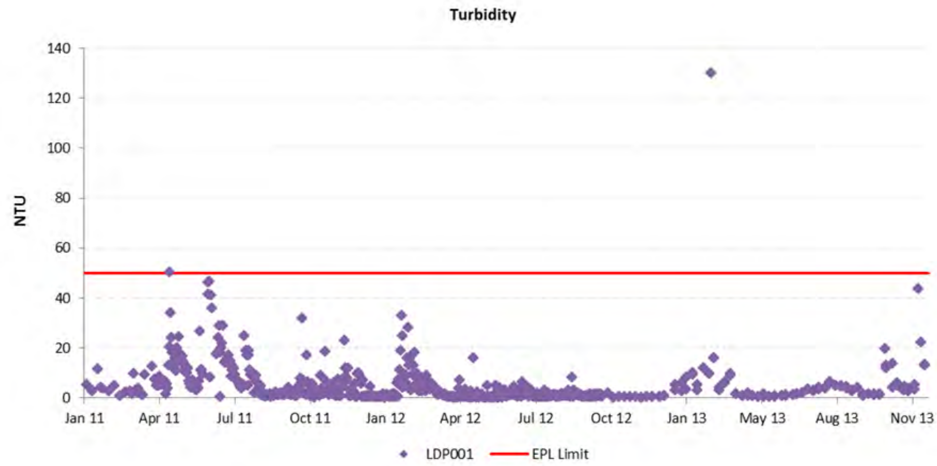
LDP001

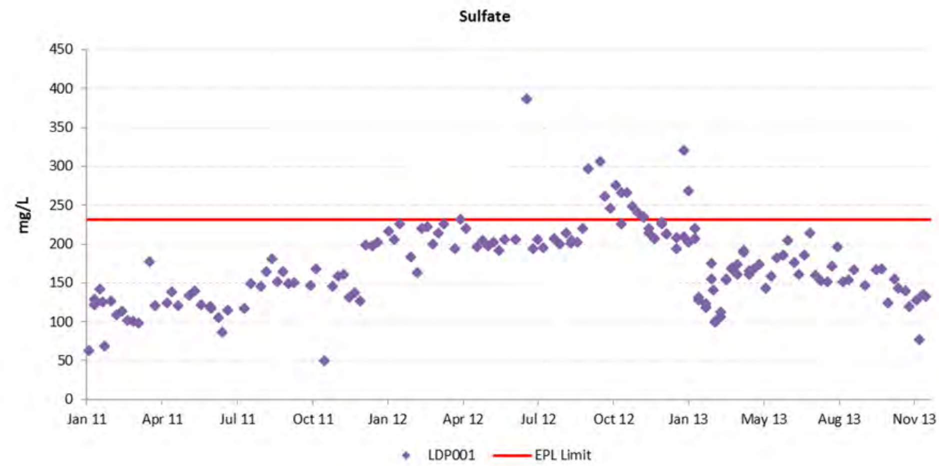


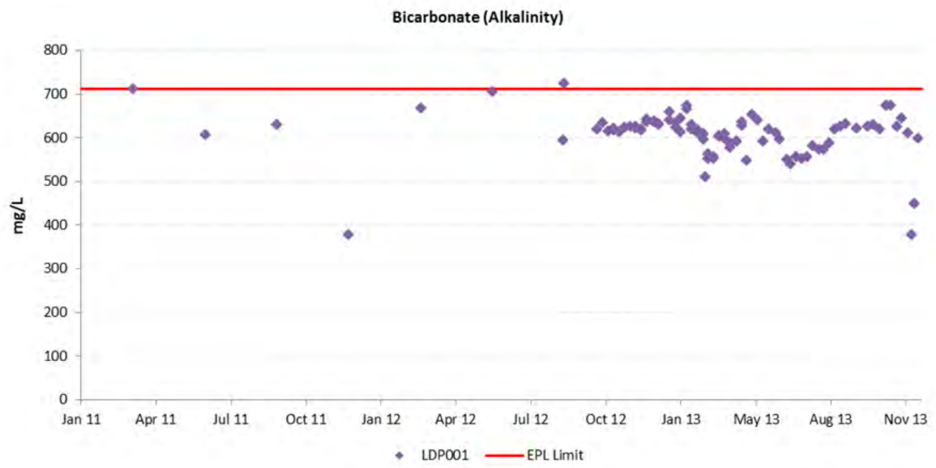


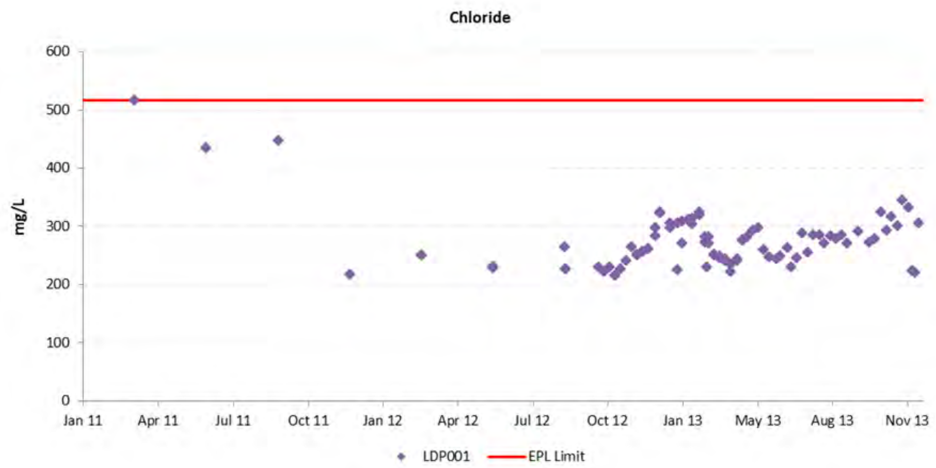


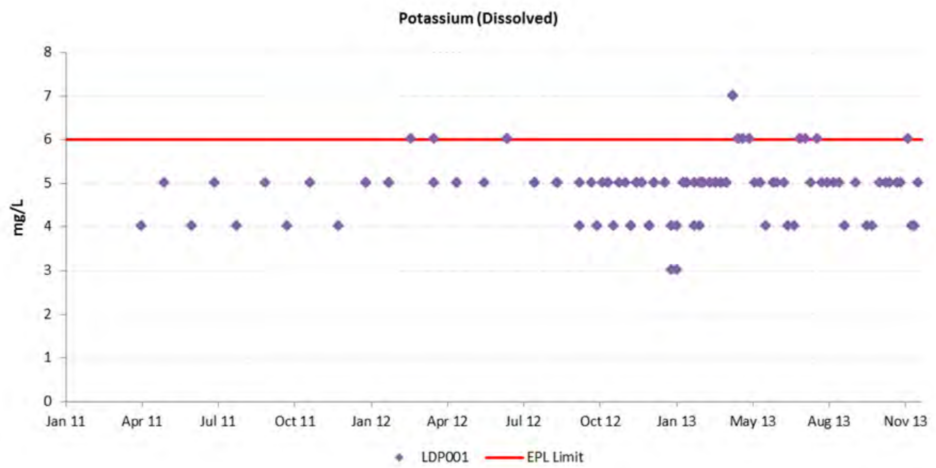

Oil and Grease
mg/L
0
1
2
3
4
5
6
7
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

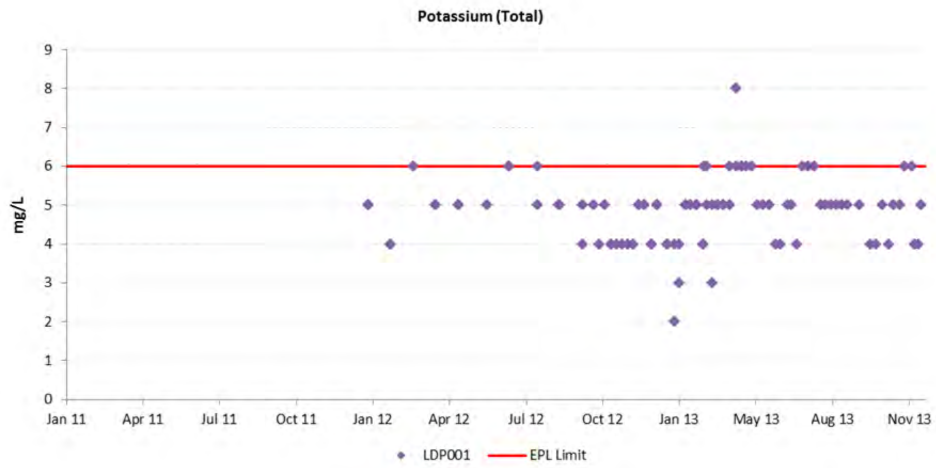

Turbidity
NTU
0
20
40
60
80
100
120
140
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

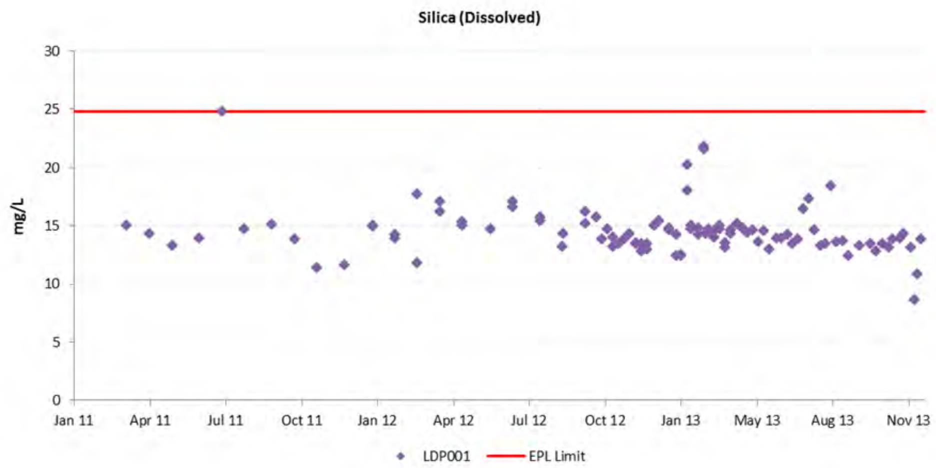

Sulfate
mg/L
0
50
100
150
200
250
300
350
400
450
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

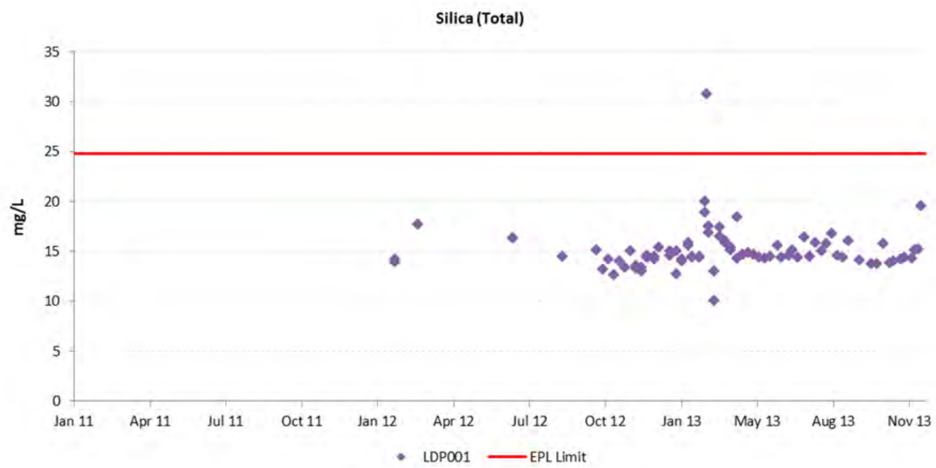

Bicarbonate (Alkalinity)
800
700
600
500
400
300
200
100
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

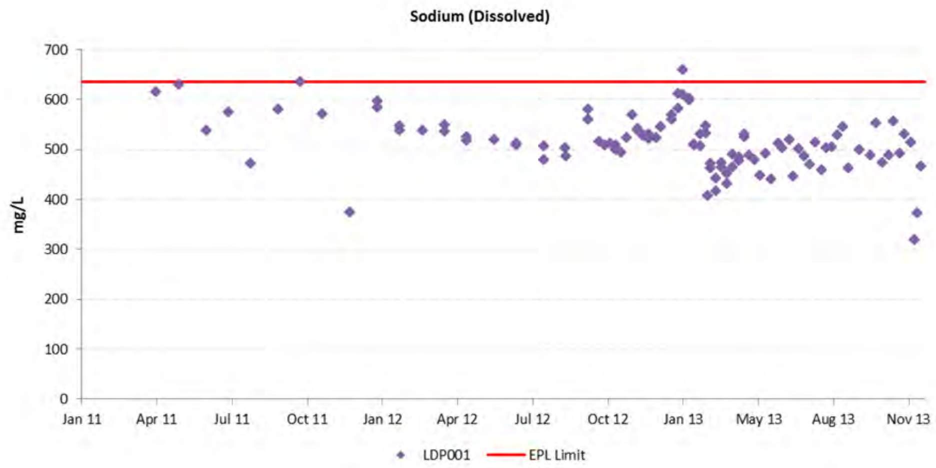

Chloride
600
500
400
300
200
100
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

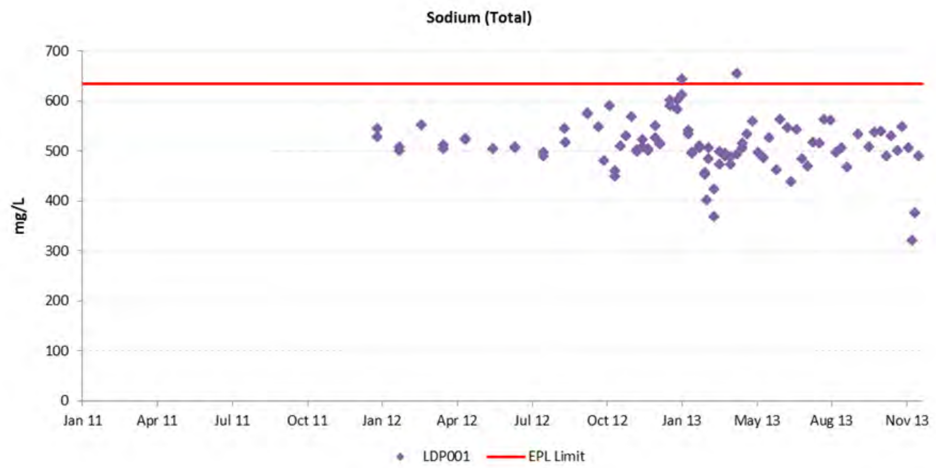

Potassium (Dissolved)
8
7
6
5
4
3
2
1
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

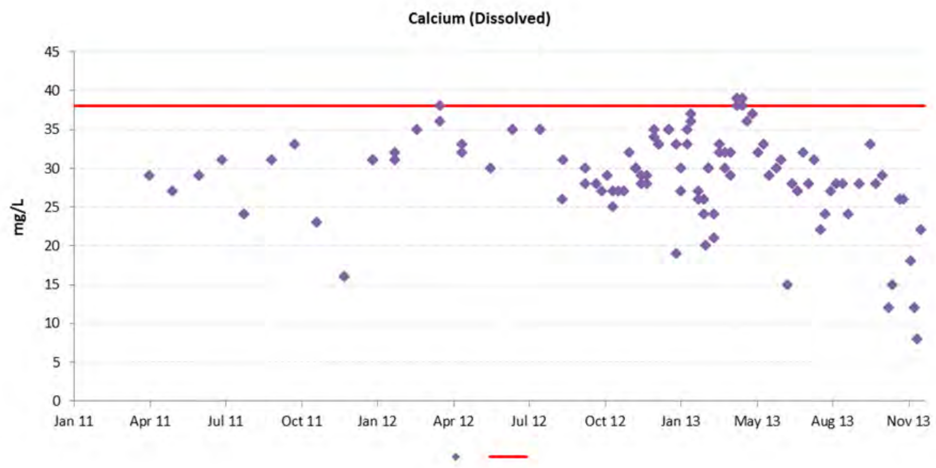

Potassium (Total)
mg/L
9
8
7
6
5
4
3
2
1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

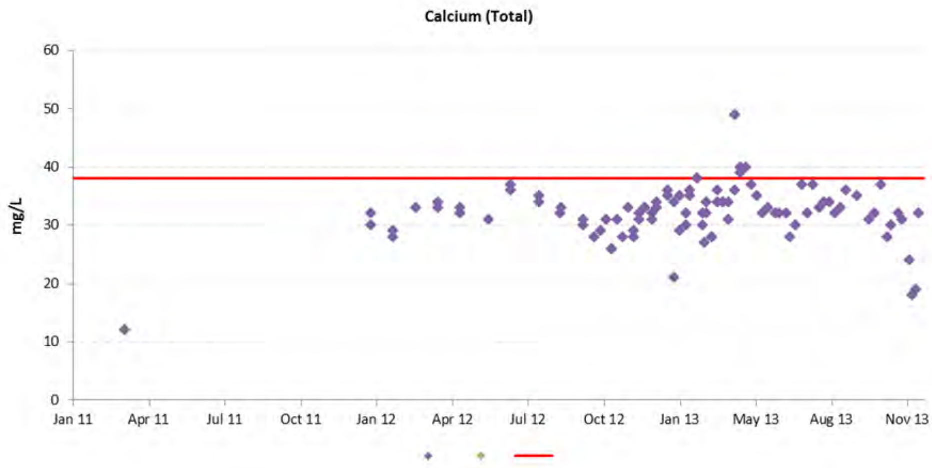

Silica (Dissolved)
mg/L
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

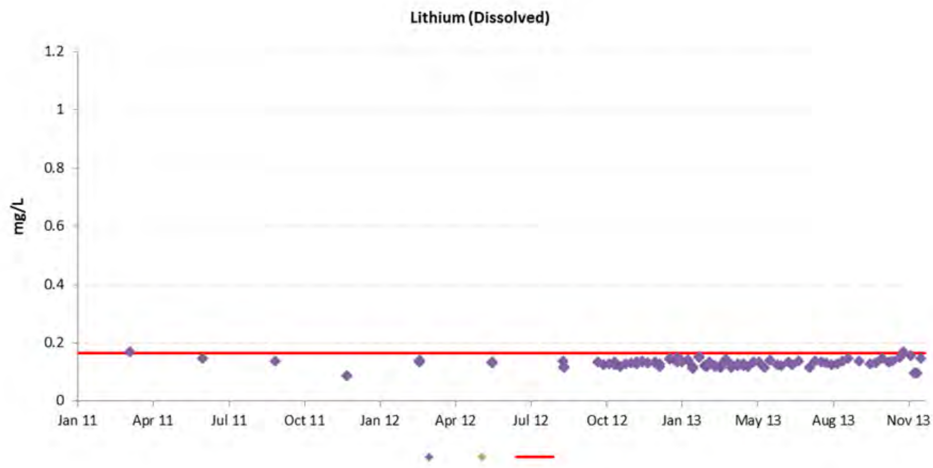

Silica (Total)
mg/L
35
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

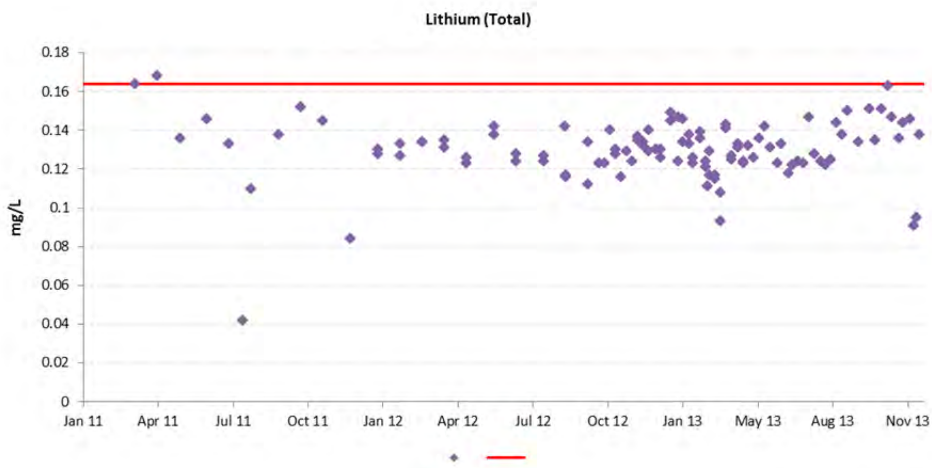

Sodium (Dissolved)
mg/L
700
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

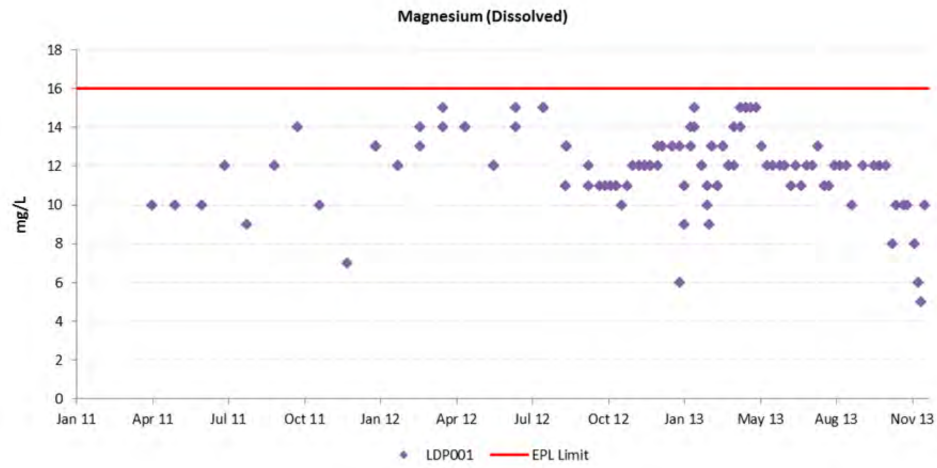

Sodium (Total)
mg/L
700
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

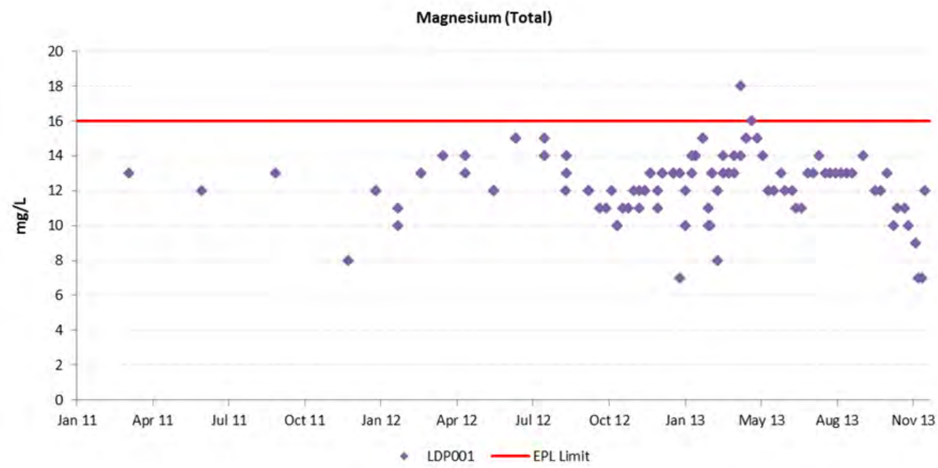

Calcium (Dissolved)
mg/L
45
40
35
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13

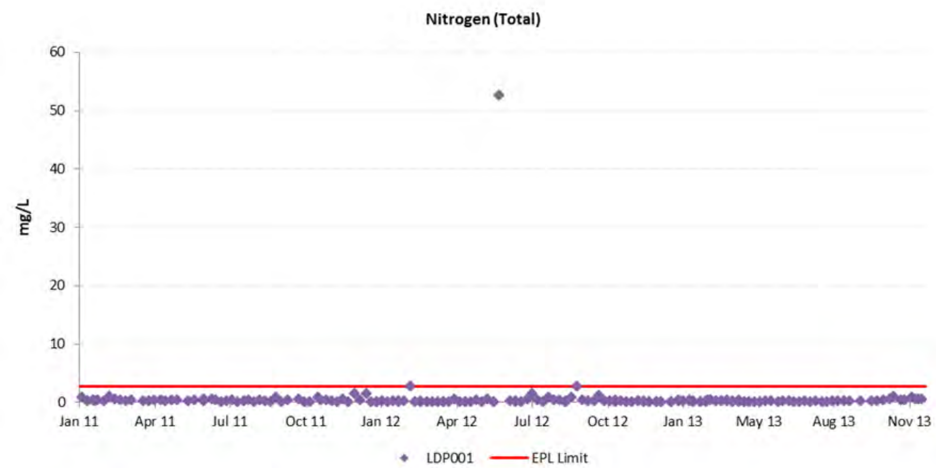

Calcium (Total)
mg/L
60
50
40
30
20
10
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13

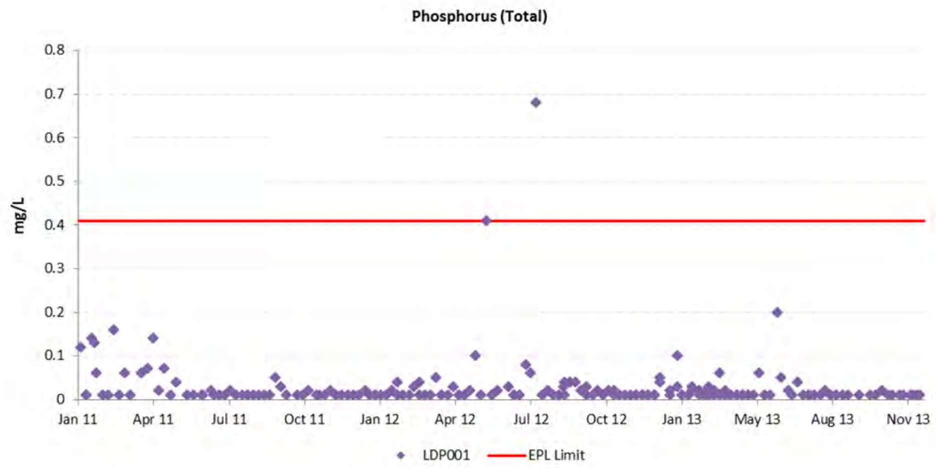

Lithium (Dissolved)
mg/L
1.2
1
0.8
0.6
0.4
0.2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13

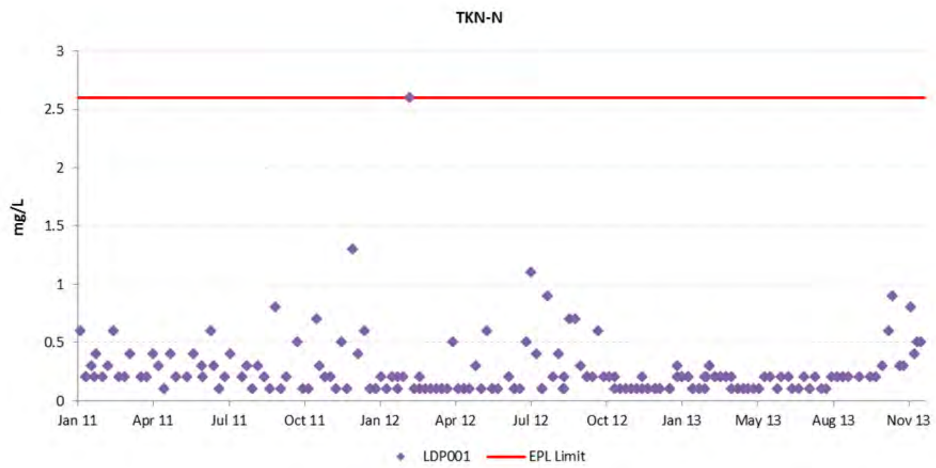

Lithium (Total)
mg/L
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13

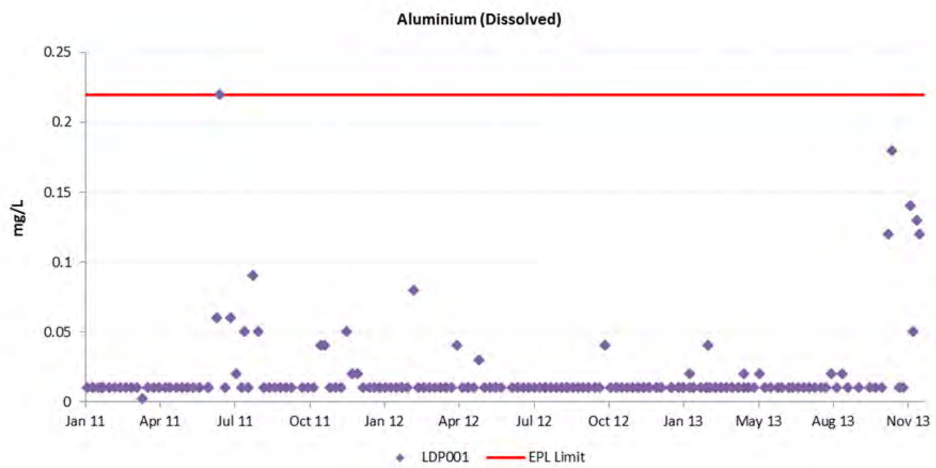

Magnesium (Dissolved)
mg/L
18
16
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

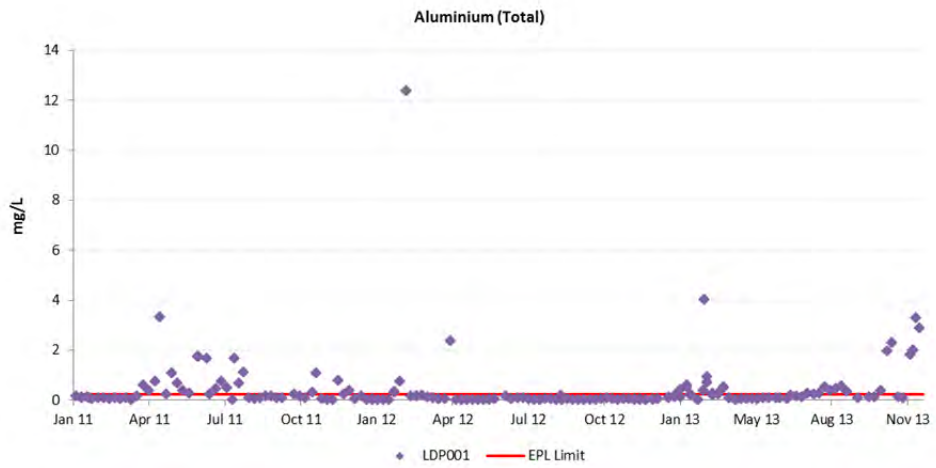

Magnesium (Total)
mg/L
20
18
16
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

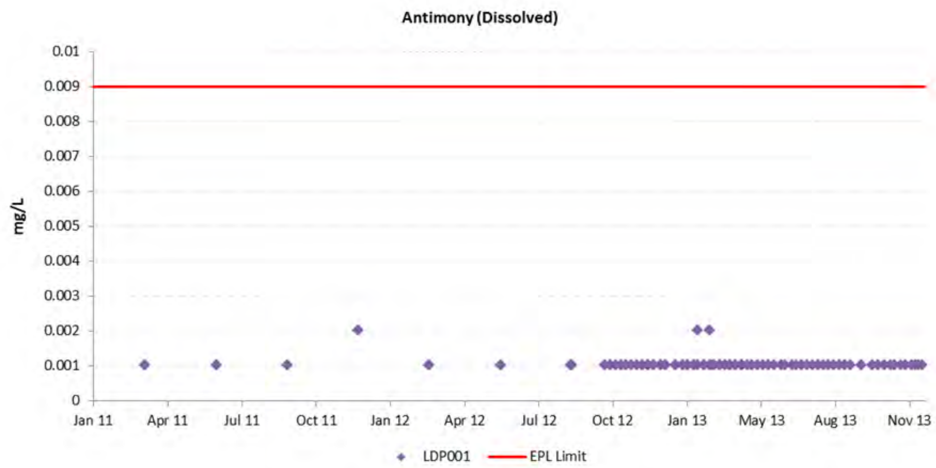

Nitrogen (Total)
mg/L
60
50
40
30
20
10
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

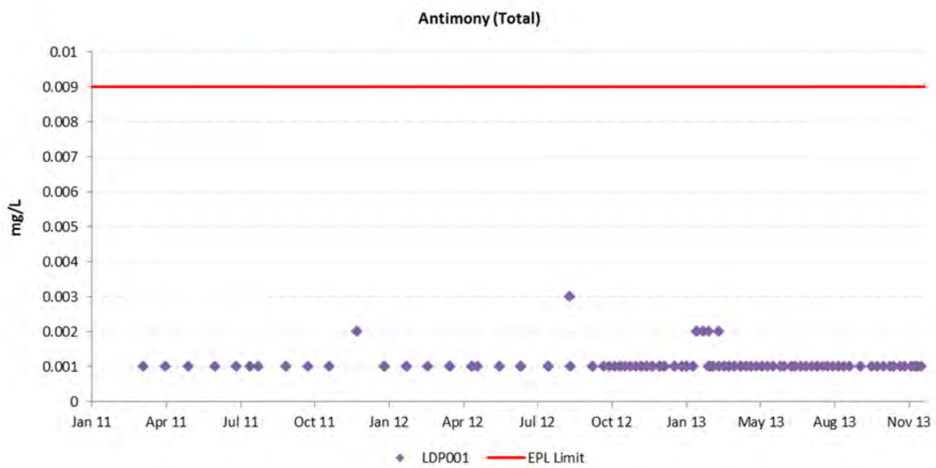

Phosphorus (Total)
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

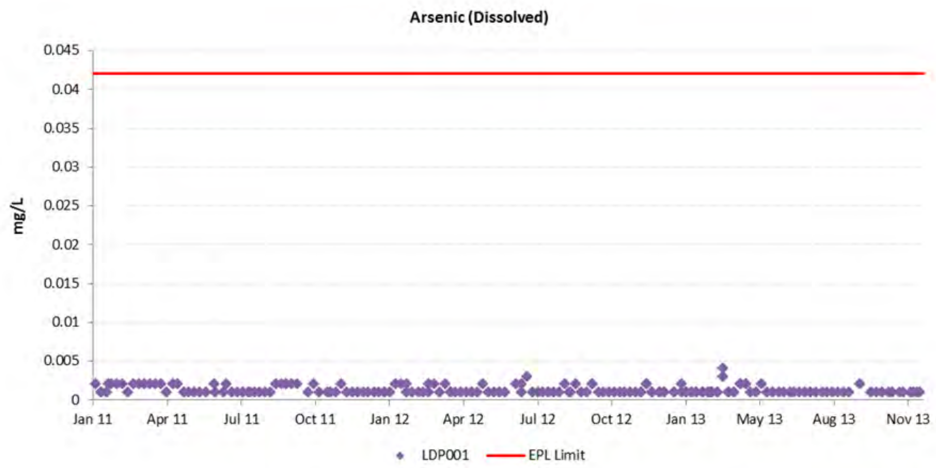

TKN-N
mg/L
3
2.5
2
1.5
1
0.5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

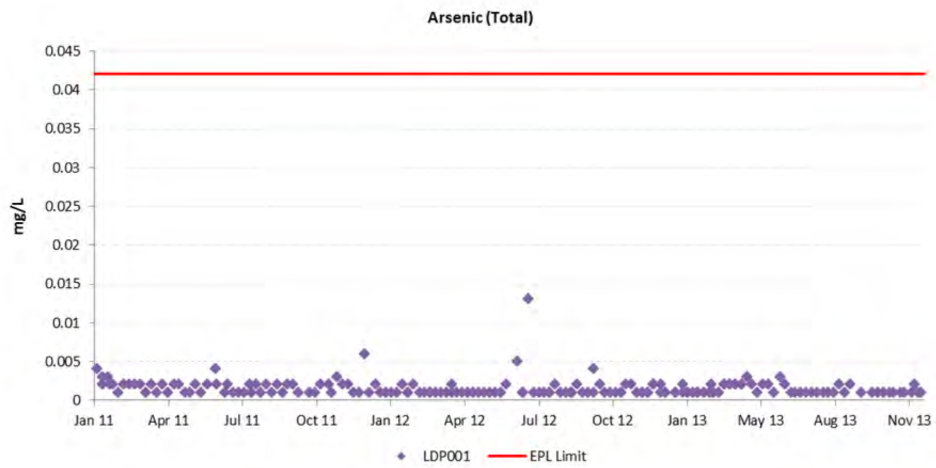

Aluminium (Dissolved)
mg/L
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

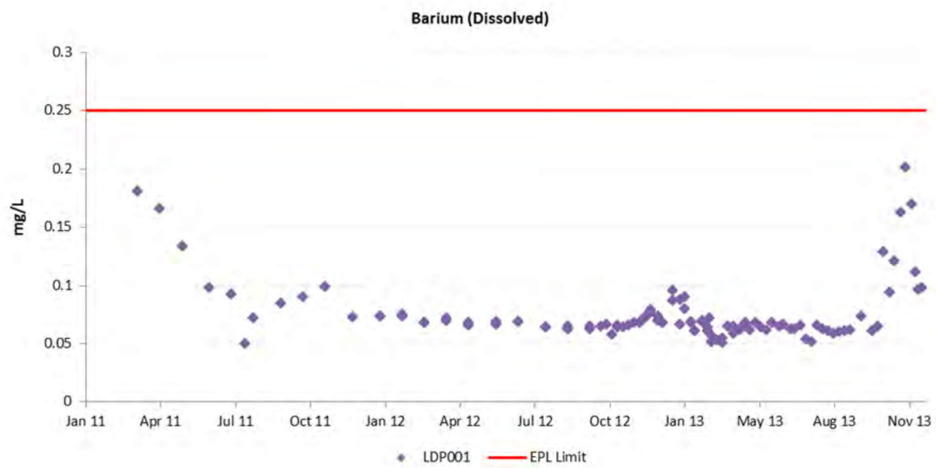

Aluminium (Total)
mg/L
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

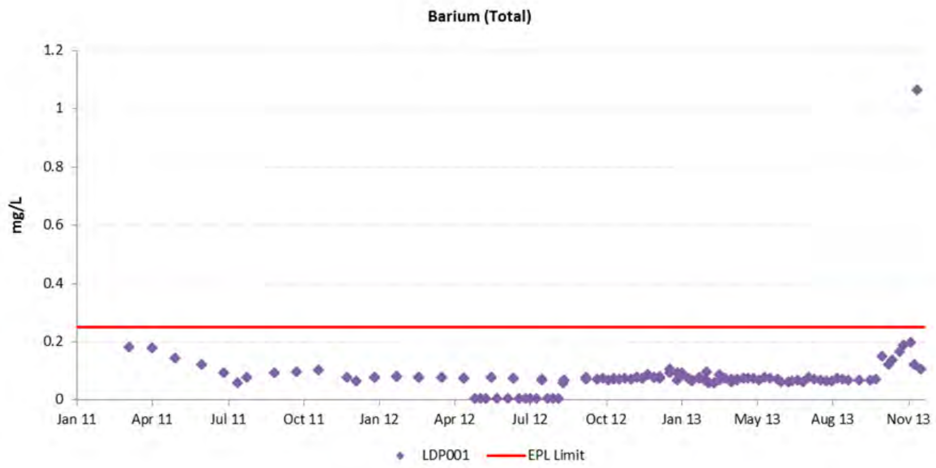

Antimony (Dissolved)
mg/L
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

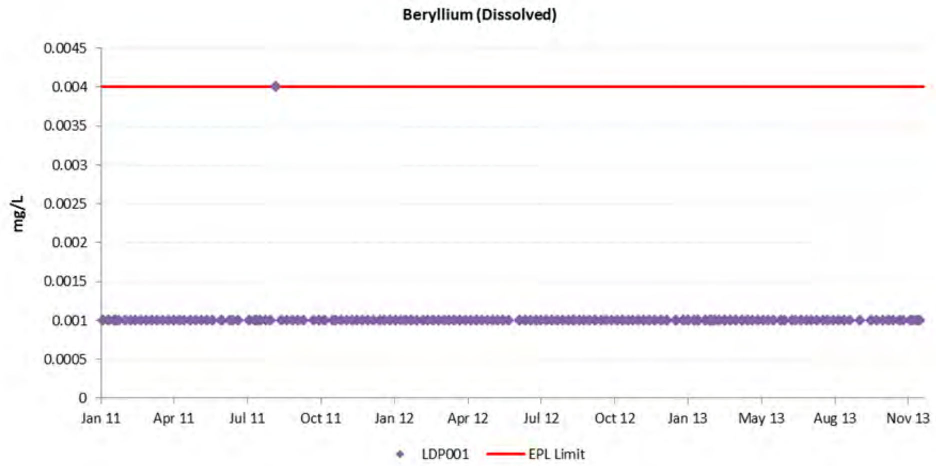

Antimony (Total)
mg/L
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

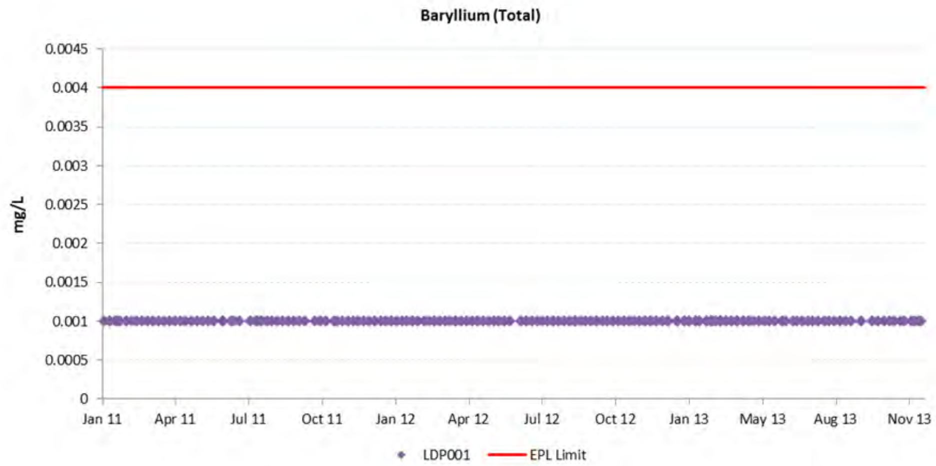

Arsenic (Dissolved)
mg/L
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

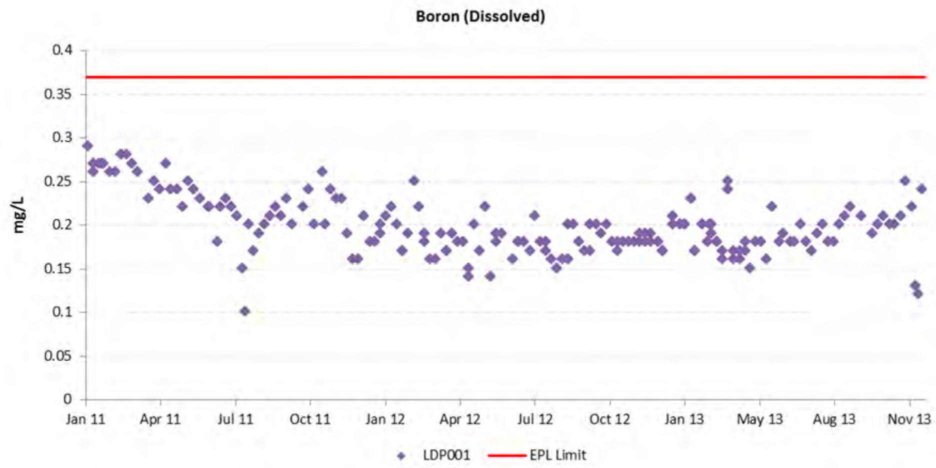

Arsenic (Total)
mg/L
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

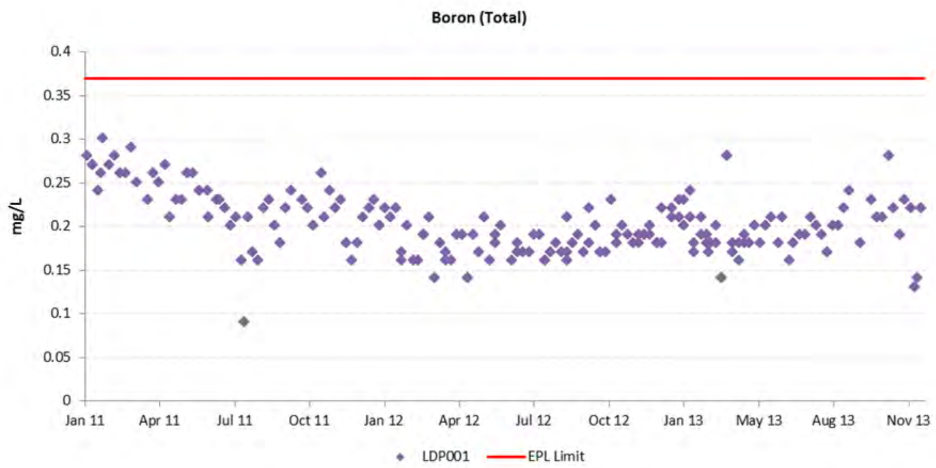

Barium (Dissolved)
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

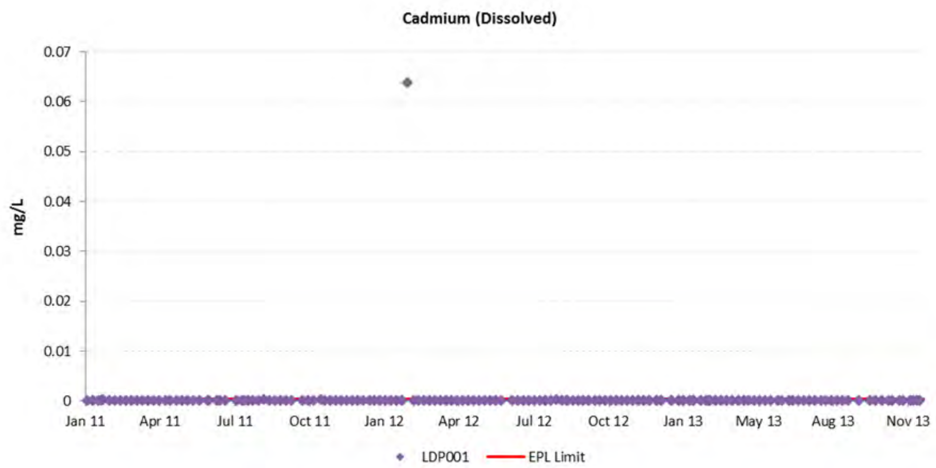

Barium (Total)
mg/L
1.2
1
0.8
0.6
0.4
0.2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

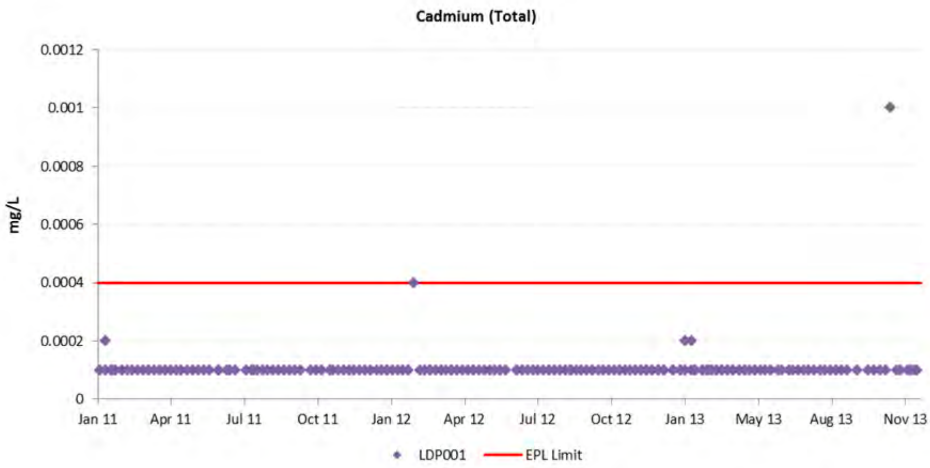

Beryllium (Dissolved)
mg/L
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

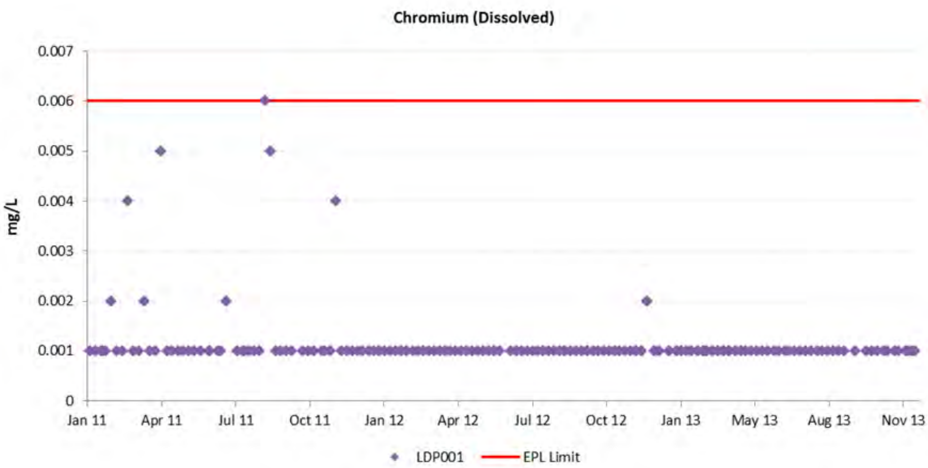

Baryllium (Total)
mg/L
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

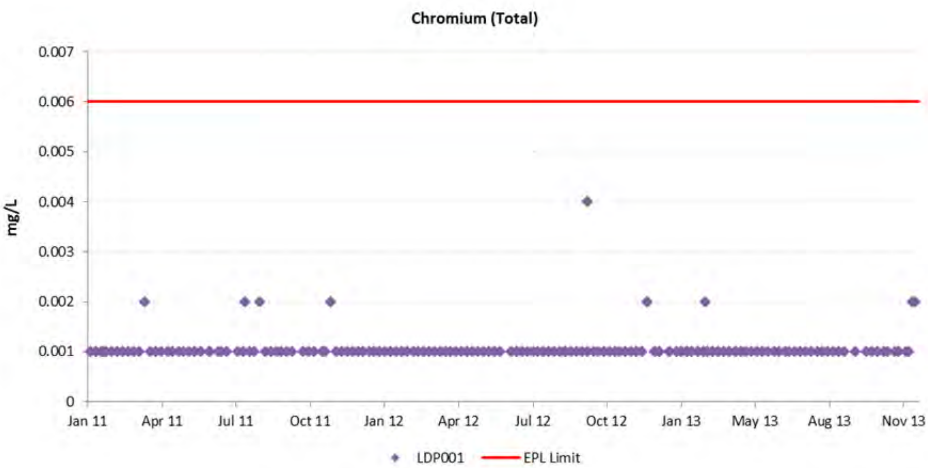

Boron (Dissolved)
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

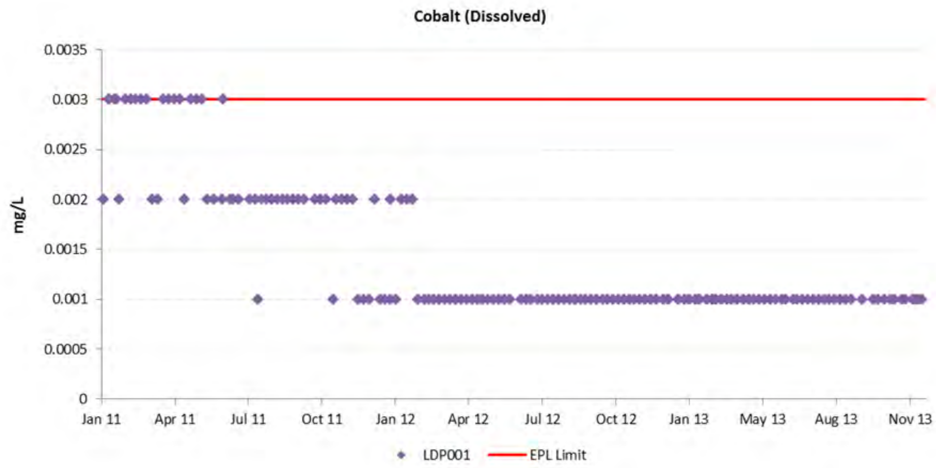

Boron (Total)
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

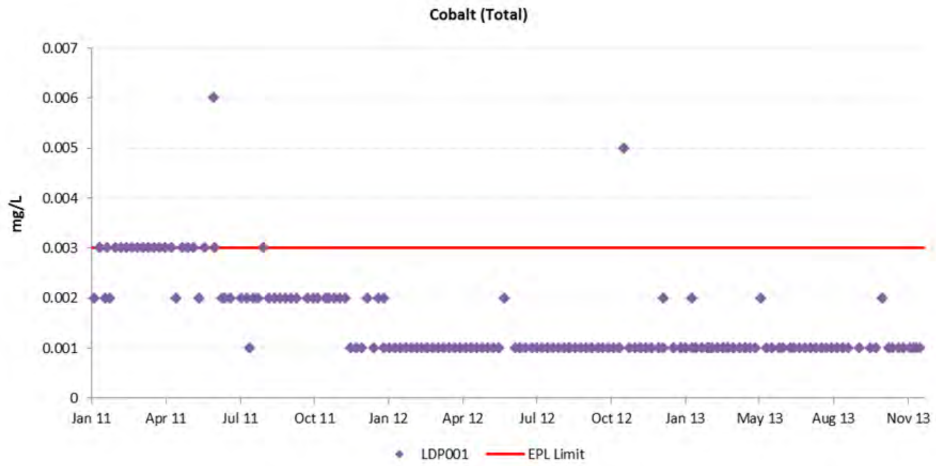

Cadmium (Dissolved)
mg/L
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

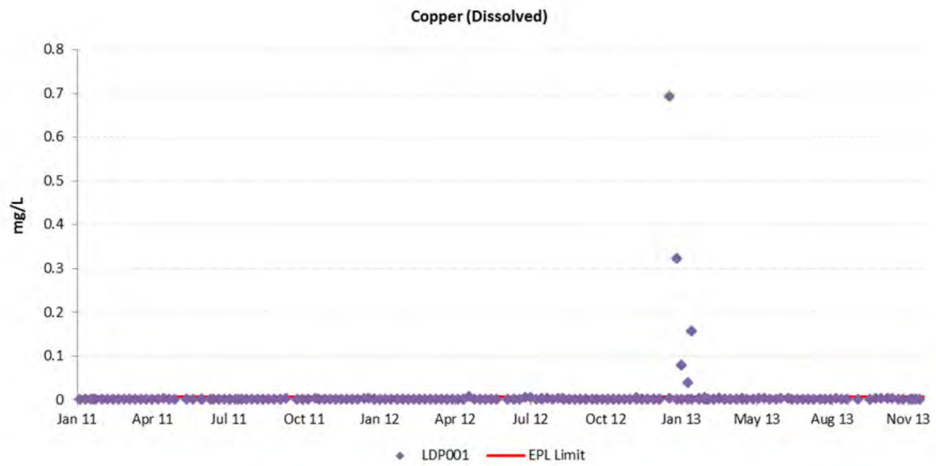

Cadmium (Total)
mg/L
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

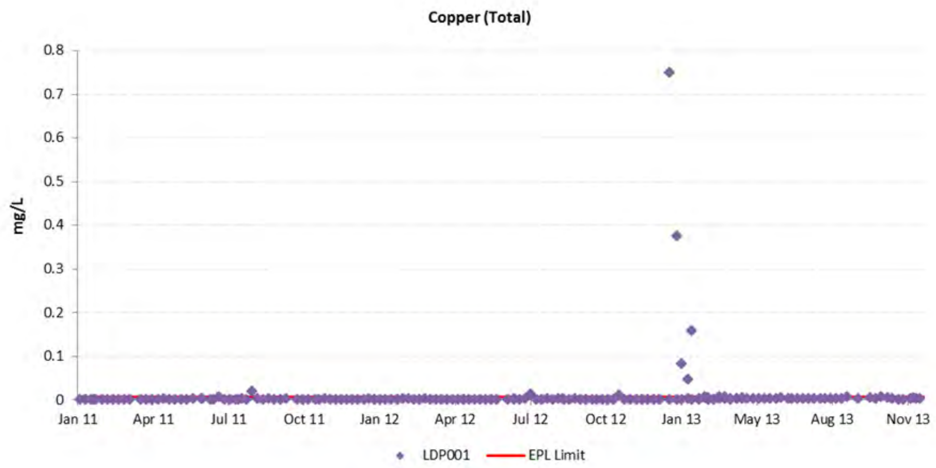

Chromium (Dissolved)
mg/L
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

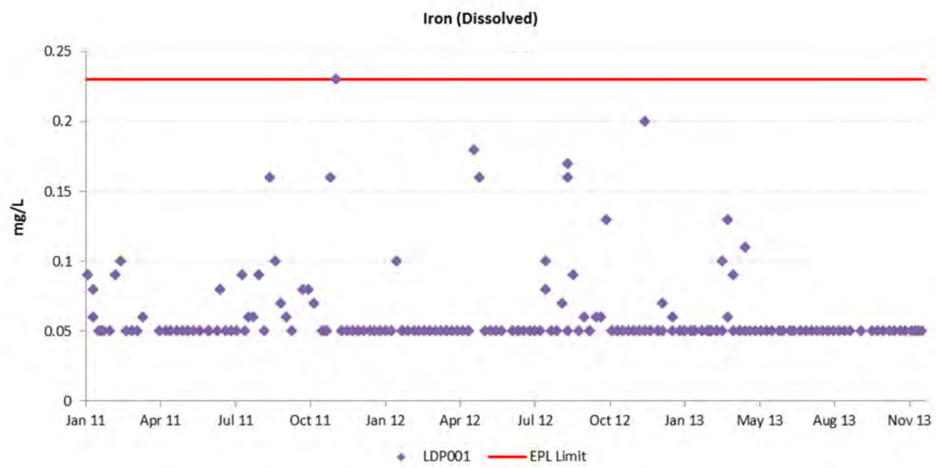

Chromium (Total)
mg/L
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

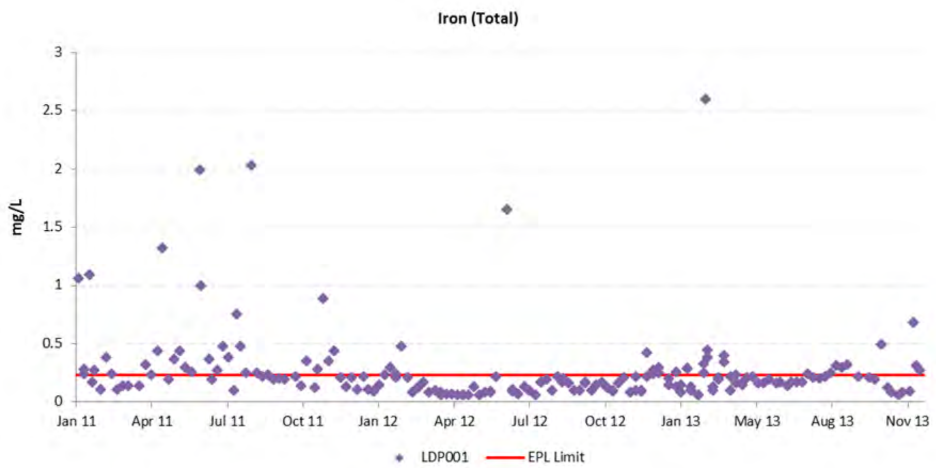

Cobalt (Dissolved)
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

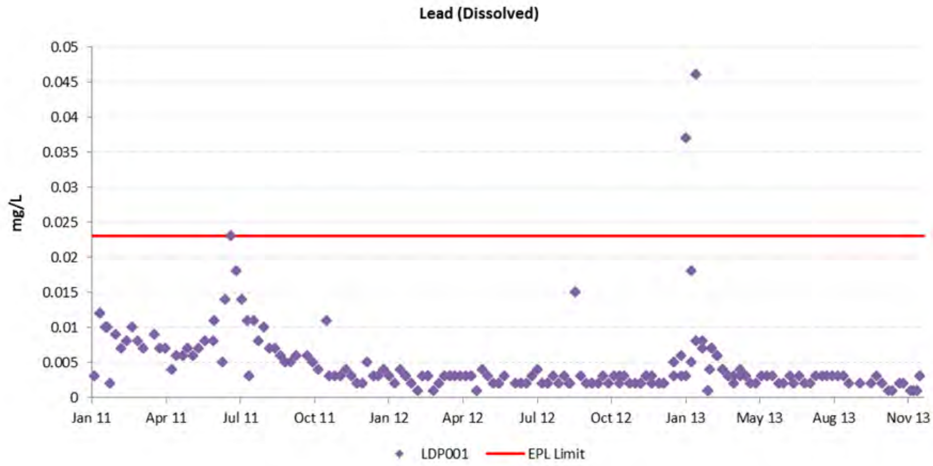

Cobalt (Total)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

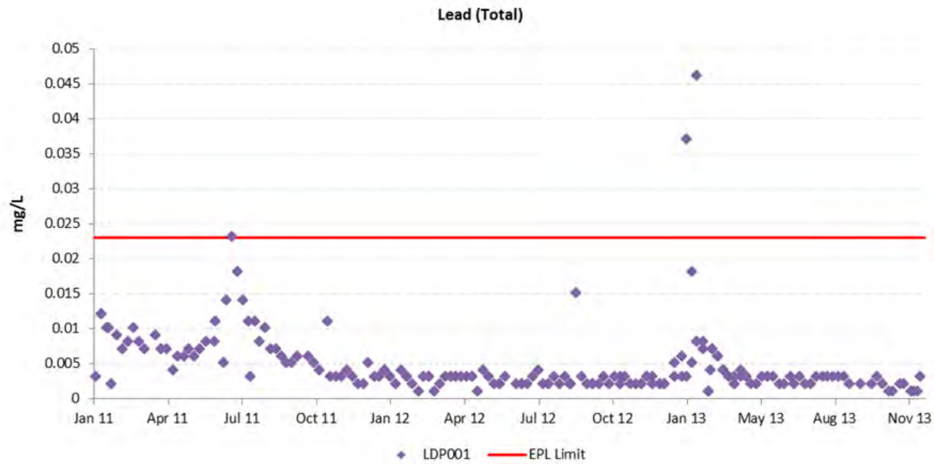

Copper (Dissolved)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

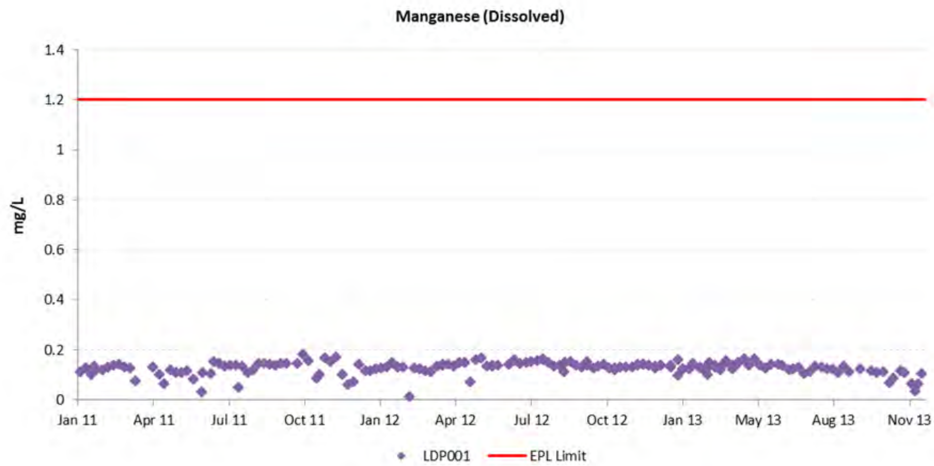

Copper (Total)
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

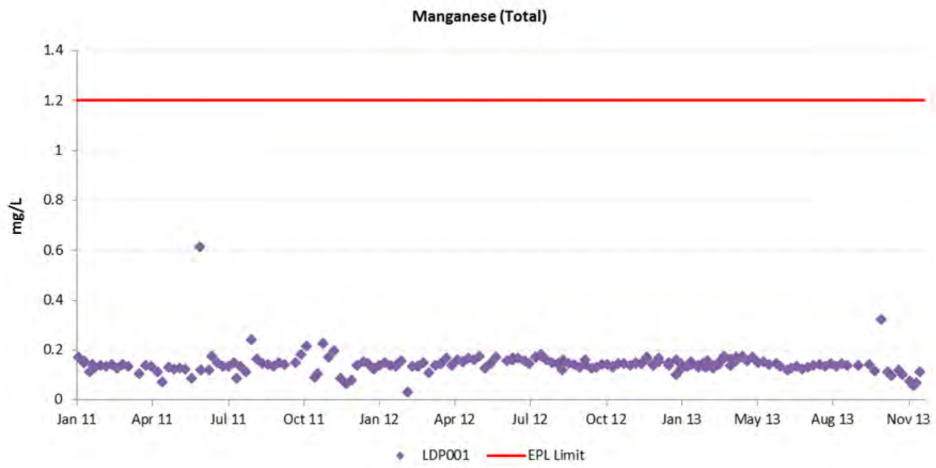

Iron (Dissolved)
mg/L
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

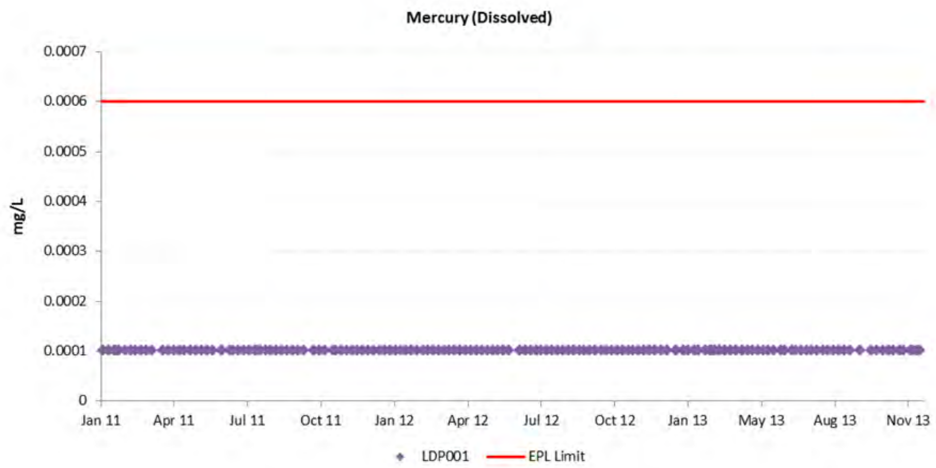

Iron (Total)
mg/L
3
2.5
2
1.5
1
0.5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

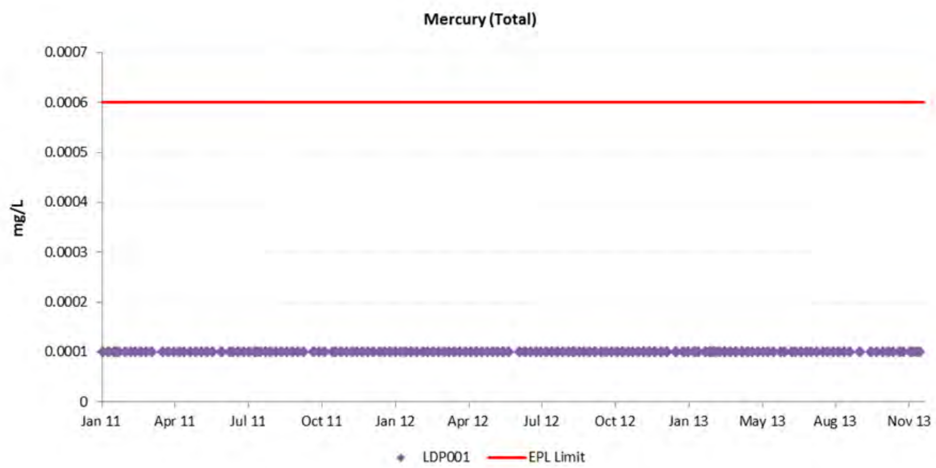

Lead (Dissolved)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

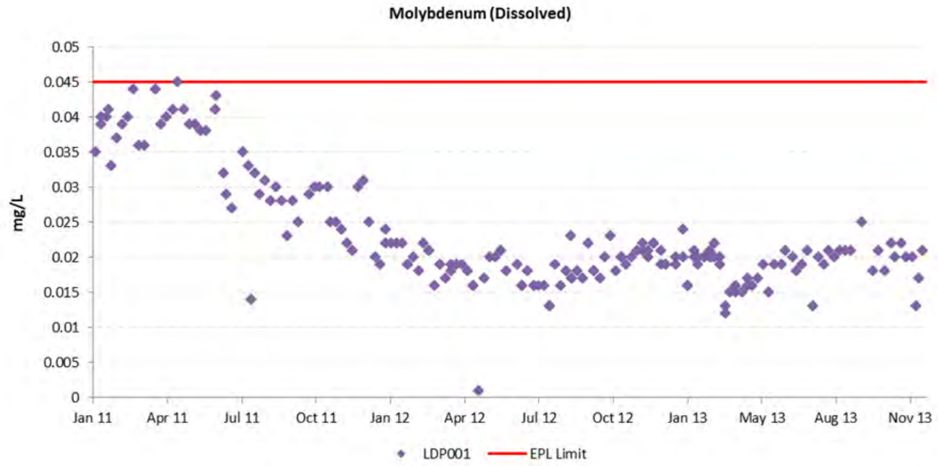

Lead (Total)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

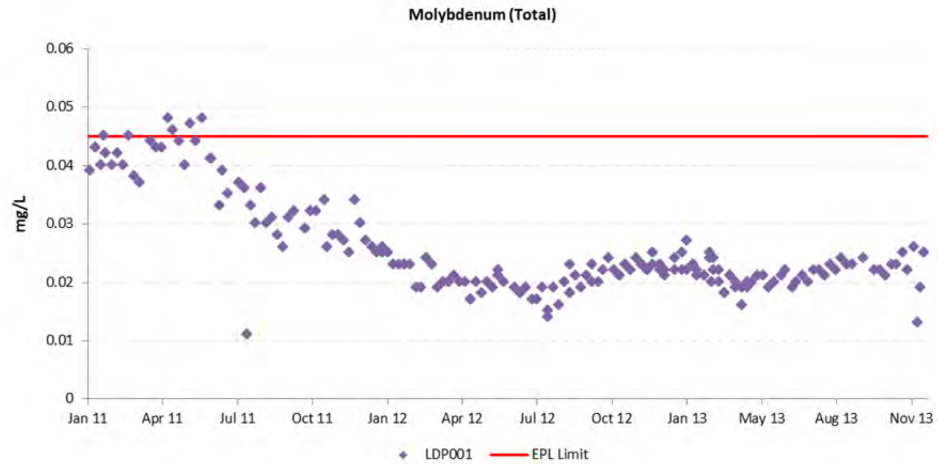

Manganese (Dissolved)
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

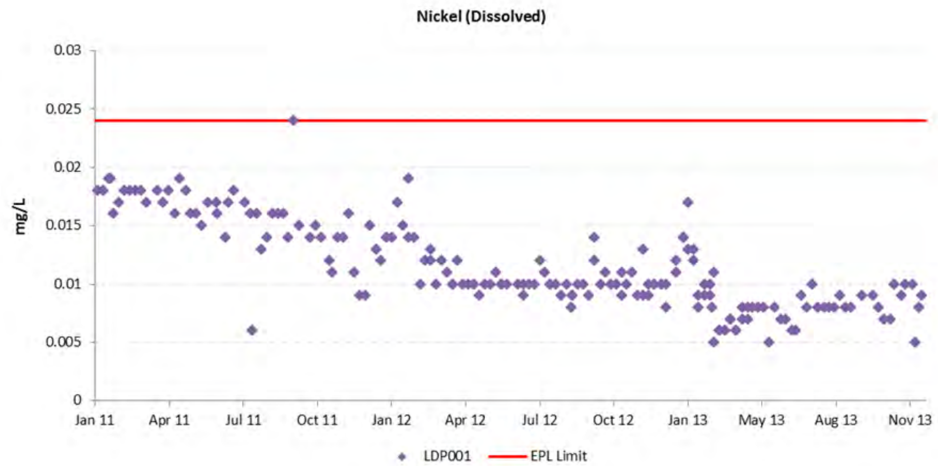

Manganese (Total)
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

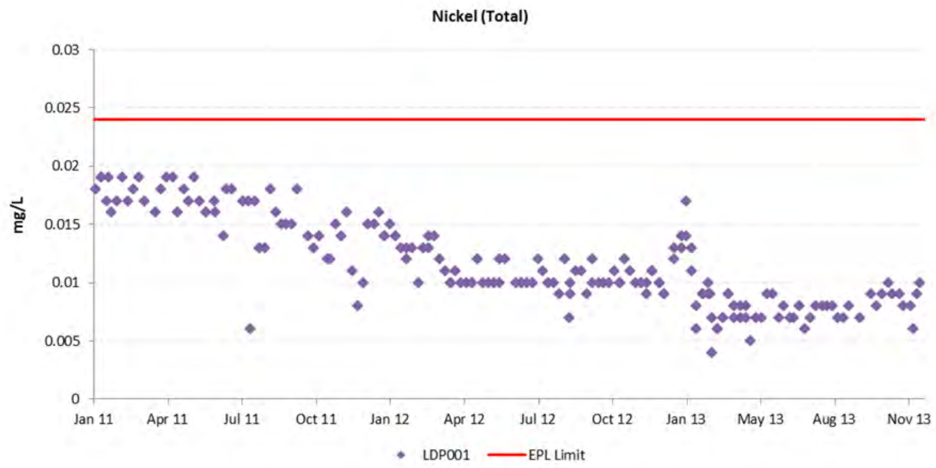

Mercury (Dissolved)
mg/L
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

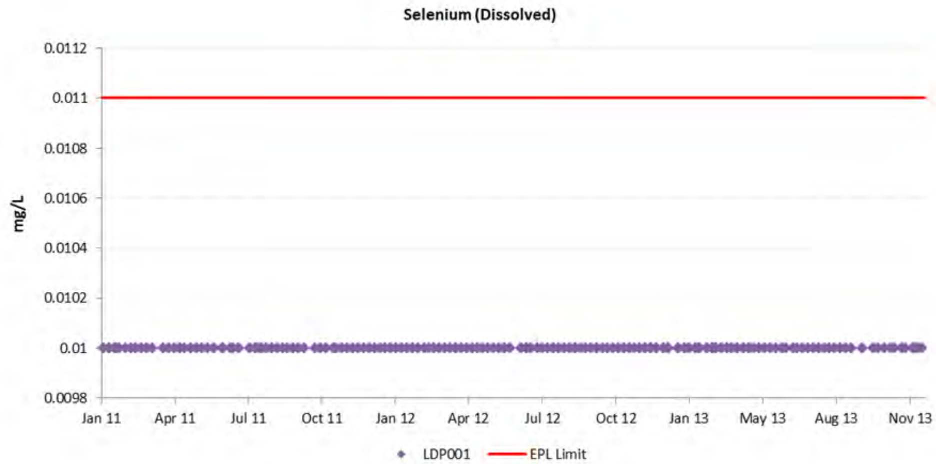

Mercury (Total)
mg/L
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

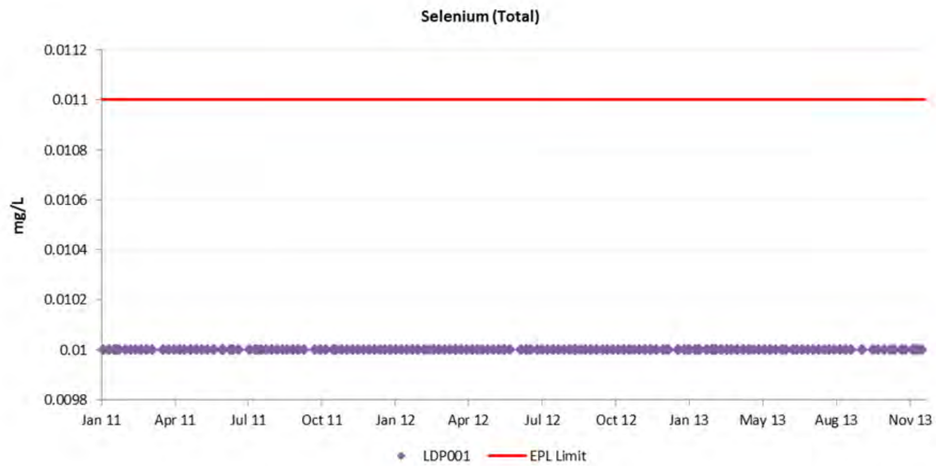

Molybdenum (Dissolved)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

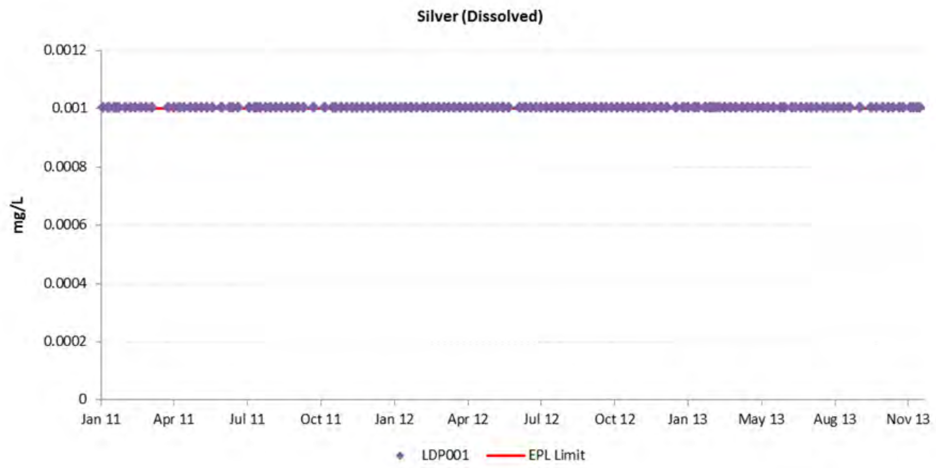

Molybdenum (Total)
mg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

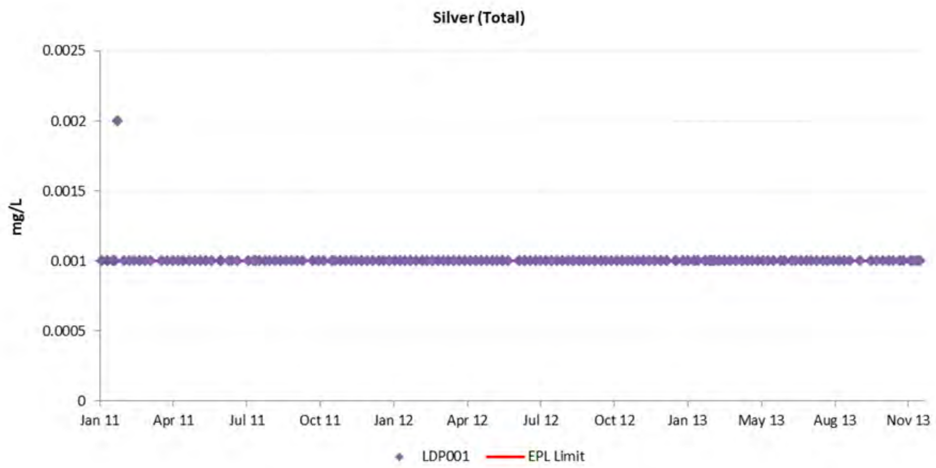

Nickel (Dissolved)
mg/L
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

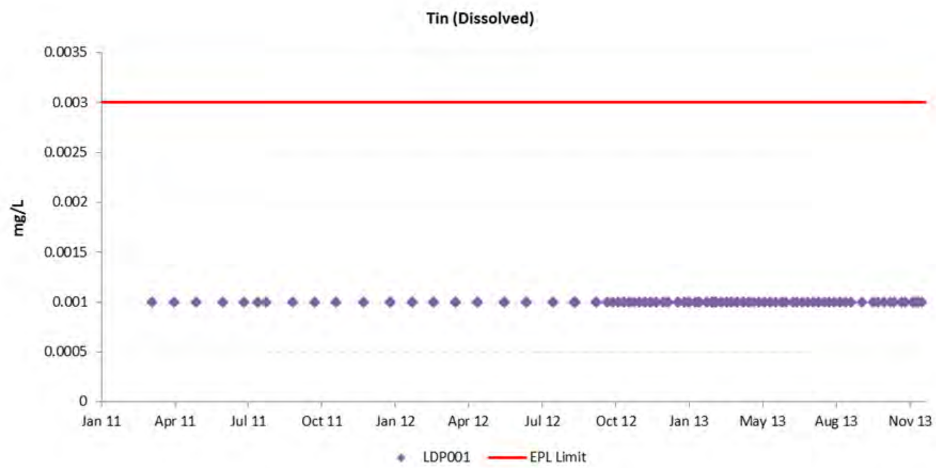

Nickel (Total)
0.03
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

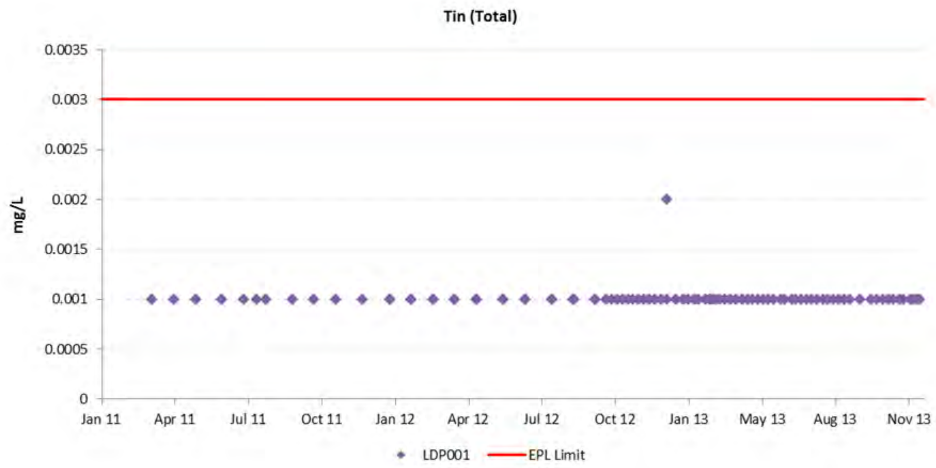

Selenium (Dissolved)
0.0112
0.011
0.0108
0.0106
0.0104
0.0102
0.01
0.0098
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

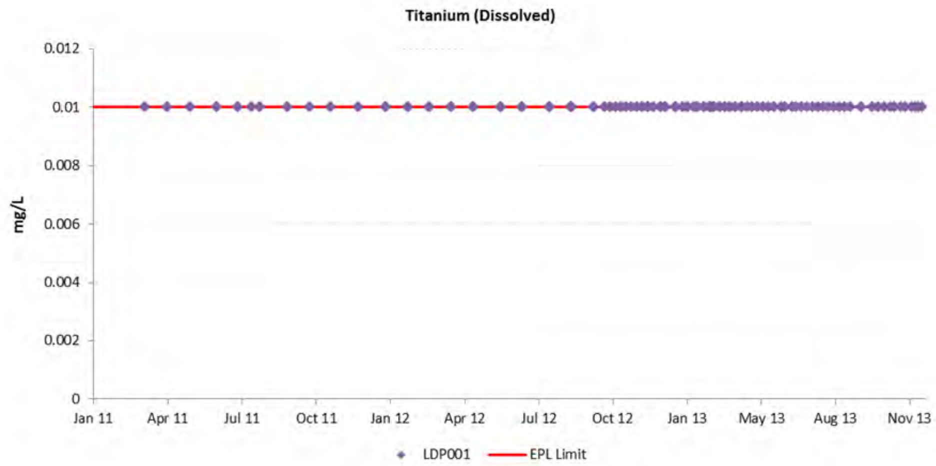

Selenium (Total)
0.0112
0.011
0.0108
0.0106
0.0104
0.0102
0.01
0.0098
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

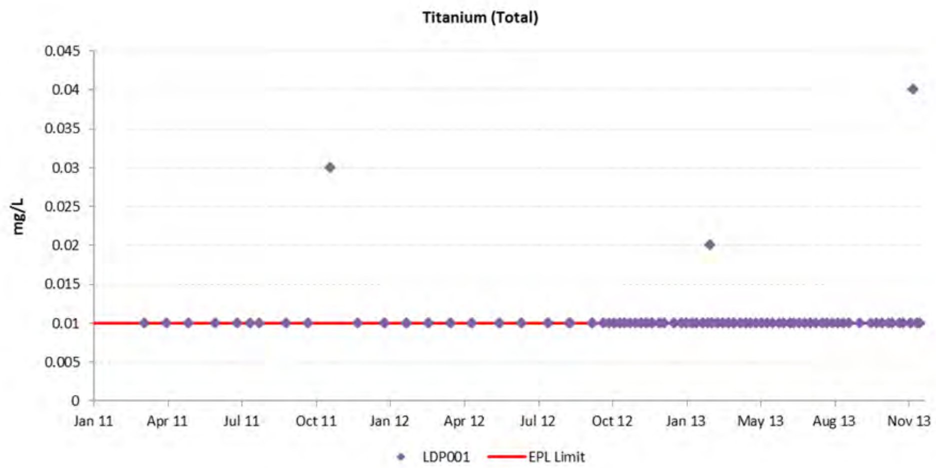

Silver (Dissolved)
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

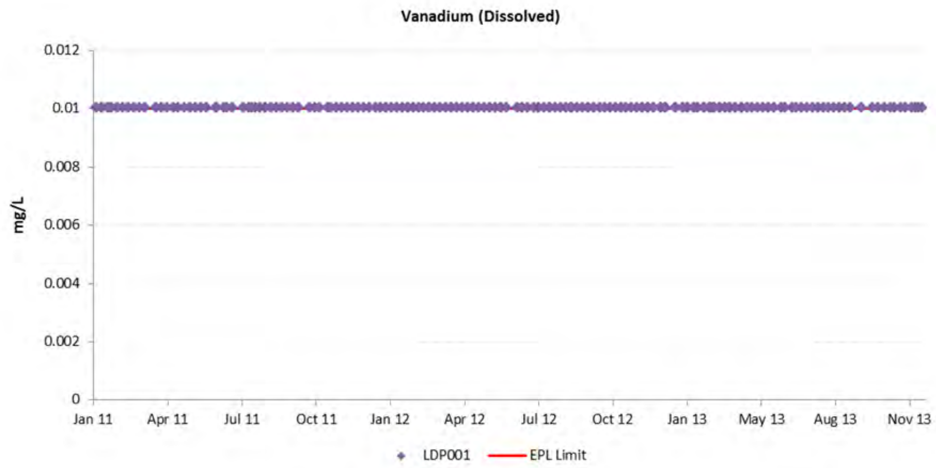

Silver (Total)
0.0025
0.002
0.0015
0.001
0.0005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

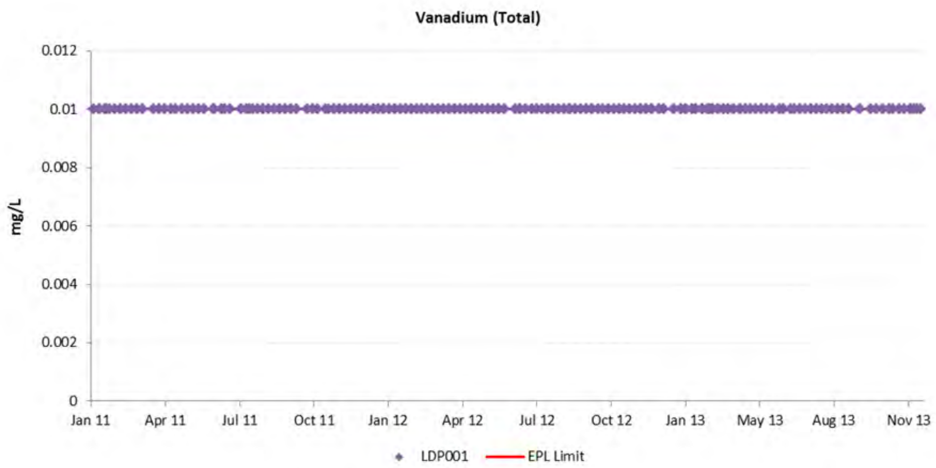

Tin (Dissolved)
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

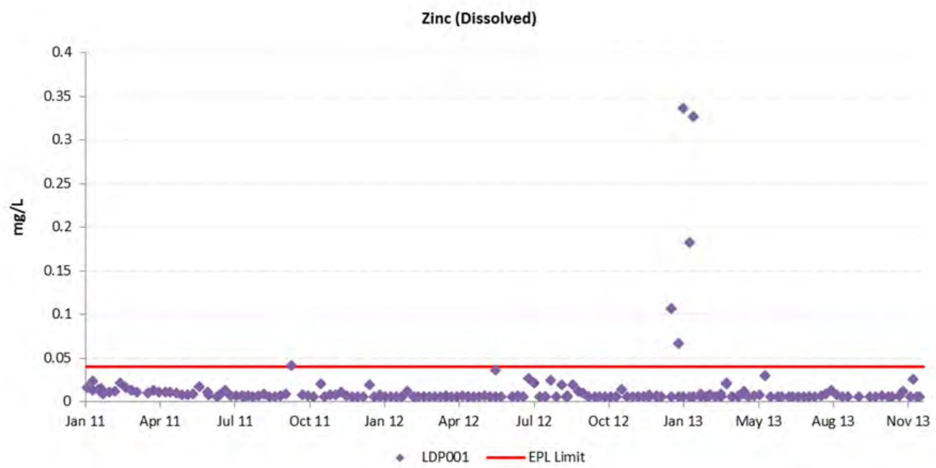

Tin (Total)
mg/L
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

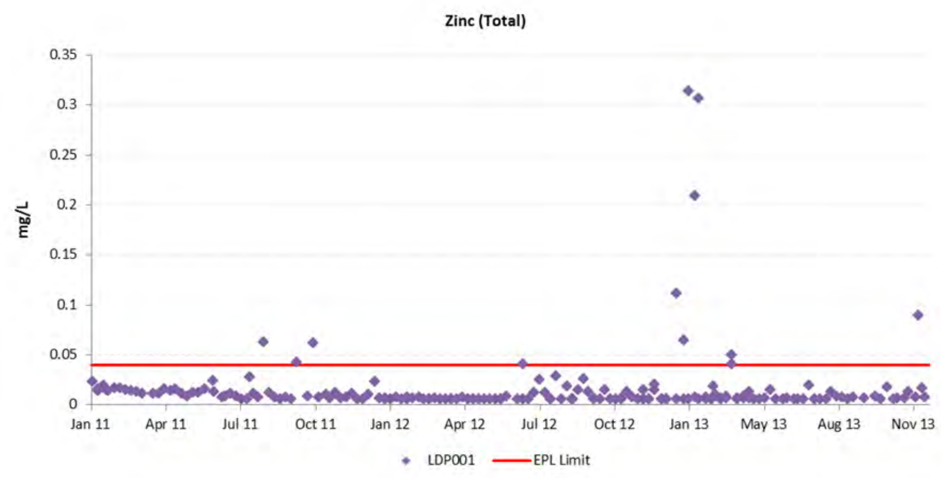

Titanium (Dissolved)
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit


Titanium (Total)
mg/L
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

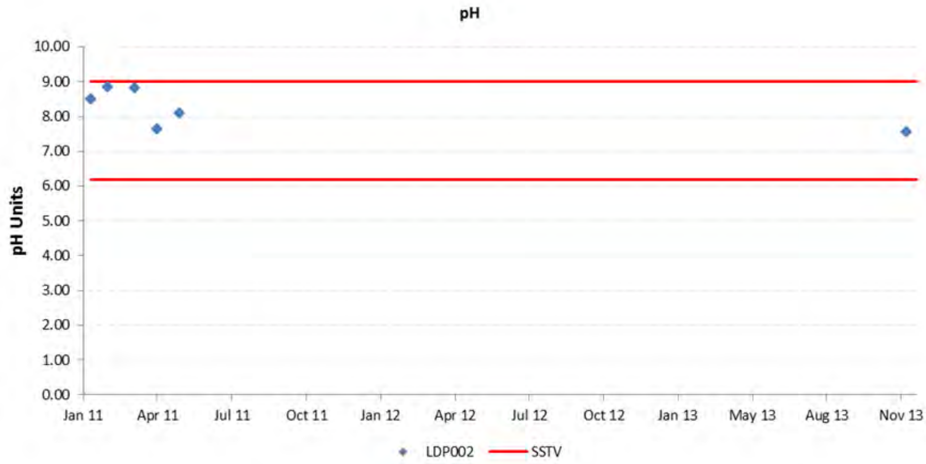

Vanadium (Dissolved)
0.012
0.01
0.008
0.006
0.004
0.002
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

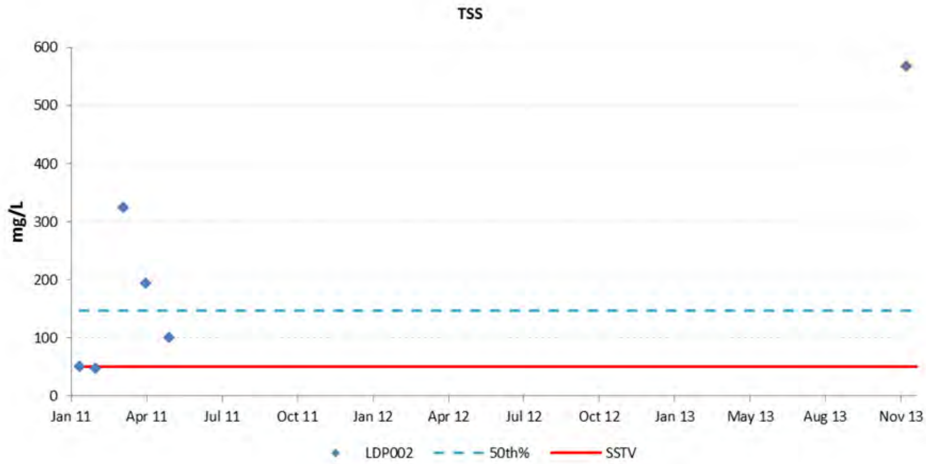

Vanadium (Total)
0.012
0.01
0.008
0.006
0.004
0.002
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

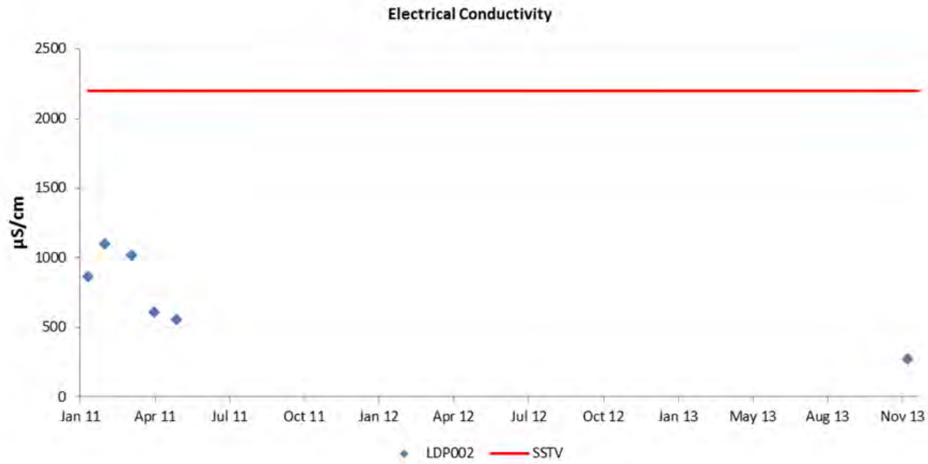

Zinc (Dissolved)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

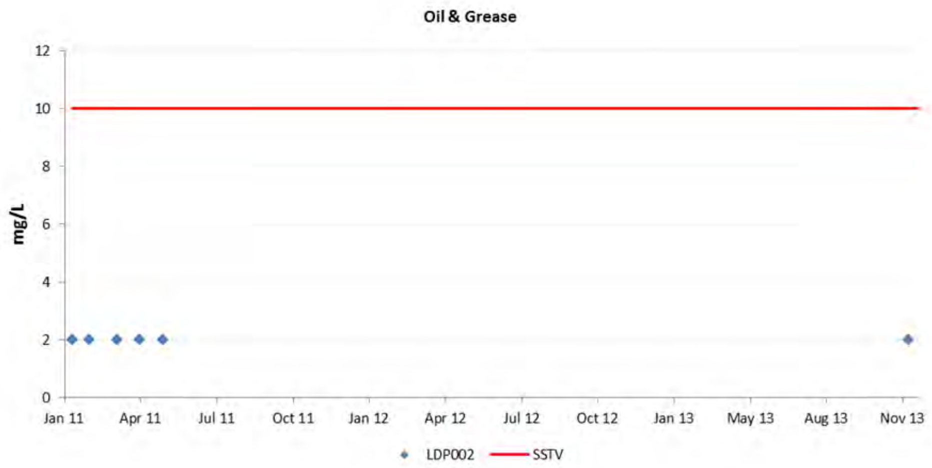

Zinc (Total)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
EPL Limit

LDP002

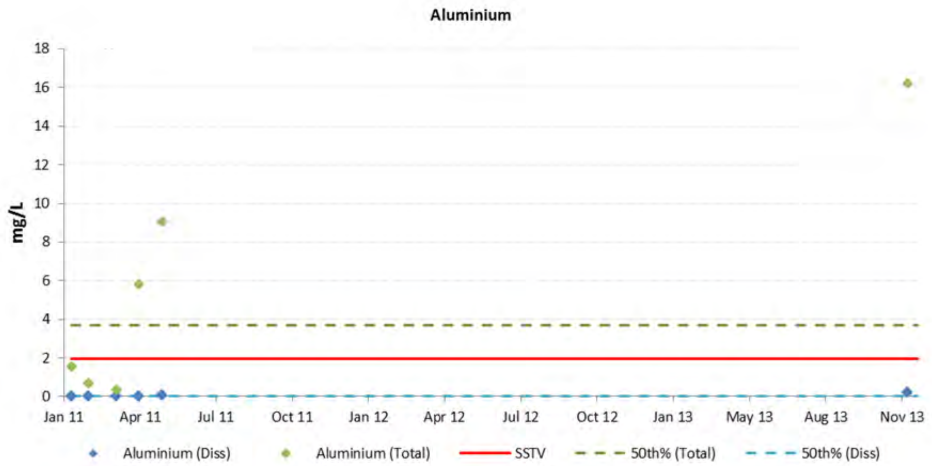

pH
pH Units
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP002
SSTV


TSS
mg/L
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP002
50th%
SSTV

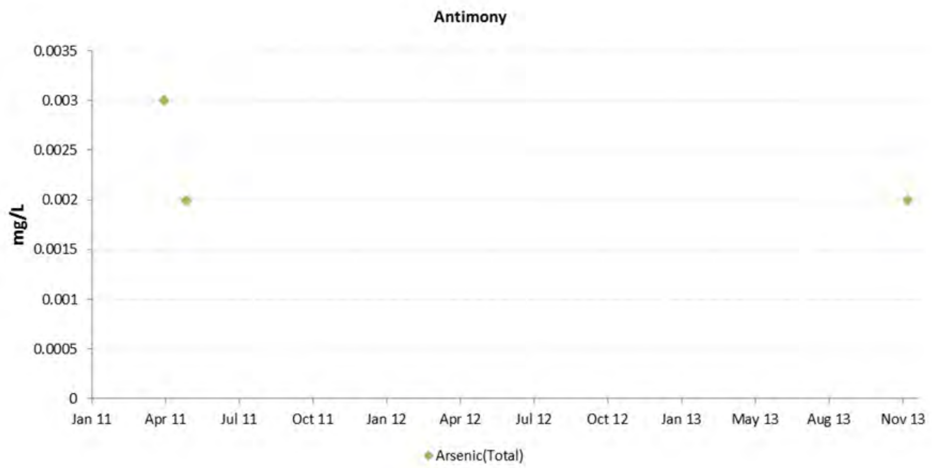

Electrical Conductivity
µS/cm
2500
2000
1500
1000
500
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP002
SSTV



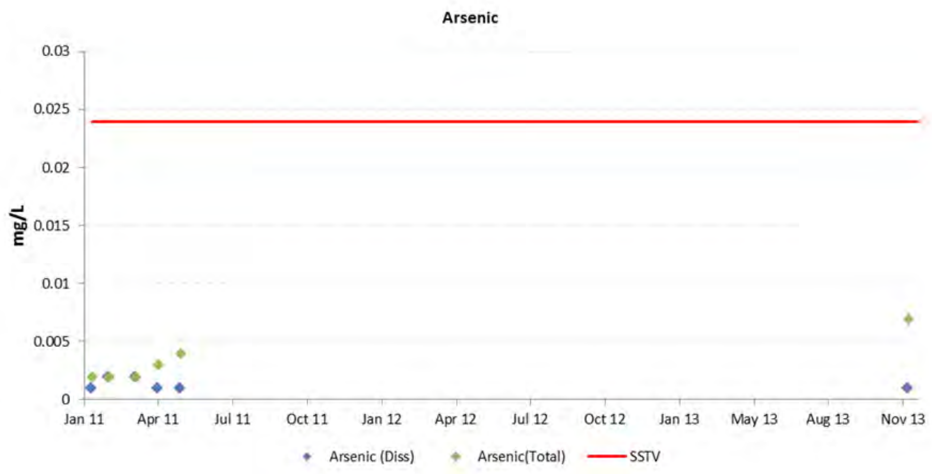
Oil & Grease
mg/L
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP002
SSTV

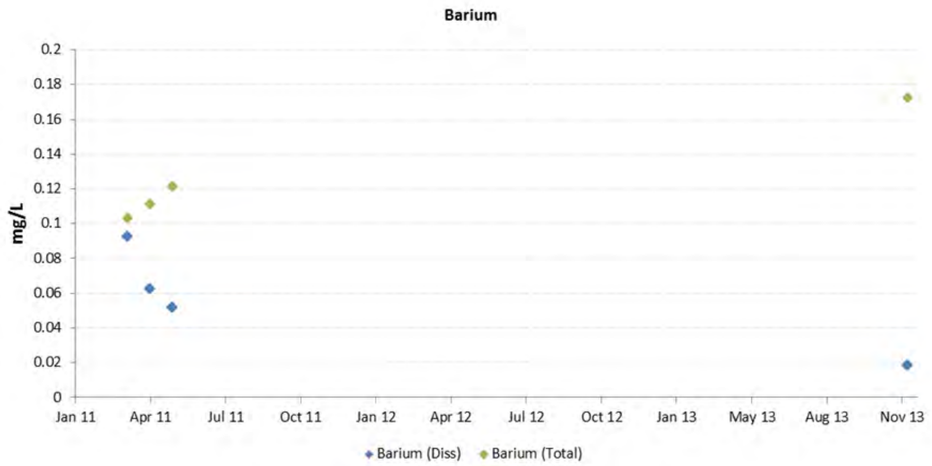


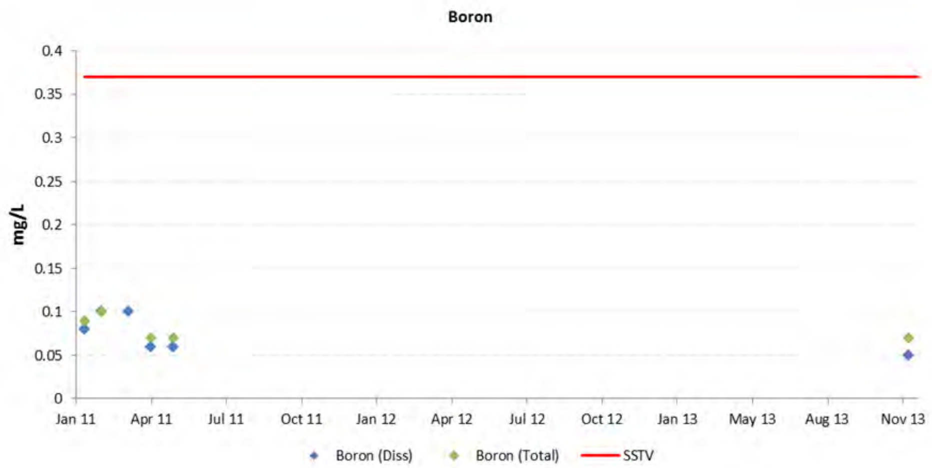
Aluminium
mg/L
18
16
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Aluminium (Diss)
Aluminium (Total)
SSTV
50th% (Total)
50th% (Diss)

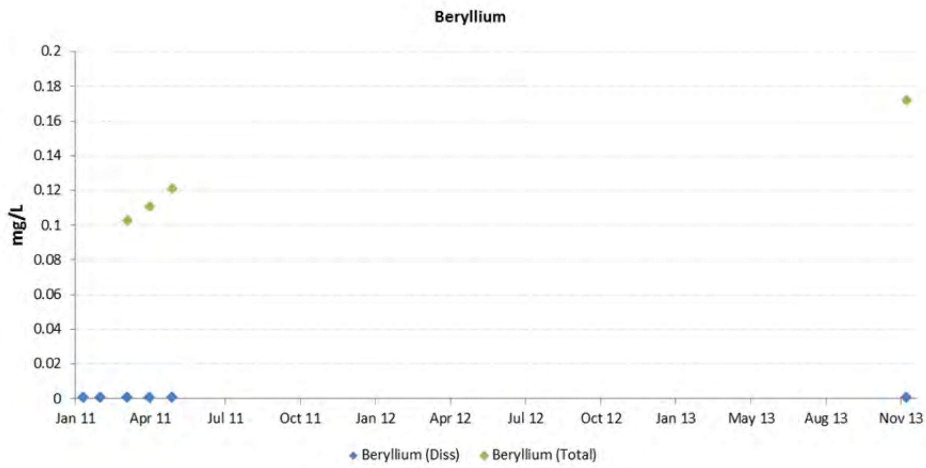


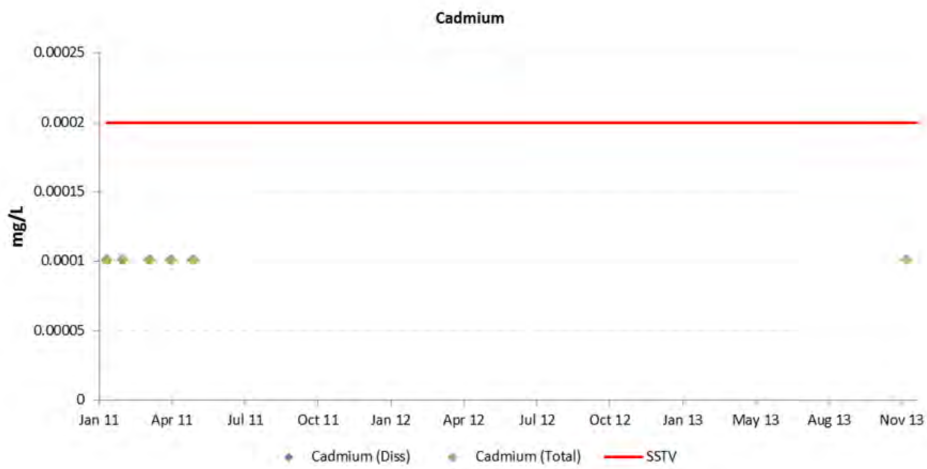
Antimony
mg/L
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Arsenic(Total)

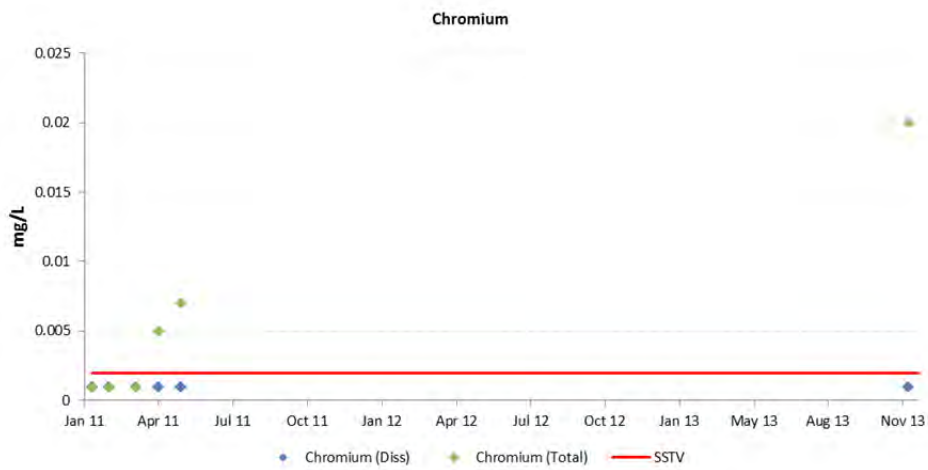

Arsenic
0.03
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Arsenic (Diss)
Arsenic(Total)
SSTV

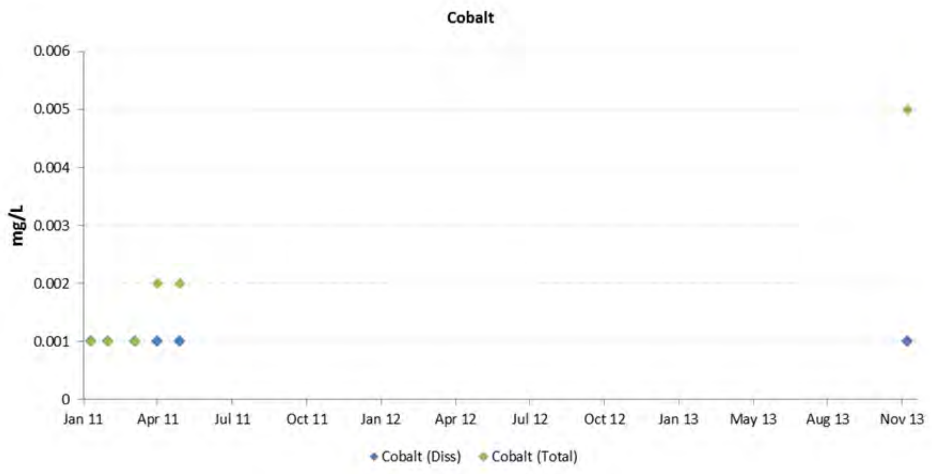

Barium
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Barium (Diss)
Barium (Total)

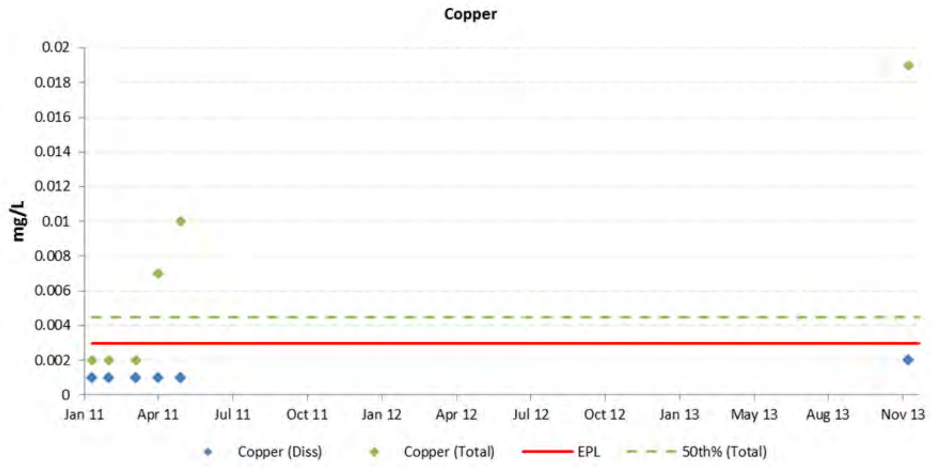

Boron
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Boron (Diss)
Boron (Total)
SSTV

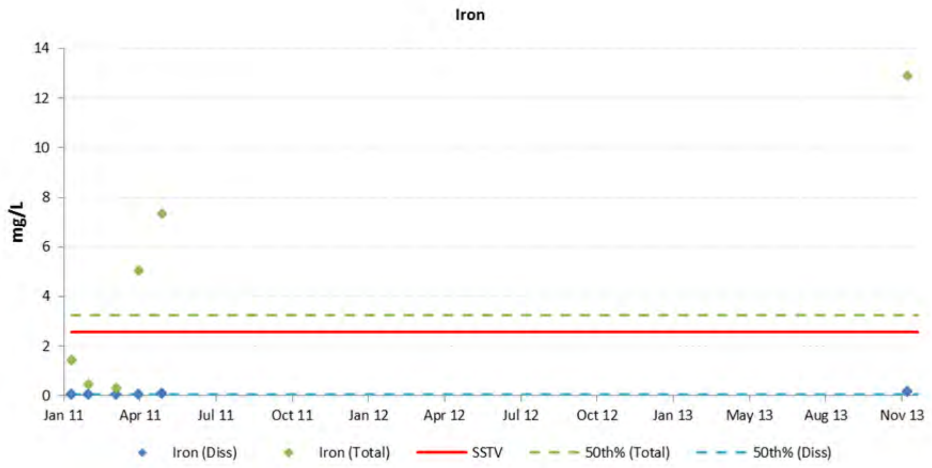

Beryllium
mg/L
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Beryllium (Diss)
Beryllium (Total)

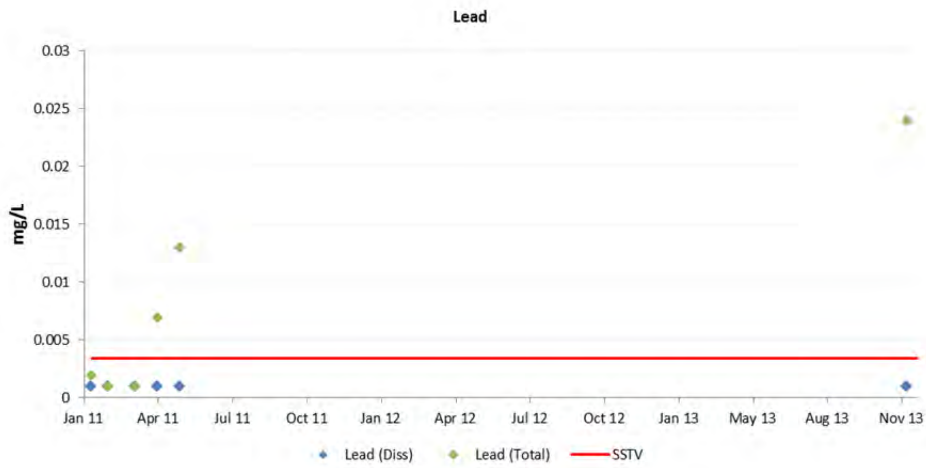

Cadmium
mg/L
0.00025
0.0002
0.00015
0.0001
0.00005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Cadmium (Diss)
Cadmium (Total)
SSTV


Chromium
mg/L
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Chromium (Diss)
Chromium (Total)
SSTV

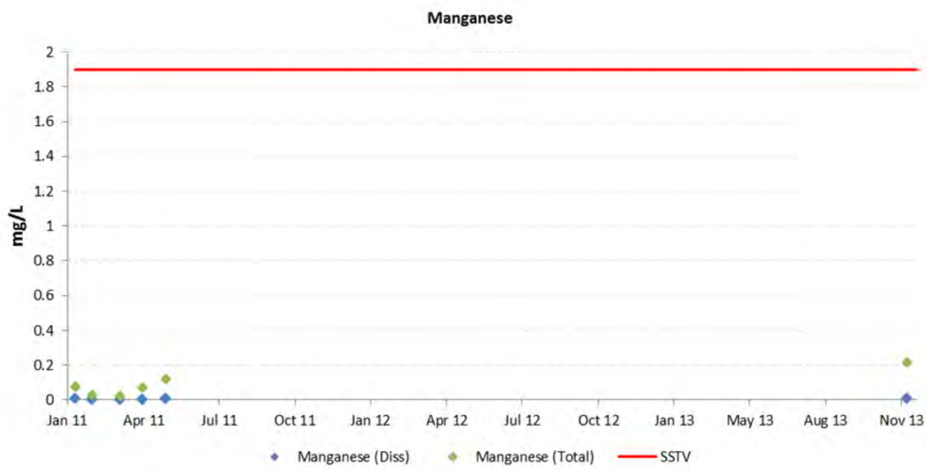

Cobalt
mg/L
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Cobalt (Diss)
Cobalt (Total)


Copper
mg/L
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Copper (Diss)
Copper (Total)
EPL
50th% (Total)

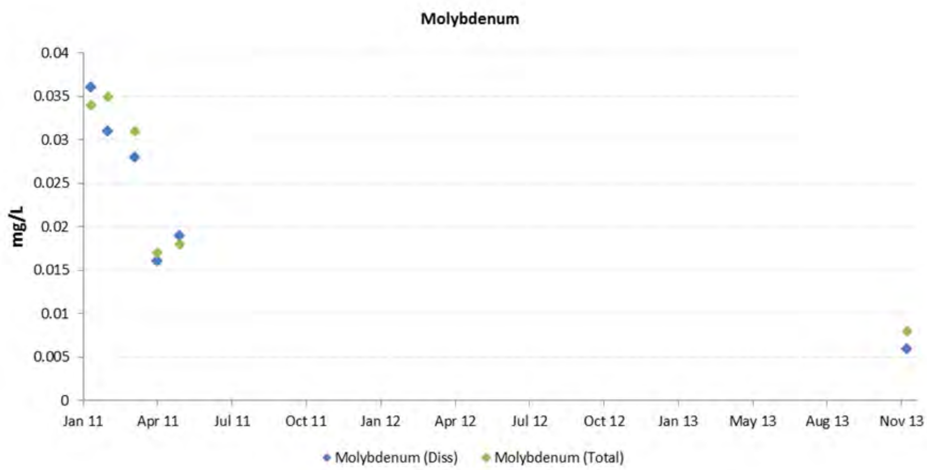

Iron
mg/L
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Iron (Diss)
Iron (Total)
SSTV
50th% (Total)
50th% (Diss)



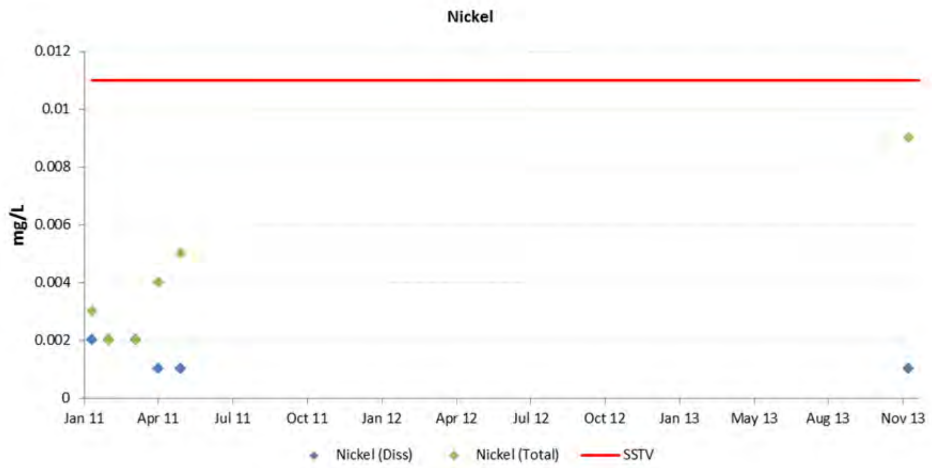
Lead
0.03
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Lead (Diss)
Lead (Total)
SSTV

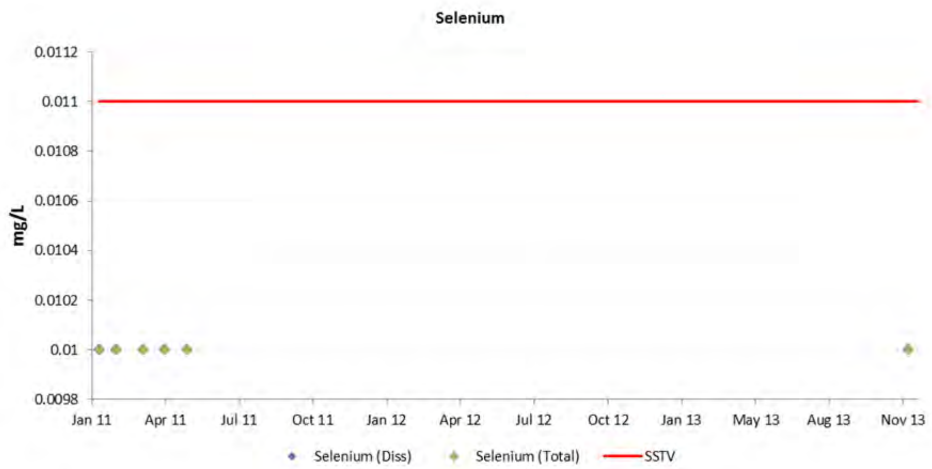


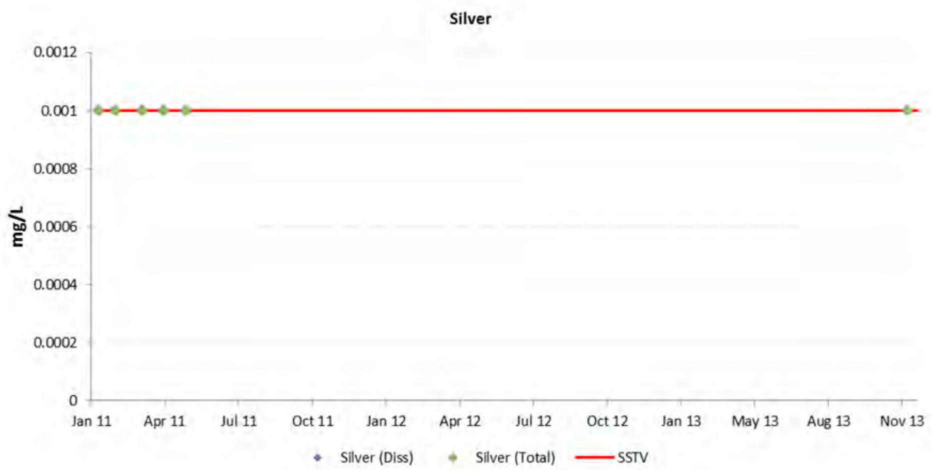
Manganese
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Manganese (Diss)
Manganese (Total)
SSTV

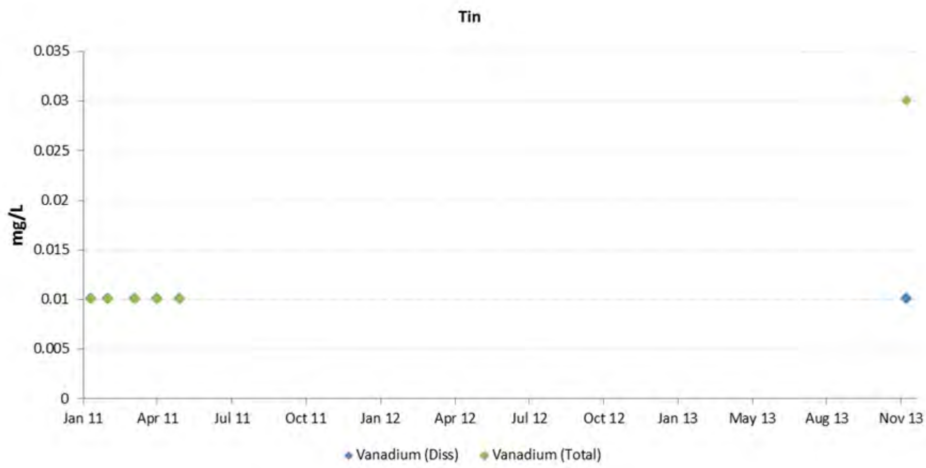


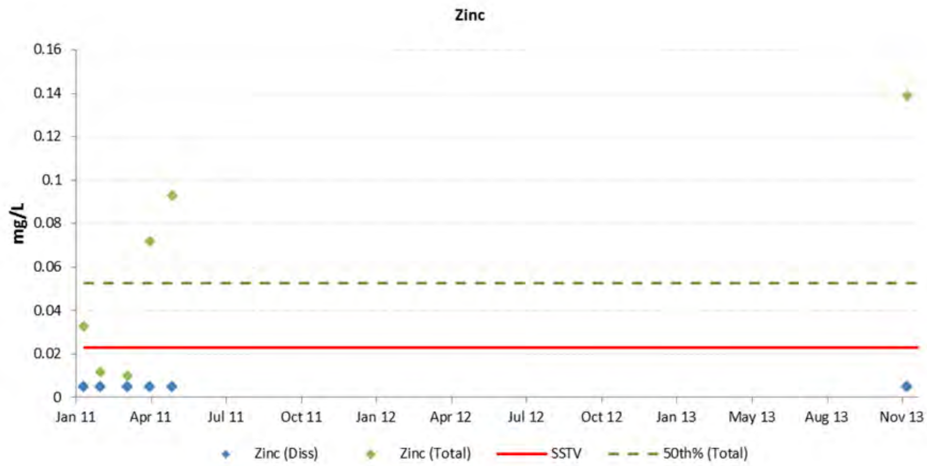
Molybdenum
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Molybdenum (Diss)
Molybdenum (Total)


Nickel
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Nickel (Diss)
Nickel (Total)
SSTV

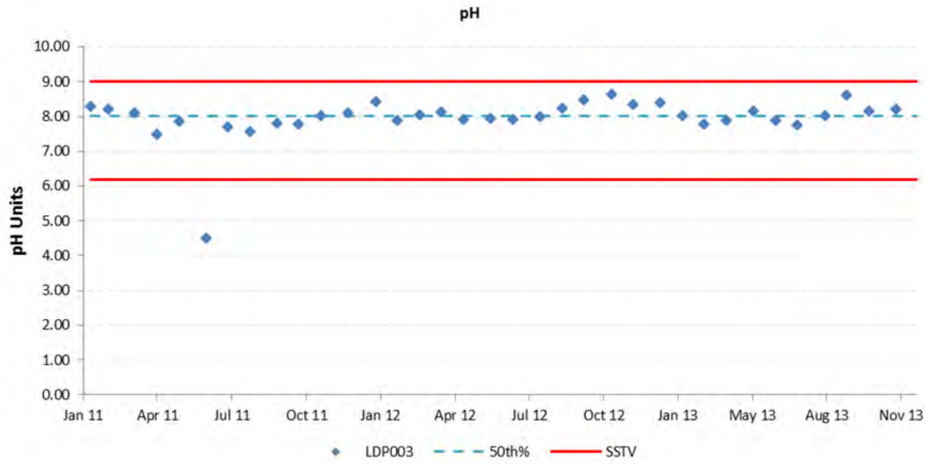

Selenium
mg/L
0.0112
0.011
0.0108
0.0106
0.0104
0.0102
0.01
0.0098
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Selenium (Diss)
Selenium (Total)
SSTV

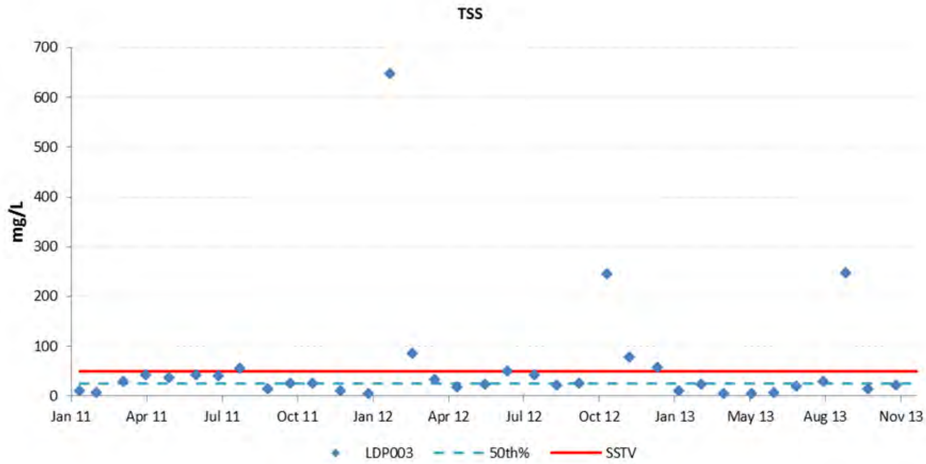

Silver
mg/L
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Silver (Diss)
Silver (Total)
SSTV

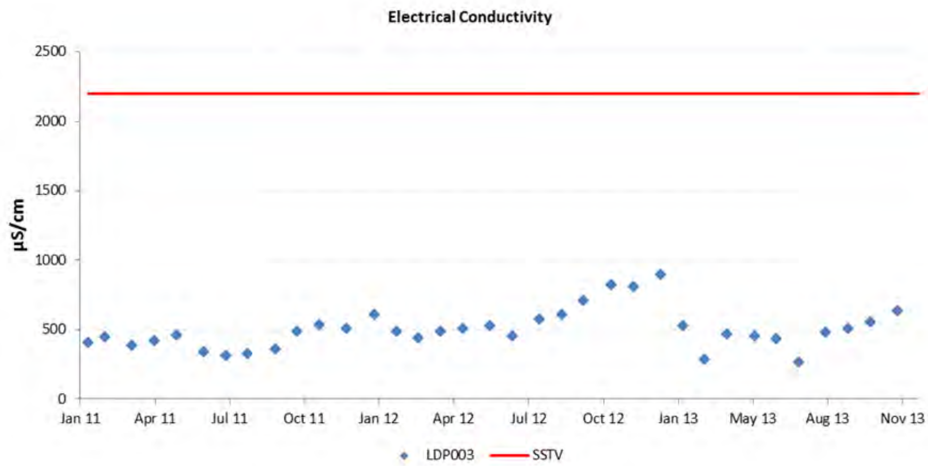

Tin
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Vanadium (Diss)
Vanadium (Total)

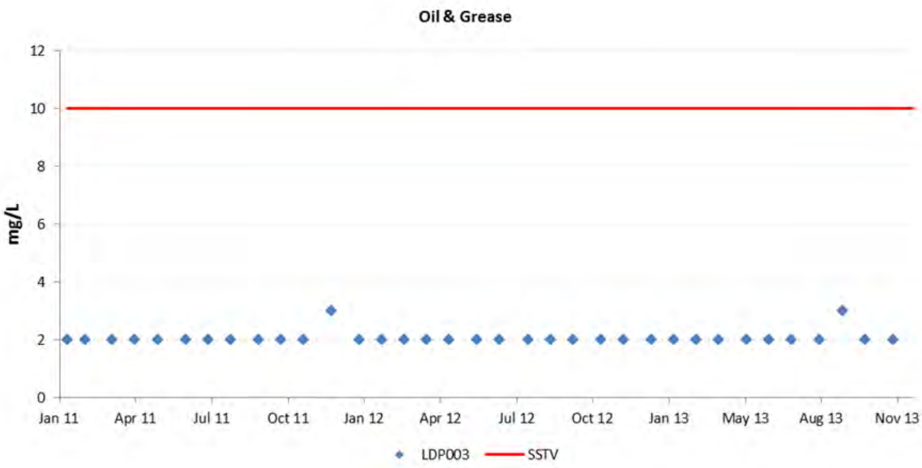

Zinc
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Zinc (Diss)
Zinc (Total)
SSTV
50th% (Total)

Proposed LDP003

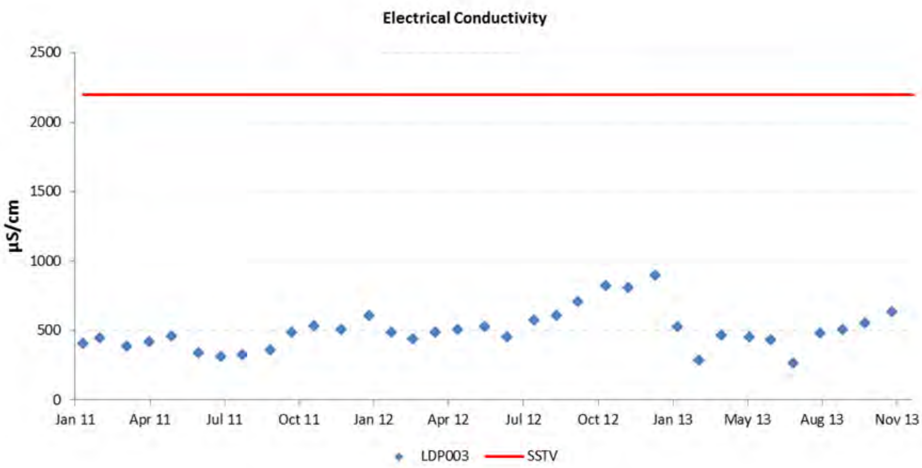




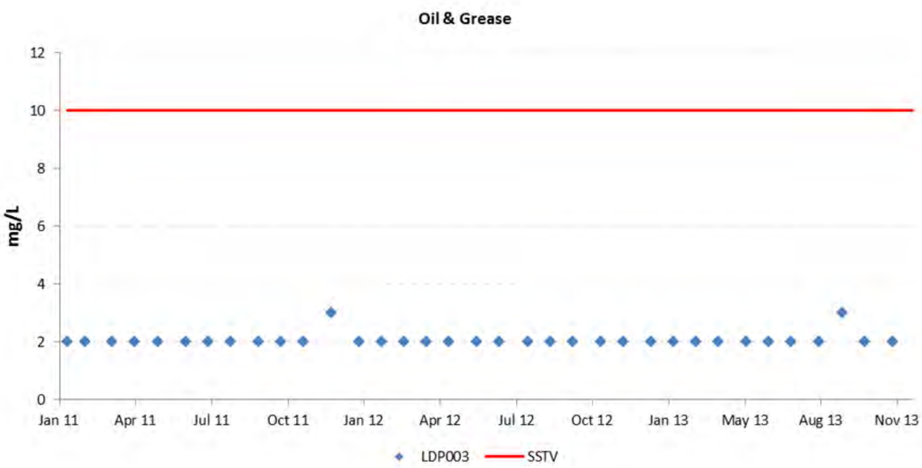




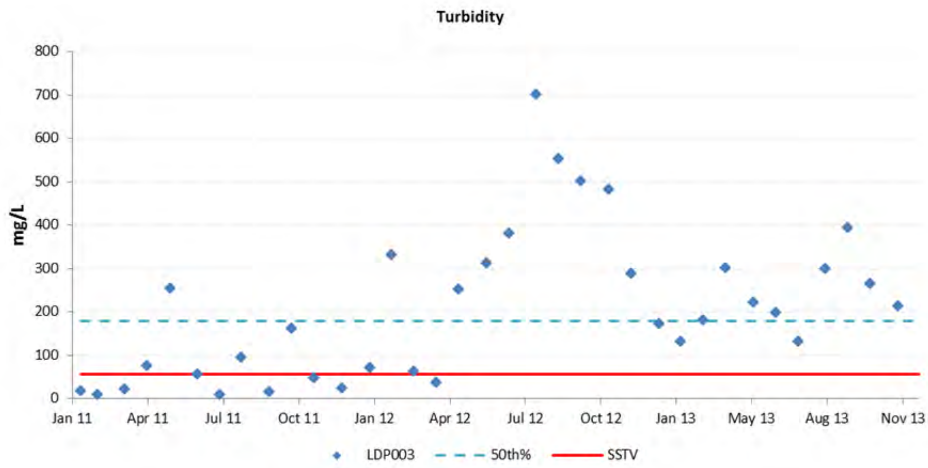
Oil & Grease
mg/L
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP003
SSTV

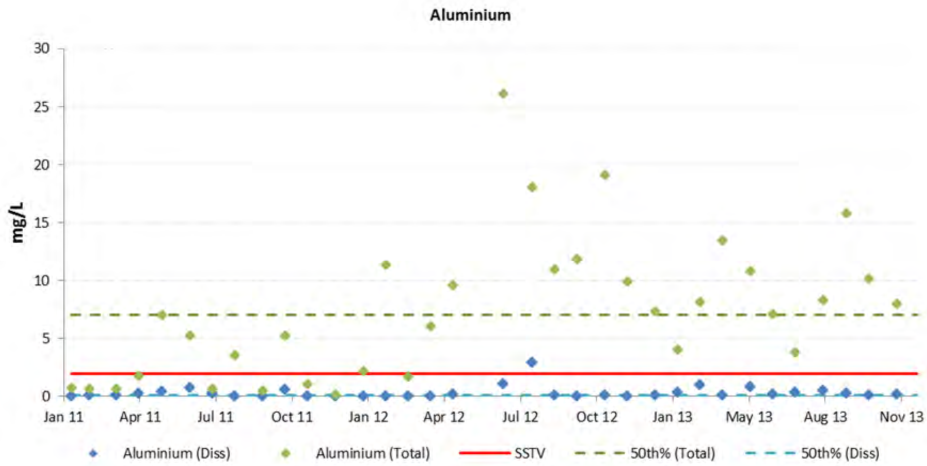


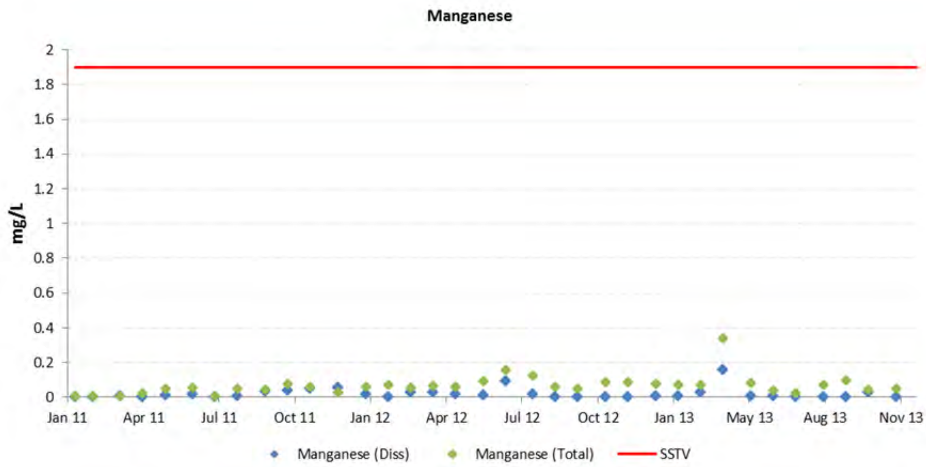
Electrical Conductivity
µS/cm
2500
2000
1500
1000
500
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP003
SSTV

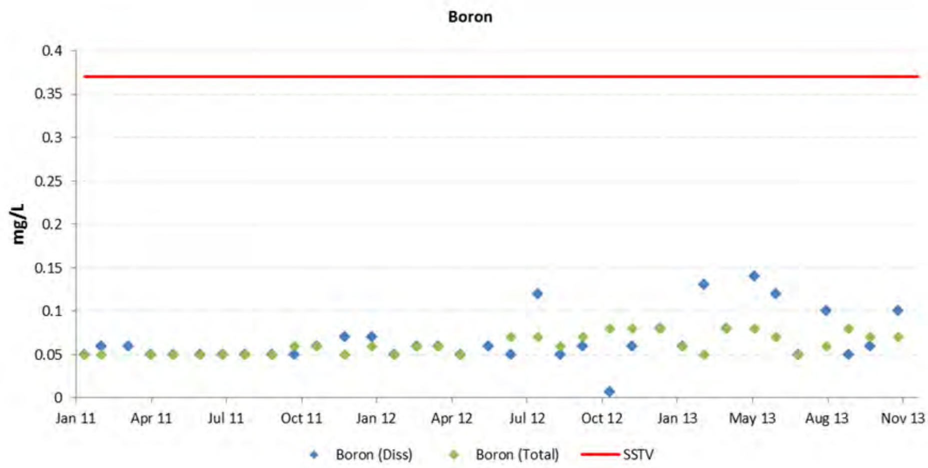


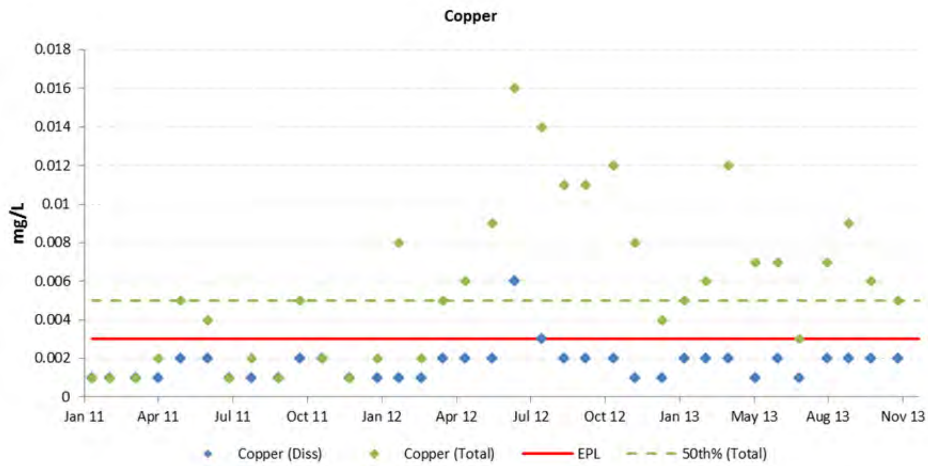
Oil & Grease
mg/L
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP003
SSTV

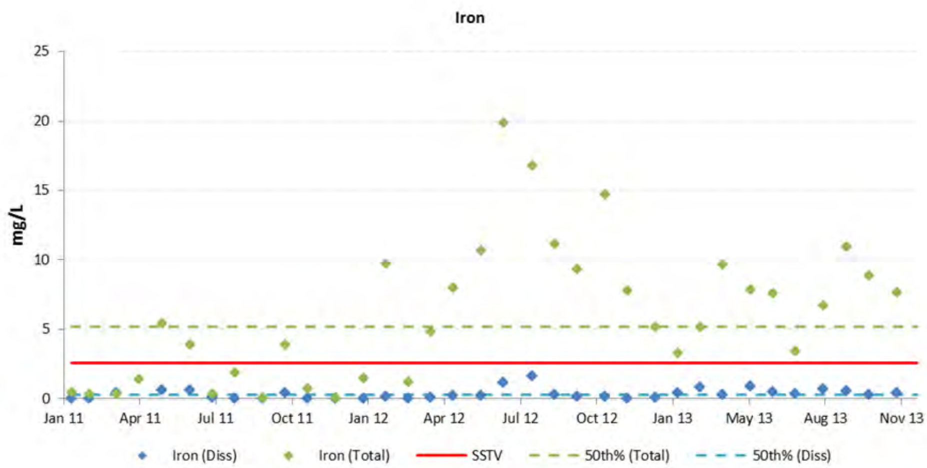

Turbidity
mg/L
800
700
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP003
50th%
SSTV

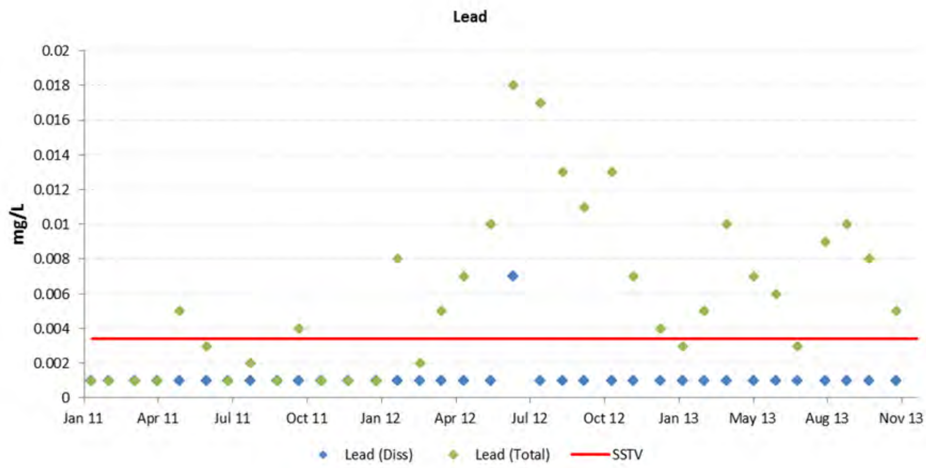

Aluminium
mg/L
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Aluminium (Diss)
Aluminium (Total)
SSTV
50th% (Total)
50th% (Diss)

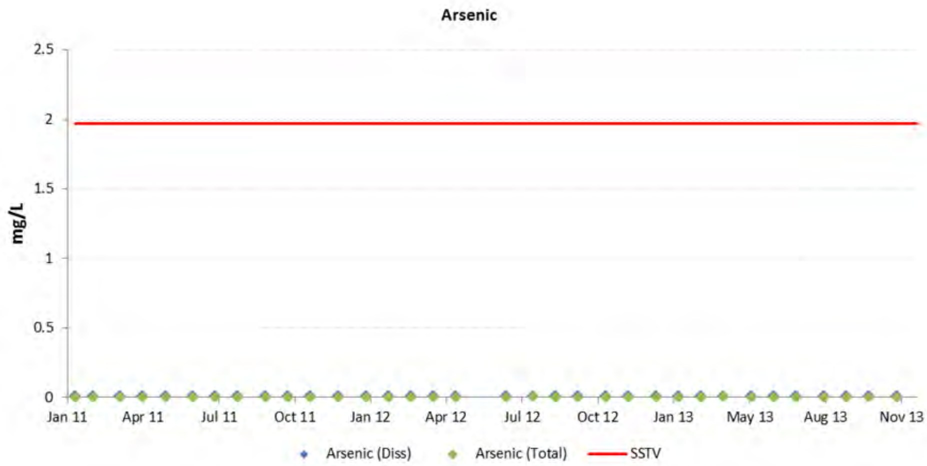

Manganese
mg/L
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Manganese (Diss)
Manganese (Total)
SSTV

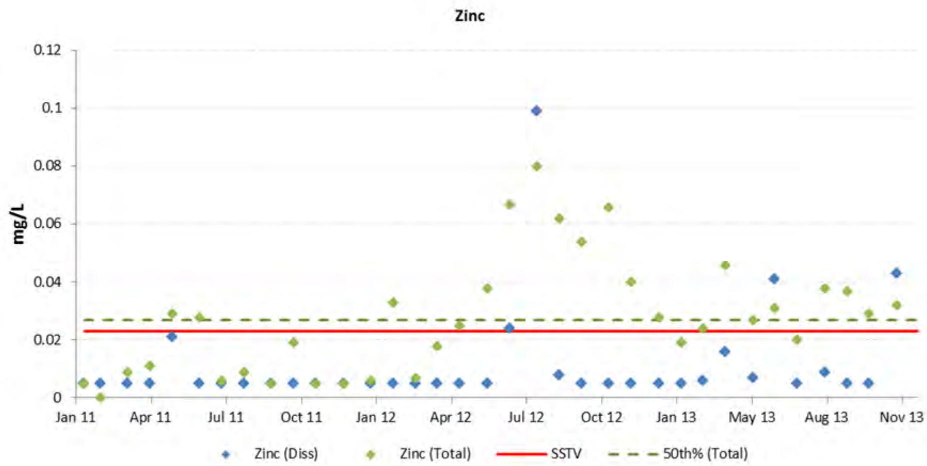

Boron
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Boron (Diss)
Boron (Total)
SSTV

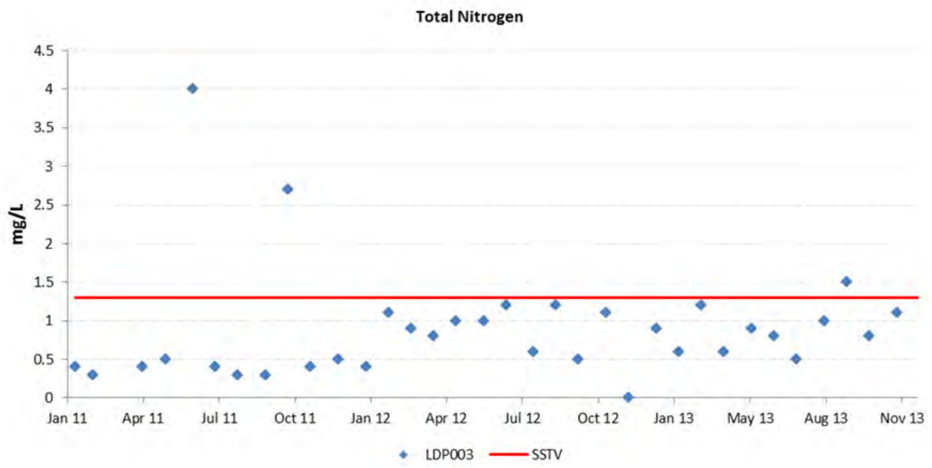

Copper
mg/L
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Copper (Diss)
Copper (Total)
EPL
50th% (Total)

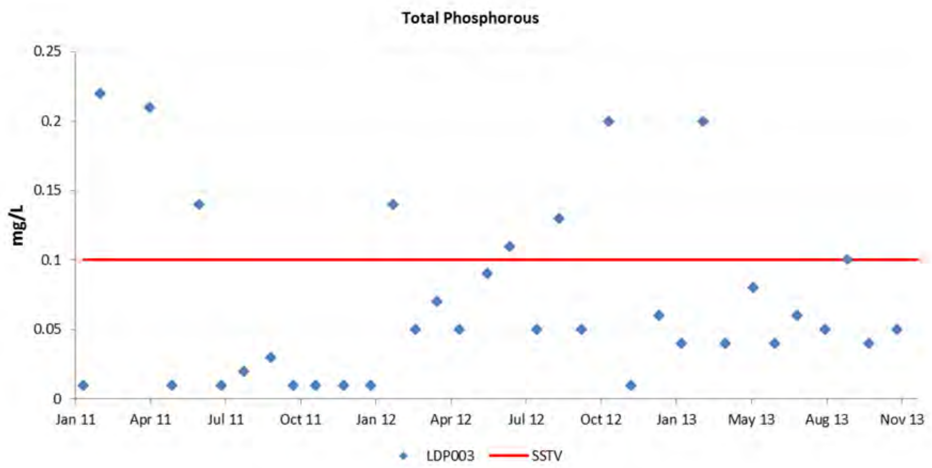

Iron
mg/L
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Iron (Diss)
Iron (Total)
SSTV
50th% (Total)
50th% (Diss)


Lead
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Lead (Diss)
Lead (Total)
SSTV

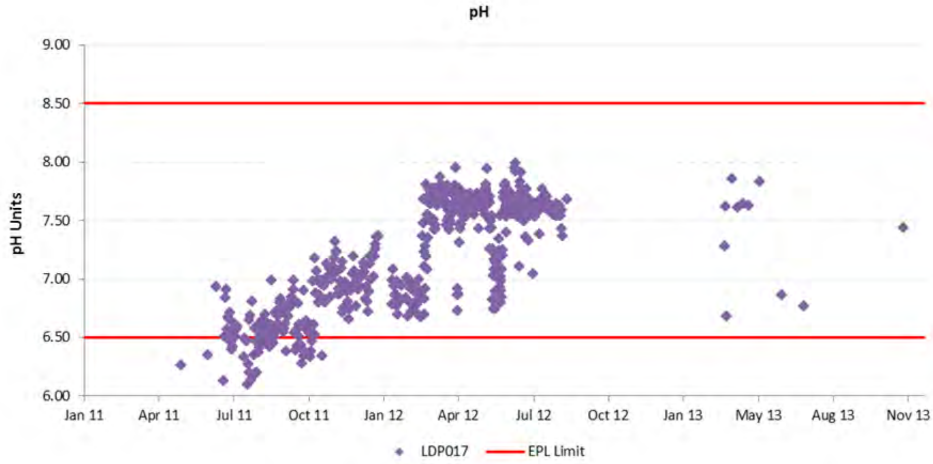

Arsenic
2.5
2
1.5
1
0.5
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Arsenic (Diss)
Arsenic (Total)
SSTV


Zinc
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
Zinc (Diss)
Zinc (Total)
SSTV
50th% (Total)

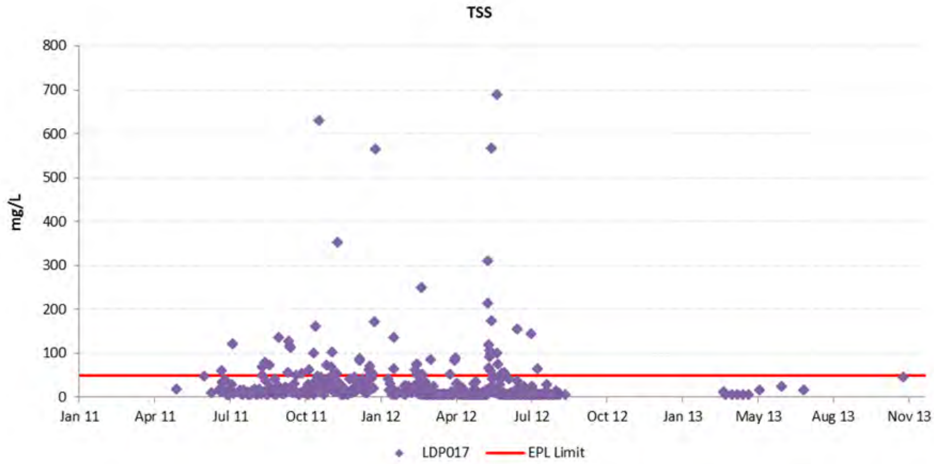

Total Nitrogen
mg/L
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP003
SSTV


Total Phosphorous
mg/L
0
0.05
0.1
0.15
0.2
0.25
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP003
SSTV

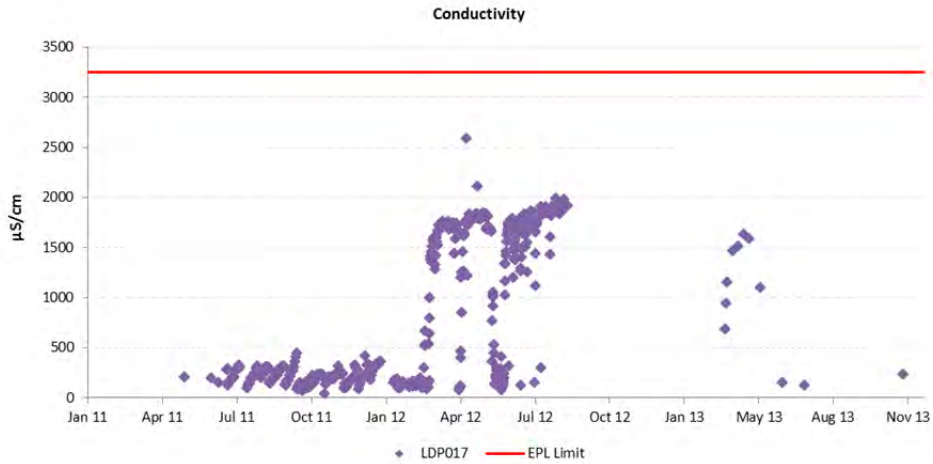
LDP017



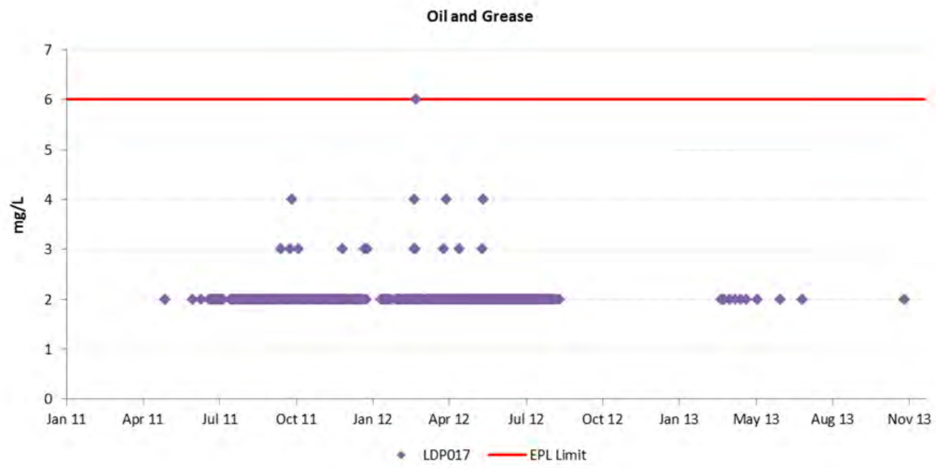
pH
pH Units
9.00
8.50
8.00
7.50
7.00
6.50
6.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

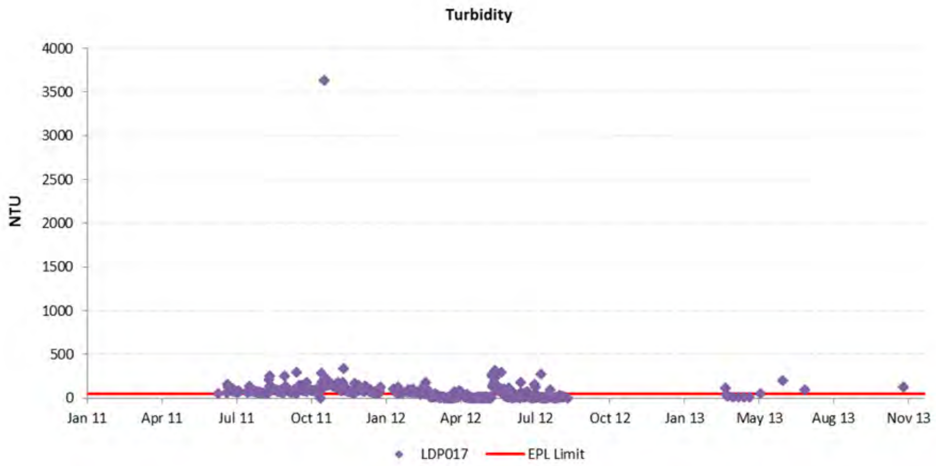


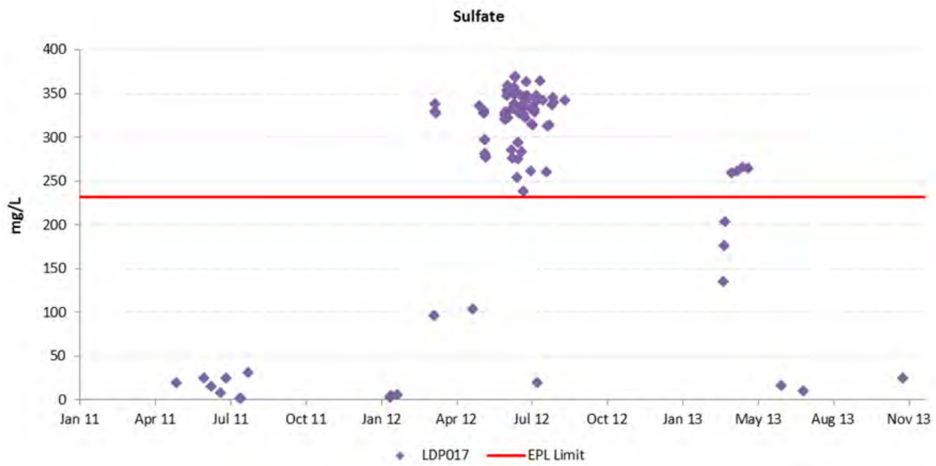
TSS
mg/L
800
700
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

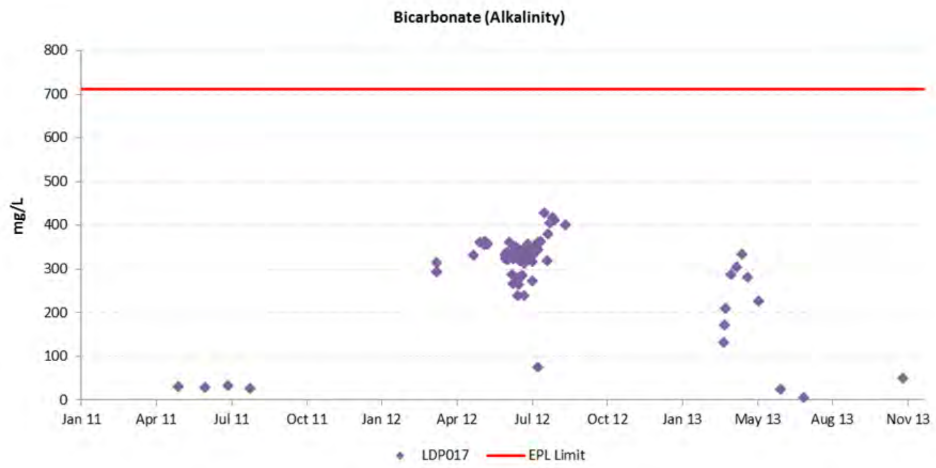


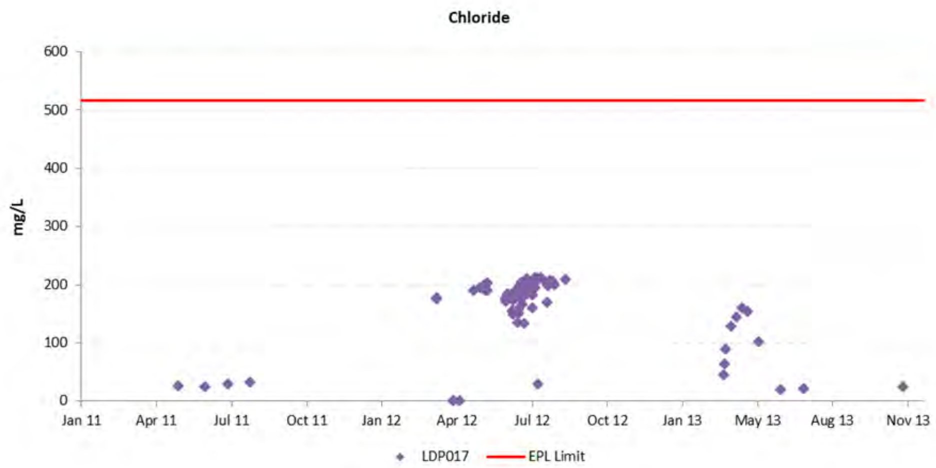
Conductivity
µS/cm
3500
3000
2500
2000
1500
1000
500
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

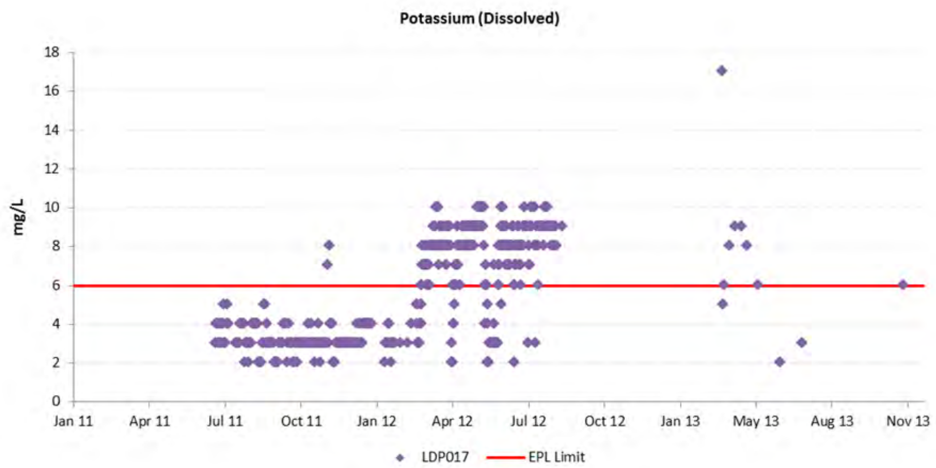

Oil and Grease
mg/L
7
6
5
4
3
2
1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

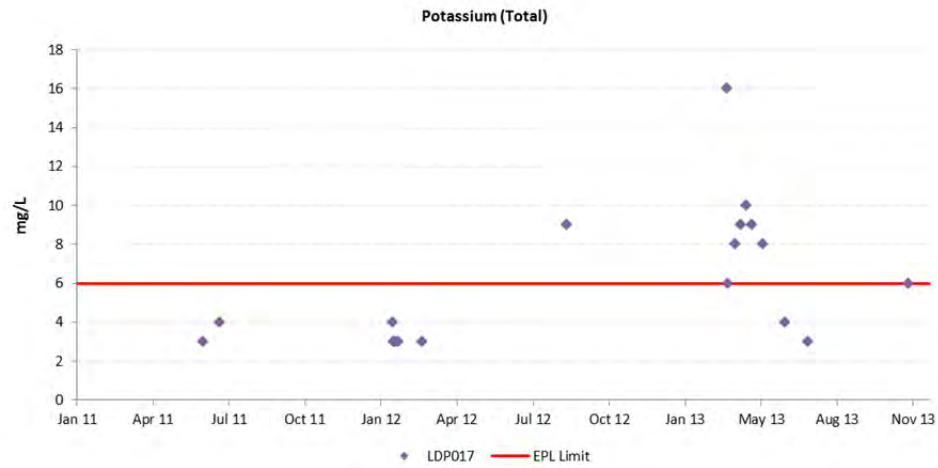

Turbidity
NTU
4000
3500
3000
2500
2000
1500
1000
500
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

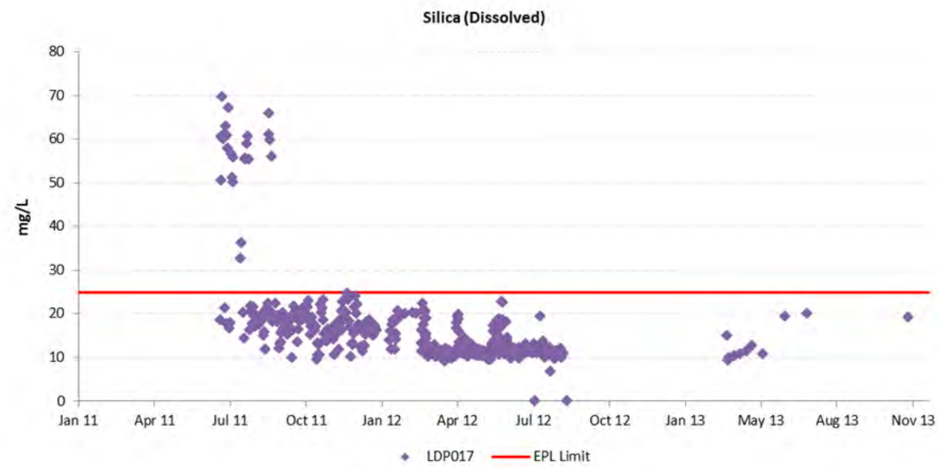

Sulfate
mg/L
400
350
300
250
200
150
100
50
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

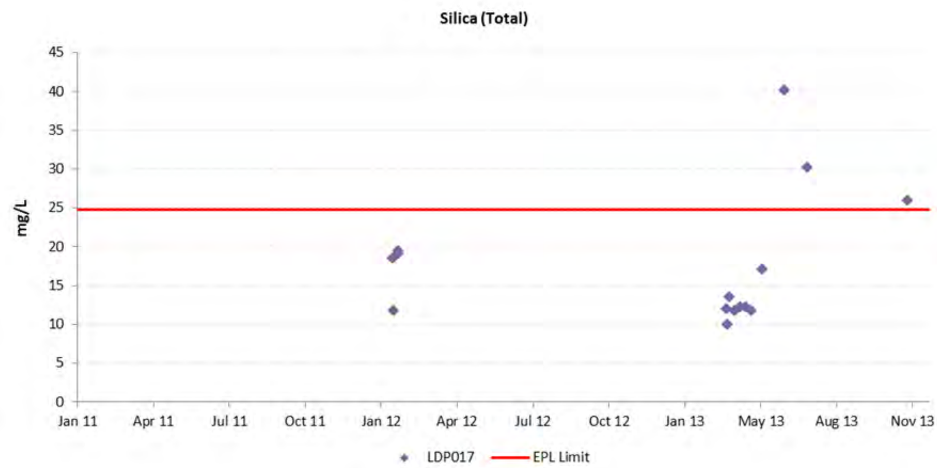

Bicarbonate (Alkalinity)
mg/L
800
700
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

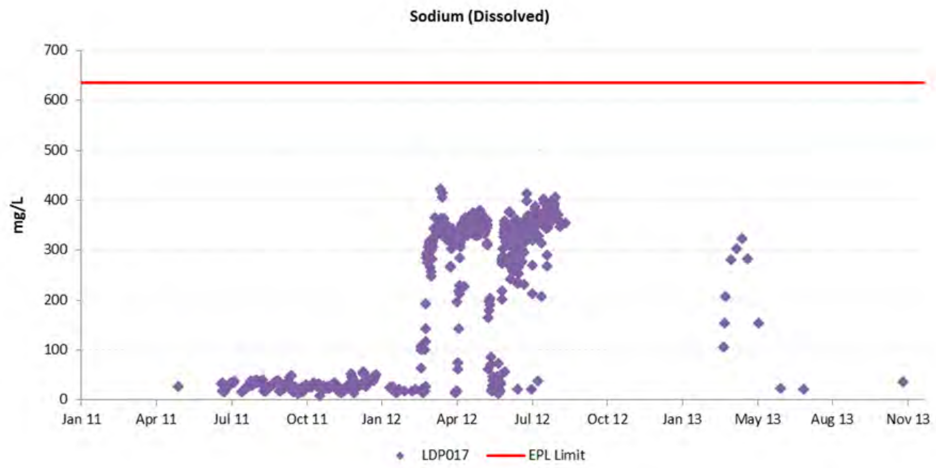

Chloride
mg/L
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

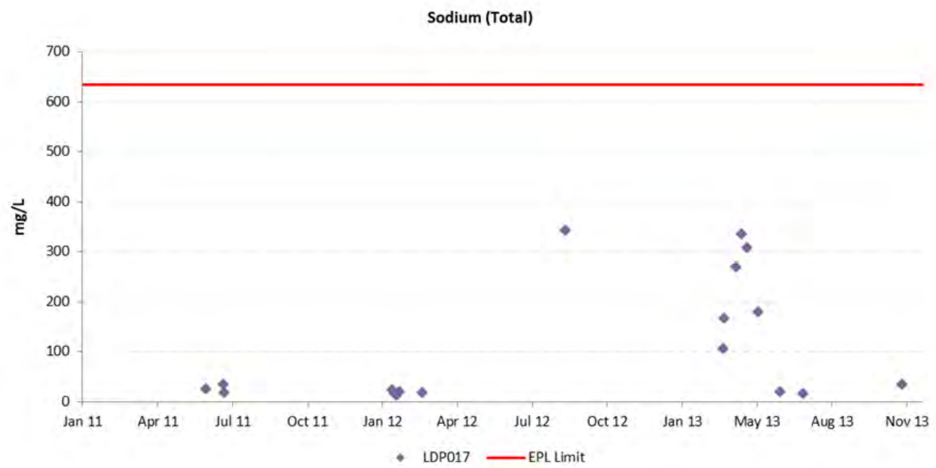

Potassium (Dissolved)
mg/L
18
16
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

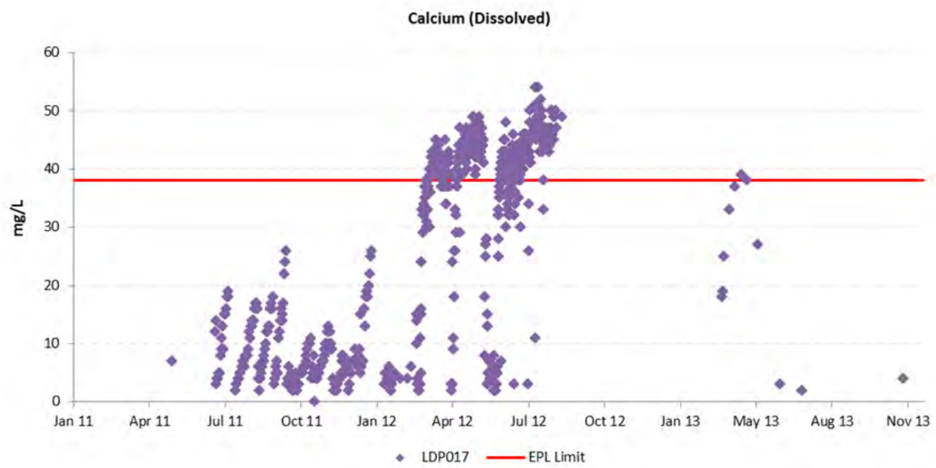

Potassium (Total)
18
16
14
12
10
8
6
4
2
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

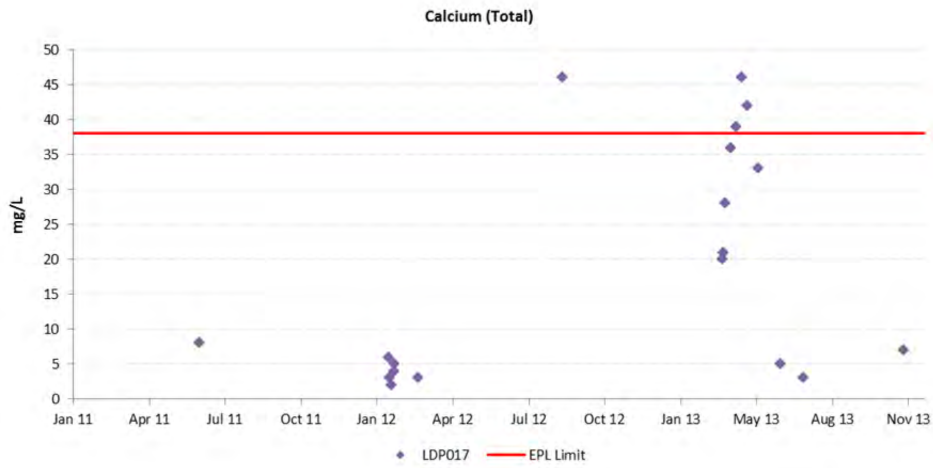

Silica (Dissolved)
80
70
60
50
40
30
20
10
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

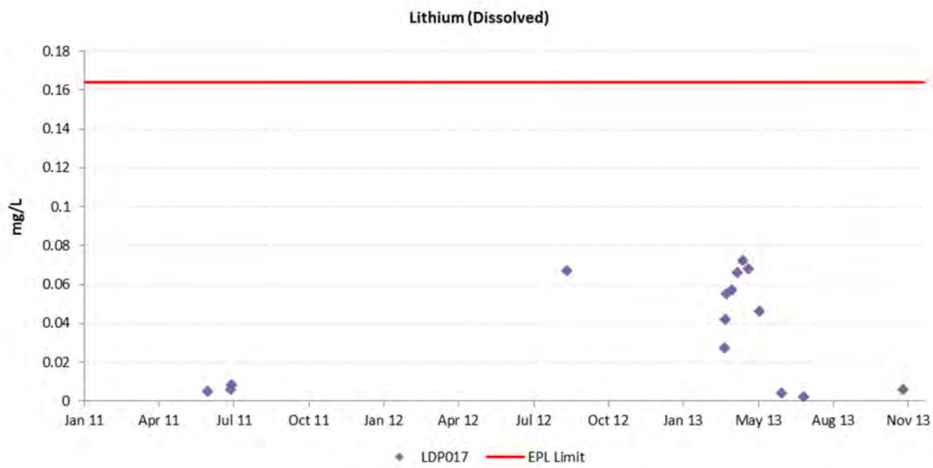

Silica (Total)
45
40
35
30
25
20
15
10
5
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

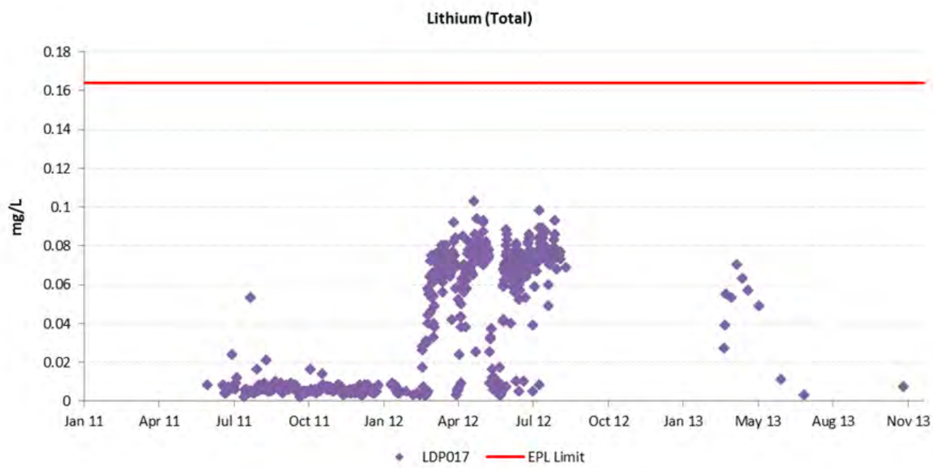

Sodium (Dissolved)
700
600
500
400
300
200
100
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

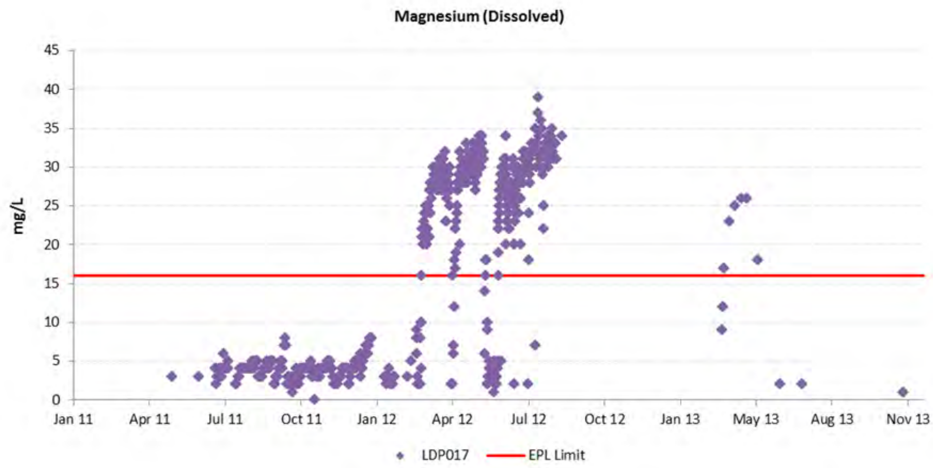

Sodium (Total)
700
600
500
400
300
200
100
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

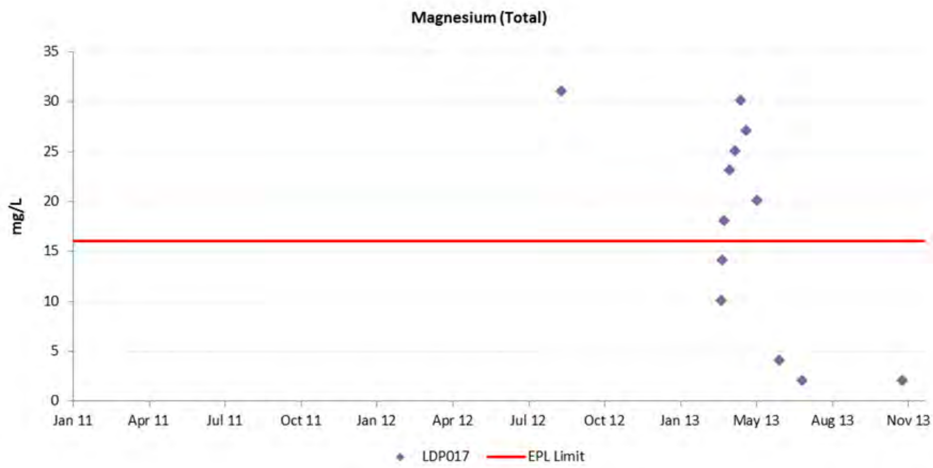

Calcium (Dissolved)
60
50
40
30
20
10
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

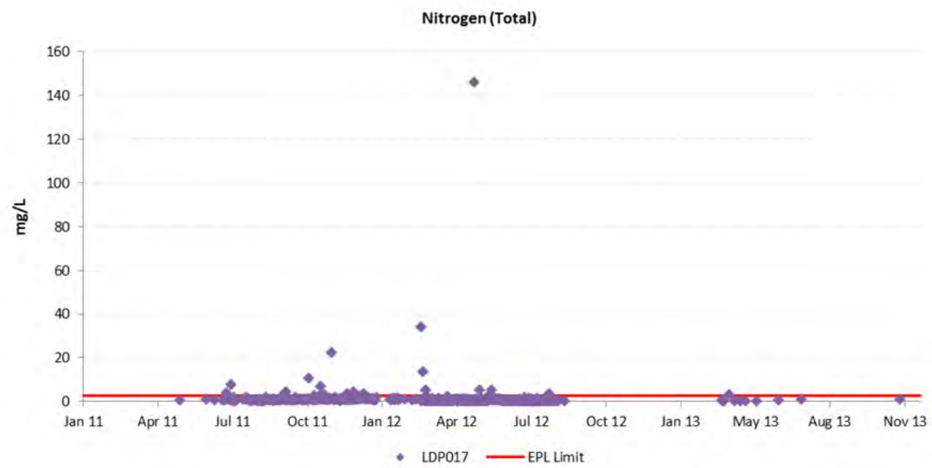

Calcium (Total)
mg/L
0
5
10
15
20
25
30
35
40
45
50
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

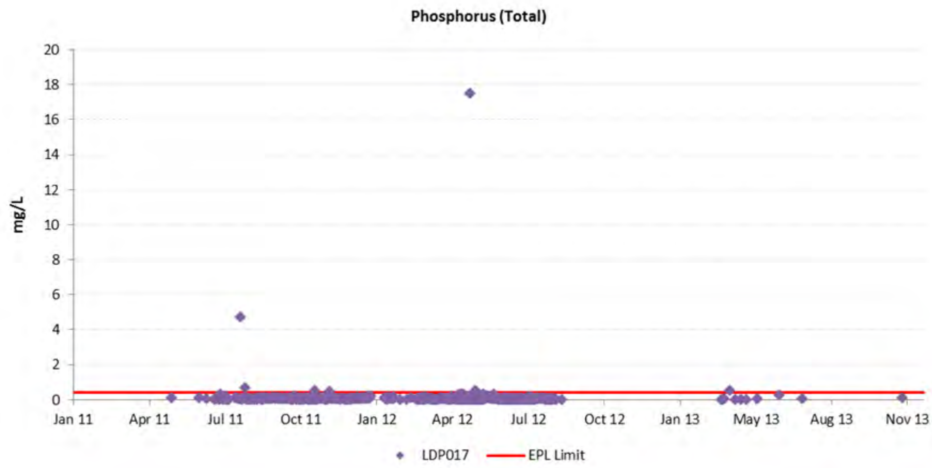

Lithium (Dissolved)
mg/L
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

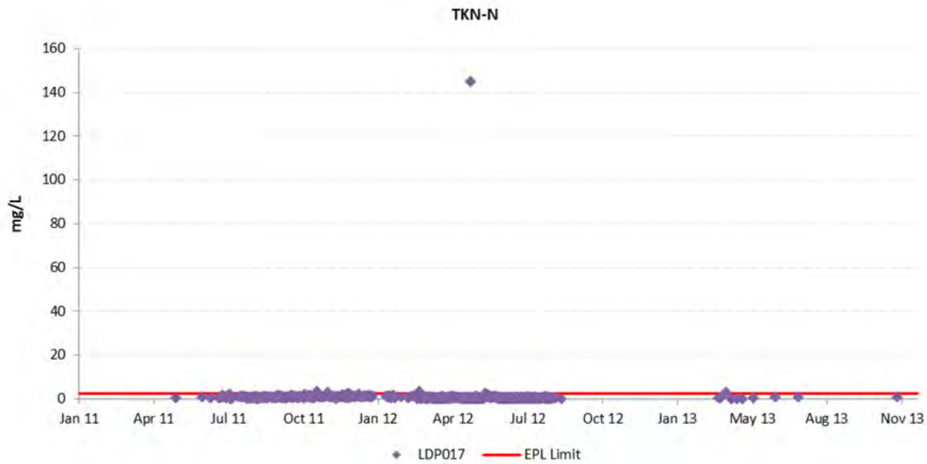

Lithium (Total)
mg/L
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

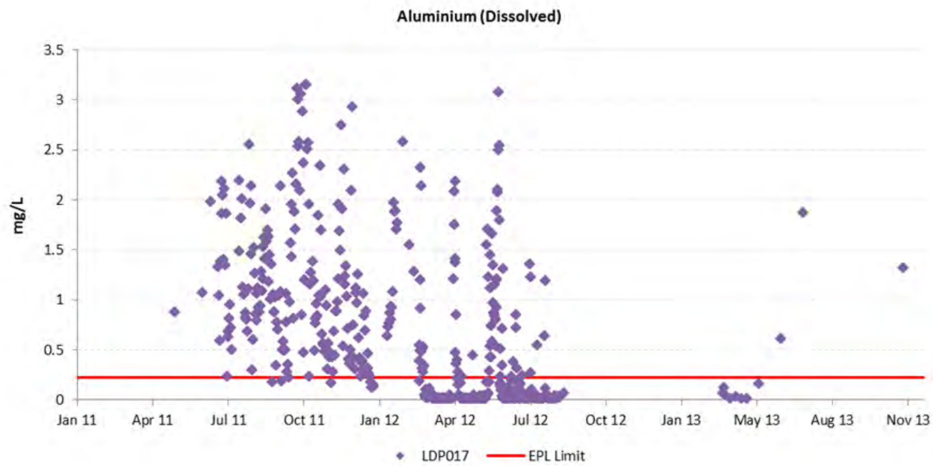

Magnesium (Dissolved)
mg/L
45
40
35
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

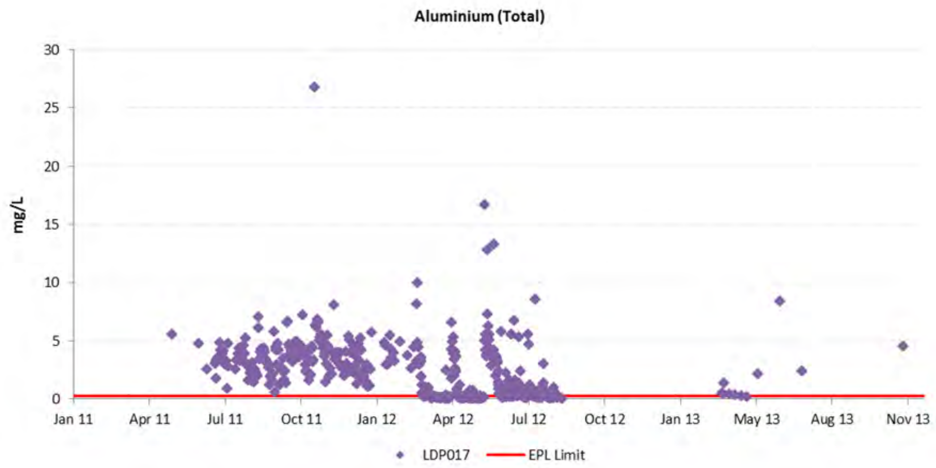

Magnesium (Total)
mg/L
35
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

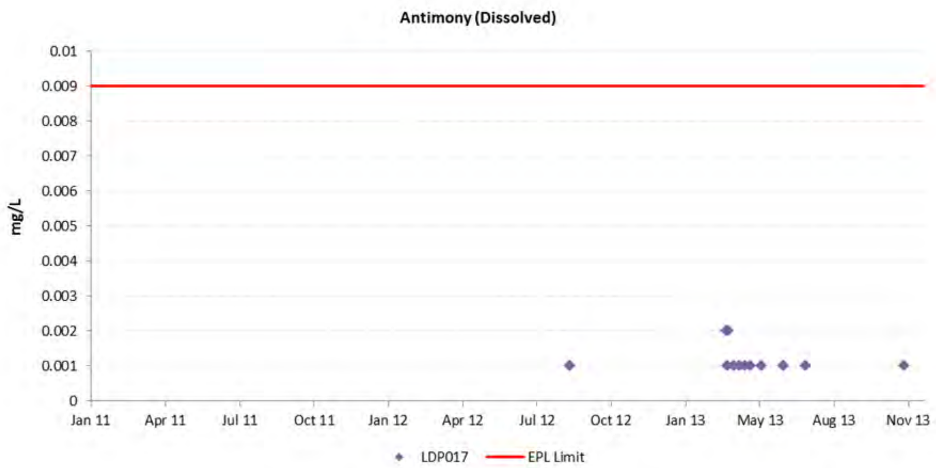

Nitrogen (Total)
mg/L
160
140
120
100
80
60
40
20
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

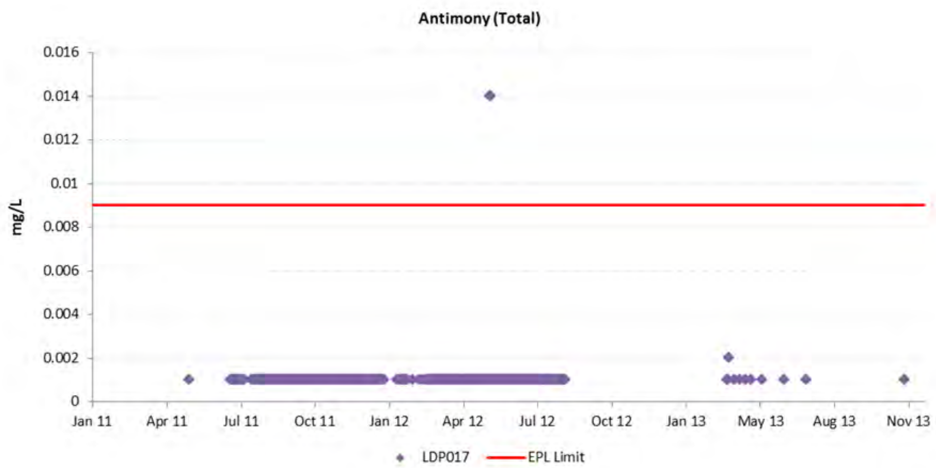

Phosphorus (Total)
mg/L
20
18
16
14
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

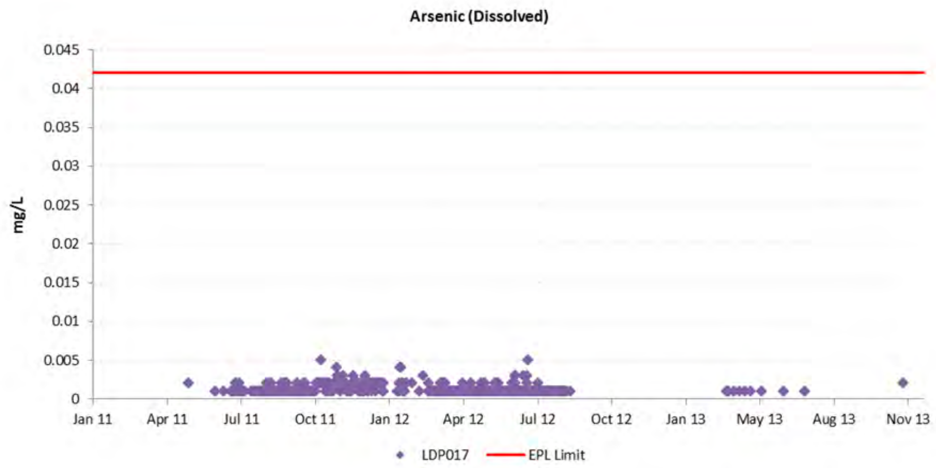

TKN-N
mg/L
160
140
120
100
80
60
40
20
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

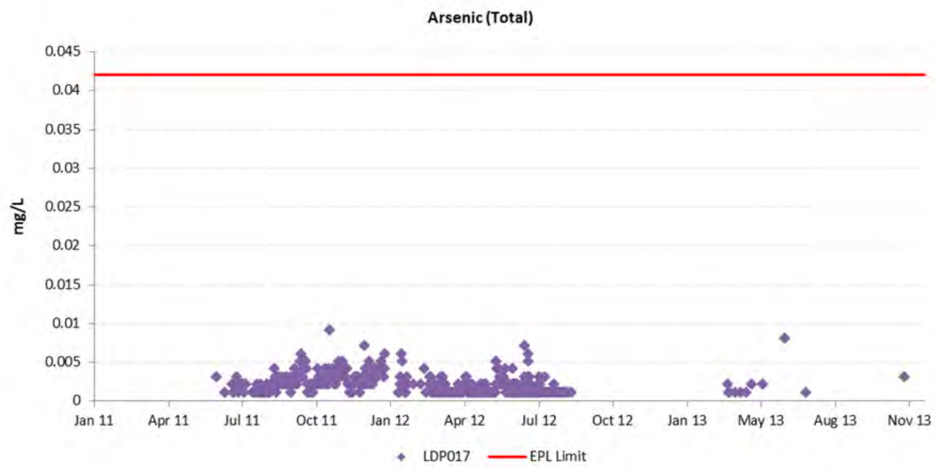

Aluminium (Dissolved)
mg/L
3.5
3
2.5
2
1.5
1
0.5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

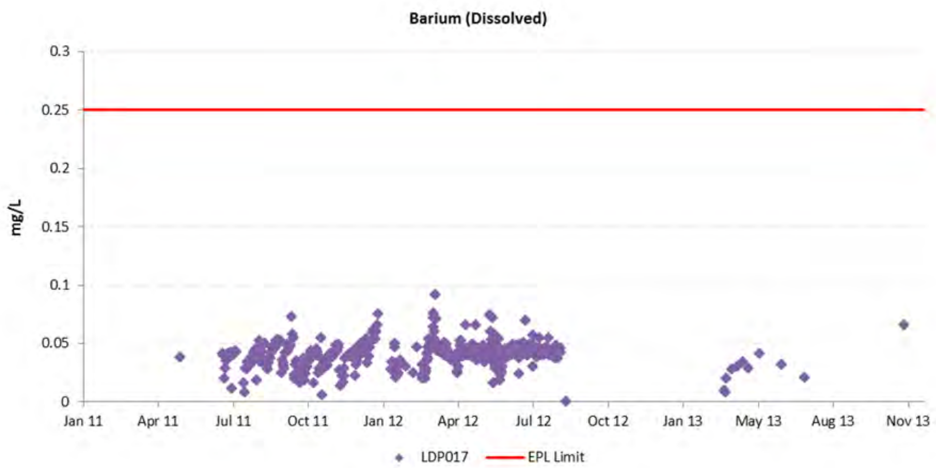

Aluminium (Total)
mg/L
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

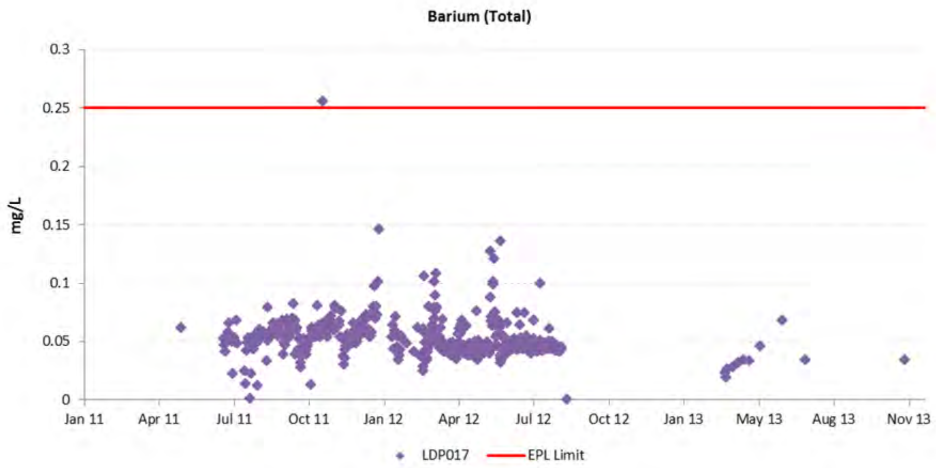

Antimony (Dissolved)
mg/L
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit


Antimony (Total)
mg/L
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

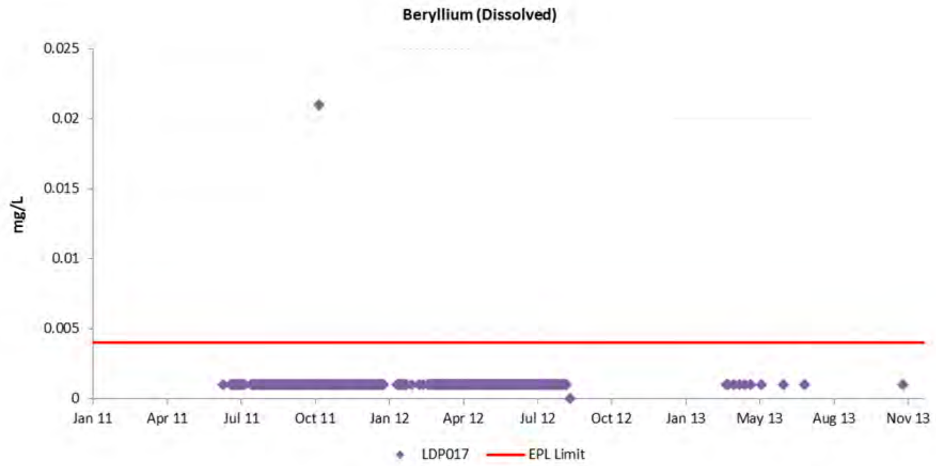

Arsenic (Dissolved)
mg/L
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit


Arsenic (Total)
mg/L
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

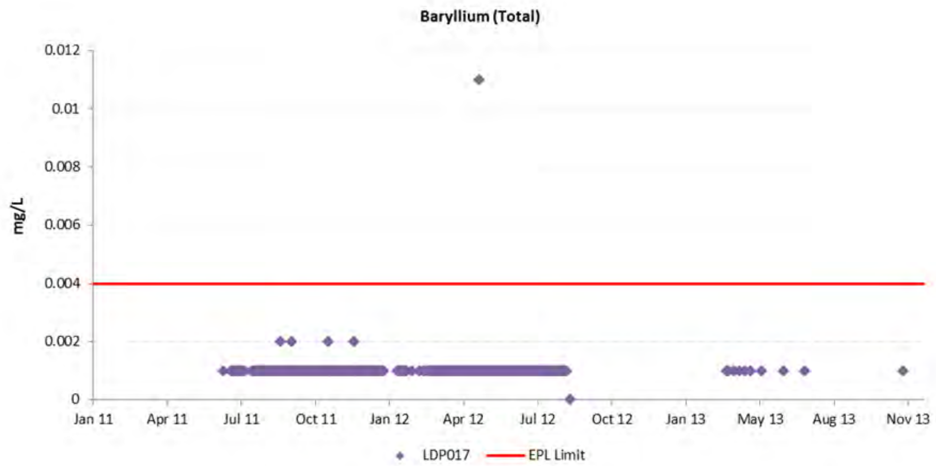

Barium (Dissolved)
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit



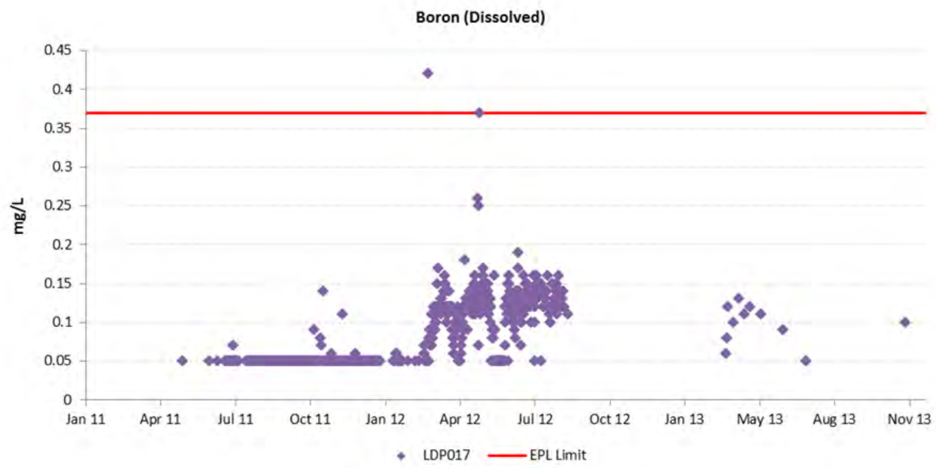
Barium (Total)
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

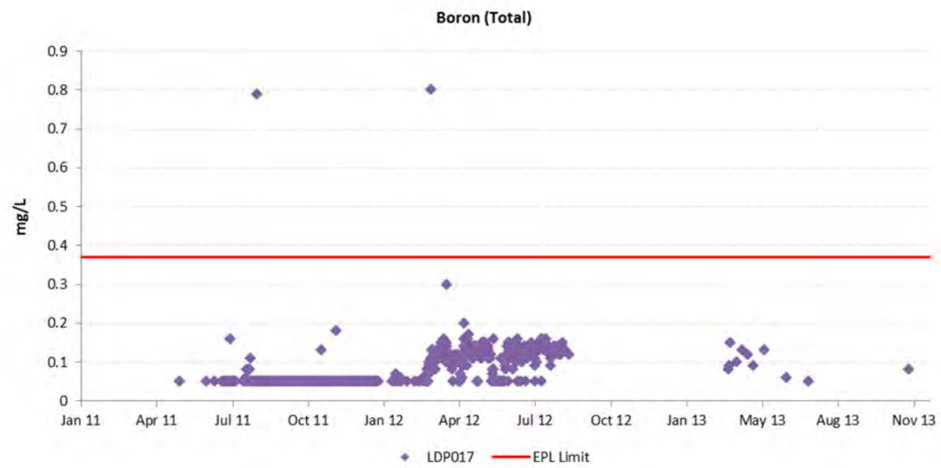


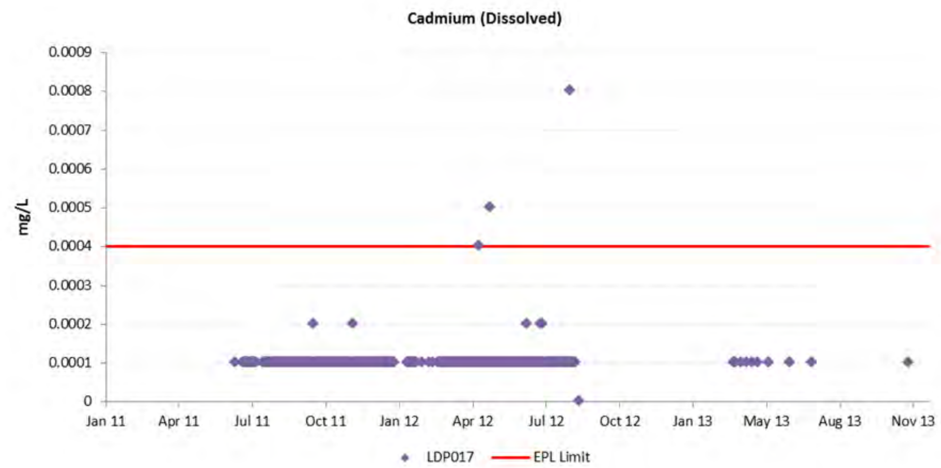
Beryllium (Dissolved)
mg/L
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

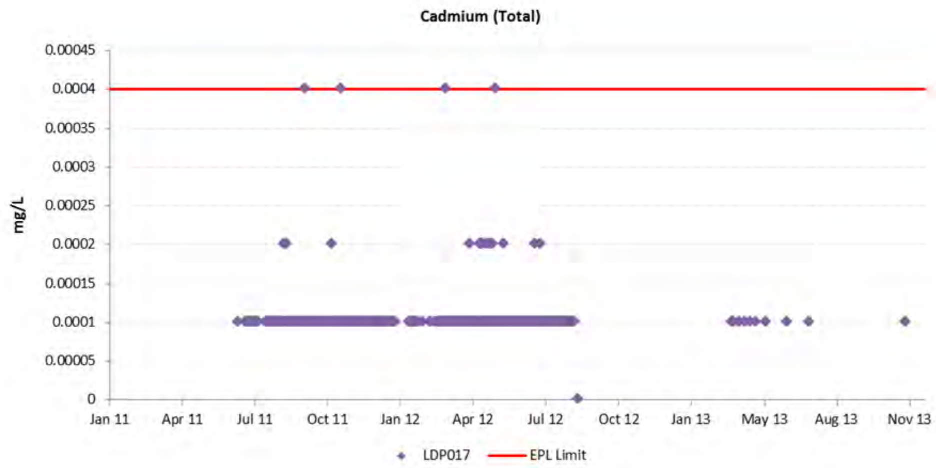


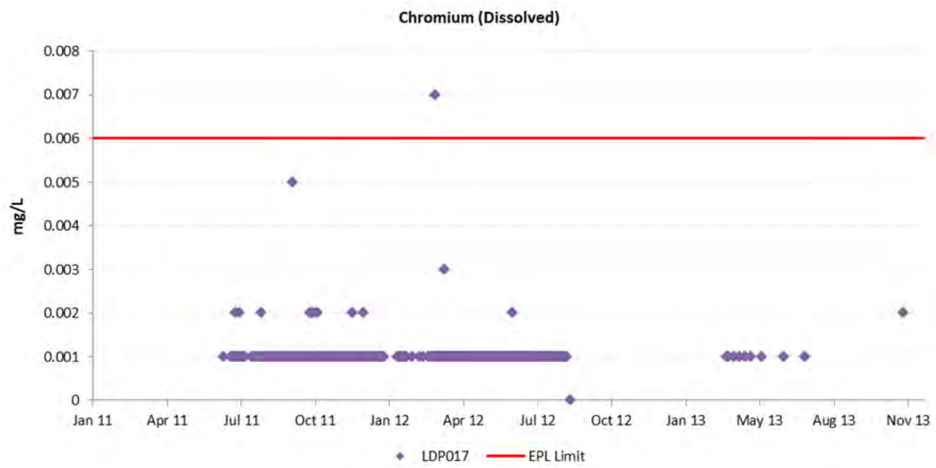
Baryllium (Total)
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

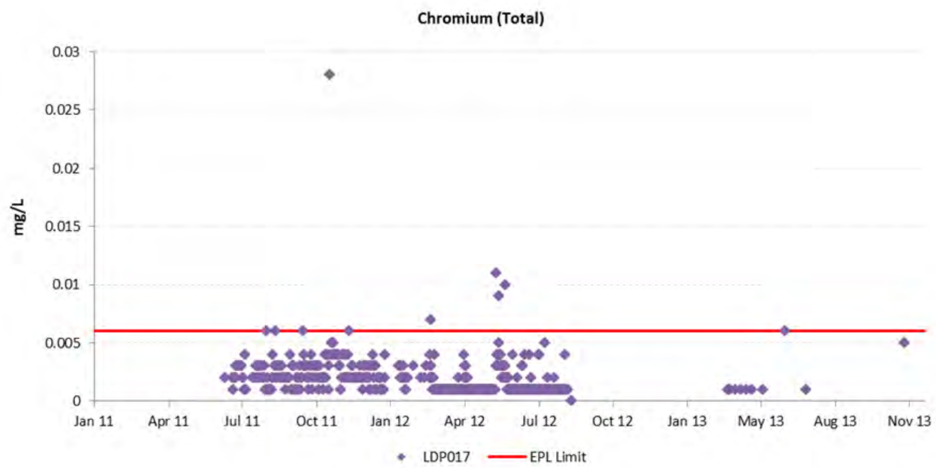

Boron (Dissolved)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

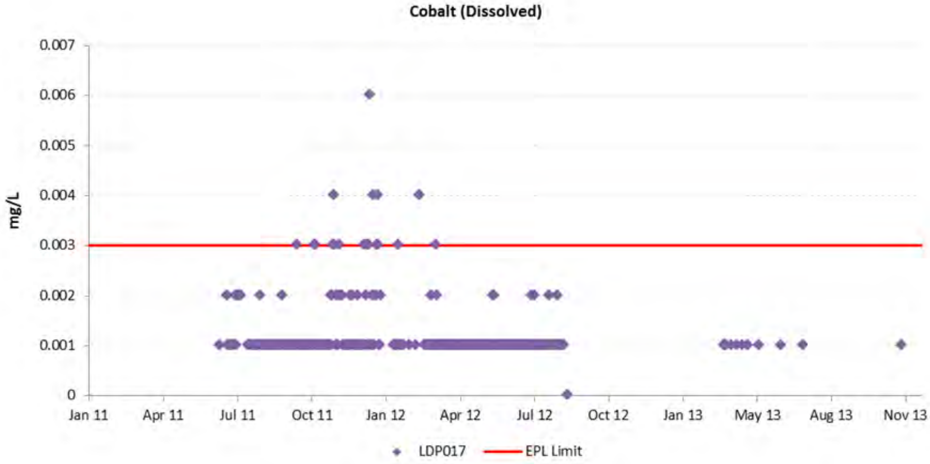

Boron (Total)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

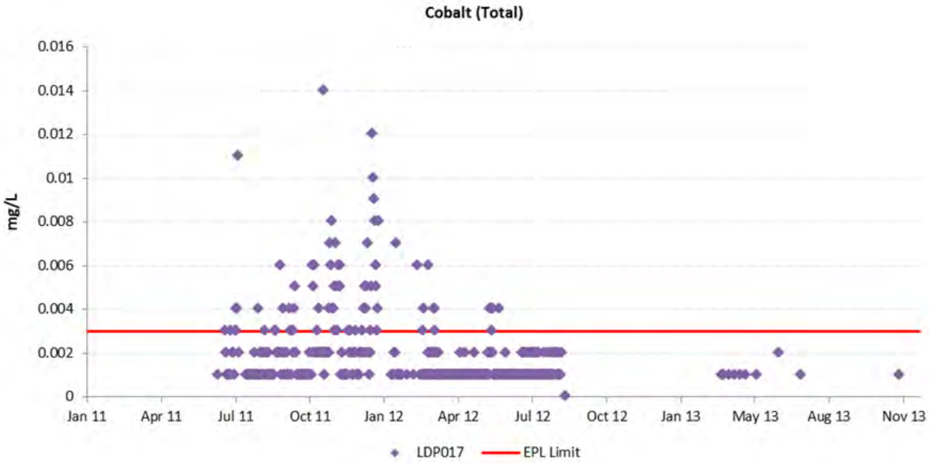

Cadmium (Dissolved)
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

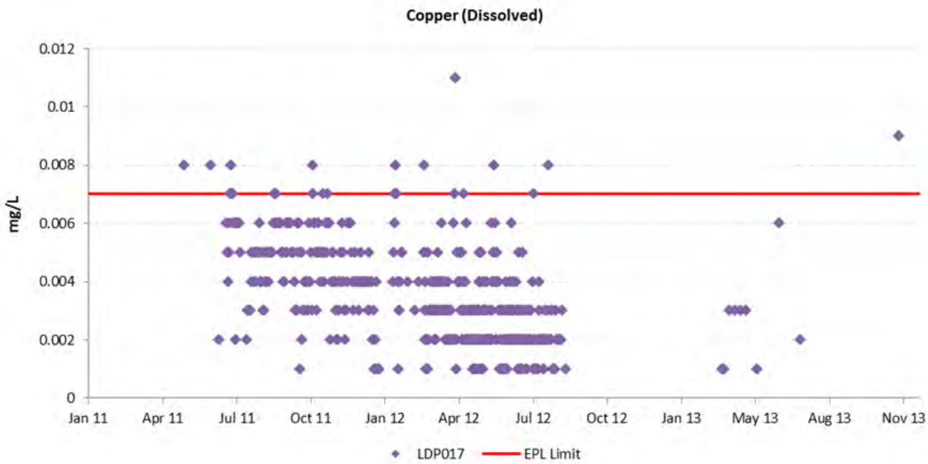

Cadmium (Total)
mg/L
0.00045
0.0004
0.00035
0.0003
0.00025
0.0002
0.00015
0.0001
0.00005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

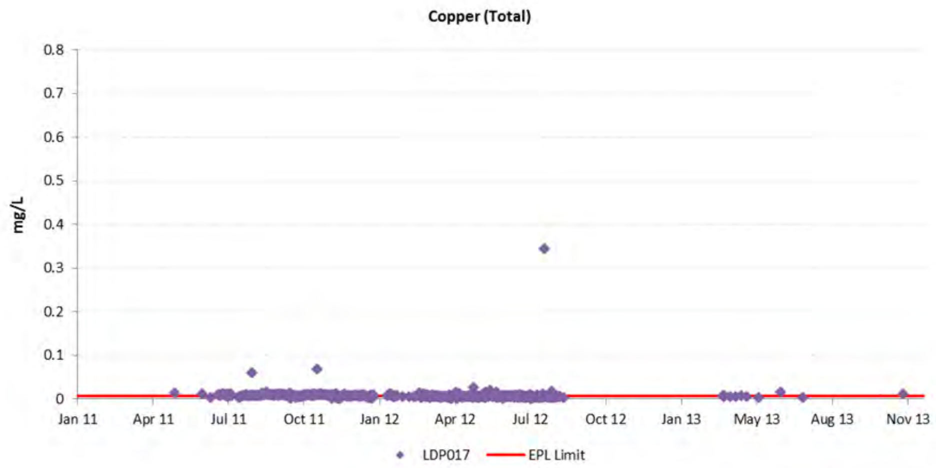

Chromium (Dissolved)
mg/L
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

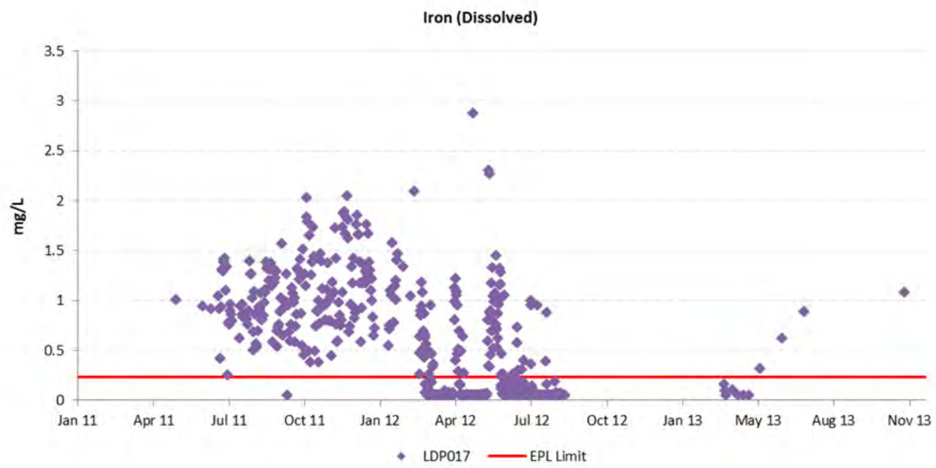

Chromium (Total)
mg/L
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

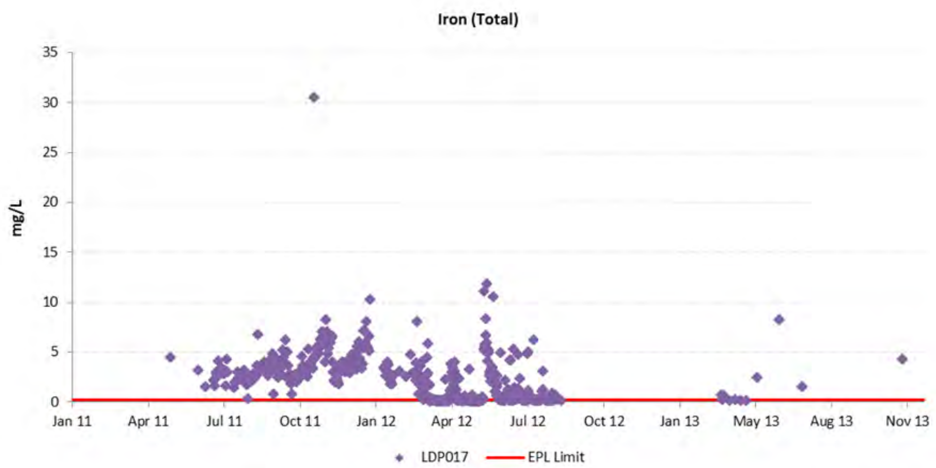

Cobalt (Dissolved)
mg/L
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

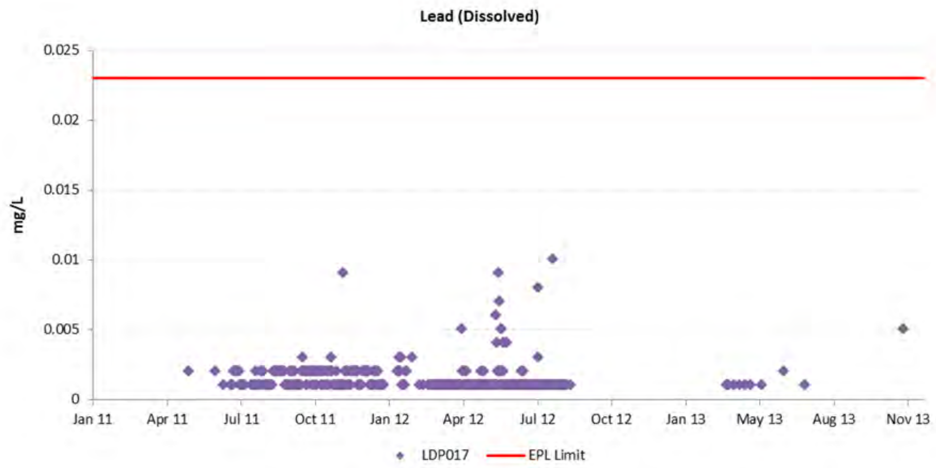

Cobalt (Total)
mg/L
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

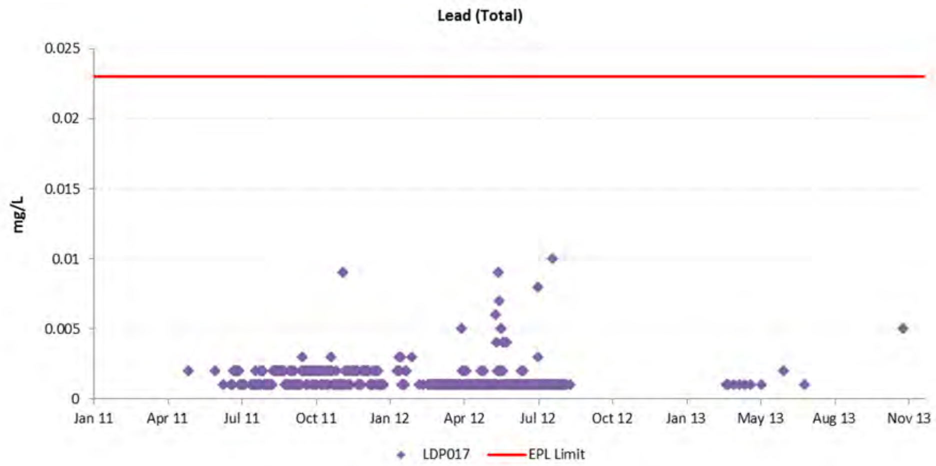

Copper (Dissolved)
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

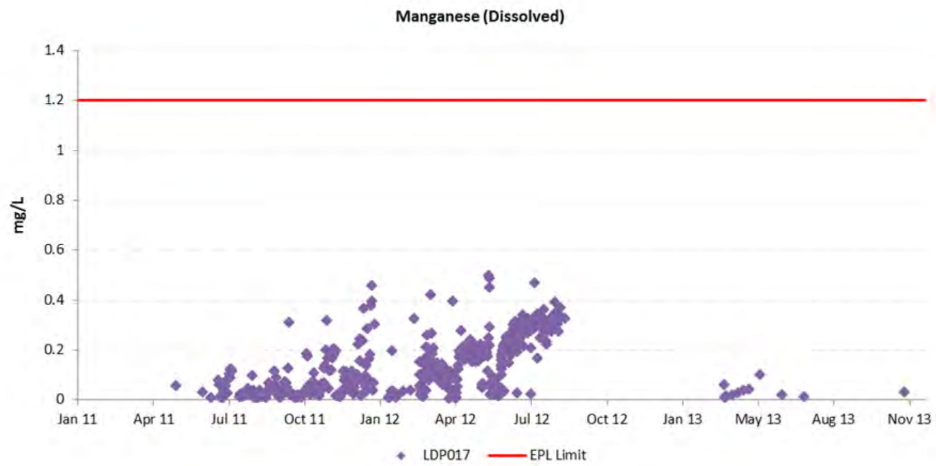

Copper (Total)
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

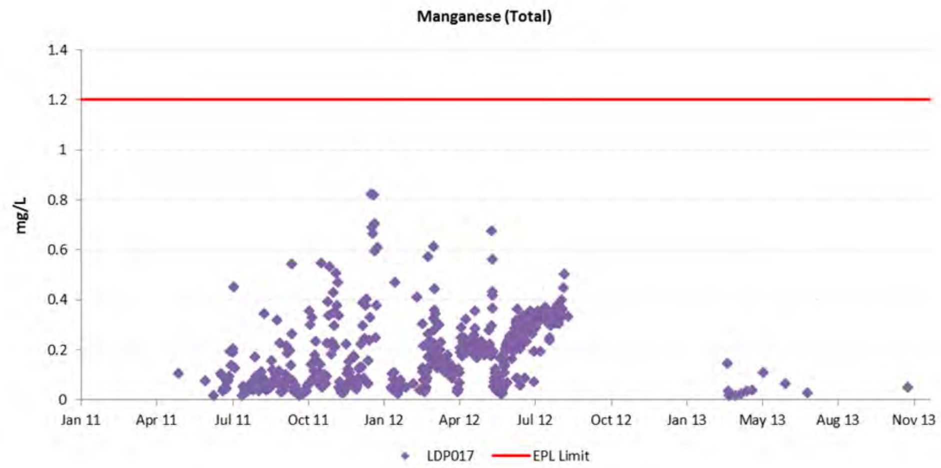

Iron (Dissolved)
mg/L
3.5
3
2.5
2
1.5
1
0.5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

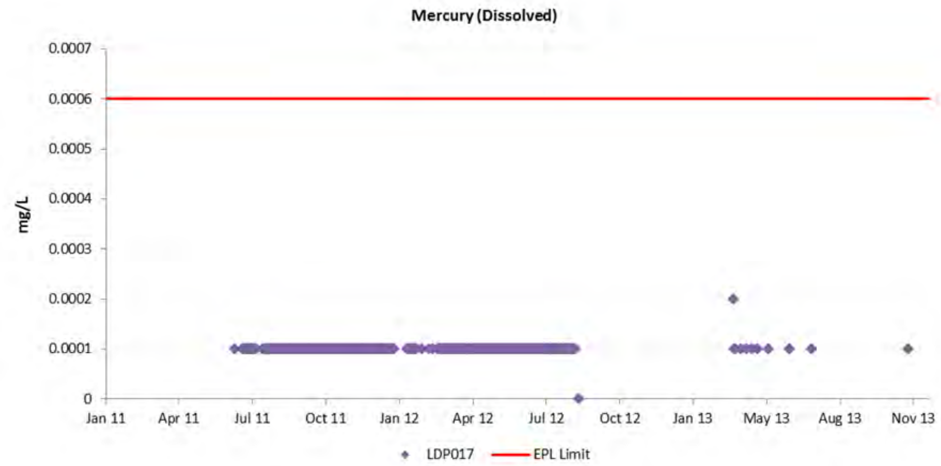

Iron (Total)
mg/L
35
30
25
20
15
10
5
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

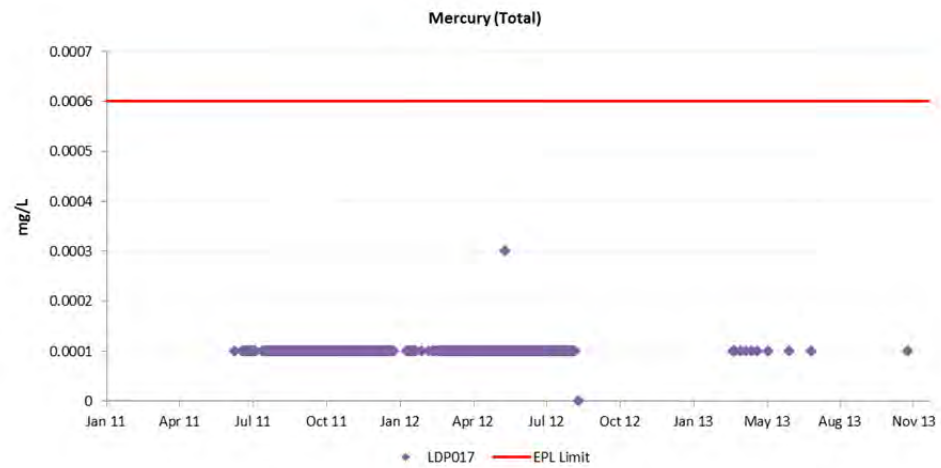

Lead (Dissolved)
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

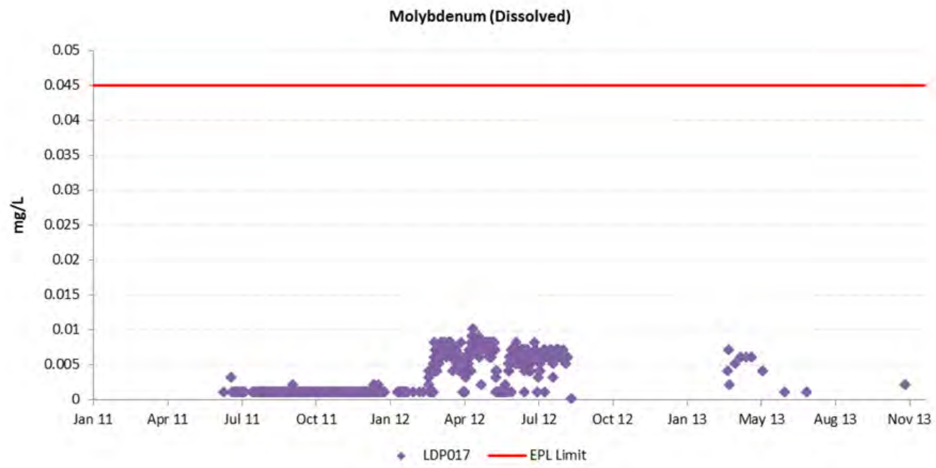

Lead (Total)
0.025
0.02
0.015
0.01
0.005
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

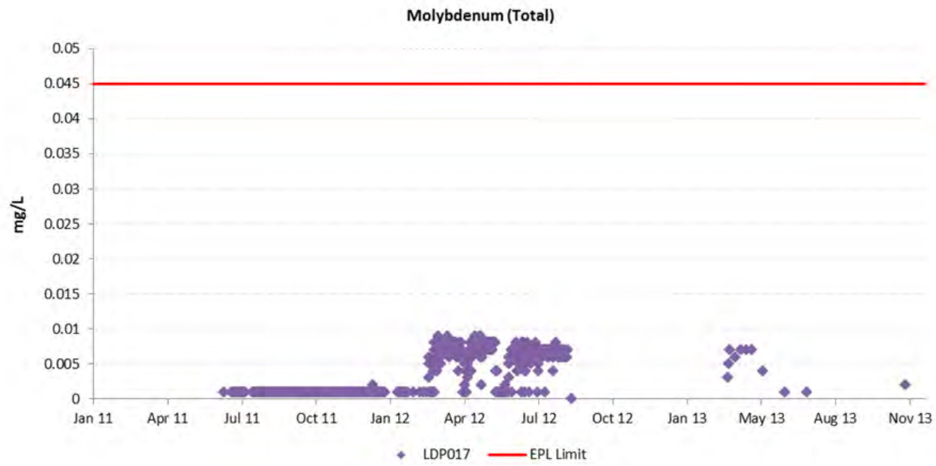

Manganese (Dissolved)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

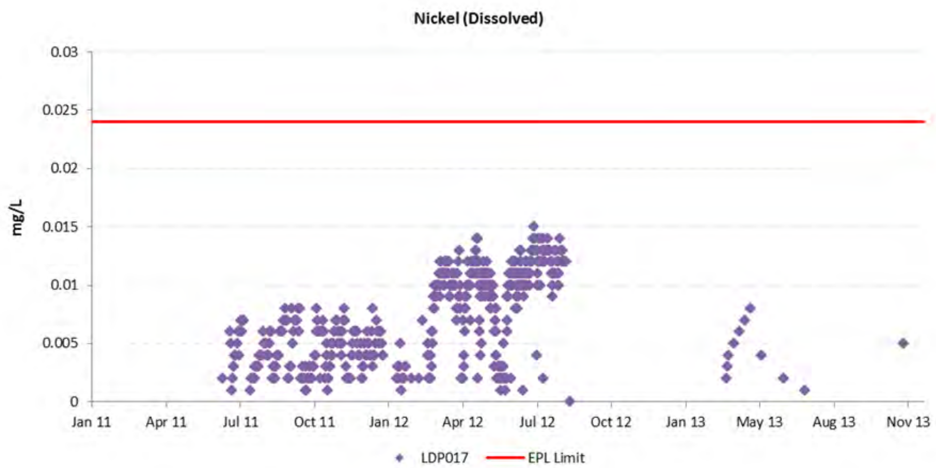

Manganese (Total)
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

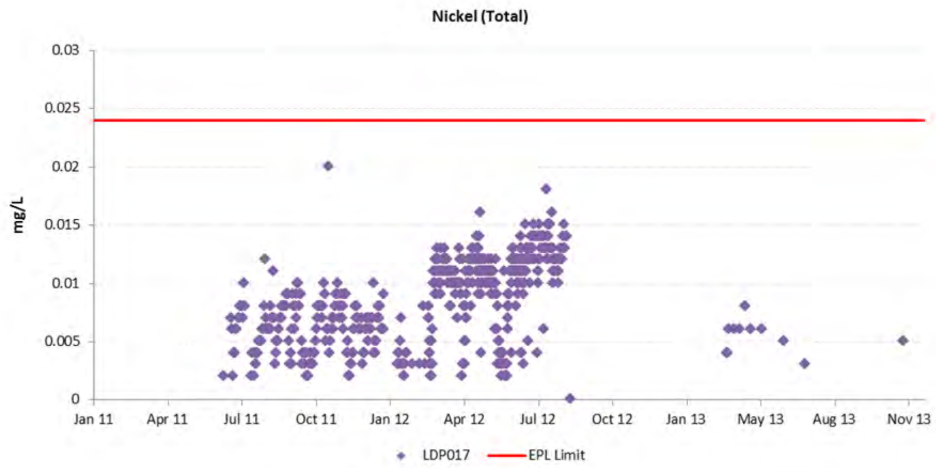

Mercury (Dissolved)
mg/L
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit


Mercury (Total)
mg/L
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

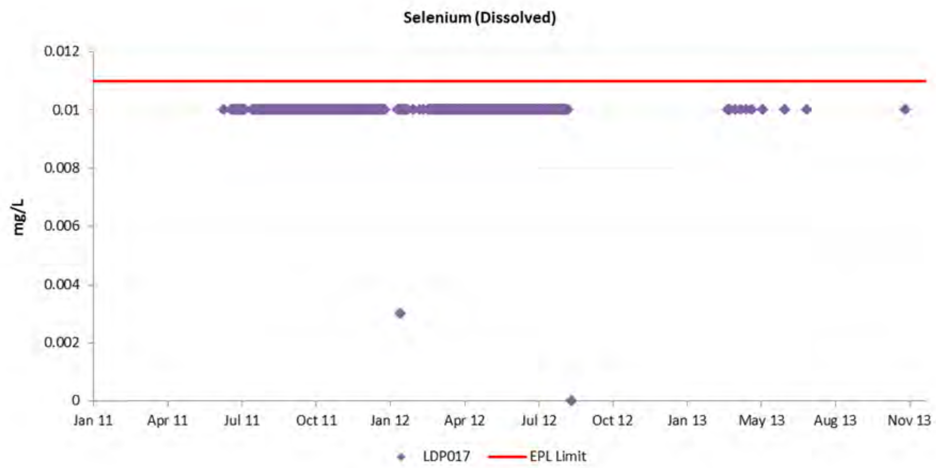

Molybdenum (Dissolved)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit


Molybdenum (Total)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

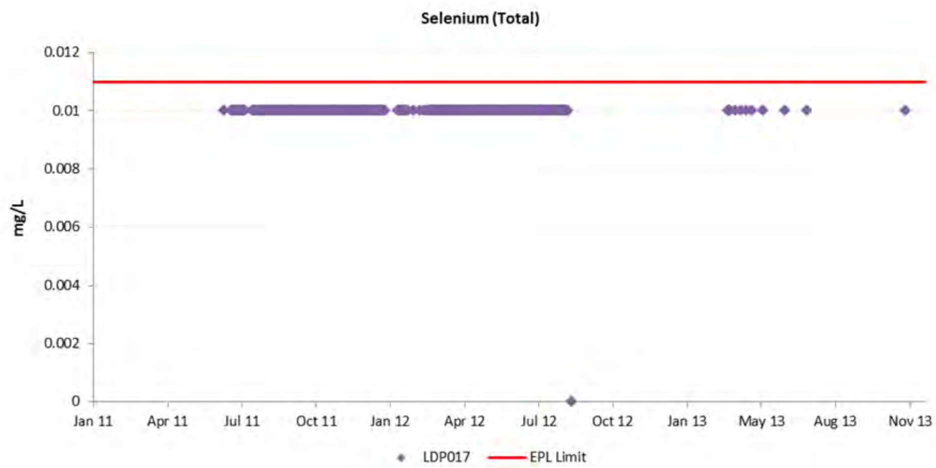

Nickel (Dissolved)
mg/L
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit



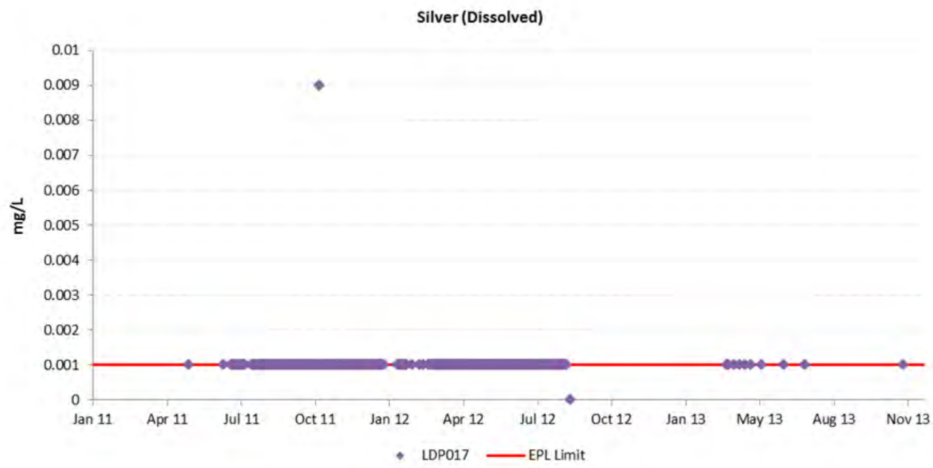
Nickel (Total)
mg/L
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

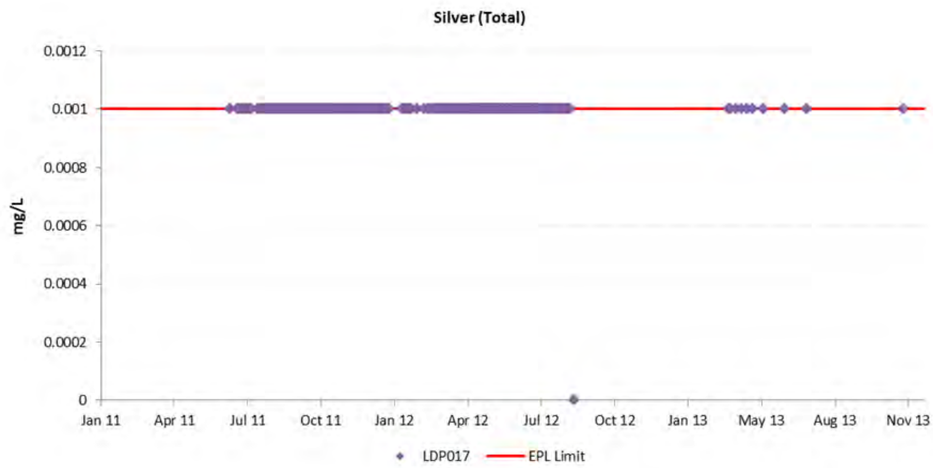


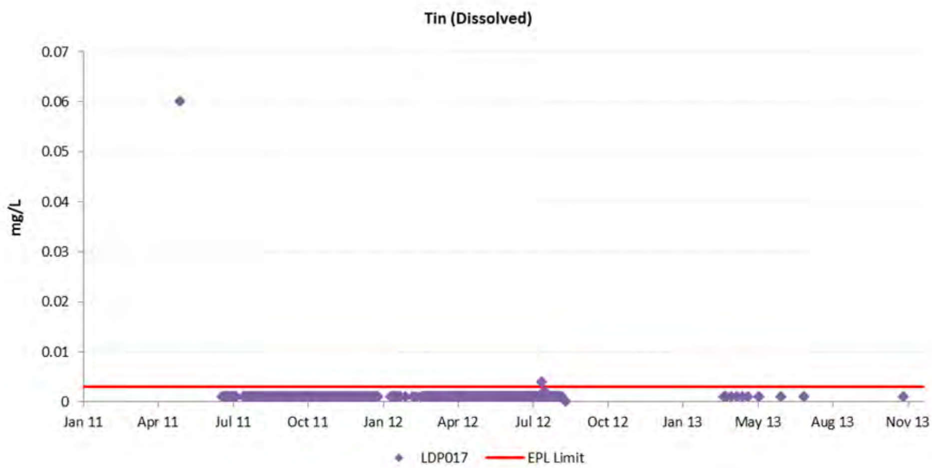
Selenium (Dissolved)
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

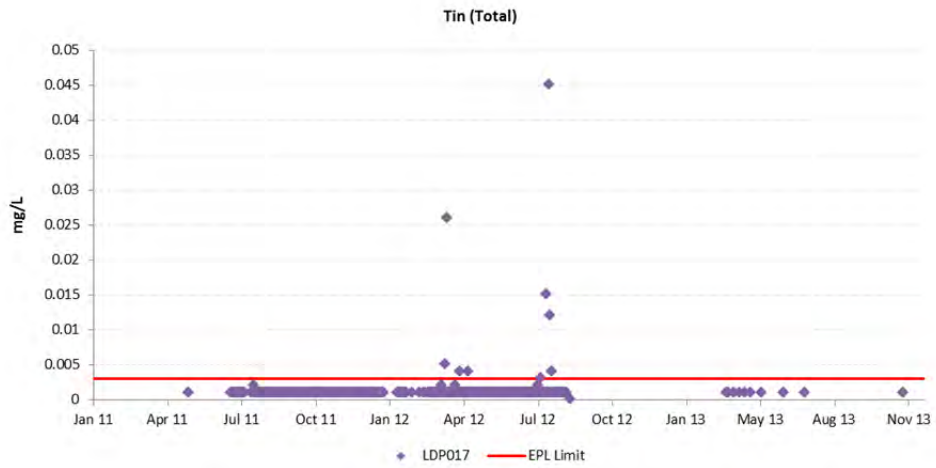


Selenium (Total)
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

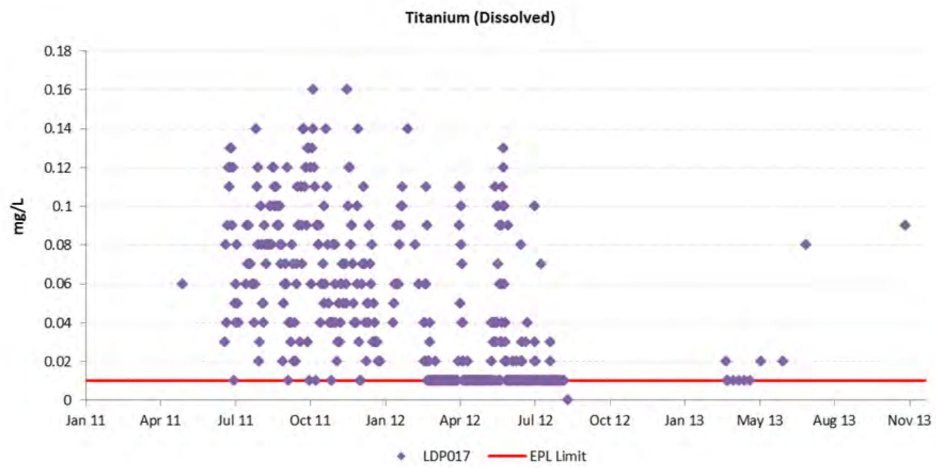

Silver (Dissolved)
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit


Silver (Total)
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

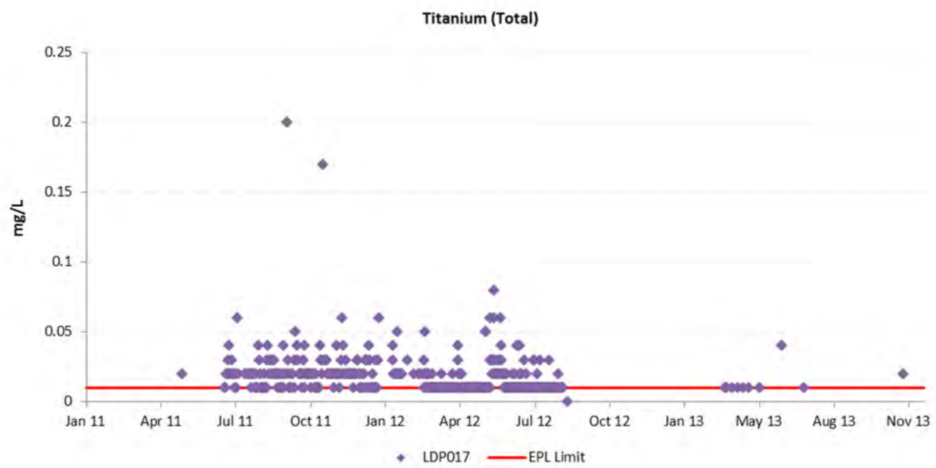

Tin (Dissolved)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit



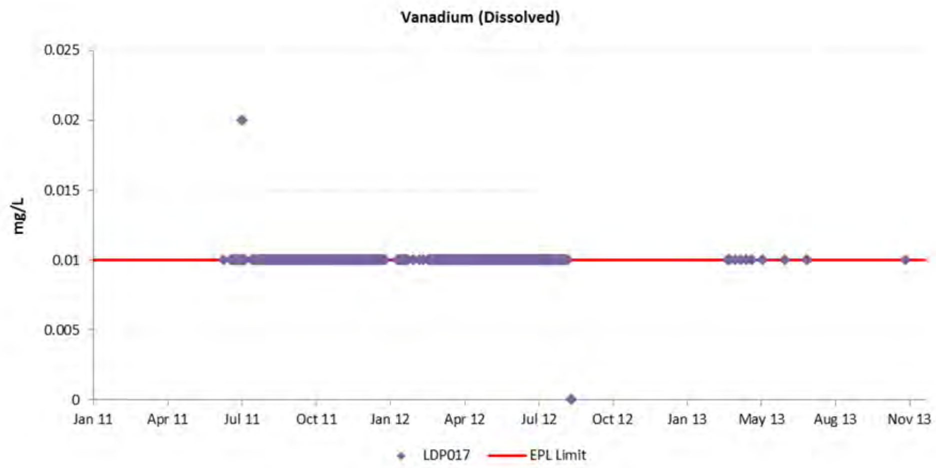
Tin (Total)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

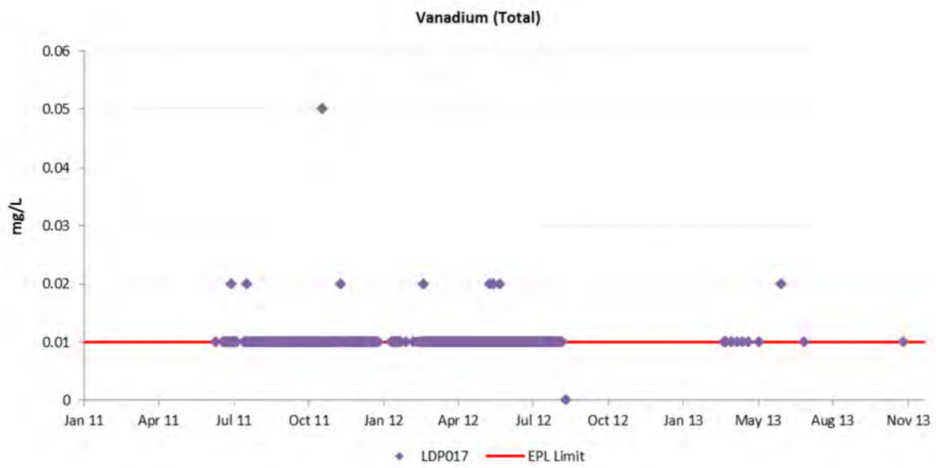


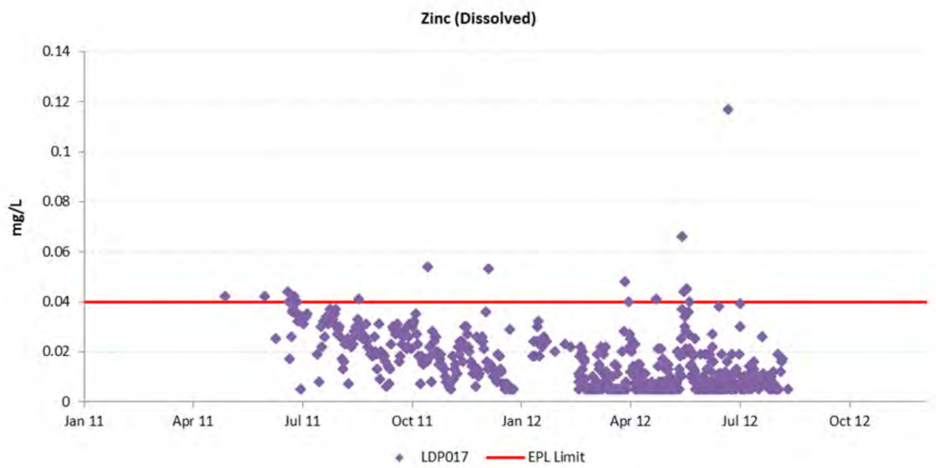
Titanium (Dissolved)
mg/L
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

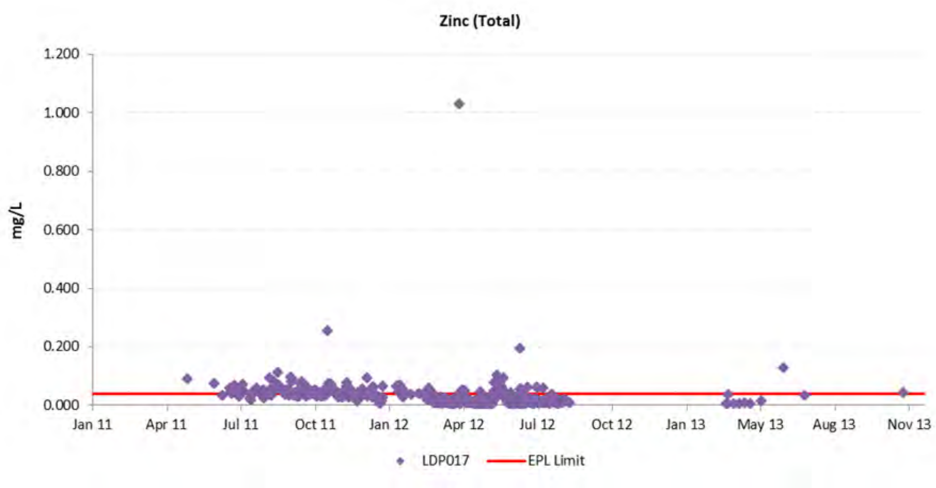


Titanium (Total)
mg/L
0.25
0.2
0.15
0.1
0.05
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit


Vanadium (Dissolved)
mg/L
0.025
0.02
0.015
0.01
0.005
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

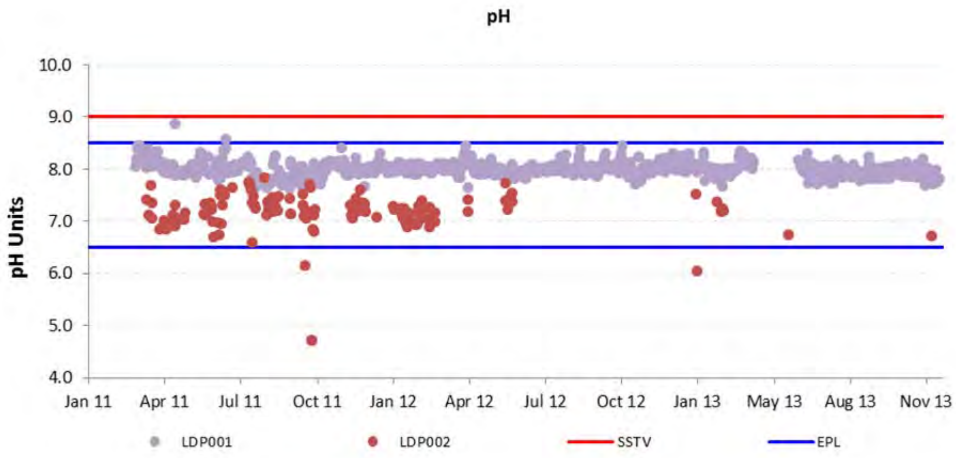

Vanadium (Total)
mg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

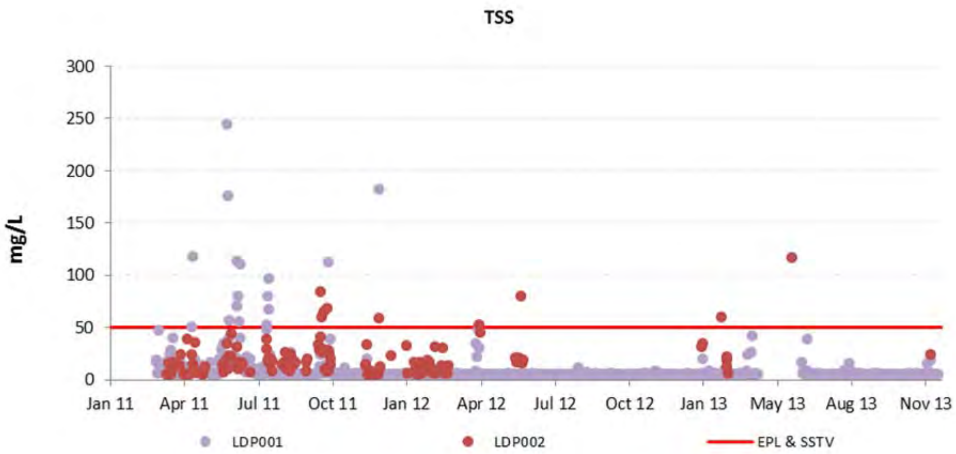

Zinc (Dissolved)
mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
LDP017
EPL Limit

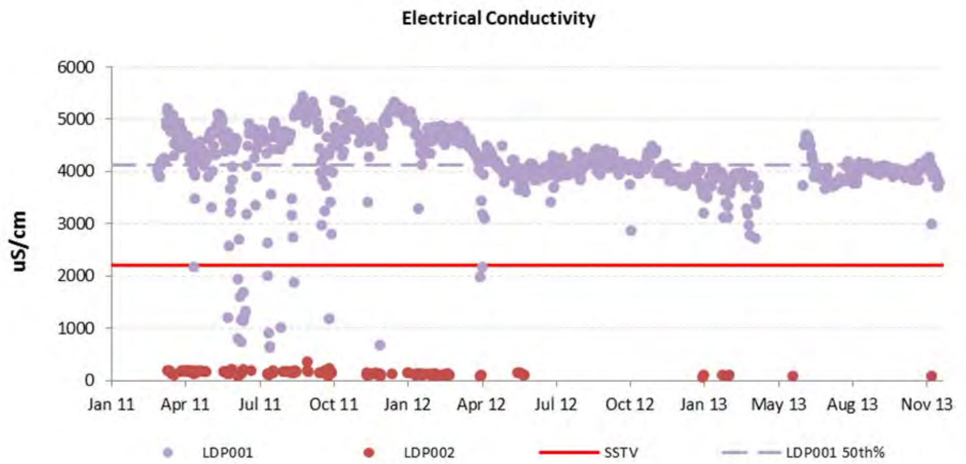

Zinc (Total)
mg/L
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP017
EPL Limit

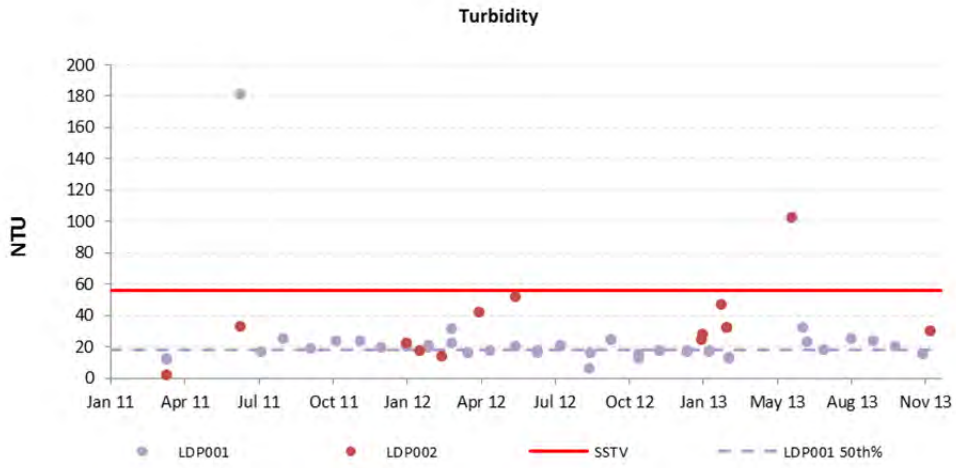
Cooranbong Entry Site

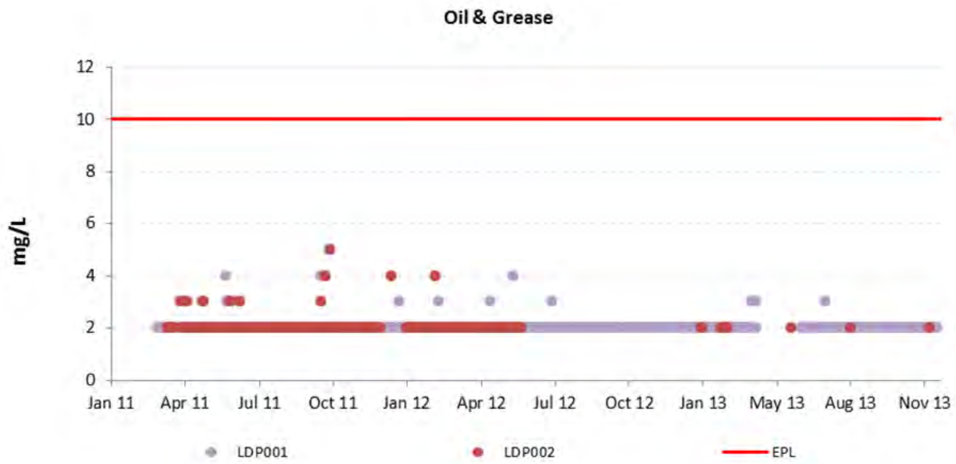
LDP001 and LDP002

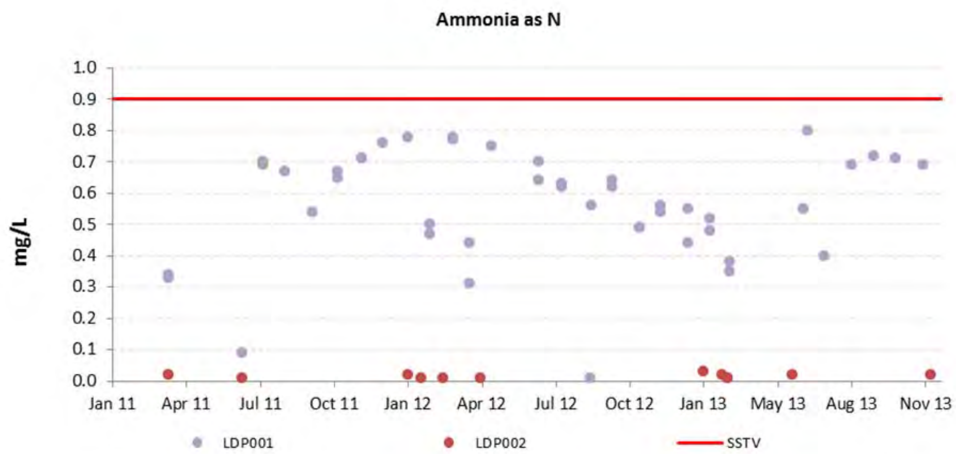


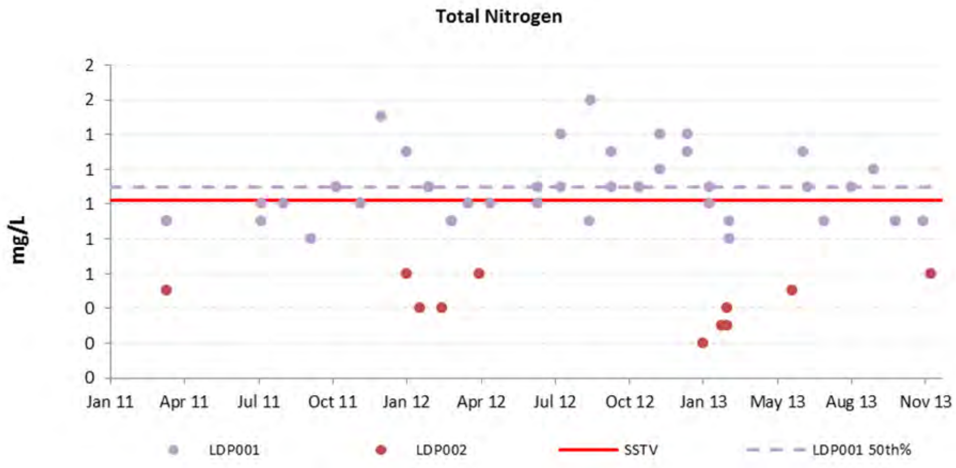


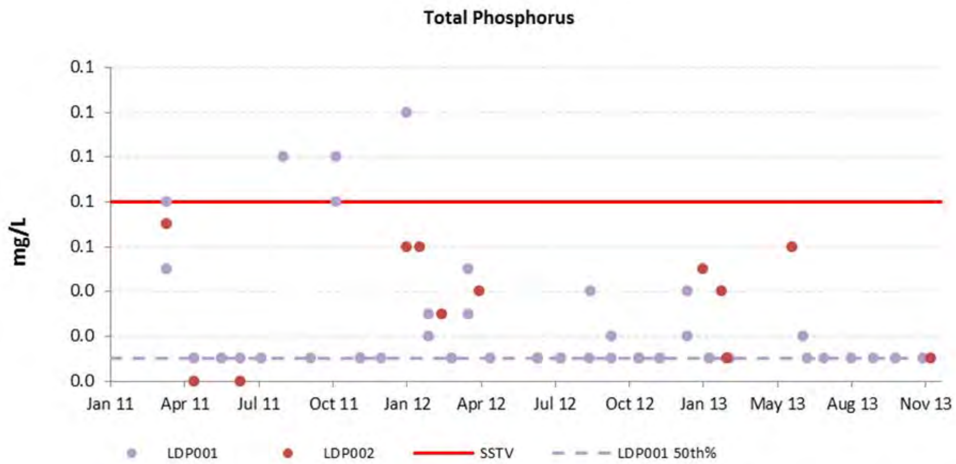


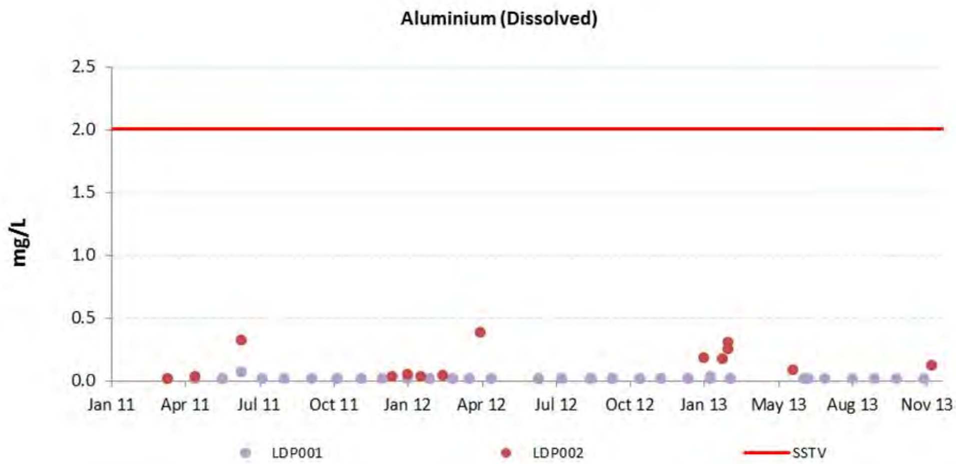

Turbidity
NTU
200
180
160
140
120
100
80
60
40
20
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%

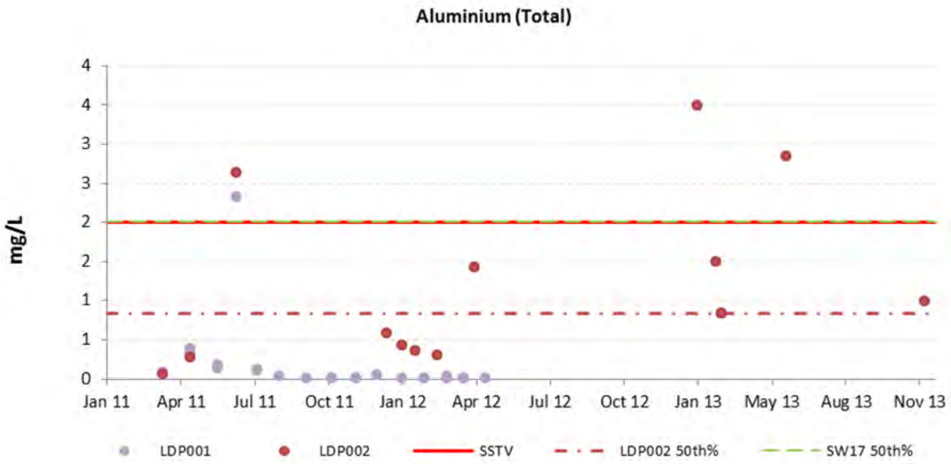

Oil & Grease
mg/L
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
EPL


Ammonia as N
mg/L
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

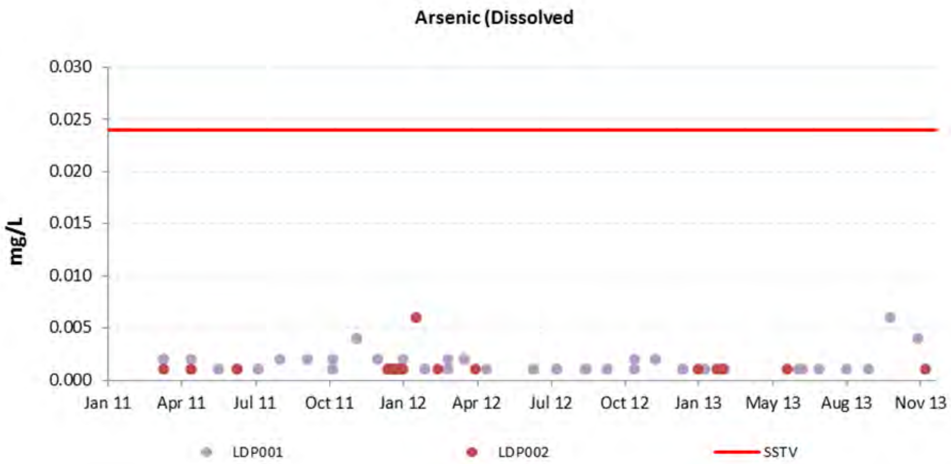

Total Nitrogen
mg/L
2
2
1
1
1
1
1
0
0
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%


Total Phosphorus
mg/L
0.1
0.1
0.1
0.1
0.1
0.0
0.0
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%

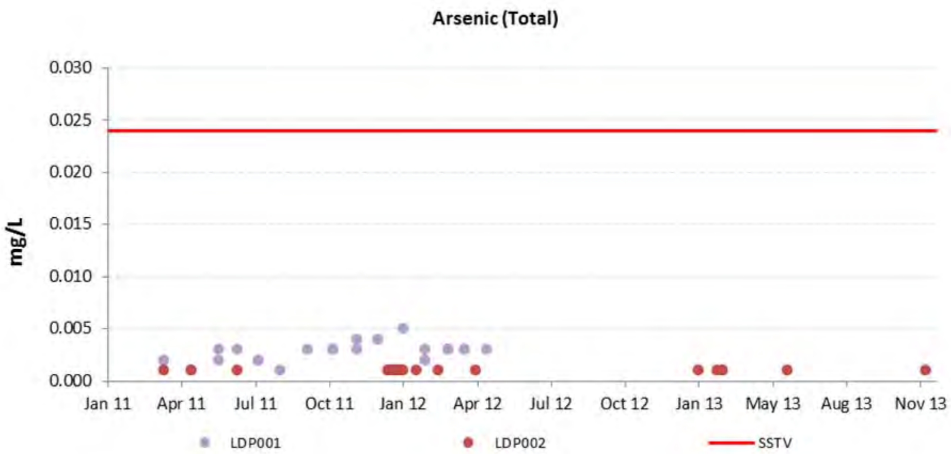

Aluminium (Dissolved)
mg/L
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV



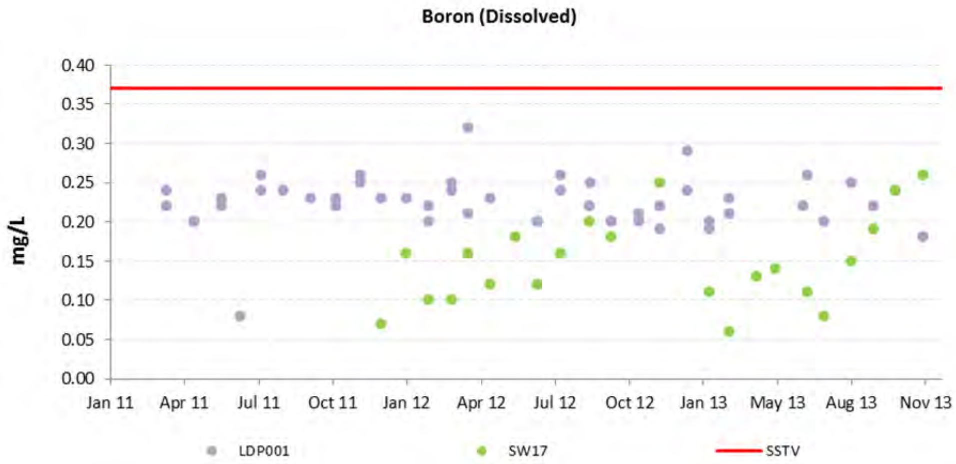
Aluminium (Total)
mg/L
4
4
3
3
2
2
1
1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP002 50th%
SW17 50th%

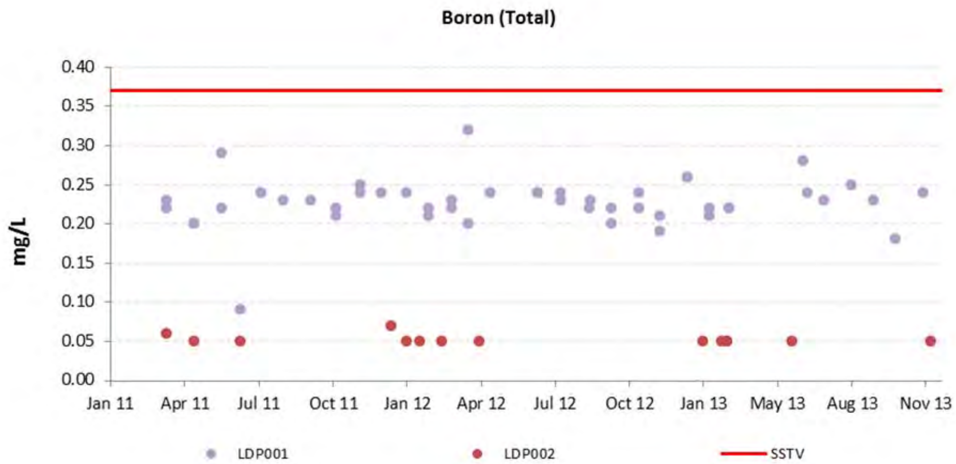


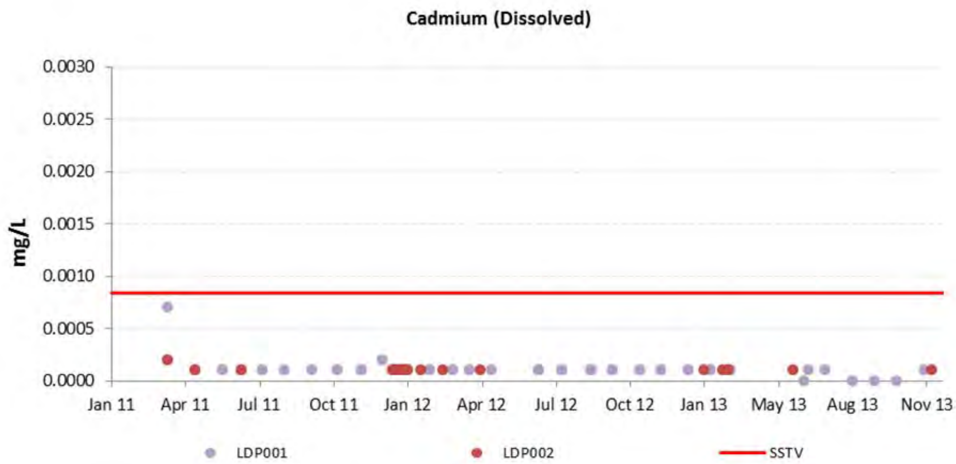
Arsenic (Dissolved
mg/L
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

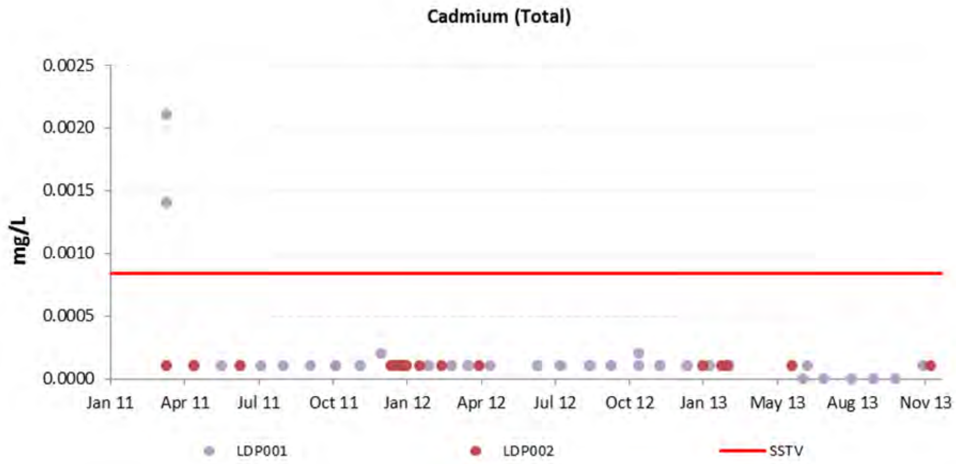


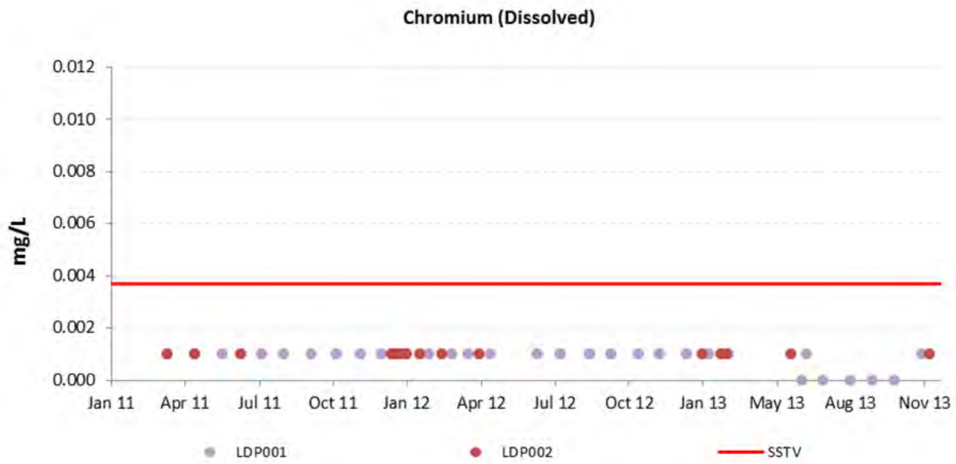
Arsenic (Total)
mg/L
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

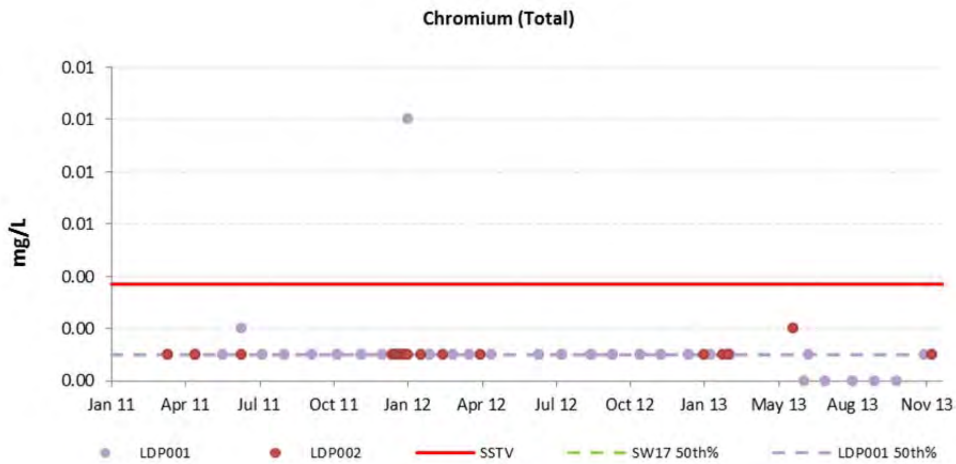

Boron (Dissolved)
mg/L
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
SW17
SSTV

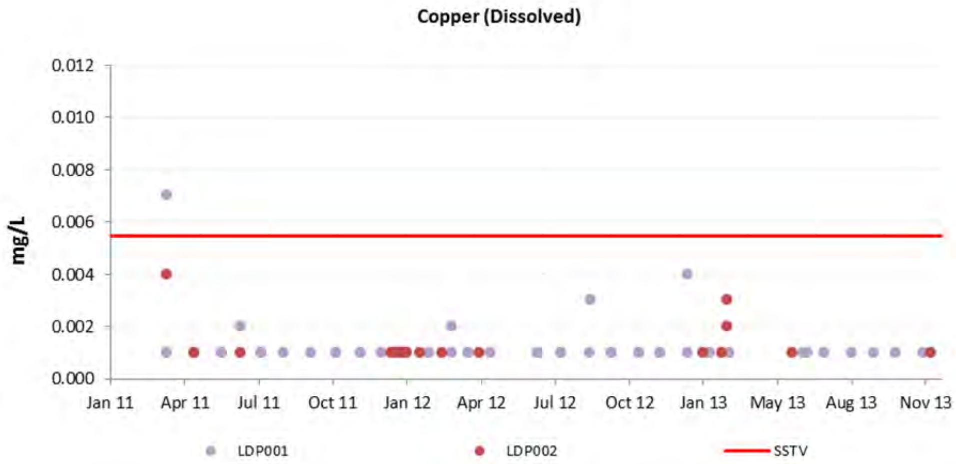

Boron (Total)
mg/L
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

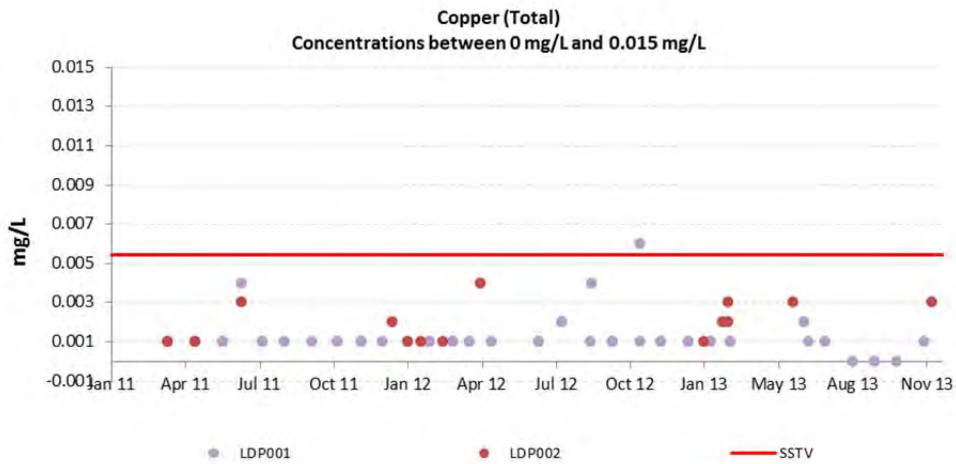

Cadmium (Dissolved)
mg/L
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

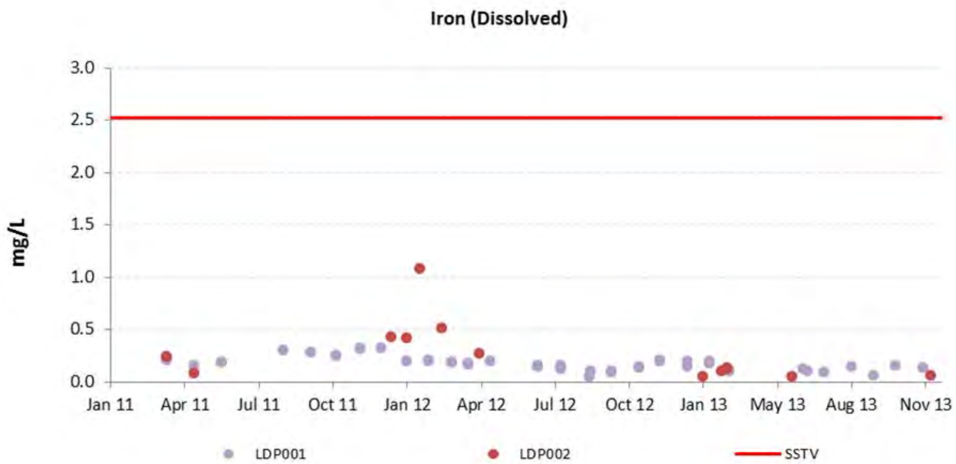

Cadmium (Total)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

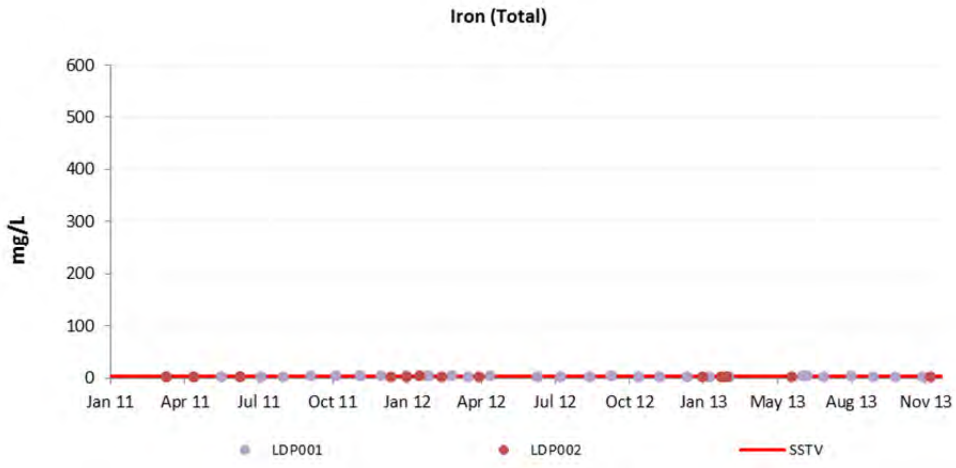

Chromium (Dissolved)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

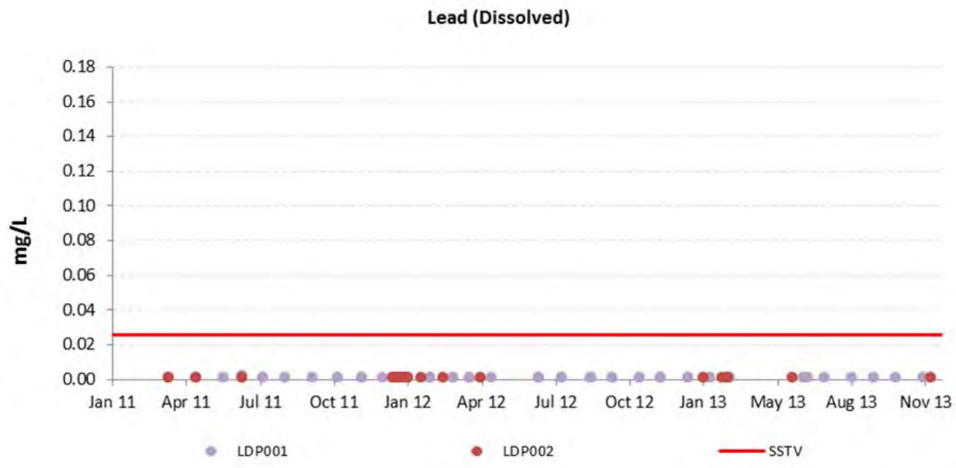

Chromium (Total)
0.01
0.01
0.01
0.01
0.00
0.00
0.00
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
SW17 50th%
LDP001 50th%

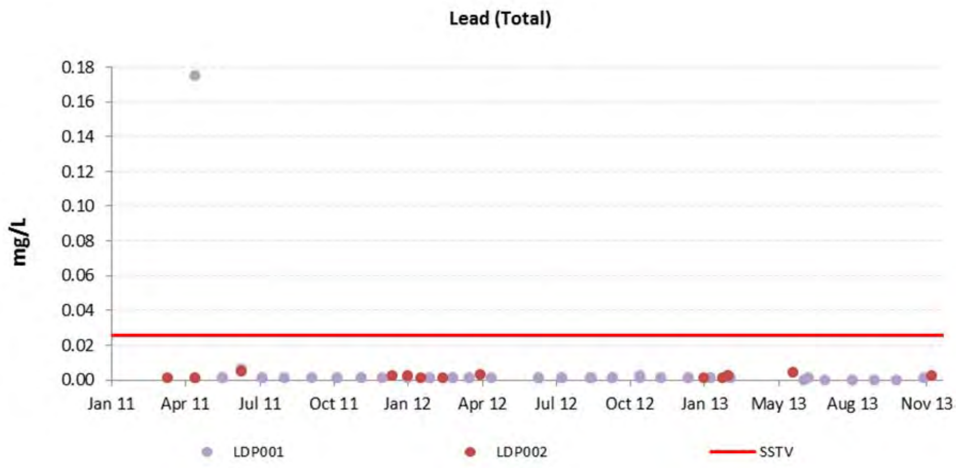

Copper (Dissolved)
mg/L
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

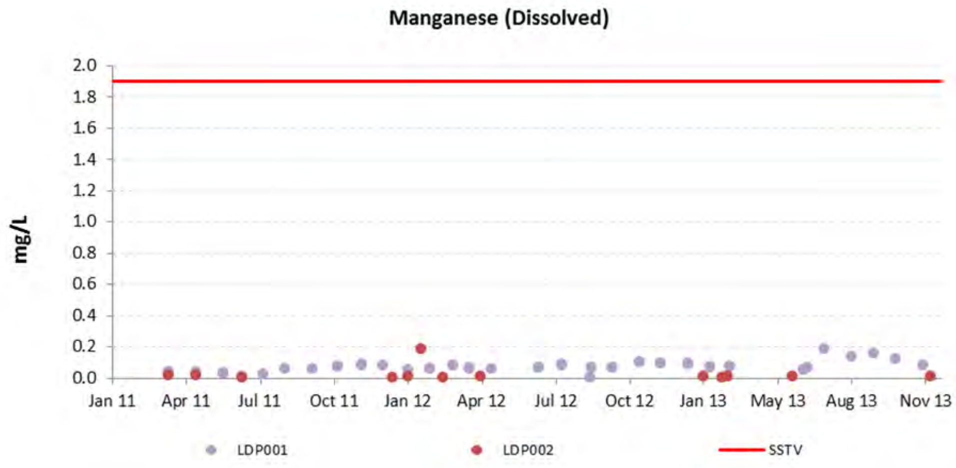

Copper (Total)
Concentrations between 0 mg/L and 0.015 mg/L
mg/L
0.015
0.013
0.011
0.009
0.007
0.005
0.003
0.001
-0.001
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV


Iron (Dissolved)
mg/L
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

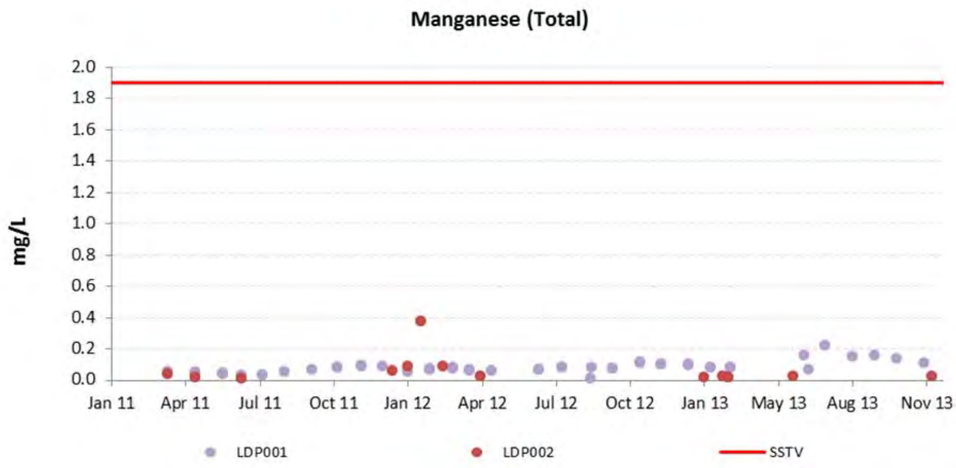

Iron (Total)
mg/L
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV


Lead (Dissolved)
mg/L
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

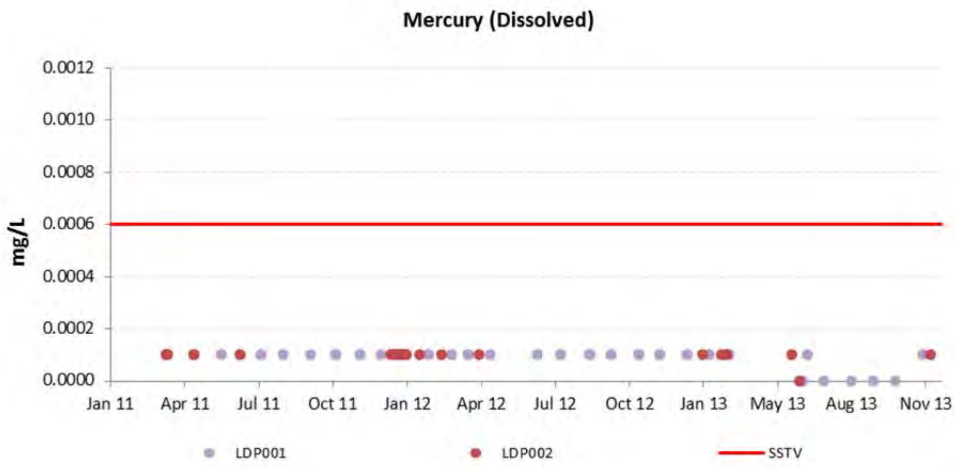

Lead (Total)
mg/L
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV



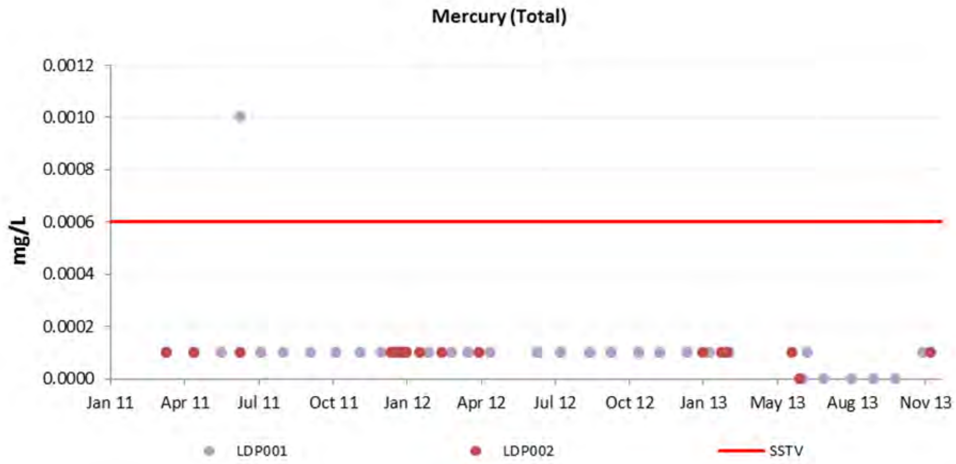
Manganese (Dissolved)
mg/L
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

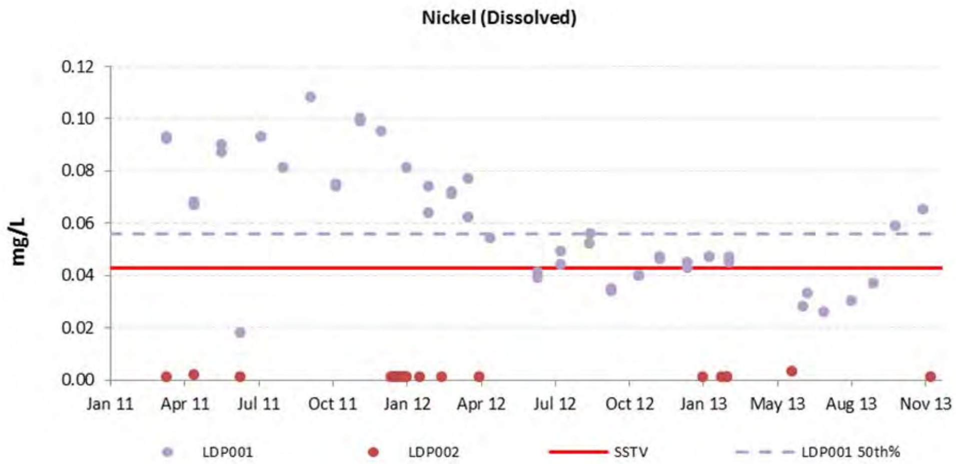


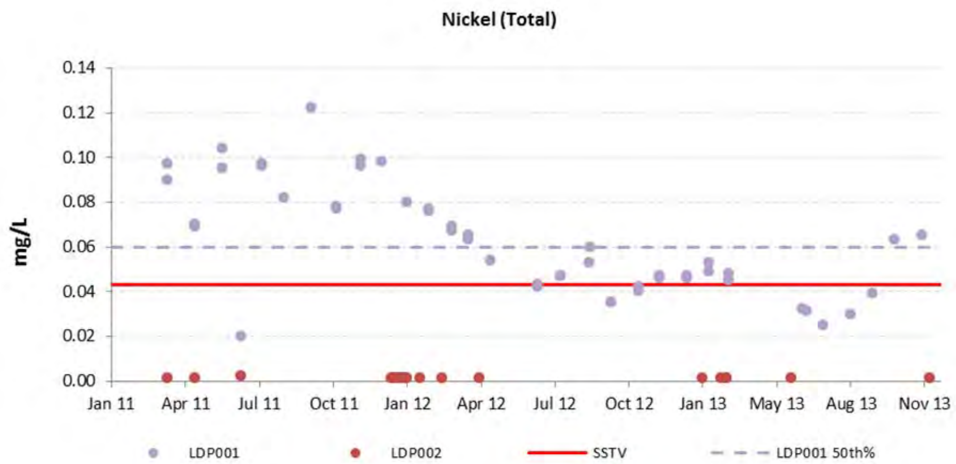
Manganese (Total)
mg/L
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

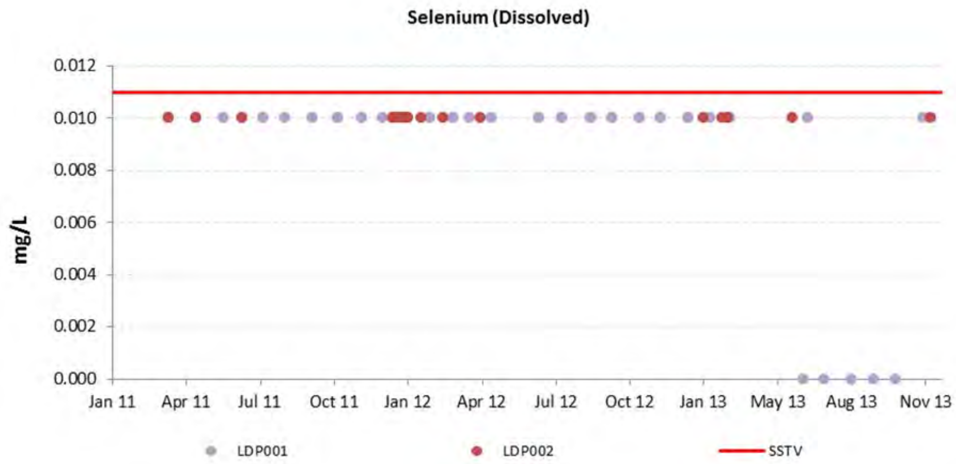


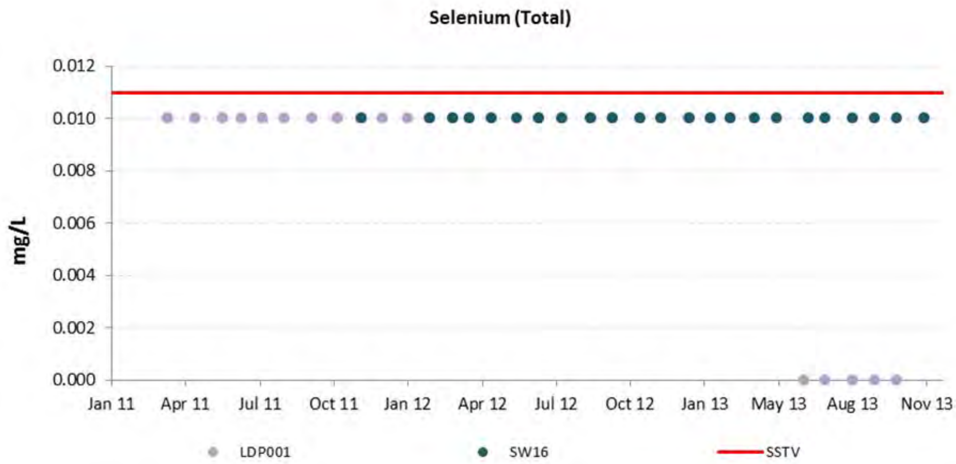
Mercury (Dissolved)
mg/L
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

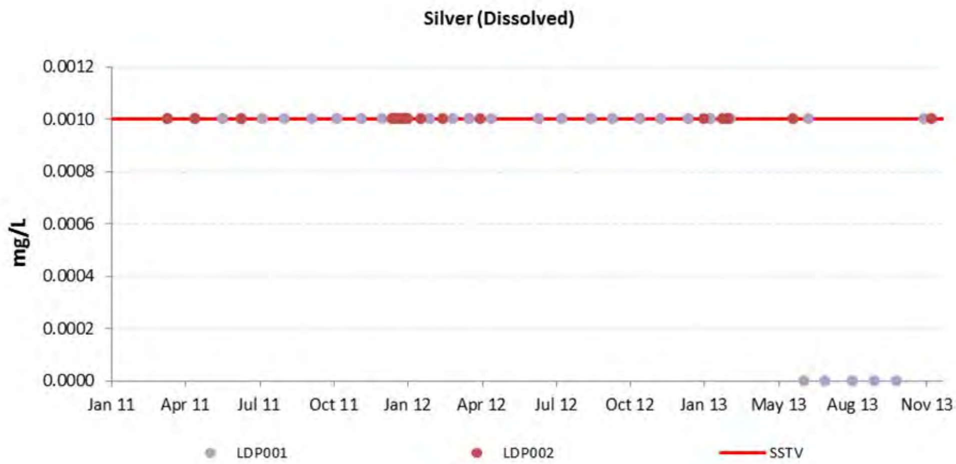

Mercury (Total)
mg/L
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

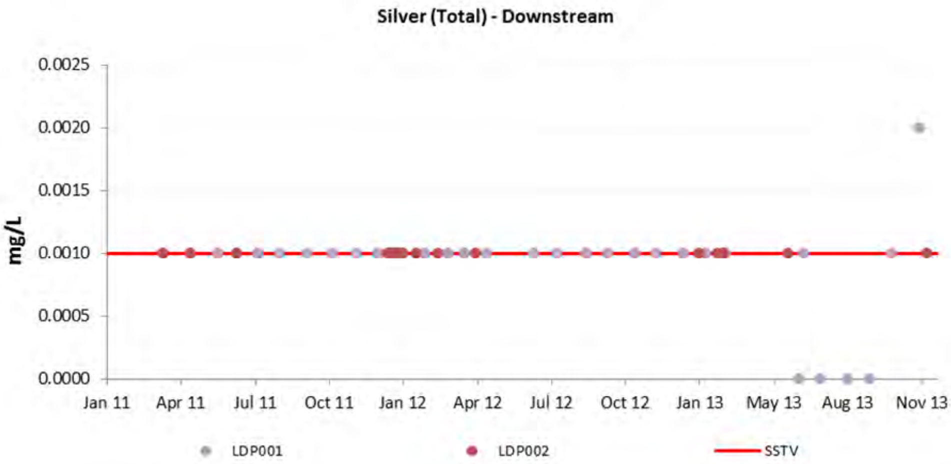

Nickel (Dissolved)
mg/L
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%

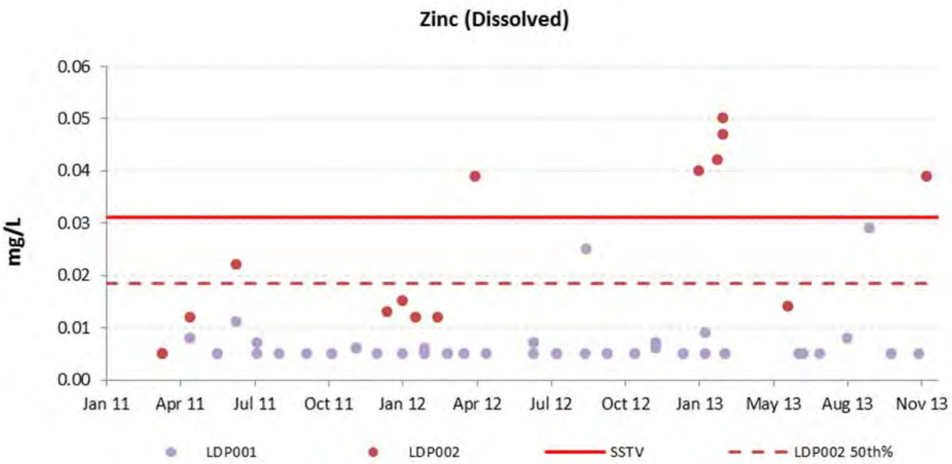

Nickel (Total)
mg/L
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%

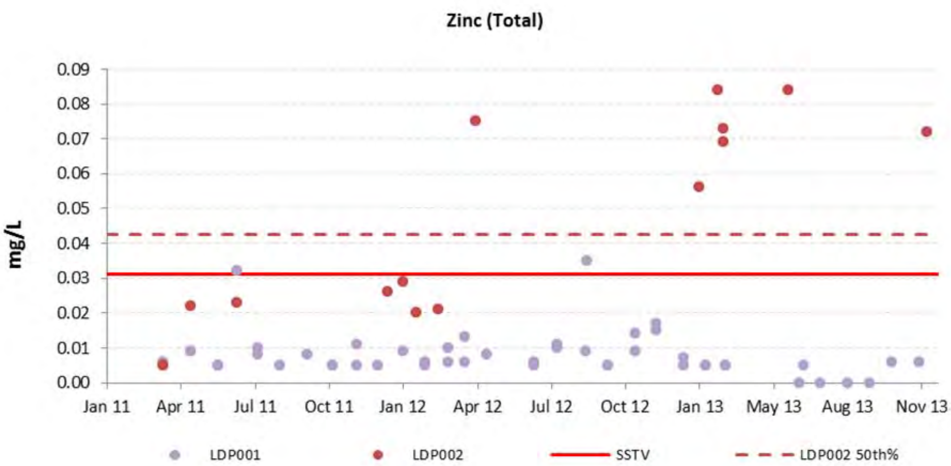

Selenium (Dissolved)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

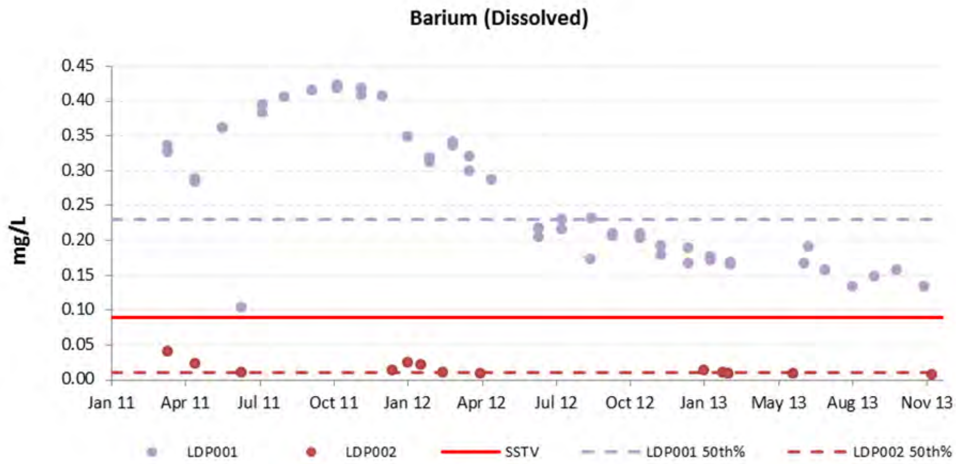

Selenium (Total)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
SW16
SSTV

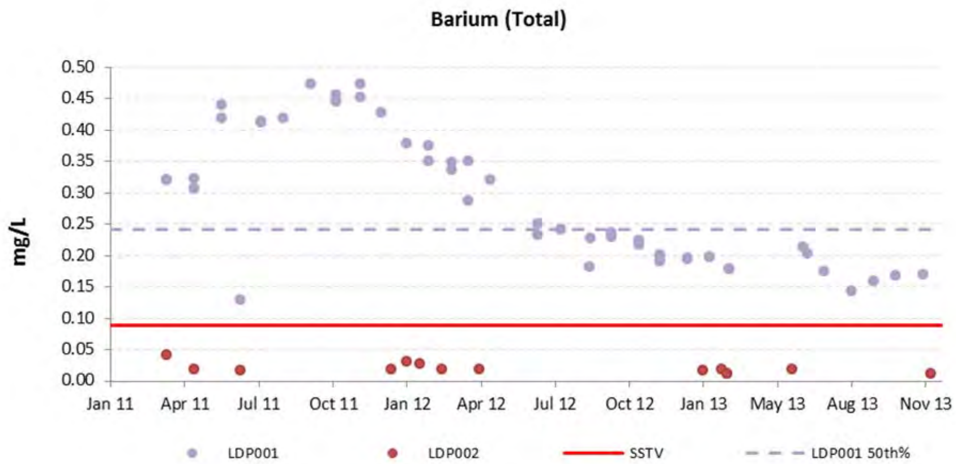

Silver (Dissolved)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
mg/L
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

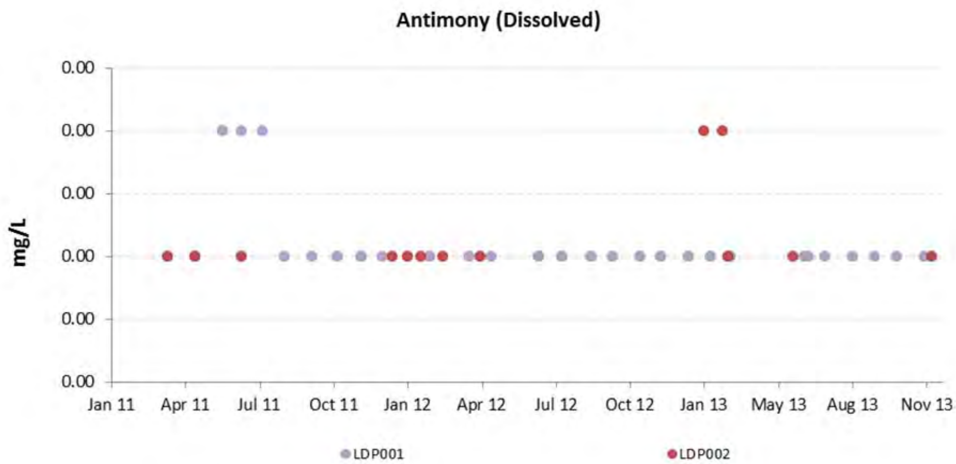

Silver (Total) - Downstream
0.0025
0.0020
0.0015
mg/L
0.0010
0.0005
0.0000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV

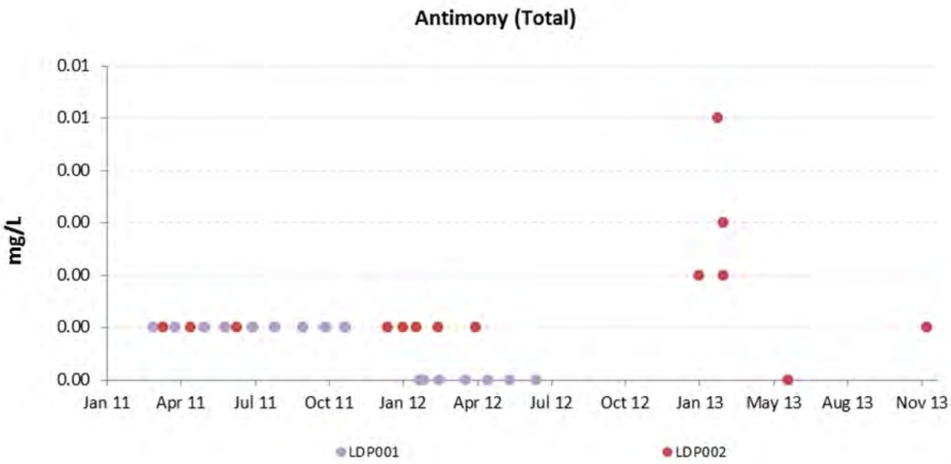

Zinc (Dissolved)
0.06
0.05
0.04
0.03
mg/L
0.02
0.01
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP002 50th%

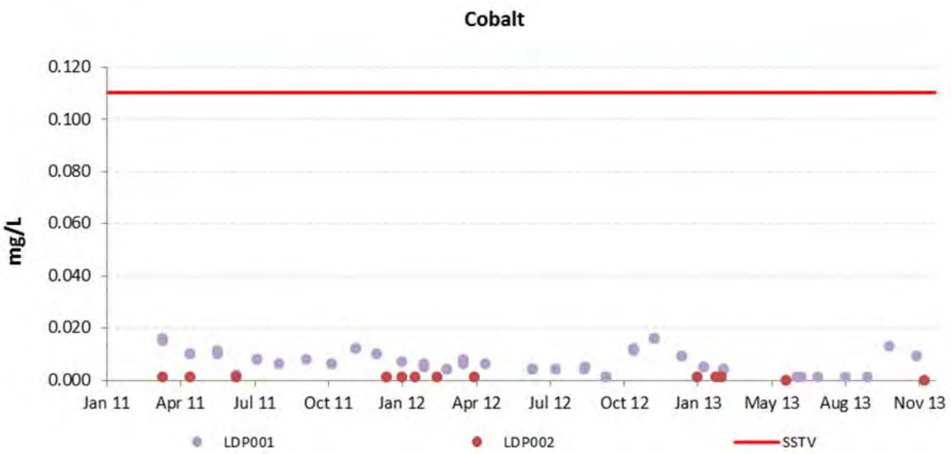

Zinc (Total)
0.09
0.08
0.07
0.06
0.05
0.04
mg/L
0.03
0.02
0.01
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP002 50th%

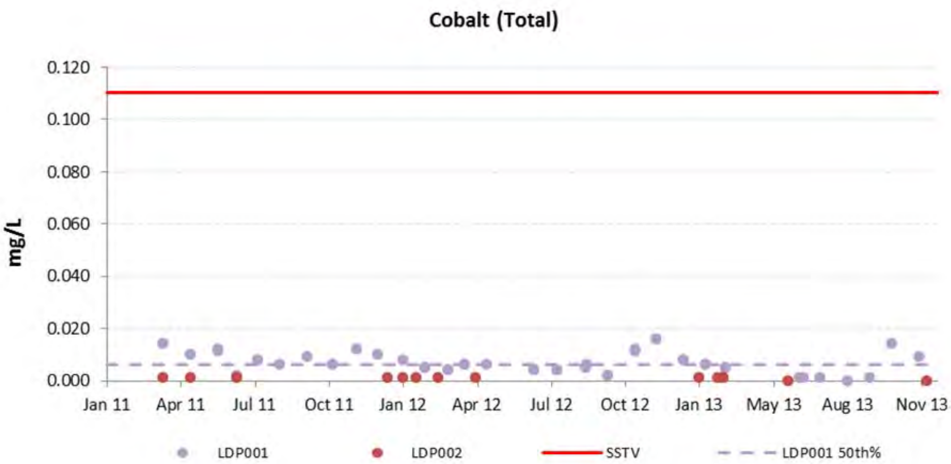

Barium (Dissolved)
mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%
LDP002 50th%

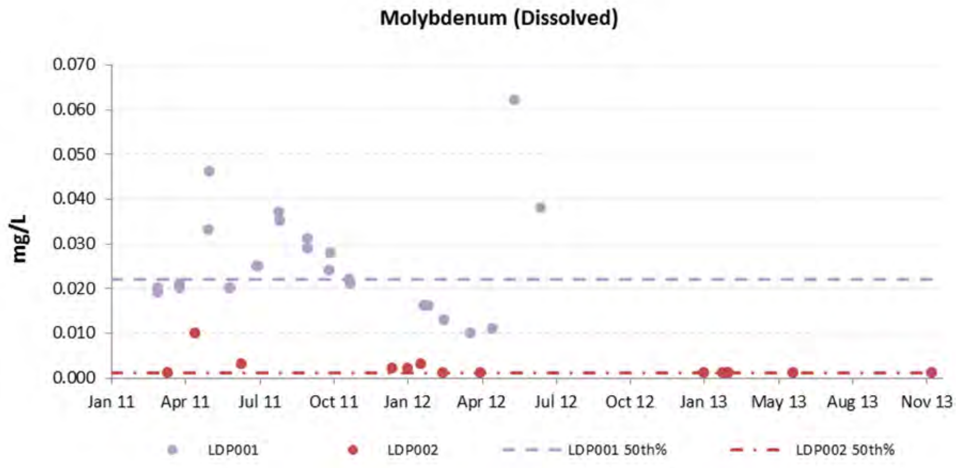

Barium (Total)
mg/L
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%


Antimony (Dissolved)
mg/L
0.00
0.00
0.00
0.00
0.00
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002

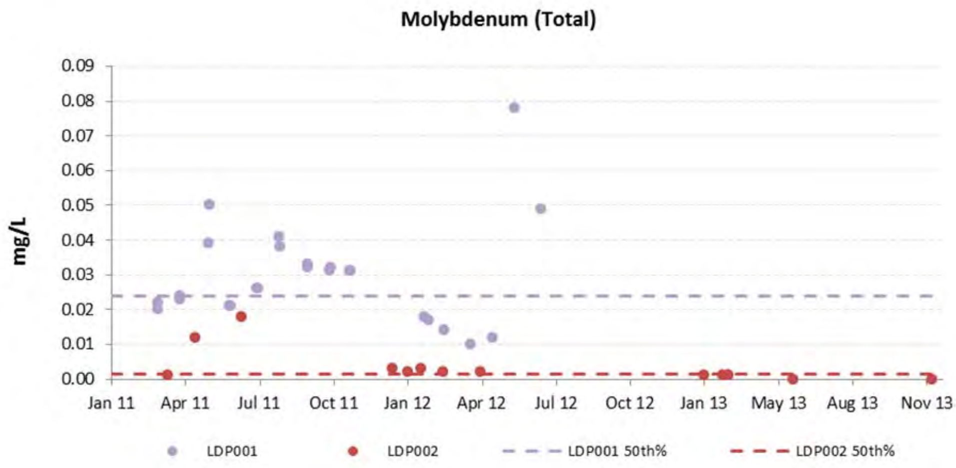

Antimony (Total)
mg/L
0.01
0.01
0.00
0.00
0.00
0.00
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002


Cobalt
mg/L
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV


Cobalt (Total)
mg/L
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
SSTV
LDP001 50th%

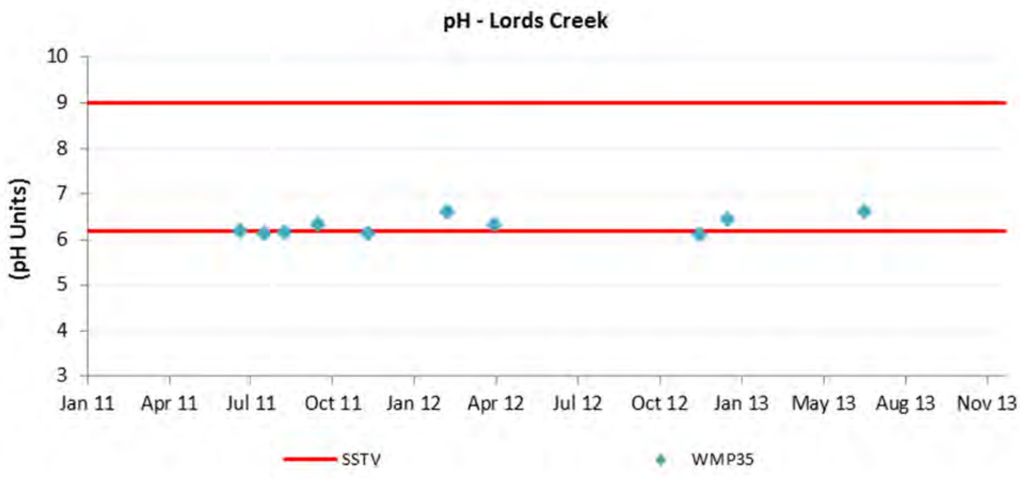


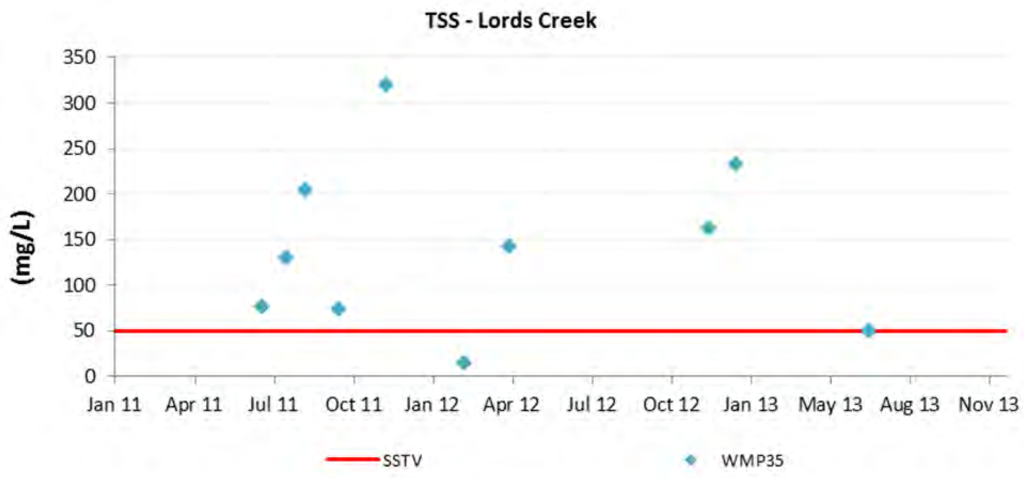
Molybdenum (Dissolved)
mg/L
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
LDP001 50th%
LDP002 50th%

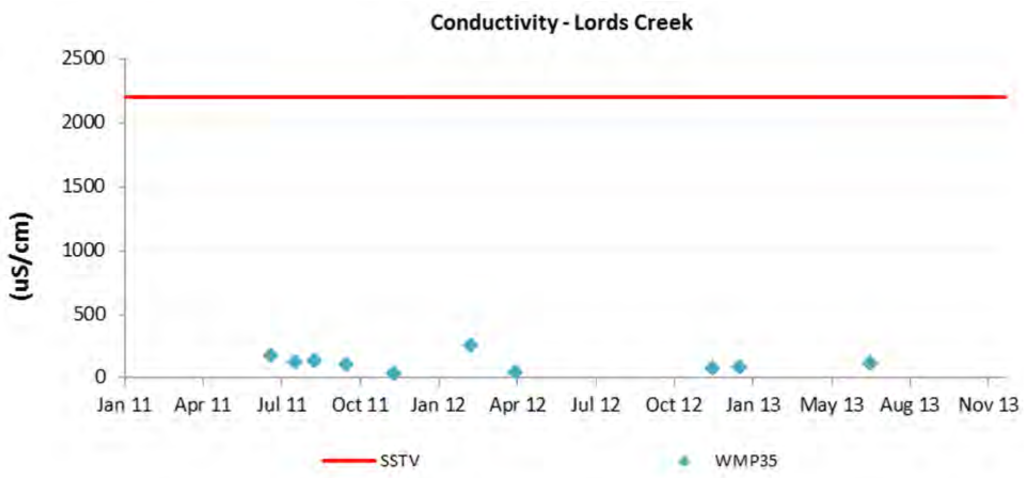


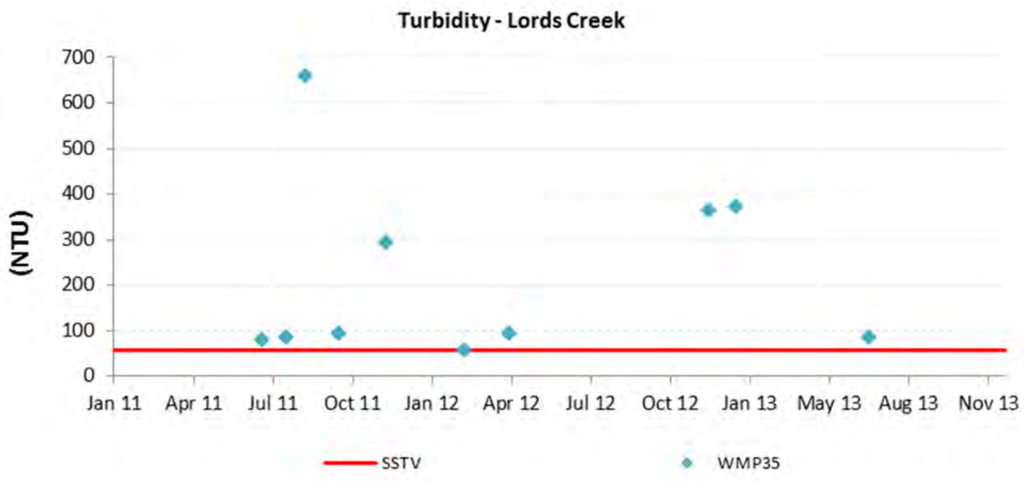
Molybdenum (Total)
mg/L
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
LDP001
LDP002
LDP001 50th%
LDP002 50th%

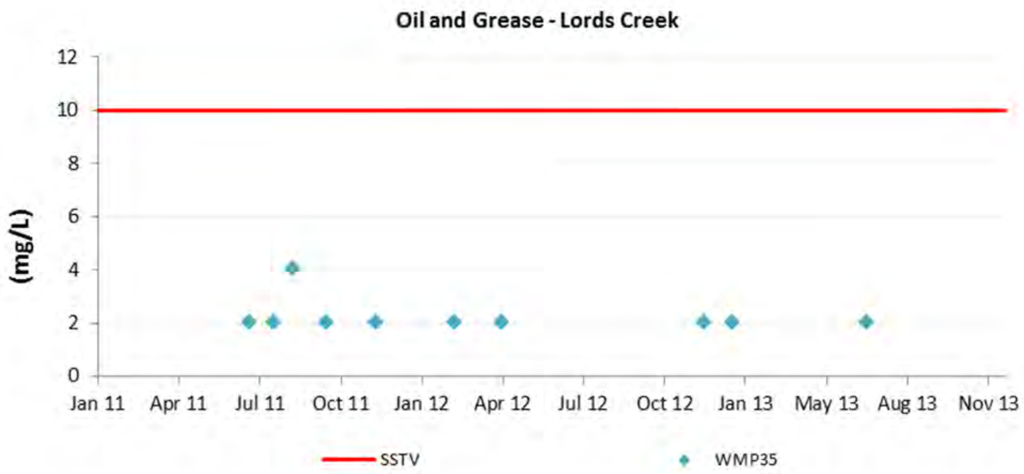
Hawkmount Quarry

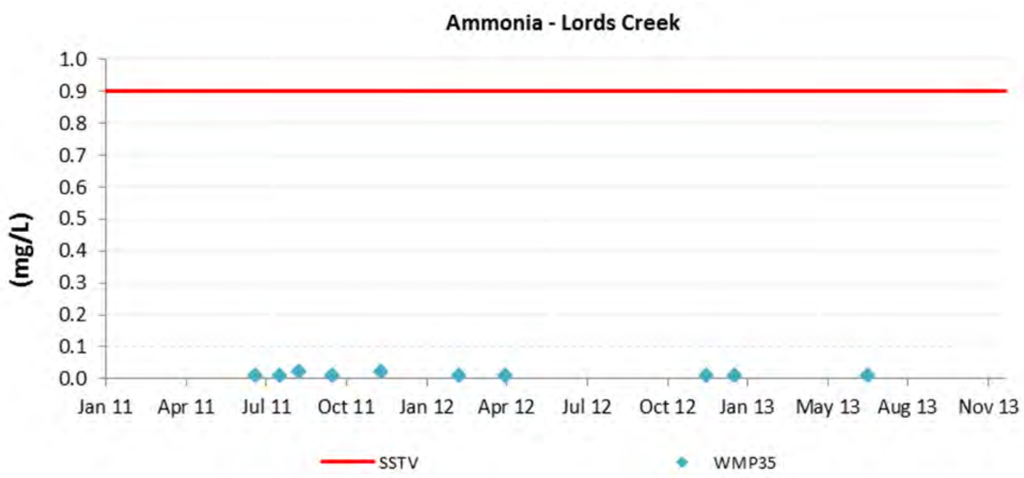


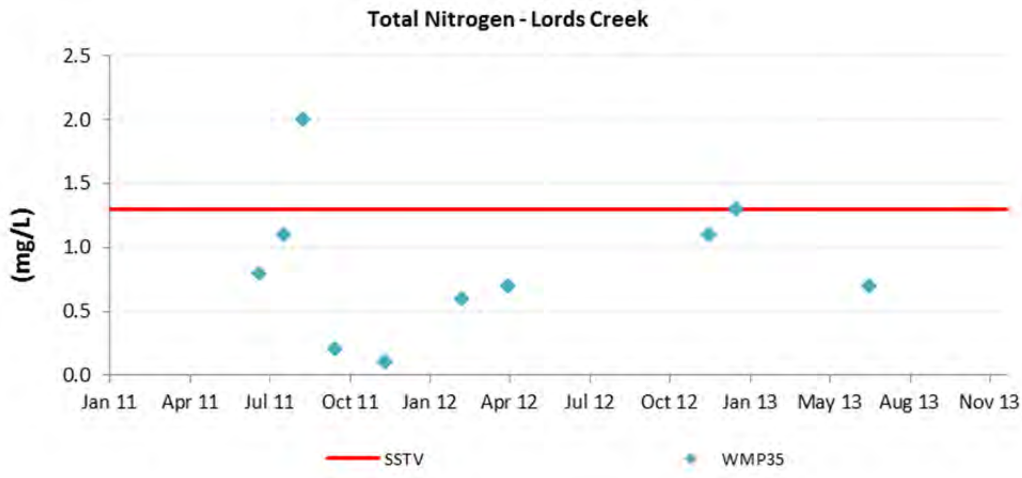


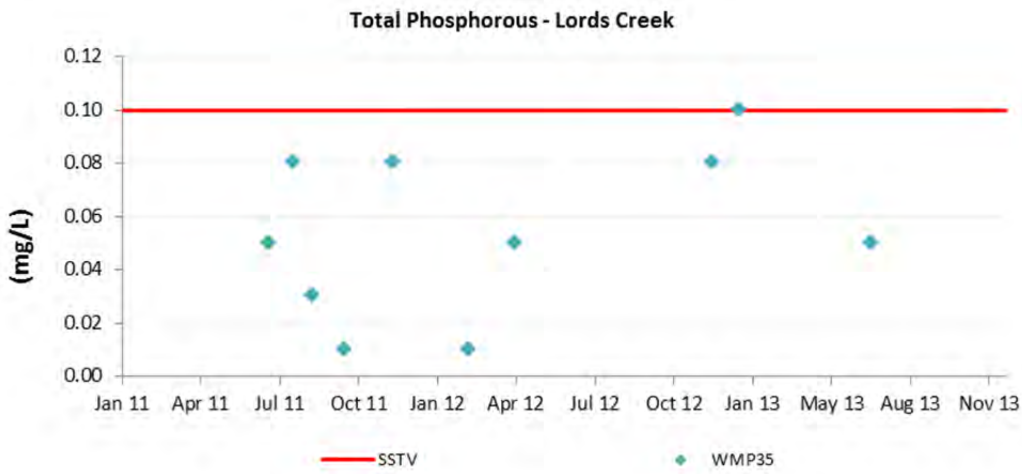


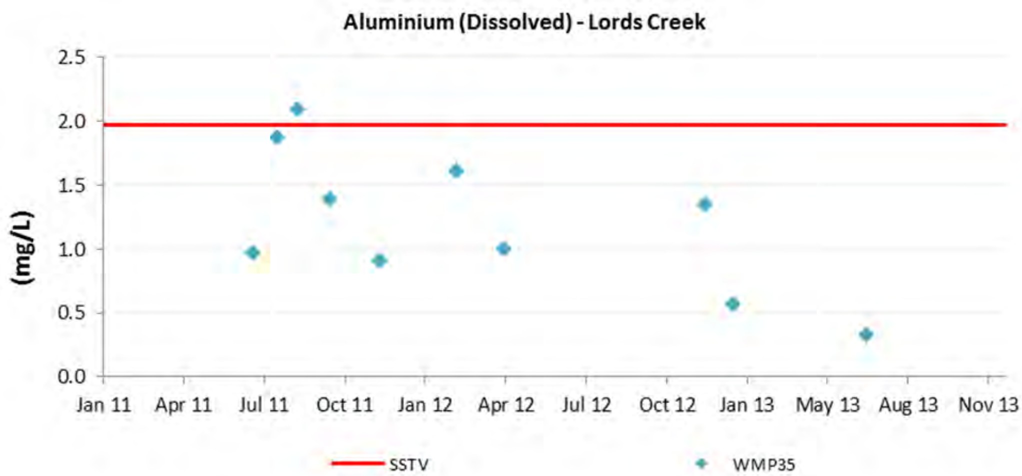

Turbidity - Lords Creek
(NTU)
700
600
500
400
300
200
100
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

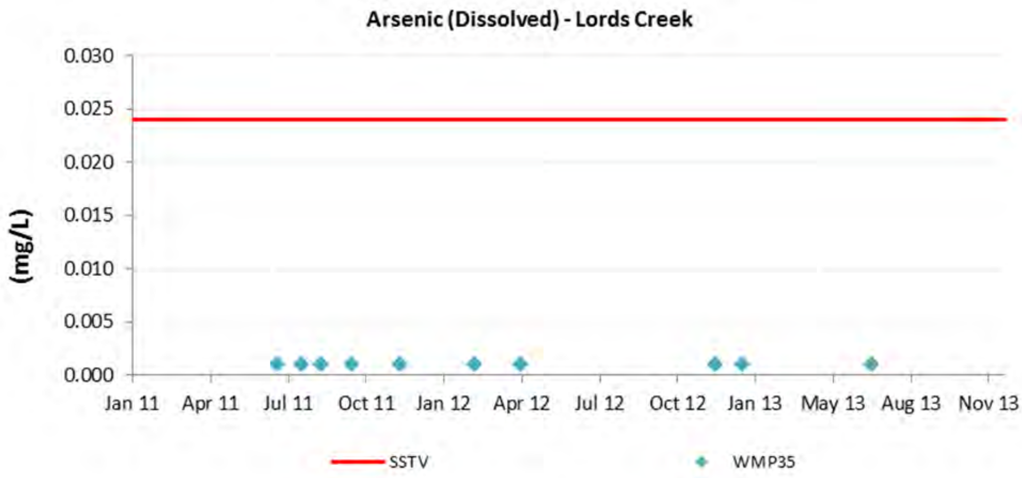

Oil and Grease - Lords Creek
(mg/L)
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

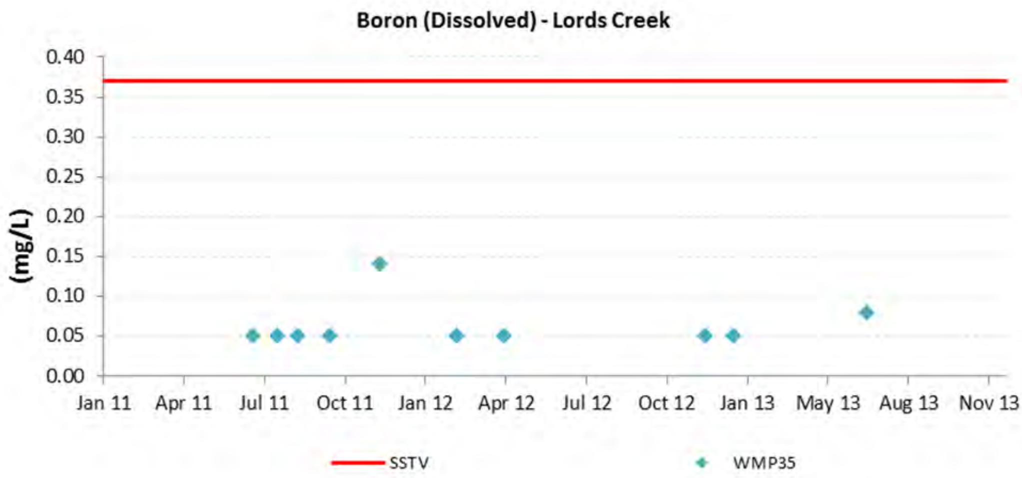

Ammonia - Lords Creek
(mg/L)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

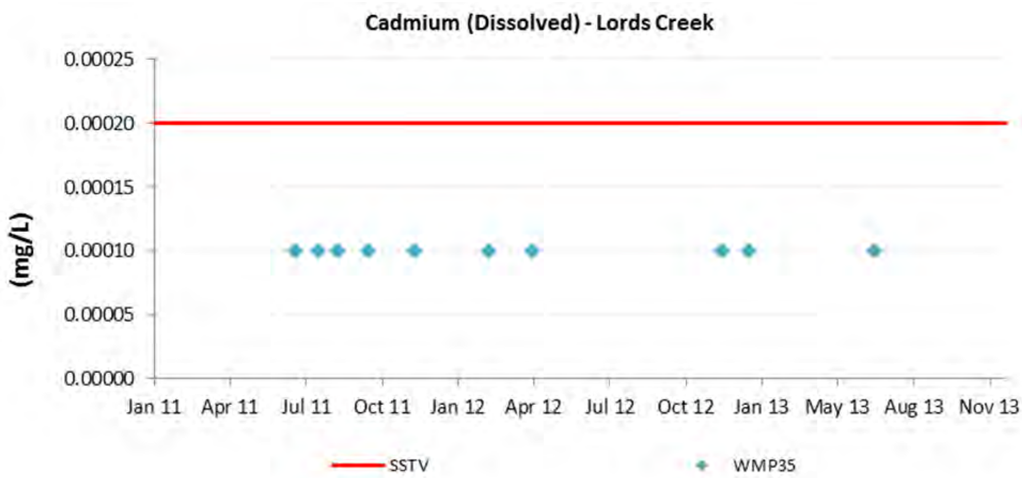

Total Nitrogen - Lords Creek
(mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

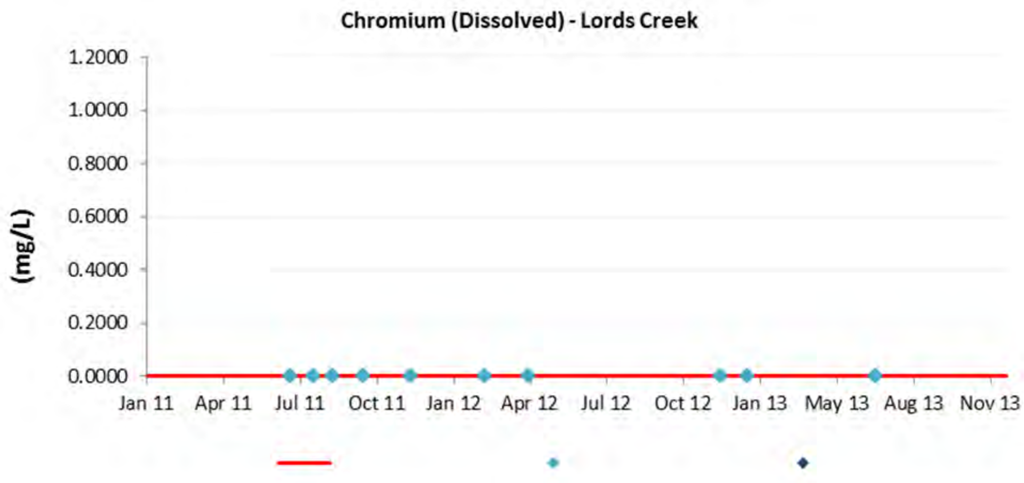

Total Phosphorous - Lords Creek
(mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35


Aluminium (Dissolved) - Lords Creek
(mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

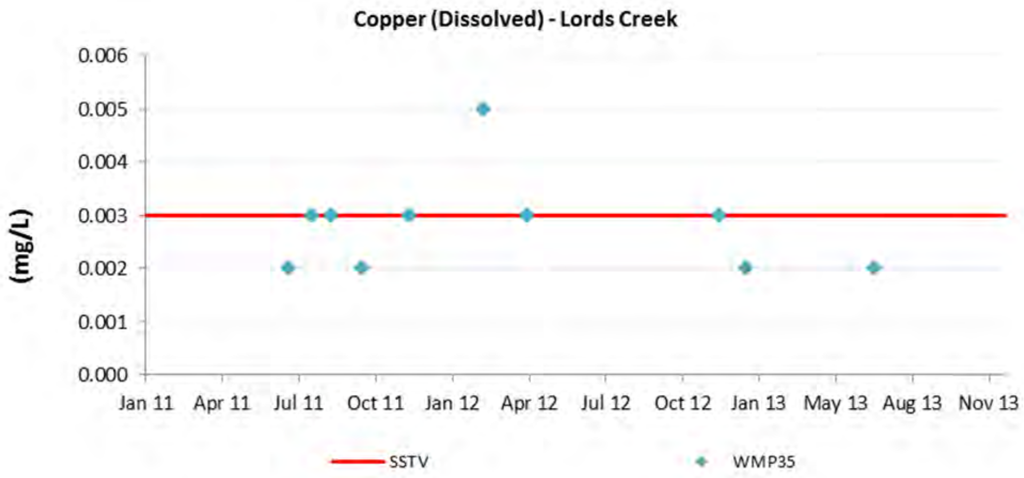

Arsenic (Dissolved) - Lords Creek
(mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35


Boron (Dissolved) - Lords Creek
(mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

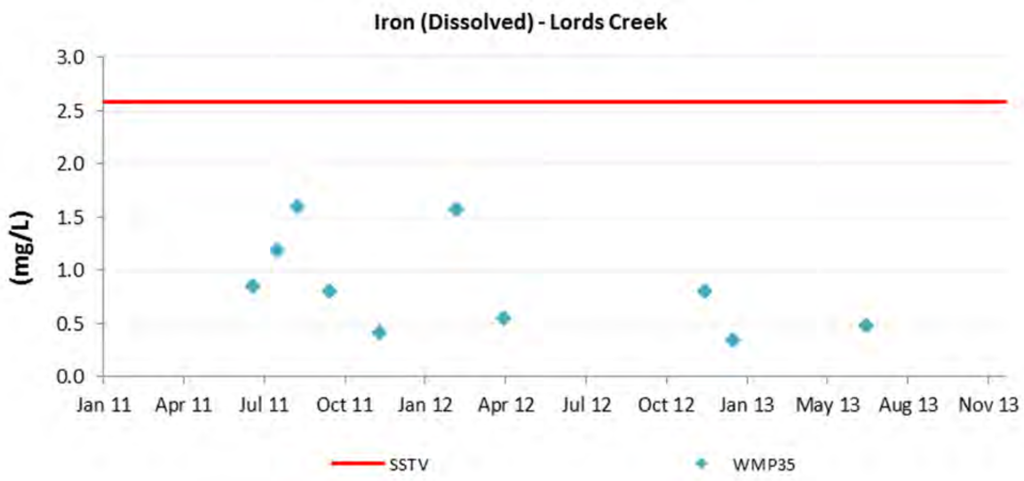

Cadmium (Dissolved) - Lords Creek
(mg/L)
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35



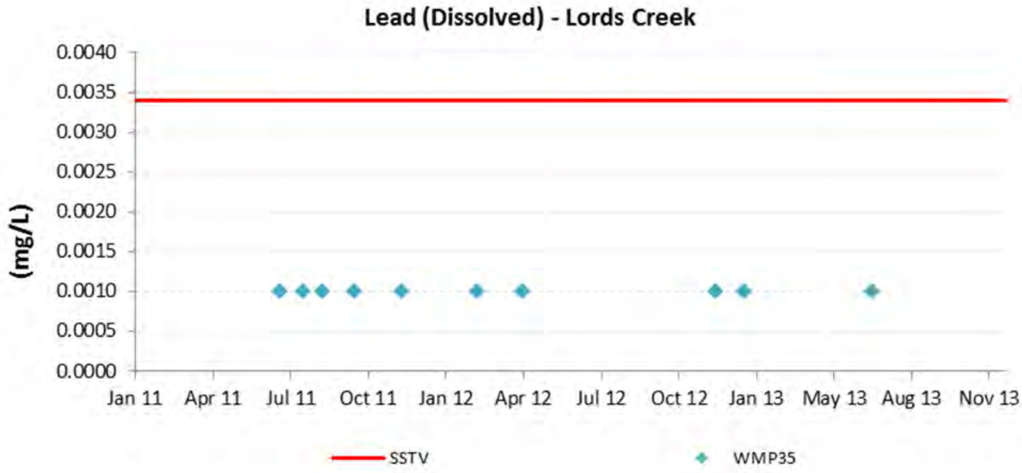
Chromium (Dissolved) - Lords Creek
1.2000
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
(mg/L)
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13

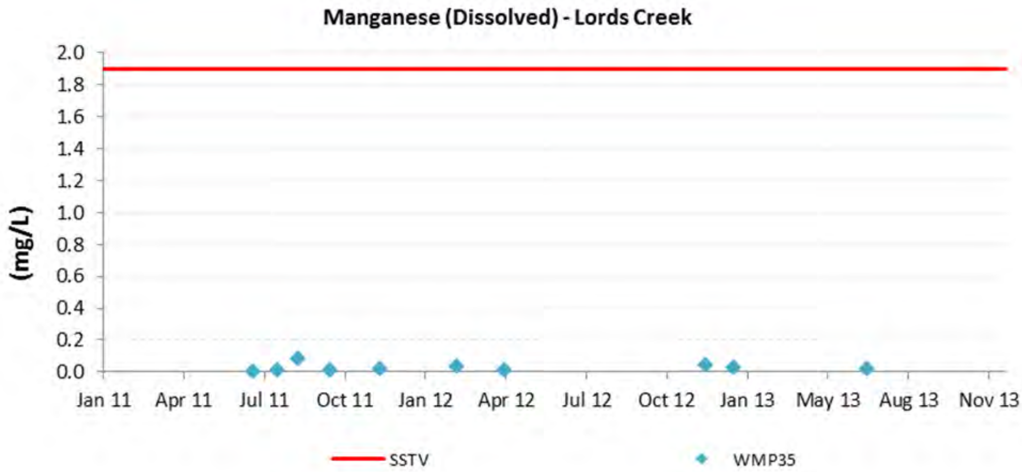


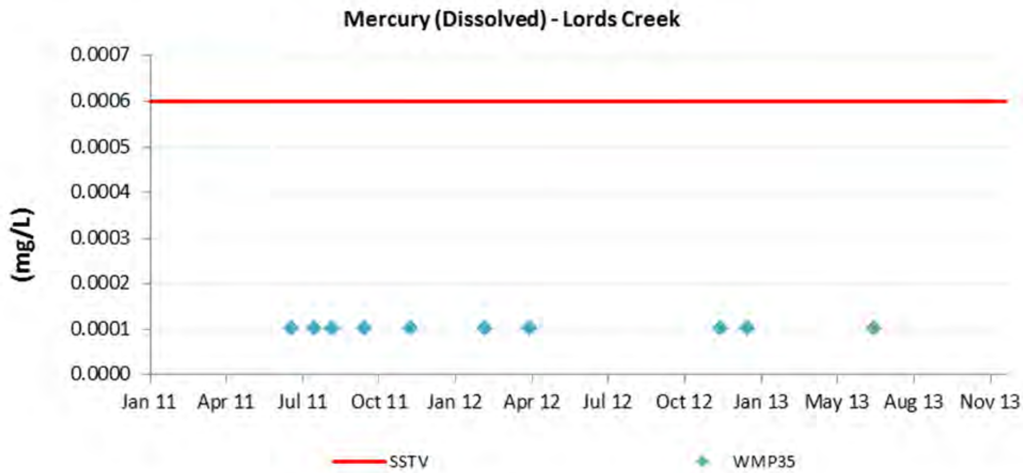
Copper (Dissolved) - Lords Creek
0.006
0.005
0.004
0.003
0.002
0.001
0.000
(mg/L)
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

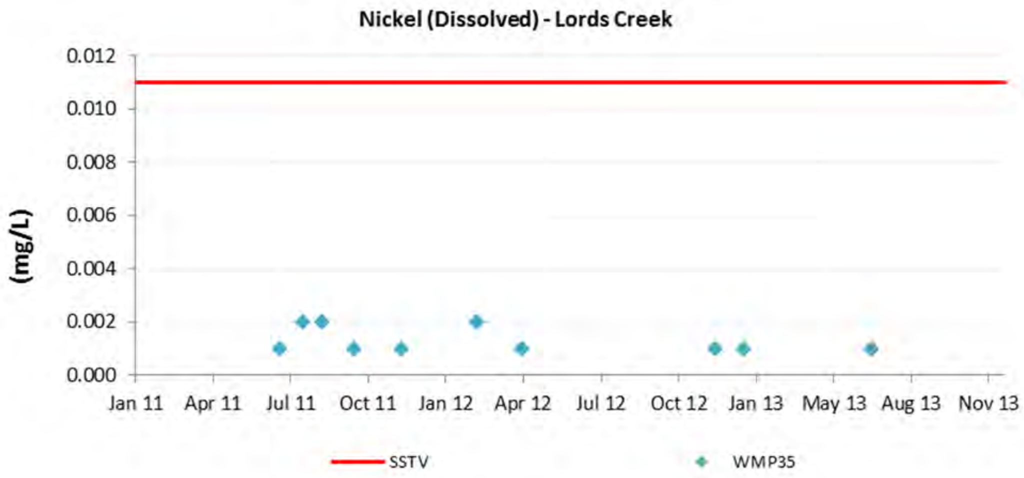


Iron (Dissolved) - Lords Creek
3.0
2.5
2.0
1.5
1.0
0.5
0.0
(mg/L)
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

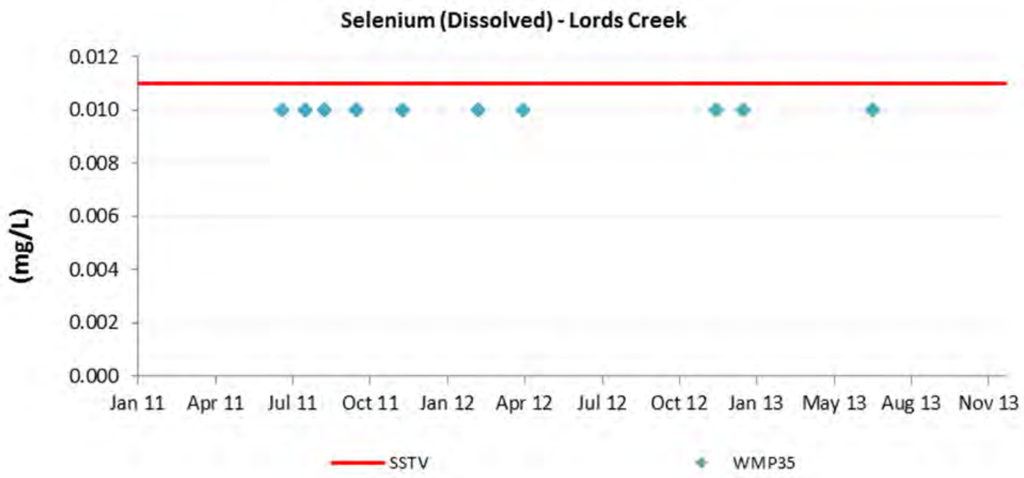

Lead (Dissolved) - Lords Creek
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
(mg/L)
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35


Manganese (Dissolved) - Lords Creek
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
(mg/L)
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

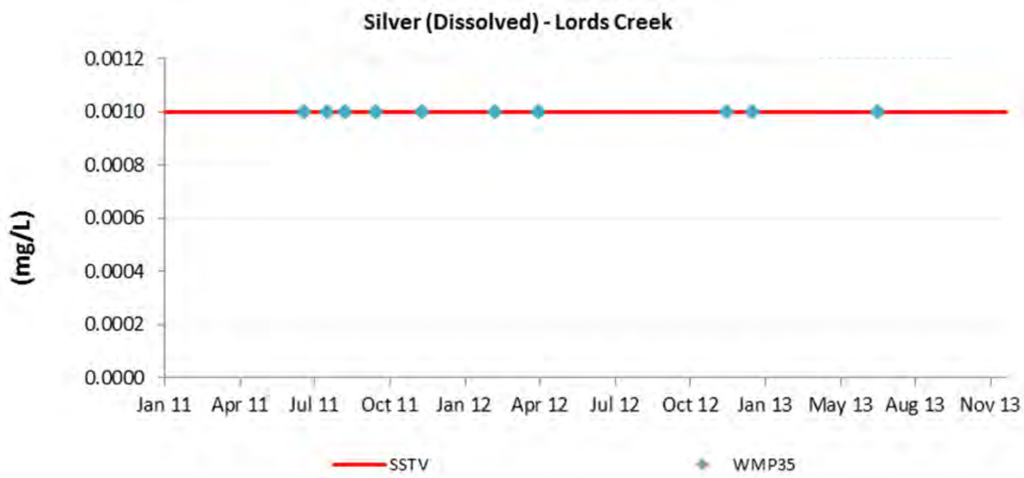

Mercury (Dissolved) - Lords Creek
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
(mg/L)
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35



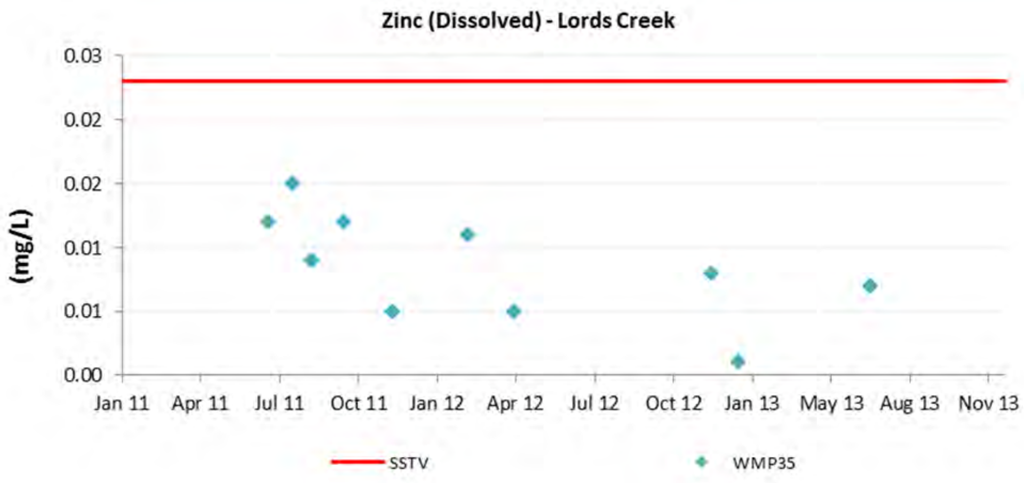
Nickel (Dissolved) - Lords Creek
(mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11 Apr 11 Jul 11 Oct 11 Jan 12 Apr 12 Jul 12 Oct 12 Jan 13 May 13 Aug 13 Nov 13
SSTV
WMP35

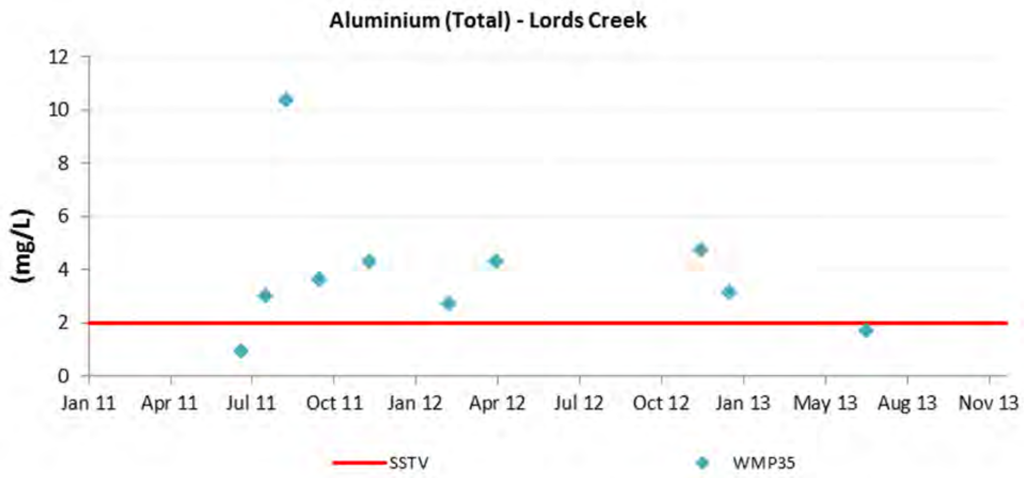


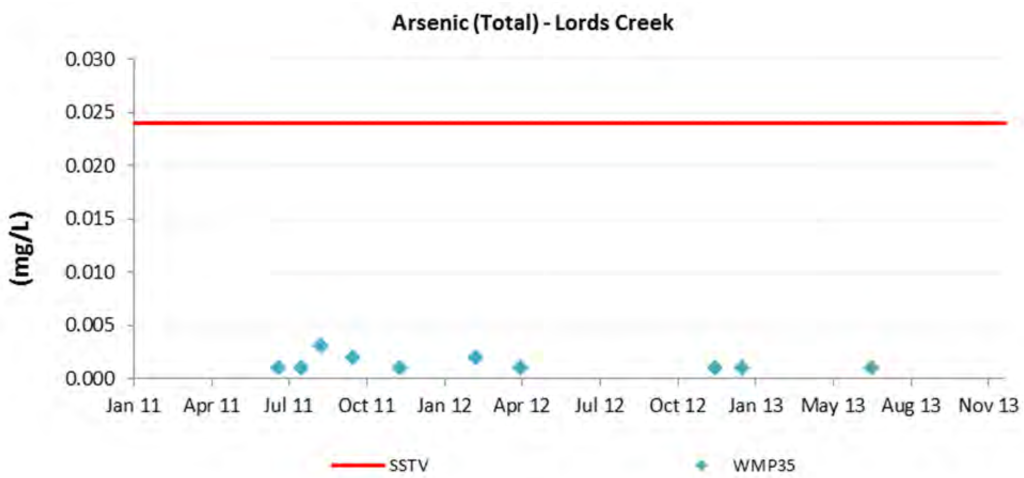
Selenium (Dissolved) - Lords Creek
(mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11 Apr 11 Jul 11 Oct 11 Jan 12 Apr 12 Jul 12 Oct 12 Jan 13 May 13 Aug 13 Nov 13
SSTV
WMP35

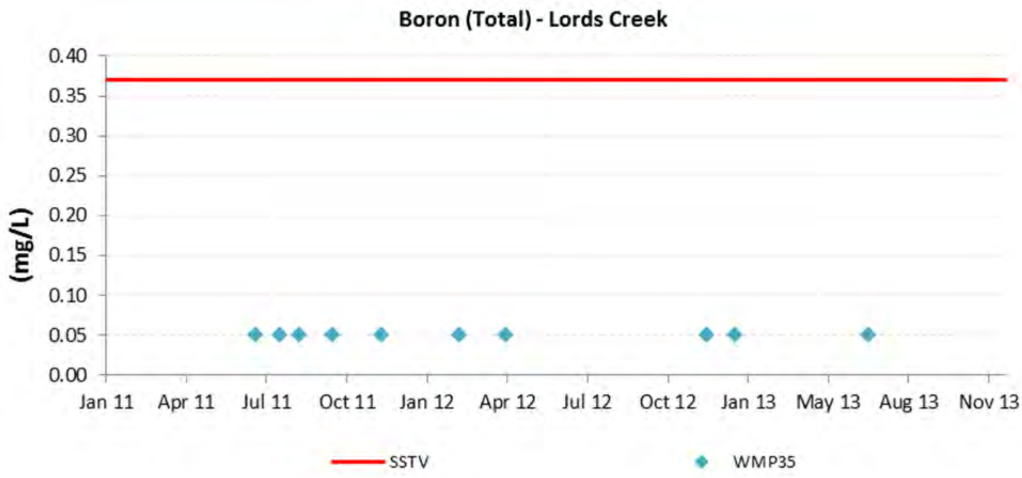


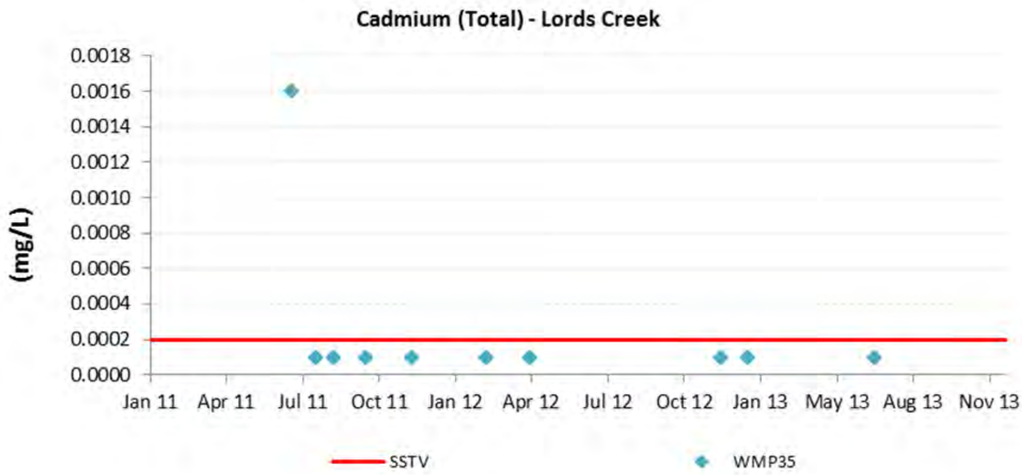
Silver (Dissolved) - Lords Creek
(mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11 Apr 11 Jul 11 Oct 11 Jan 12 Apr 12 Jul 12 Oct 12 Jan 13 May 13 Aug 13 Nov 13
SSTV
WMP35

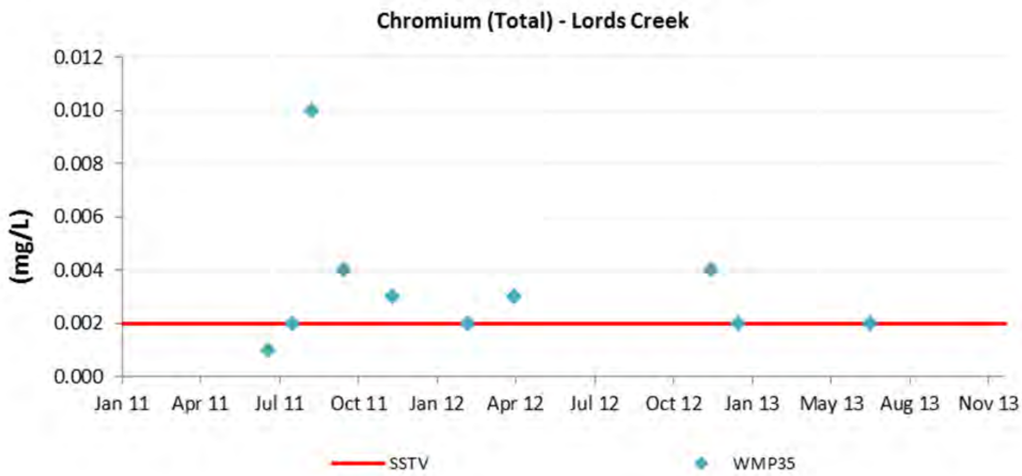

Zinc (Dissolved) - Lords Creek
(mg/L)
0.03
0.02
0.02
0.01
0.01
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

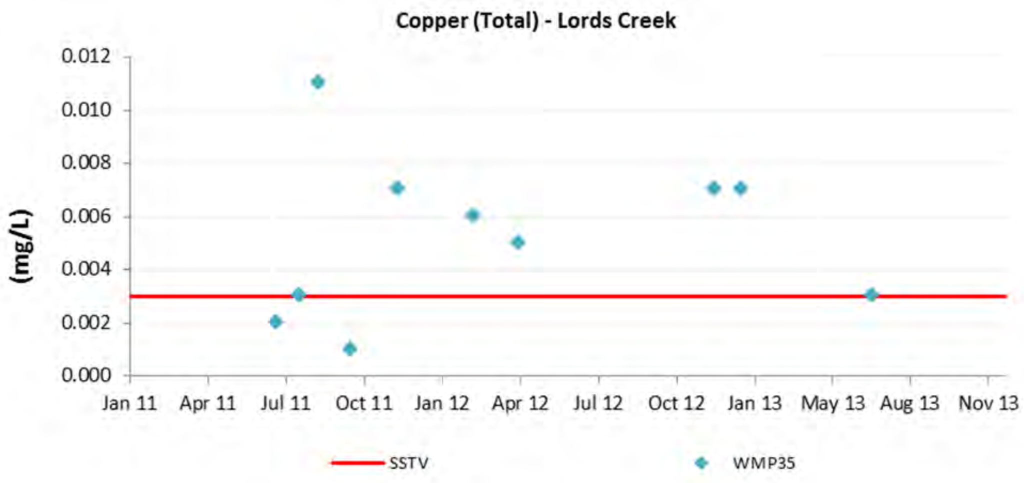

Aluminium (Total) - Lords Creek
(mg/L)
12
10
8
6
4
2
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

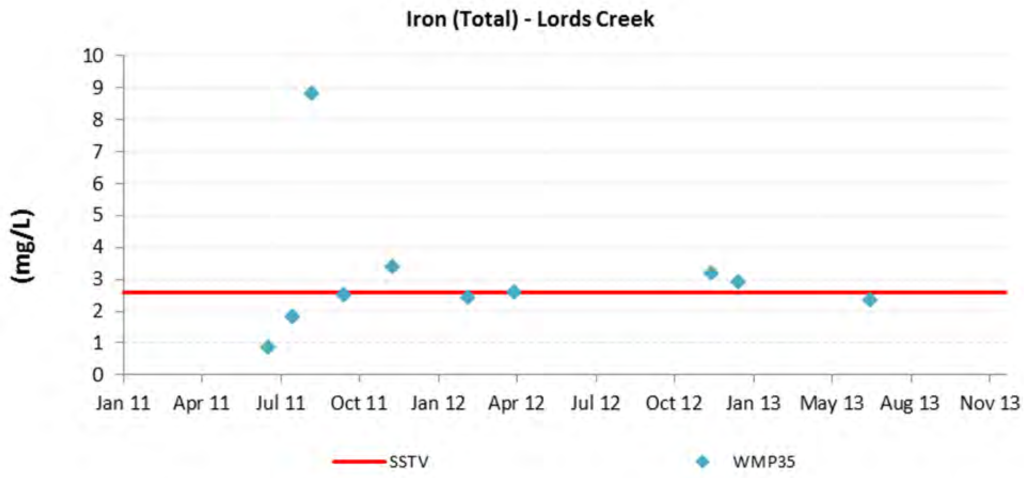

Arsenic (Total) - Lords Creek
(mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

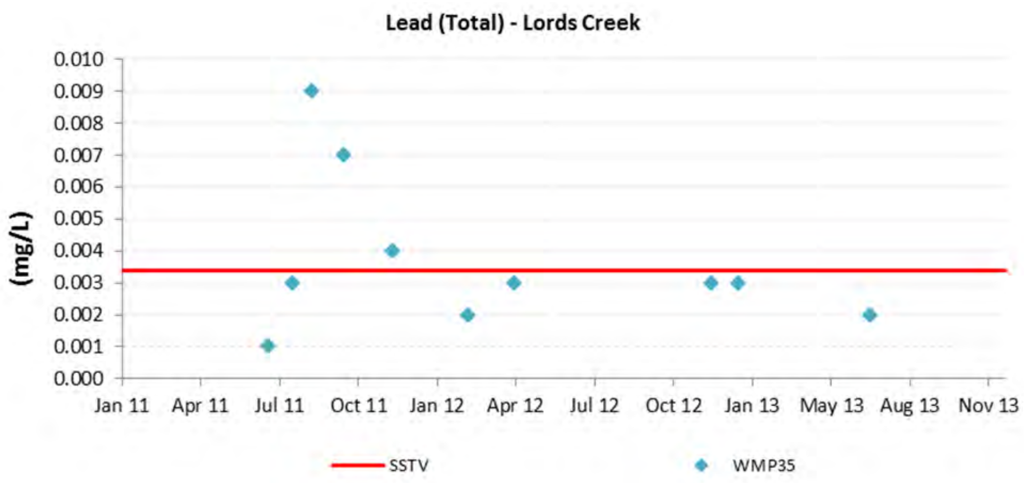

Boron (Total) - Lords Creek
(mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

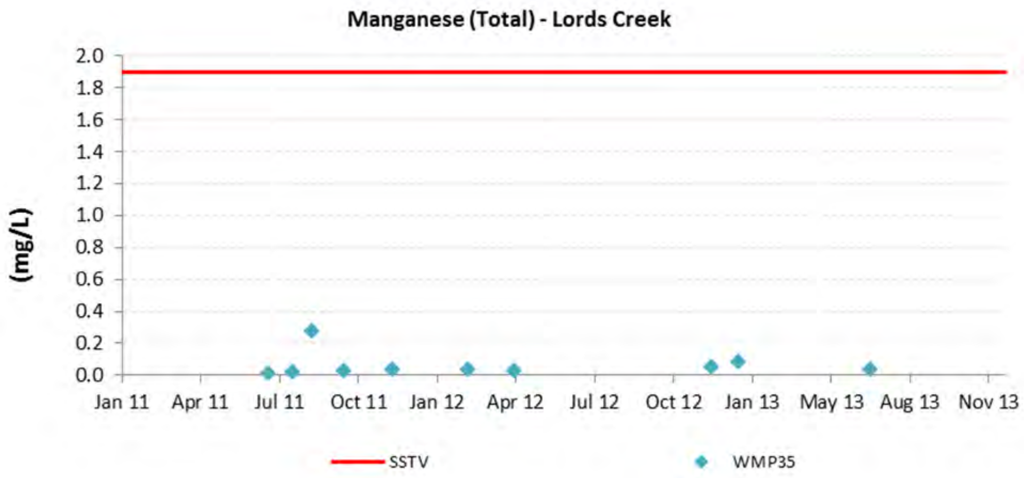

Cadmium (Total) - Lords Creek
(mg/L)
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35


Chromium (Total) - Lords Creek
(mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

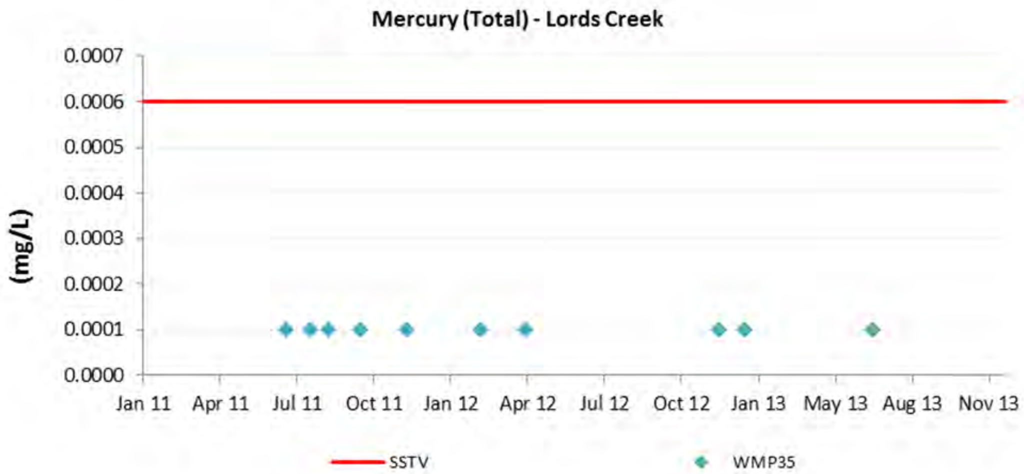

Copper (Total) - Lords Creek
(mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35


Iron (Total) - Lords Creek
(mg/L)
10
9
8
7
6
5
4
3
2
1
0
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

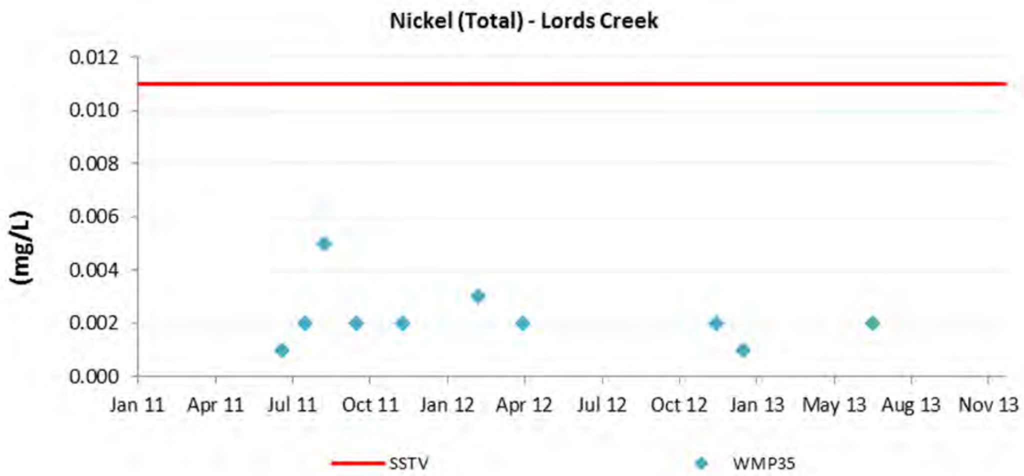

Lead (Total) - Lords Creek
(mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35



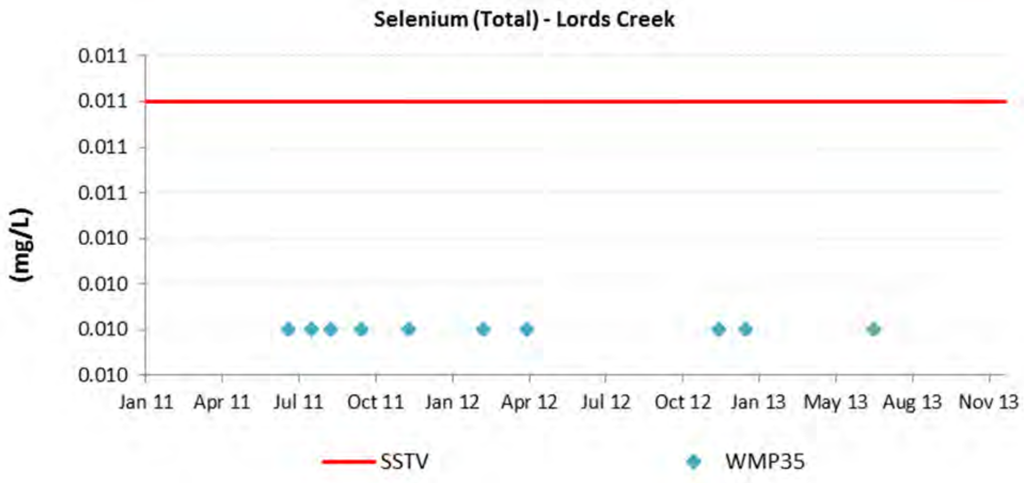
Manganese (Total) - Lords Creek
(mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11 Apr 11 Jul 11 Oct 11 Jan 12 Apr 12 Jul 12 Oct 12 Jan 13 May 13 Aug 13 Nov 13
SSTV
WMP35



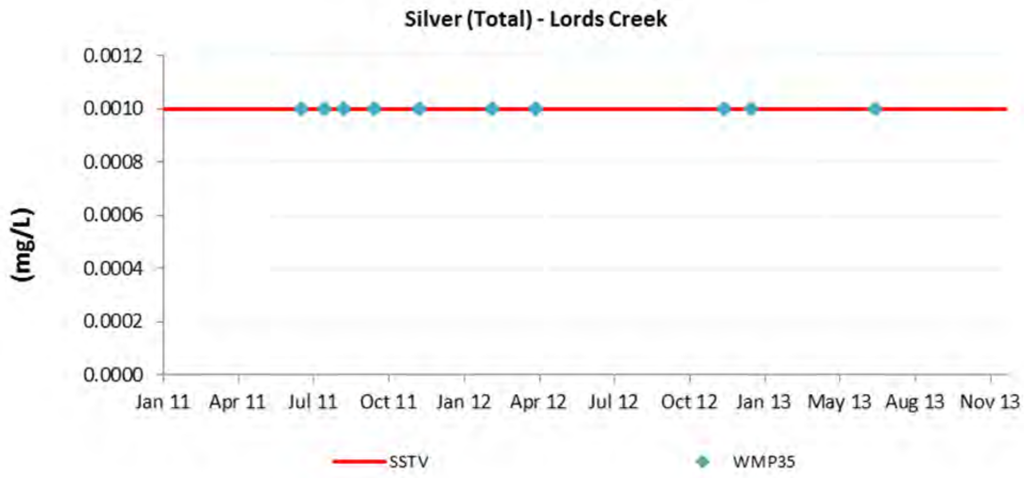
Mercury (Total) - Lords Creek
(mg/L)
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
Jan 11 Apr 11 Jul 11 Oct 11 Jan 12 Apr 12 Jul 12 Oct 12 Jan 13 May 13 Aug 13 Nov 13
SSTV
WMP35



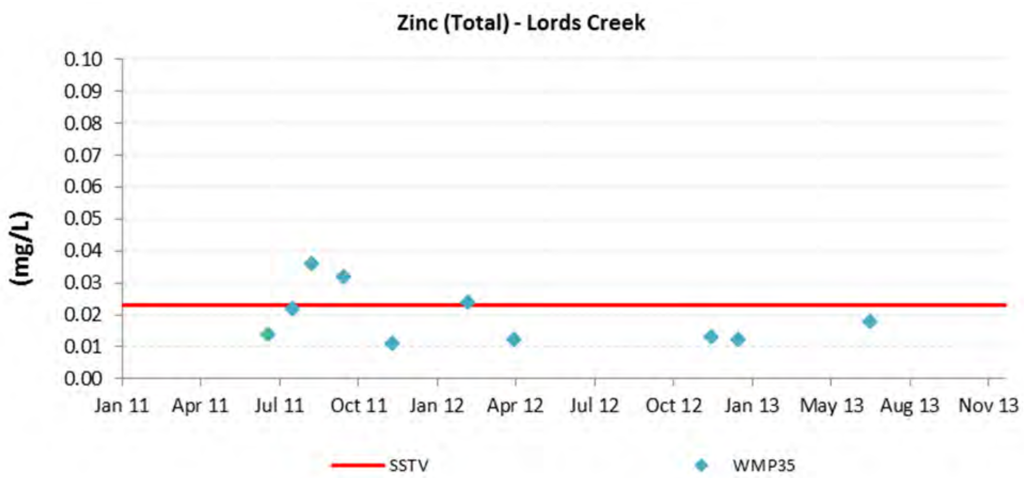
Nickel (Total) - Lords Creek
(mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11 Apr 11 Jul 11 Oct 11 Jan 12 Apr 12 Jul 12 Oct 12 Jan 13 May 13 Aug 13 Nov 13
SSTV
WMP35



Selenium (Total) - Lords Creek
(mg/L)
0.011
0.011
0.011
0.011
0.010
0.010
0.010
0.010
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35



Silver (Total) - Lords Creek
(mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35



Zinc (Total) - Lords Creek
(mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Apr 11
Jul 11
Oct 11
Jan 12
Apr 12
Jul 12
Oct 12
Jan 13
May 13
Aug 13
Nov 13
SSTV
WMP35

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GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	T Davies	L Hammersley	*L Hammersley*	S Gray	*S Gray*	28/03/14
1	T Davies	L.Hammersley	*L Hammersley*	S Gray	*S Gray*	10/04/14
2	T Davies	L.Hammersley	L Hammersley	S Gray	[illegible]	15/04/14

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