Centennial Mandalong Pty Ltd

Mandalong Mine

LW30-31 Extraction Plan WMP

June 2021

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Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate (CaCO3).
Alluvial	Deposition from running waters.
Aquifer	An underground layer of permeable material from which groundwater can be usefully extracted.
Australian Height Datum	A common national surface level datum approximately corresponding to sea level
Average recurrence interval	A statistical estimate of the average period in years between the occurrence of a flood of a given size or larger, e.g. floods with a discharge equivalent to the 1 in 100-year average recurrence interval flood event will occur on average once every 100 years.
Baseflow	The component of flow in a watercourse that is driven from the discharge of underground water.
Baseline monitoring	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g. species occurrence or water quality) prior to the commencement of a specific activity.
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.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular location.
Cumulative rainfall departure	Monthly accumulation of the difference between the observed monthly rainfall and long-term average monthly rainfall.
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	The quantity of water per unit of time flowing in a stream, for example cubic metres 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.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Fracture	Cracks within the strata that develop naturally or as a result of underground works.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report relates to the form and structure of waterways.
Groundwater	Water occurring naturally below ground level.

Groundwater extraction	For the purposes of this report, 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 value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. They indicate a risk of impact if exceeded and should 'trigger' action to conduct further investigations or to implement management or remedial processes.
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 water 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.
Interseam	The strata between the coal seams.
Ion	Electrically charged atom.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site environmental protection licence.
Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined 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.
Overburden	The strata between the recoverable topsoil and the upper coal seam.
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% of values are found.
Permian Age	The youngest geological period of the Palaeozoic era, covering a span between approximately 250 and 290 million years.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Potable water	Water of a quality suitable for drinking.
Reach	Defined section of a stream with a uniform character and behaviour.
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.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Run of mine	Raw coal production (unprocessed).
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Strata	Geological layers below the ground surface.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.

Subsidence	The vertical difference between the pre-mining surface level and the post-mining surface level at a point.
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.
Tributary	A stream or river that flows into a main river or lake.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

Abbreviations

AHD	Australian Height Datum
ARI	Average recurrence interval
bgl	Below ground level
BOD	Biochemical oxygen demand
Centennial	Centennial Coal Company Pty Limited
Centennial Mandalong	Centennial Mandalong Pty Limited
CES	Cooranbong Entry Site
CRD	Cumulative rainfall departure
DES	Delta Entry Site
DGV	Default guideline value
DP&E	Department of Planning and Environment
DILW	Department of Industry – Lands and Water
DRE	Department of Resources and Energy
EC	Electrical conductivity
EPA	Environmental Protection Authority
EPL	Environment protection licence
GDE	Groundwater dependent ecosystem
HARTT	Hydrograph Analysis: Rainfall and Time Trends
km	Kilometre
L/s	Litre per second
LOR	Limit of reporting
LDP	Licensed discharge point
m	Metre
m/s	Metre per second
m/year	Metre per year
mg/L	Milligram per litre
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
MMAS	Mandalong Mine Access Site
MSSS	Mandalong South Surface Site
NTU	Nephelometric turbidity unit
PIRMP	Pollution Incident Response Management Plan
ROM	Run of mine
SSGV	Site-specific guideline value
TARP	Trigger action response plan
TKN	Total Kejldahl nitrogen
TSS	Total suspended solids
VWP	Vibrating wire piezometer
WAL	Water access licence
WMP	Water management plan
µS/cm	Microsiemens per centimetre

1. Introduction

1.1 Background

Mandalong Mine is an underground coal mine located approximately 35 km south-west of Newcastle on the western side of Lake Macquarie. Centennial Mandalong Pty Limited (Centennial Mandalong), which is a wholly owned subsidiary of Centennial Coal Company Limited (Centennial), acquired the mine in August 2002, with mining operations commencing in 2005. Mandalong Mine consists of underground mine workings and surface facilities located at four sites: Mandalong Mine Access Site (MMAS), Cooranbong Entry Site (CES), Mandalong South Surface Site (MSSS) and Delta Entry Site (DES). The location of the surface sites and the Mandalong Mine Holding Boundary are shown in Figure 1-1.

Mandalong Mine currently operates under development consent SSD-5144, granted by the Planning Assessment Commission on 12 October 2015 for the Mandalong Southern Extension Project. The development consent provides for an extension of the mining area with a production limit of 6.5 million tonnes per annum of thermal coal from the West Wallarah and Wallarah-Great Northern seams.

This Water Management Plan (WMP) has been prepared for the Extraction Plan for secondary extraction of Longwalls 30 to 31. The mine plan for Longwalls 30 to 31 is shown in Figure 1-2 and potential subsidence predictions, provided by Centennial, are shown on Figure 1-3. The WMP has been developed for the management of potential impacts to watercourses and aquifers from the proposed secondary extraction of Longwalls 30 to 31 at Mandalong Mine, as stipulated by development consent SSD-5144.

Ian Gilmore and Tyler Tinkler of GHD Pty Ltd has prepared the WMP and Dr Stuart Gray of GHD Pty Ltd has reviewed the WMP. Preparation of the WMP was undertaken in consultation with Centennial Mandalong and in accordance with the conditions of development consent SSD-5144 for Mandalong Mine.

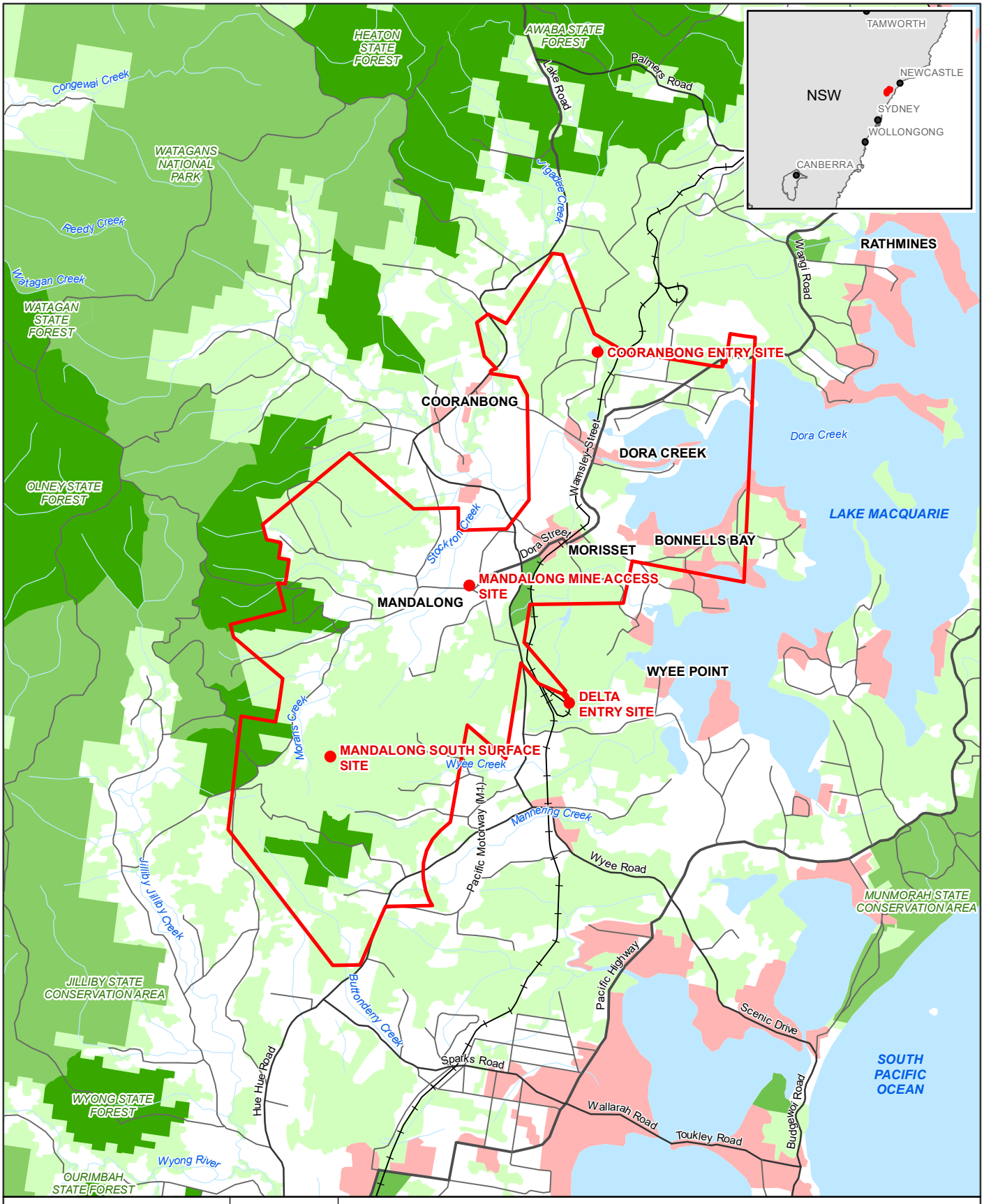
1.2 Overview of site operations

The currently approved Mandalong Mine comprises the following underground workings and surface infrastructure:

- MMAS, encompassing underground workings and associated surface infrastructure near Morisset.
- Delivery of run of mine (ROM) coal from the underground workings to the CES. The CES coal handling and processing facilities are approved under the Northern Coal Logistic Project (SSD-5145).
- Delivery of ROM coal from the underground workings to the DES, located near Wyee at the Vales Point Rail Unloader Facility. The coal handling facility is approved under DA35-2-2004.
- MSSS, encompassing ventilation shafts, ventilation fans and underground delivery boreholes located approximately 6 km south-west of the MMAS.

1.3 Study area

The study area for this WMP primarily encompasses the 26.5 degree angle of draw and 20 mm subsidence limit around the extraction areas of Longwalls 30 to 31 as shown in Figure 1-2. However, this WMP also considers impacts on mine water inflows, underground water storages and groundwater bores that extend beyond the primary study area.



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0 0.5 1 2 3 4

Kilometers

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

N

GHD

LEGEND

- Site location
- Development consent boundary
- Existing rail
- Motorway
- Principal road
- Secondary road
- Minor road
- Watercourse
- Watercourse area
- Built up area
- Recreation areas
- Nature conservation
- State forest
- Forest or shrub

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

Locality Plan

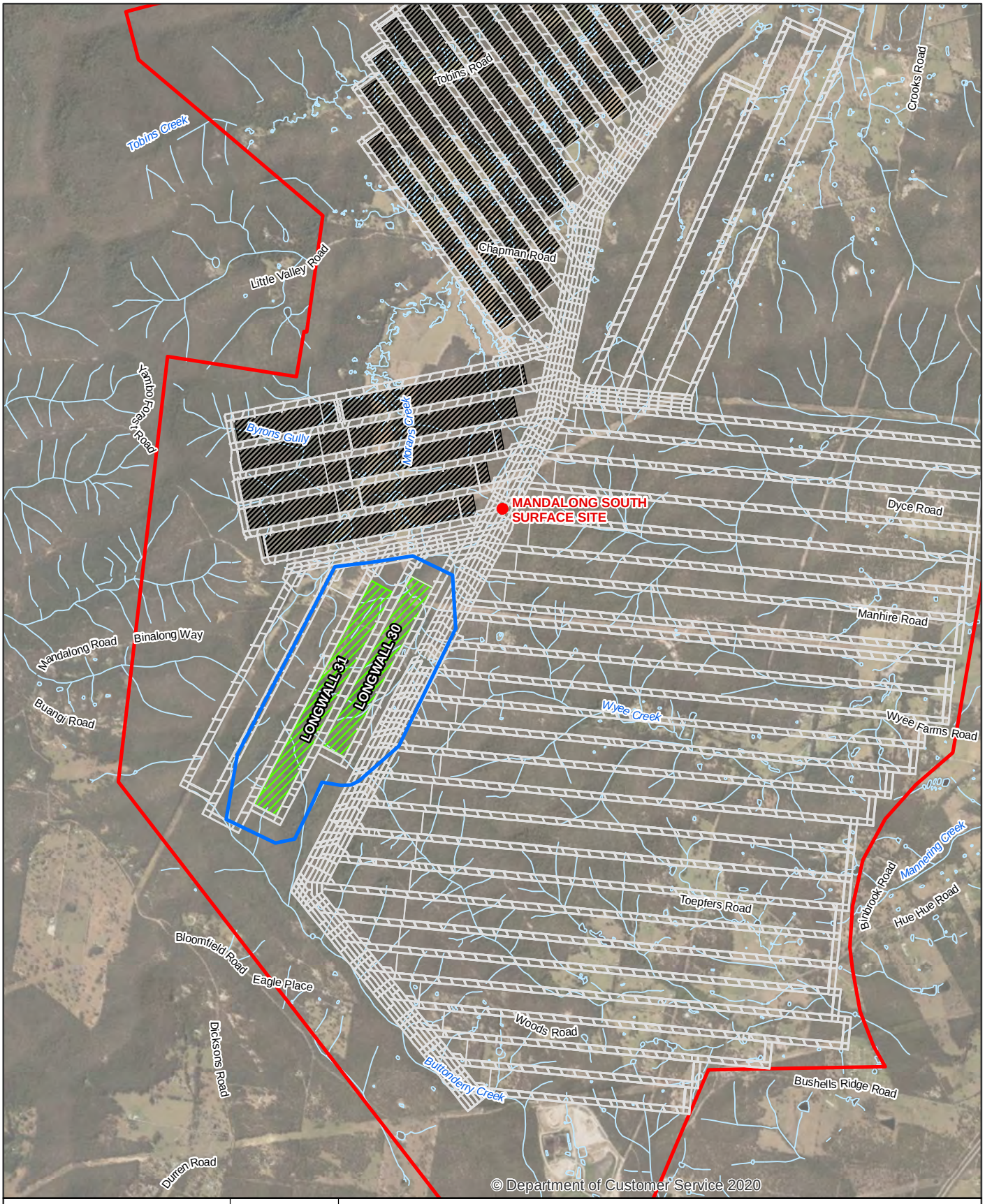
CENTENNIAL

DATE 22/12/2020

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP001_LocalityPlan_0.mxd

Data source: Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006; Centennial: Holdings Boundary, 2016. Created by: smacdonald, kpsroba



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0 300 600 900 1,200

Metres

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

N

LEGEND

- Site location
- Study area
- Existing extraction area
- Proposed extraction area
- Development consent boundary
- Waterway (field surveyed)
- Approved mine workings

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

Mine Plan

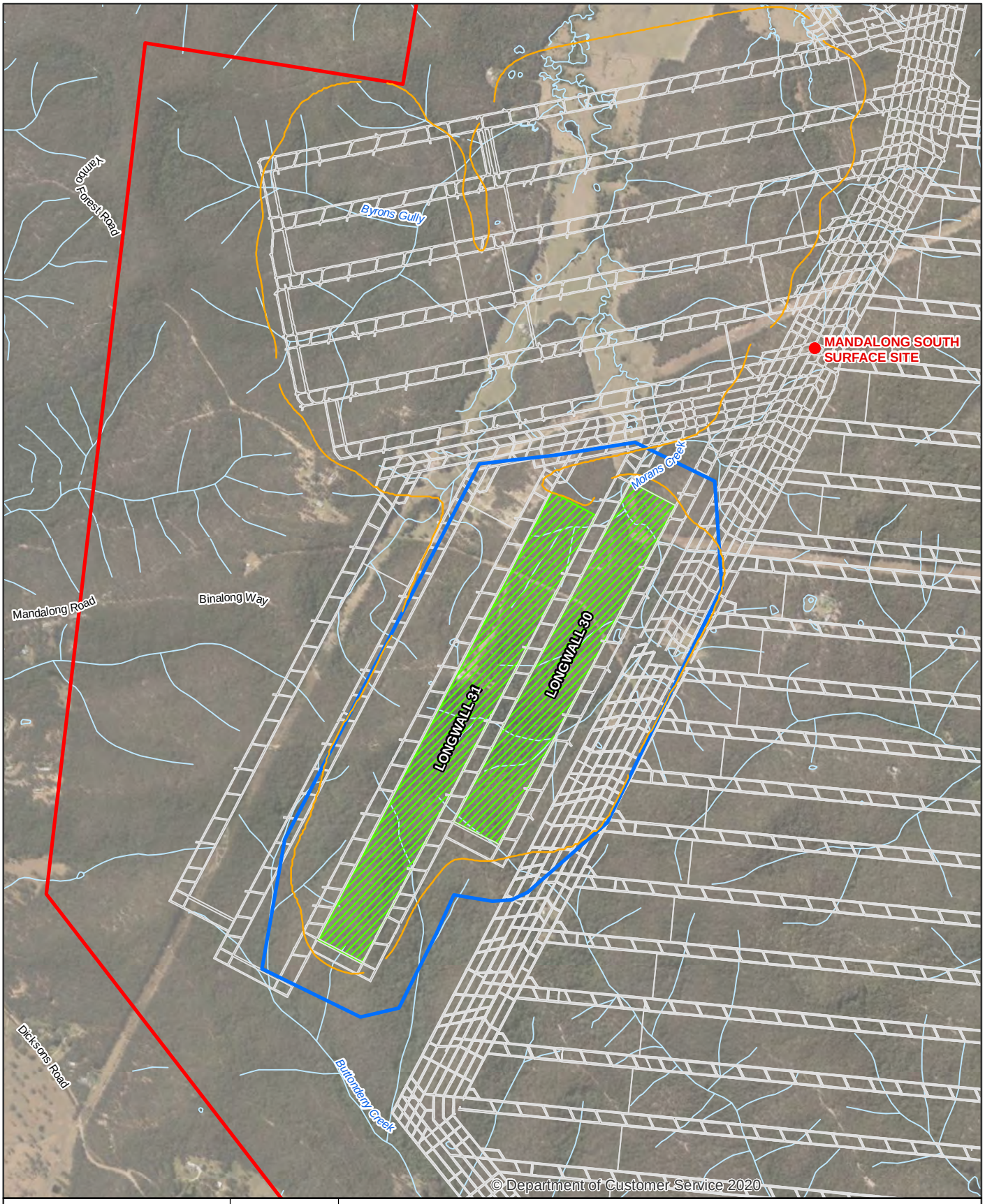
CENTENNIAL

DATE 16/06/2021

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP002_MinePlan_0.mxd

Data source: LPI:DTDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, fmackay



1:20,000 for A4

0 75 150 300 450 600

Metres

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

N

LEGEND

- Site location
- Development consent boundary
- Study area
- Approved mine workings
- Waterway (field surveyed)
- 20 mm subsidence prediction contour

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31 Water Management Plan

Subsidence Predictions for Longwalls 30 to 31

CENTENNIAL

DATE 16/06/2021

Figure 1-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP005_SubsMinePlan_0.mxd

Data source: LPI:DCDB, 2012. Centennial: Mine workings, Extraction area, consent boundary, Subsidence prediction, 2016. GSS, Imagery. Created by: smacdonald, kpsroba

1.4 Purpose

The WMP addresses specific water components of development consent SSD-5144, which was granted by the NSW Planning Assessment Commission on 12 October 2015 for the Mandalong Southern Extension Project. Schedule 4, Section 6 (i) of development consent SSD-5144 requires Centennial Mandalong to develop and implement a WMP as part of the Extraction Plan for Longwalls 30 to 31. The relevant requirements of the WMP content are outlined in Table 1-1, along with the sections of the plan where these have been addressed.

Table 1-1 Development consent SSD 5144 requirements for Water Management Plan

Condition	Where addressed
Detailed baseline data on groundwater levels, yield and quality in the region, and in privately owned groundwater bores that could be affected by the second workings.	Section 3
Surface water and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality.	Section 4
A program to monitor and report on stream morphology and stream flows, and assessment of any changes resulting from subsidence impacts, including scouring and ponding.	Section 2.1.3
A program to monitor flooding (including updated flood modelling); with recommendations to minimise, manage and mitigate (whether prospectively or retrospectively) flood impacts on residences, private properties, roads, other infrastructure and other built features.	Section 2.1.4 Section 7.1
A groundwater monitoring program which: a. includes a comprehensive monitoring bore network, ensuring all bore casings are above ground level and are purged before sampling b. samples on a monthly basis for the first two years of the development, and quarterly thereafter, unless directed by the Secretary; c. monitors and reports on: i. groundwater inflows to the mine; ii. background changes in groundwater yield/quality against mine-induced changes; and iii. impacts to: - regional and local (including alluvial) aquifers - groundwater supply to private bores - groundwater dependent ecosystems and riparian vegetation	Section 2
A program to validate the groundwater model for the development, and compare monitoring results with modelled predictions.	Section 6
A plan to respond to any exceedances of the groundwater assessment criteria.	Section 7

Relevant sections of the Statement of Commitments made as part of the Mandalong Southern Extension Project, with respect to surface water and groundwater management, are outlined in Table 1-2, along with the sections of the plan where these have been addressed.

Table 1-2 Statement of commitments

Commitment	Where addressed
Proposed locations of nested monitoring bores at locations where the depth of cover is less than 250 m. This is primarily throughout the north-eastern extent within the Wyee Creek and Mannering Creek catchments. It is intended to install three monitoring bores (nested) above each of the proposed longwall panels (two years prior to mining and pending landholder granting access) where the depth of cover is less than 250 m to monitor groundwater levels, pH and electrical conductivity. Monitoring will continue for a period of two years following the completion of mining in the subsequent adjacent panel.	Section 2.2.1
Groundwater monitoring bores and/or vibrating wire piezometers within the Southern Extension Area to monitor the height of groundwater depressurisation prior to extraction of longwalls with lower depth of cover. An adaptive management approach will be adopted to ensure that if there is a risk of fracturing extending up to alluvial aquifers (based on monitoring data) actions will be taken to mitigate these impacts.	Section 2.2.1
Installation of groundwater monitoring bores within areas of groundwater dependant ecosystems.	Section 2.2.1
Monitoring of bore GW078601, which is the only registered water supply bore within the Southern Extension Area, subject to landowner approval.	See note below table.
Monitoring of the watercourses within the Southern Extension Area to be undermined, particularly in locations identified as potential scouring points, to evaluate watercourse stability. Monitoring will be undertaken before and after undermining of the areas, with additional inspection of these locations following significant rainfall events.	Section 2.1.3
Surface water quality monitoring at the same locations within the Southern Extension Area used to gather background information.	Section 2.1.1
Continuous stream flow monitoring on Morans Creek, Mannering Creek, and Wyee Creek will be undertaken two years prior to mining and for two years after the completion of mining the adjacent longwall panel.	Section 2.1.2
TARPs for the management of subsidence impacts on watercourses in consultation with relevant government agencies.	Section 7.1

Note: Bore GW078601 is located above Longwall 64 within the Southern Extension Area and monitoring of this bore will be included in the relevant WMP for the Extraction Plan for Longwall 64.

In addition to the conditions of development consent SSD-5144 and the Statement of Commitments made as part of the Mandalong Southern Extension Project, current environment protection licence (EPL) details and groundwater bore licences have been summarised in Section 1.2.2 of the Mandalong Mine: Water Management Plan (GHD 2019).

Details of the environmental characteristics (climate, topography and hydrogeology, geology and hydrology) relevant to the study area have also been provided in Section 4 of the Mandalong Mine: Water Management Plan (GHD 2019).

2. Monitoring requirements

A comprehensive groundwater and surface water monitoring program has been developed by Mandalong Mine, as detailed in the *Mandalong Mine: Water Management Plan* (GHD 2019). The main objective of surface and groundwater monitoring is to confirm that the performance of water management measures implemented function as designed. This section summarises the monitoring specifically relevant to extraction of Longwalls 30 to 31.

2.1 Surface water

2.1.1 Surface water quality

Watercourse quality monitoring is undertaken within Morans Creek, Buttonderry Creek and Stockton Creek.

Figure 2-1 presents the surface water monitoring locations relevant to this WMP. Water quality sampling frequency and monitored parameters for each location are summarised in Table 2-1.

Table 2-1 Surface water quality monitoring frequency and parameters

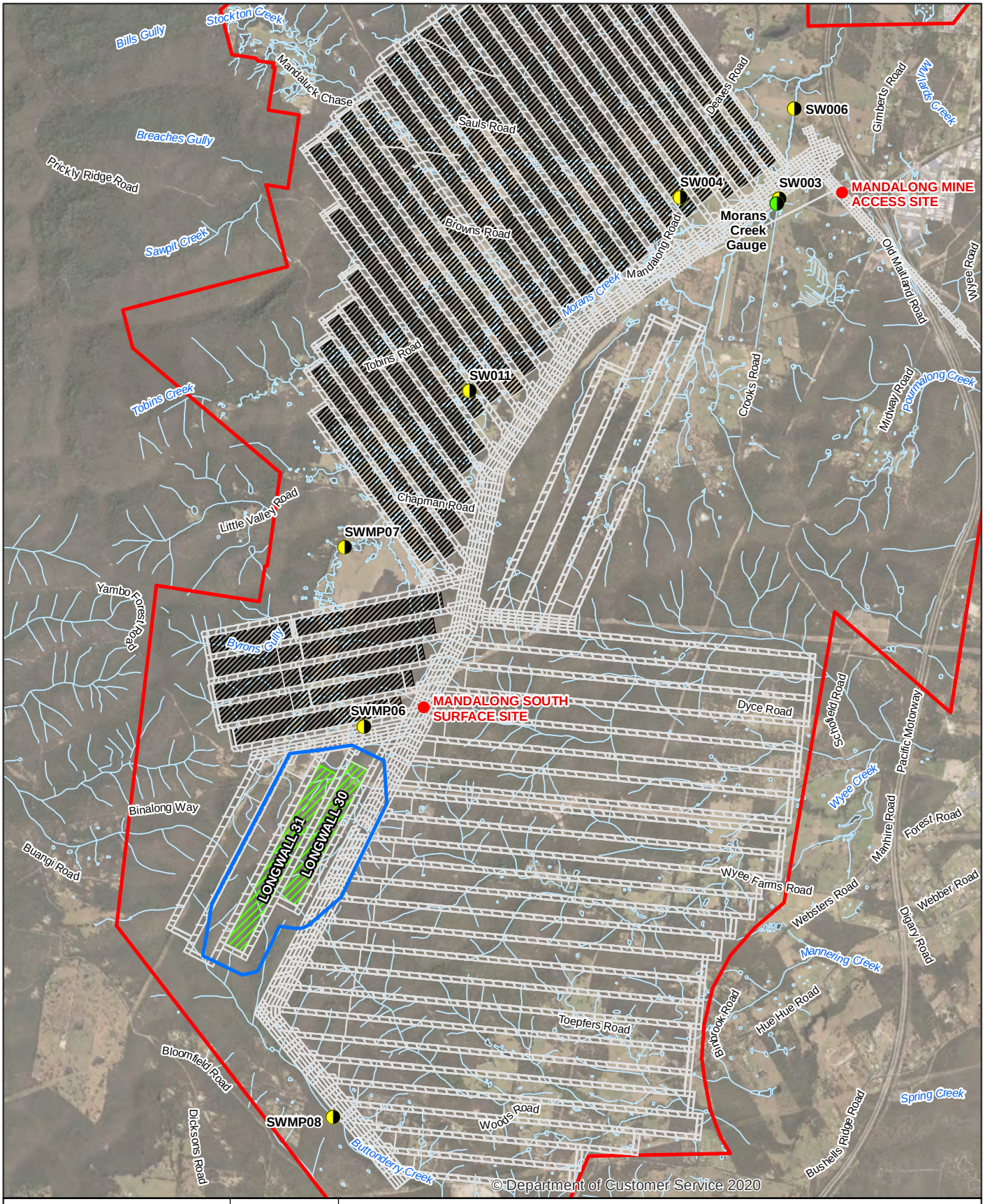
Location	Frequency	Parameters
SW003, SW004, SW011	Quarterly	**Physicochemical parameters:** electrical conductivity (EC), pH, total suspended solids (TSS), turbidity. **Others:** oil and grease.
	Annual	**Nutrients:** ammonia, total nitrogen, total phosphorus. **Metals (dissolved and total):** arsenic, barium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, zinc. **Major ions:** Chloride, sulfate, hardness
SW006	Quarterly	**Physicochemical parameters:** EC, pH, TSS, turbidity. **Others:** oil and grease.
SWMP06, SWMP07	Quarterly	**Physicochemical parameters:** EC, hardness, pH, total dissolved solids, TSS, turbidity. **Nutrients:** ammonia, biochemical oxygen demand (BOD), total Kjeldahl nitrogen (TKN), total nitrogen, total phosphorus. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. **Metals (dissolved and total):** aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc. **Others:** cyanide, fluoride, oil and grease.
SWMP08	Monthly	**Physicochemical parameters:** EC, hardness, pH, total dissolved solids, TSS, turbidity. **Nutrients:** ammonia, biochemical oxygen demand (BOD), total Kjeldahl nitrogen (TKN), total nitrogen, total phosphorus. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. **Metals (dissolved and total):** aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc. **Others:** cyanide, fluoride.

2.1.2 Flow monitoring

Longwalls 30 to 31 mainly underlie the upper catchment of Morans Creek, but also smaller areas underlie the upper catchments of Jilliby Creek, Buttonderry Creek, Mannering Creek and Wyee Creek.

Centennial Mandalong installed a flow monitoring location on Morans Creek approximately 8 km downstream of Longwall 30, as shown in Figure 2-1. Flow was monitored from 2006 to 2009 and from 2017 onwards. This monitoring will continue for the extraction of Longwalls 30 to 31.

Long-term predicted losses to baseflows are expected to have negligible impacts on streamflow conditions within potentially affected watercourses (EMM 2020). No additional flow monitoring is required for Jilliby Creek or Mannering Creek for the extraction of Longwalls 30 to 31.



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Metres

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

N

LEGEND

- Surface water monitoring location
- Morans Creek Gauge
- Site location
- Development consent boundary
- Study area
- Existing extraction area
- Proposed extraction area
- Approved mine workings
- Waterway (field surveyed)

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

Surface Water Monitoring Locations

CENTENNIAL

DATE 16/06/2021

Figure 2-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP003_SW_Monitoring_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba

2.1.3 Stream and flow path inspections

The predicted subsidence related changes to stream channel condition are assessed by flood path monitoring for each reach above longwall panels to define the pre-mining channel condition and subsidence induced changes to stream characteristics. This monitoring will continue for the extraction of Longwalls 30 to 31.

The assessment methodology consists of surveying subsidence along waterways to measure vertical subsidence movement to derive longitudinal grades. Stream condition surveys are undertaken at photographic monitoring points. These monitoring points are located in areas of highest potential differential subsidence, typically above the centre of the longwall panels and intersection with creek beds, to monitor the effects of subsidence on stream condition and changes in stream grade and are shown in Figure 2-2. Observations on the stream's condition recorded at these points include stream geomorphology (including subsidence, scouring and ponding), bank height and width, bed condition (where observable), erosion, channel flood brake out, vegetation community and subsidence deformation.

Pre-mining surveys are conducted prior to the commencement of each longwall panel. The stream condition surveys are undertaken biannually or following a flood event. Annual flood path condition reports are prepared with the key findings reported in the Annual Review for Mandalong Mine. The biannual Mandalong Mine flood path inspections aim to identify the impacts which may trigger mitigation.

The proposed ponding monitoring locations for Longwalls 30 to 31 and possible mitigation/remediation works are listed in Table 2-2 and shown in Figure 2-2.

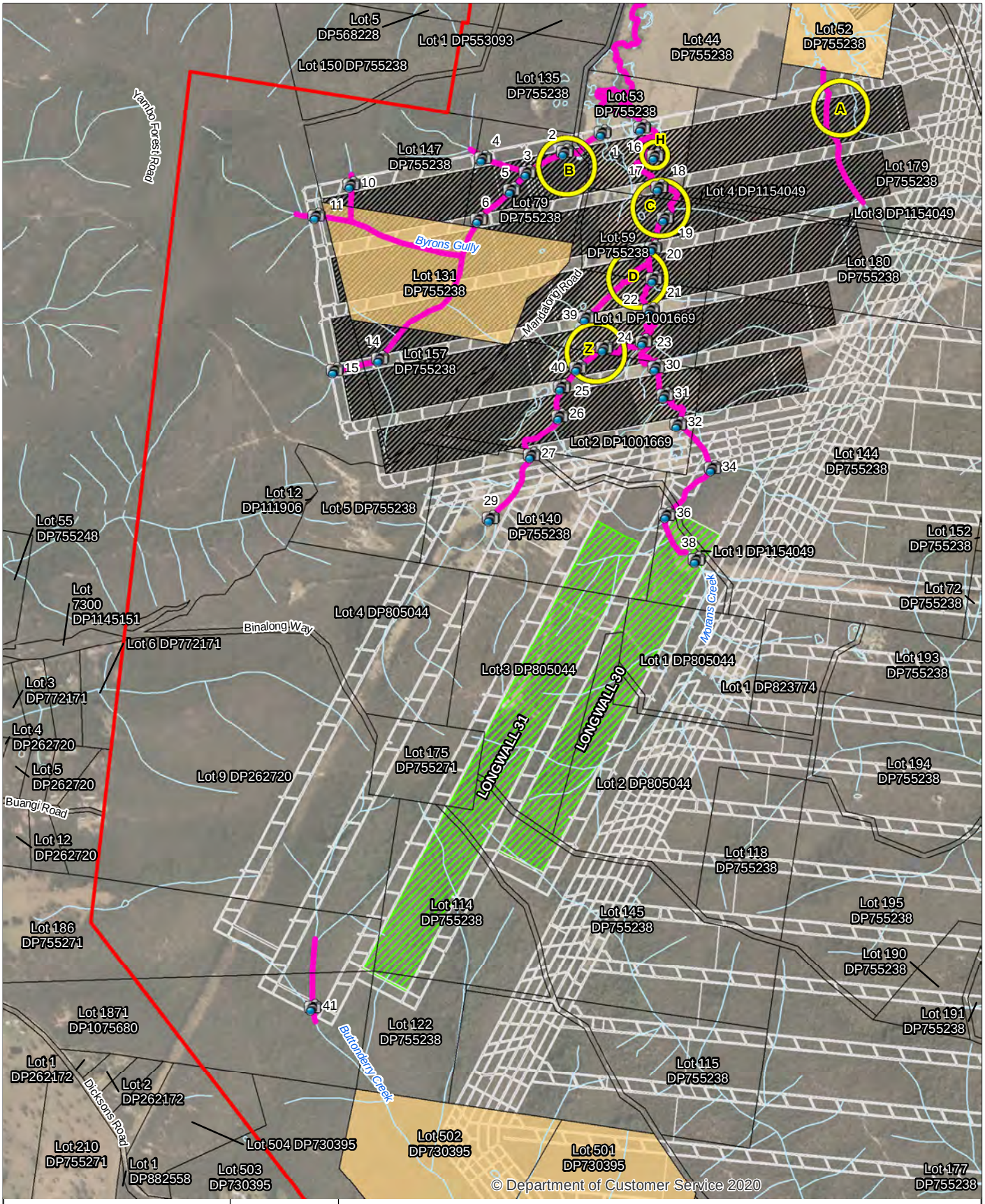
Monitoring extents for relevant waterway reaches above Longwalls 30 to 31 are provided in Figure 2-2.

Table 2-2 Monitoring locations and possible mitigation/remediation works (Umwelt 2020, 2021)

Location	Description	Possible mitigation/remediation works
A	Paddock	Drainage works
B	Channel	Drainage works
D	Paddock	Drainage works
C	Dam	Drainage works
H	Channel	Drainage works
Z	Channel	Drainage works

2.1.4 Flood monitoring

Monitoring of flooding occurs following rainfall events that exceed 100 mm in 24 hours, which is equivalent to the one year average recurrence interval (ARI), 24 hour storm event. Monitoring will include photographic records of flood depth indicators (including estimated flood levels from debris marks) at the locations presented in Figure 2-3 (Mandalong Rd Locations 2, 3 and 4) as well as recording of road closures in the area and any anecdotal evidence from community consultation.



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0 75 150 300 450 600

Metres

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

N

LEGEND

- Photographic points
- Visual monitoring extents
- Development consent boundary
- Cadastre
- Access restricted
- Remnant ponding observation point
- Existing extraction area
- Proposed extraction area
- Approved mine workings
- Waterway (field surveyed)

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31 Water Management Plan

Watercourse Stability Monitoring for Extraction of Longwalls 30 to 31

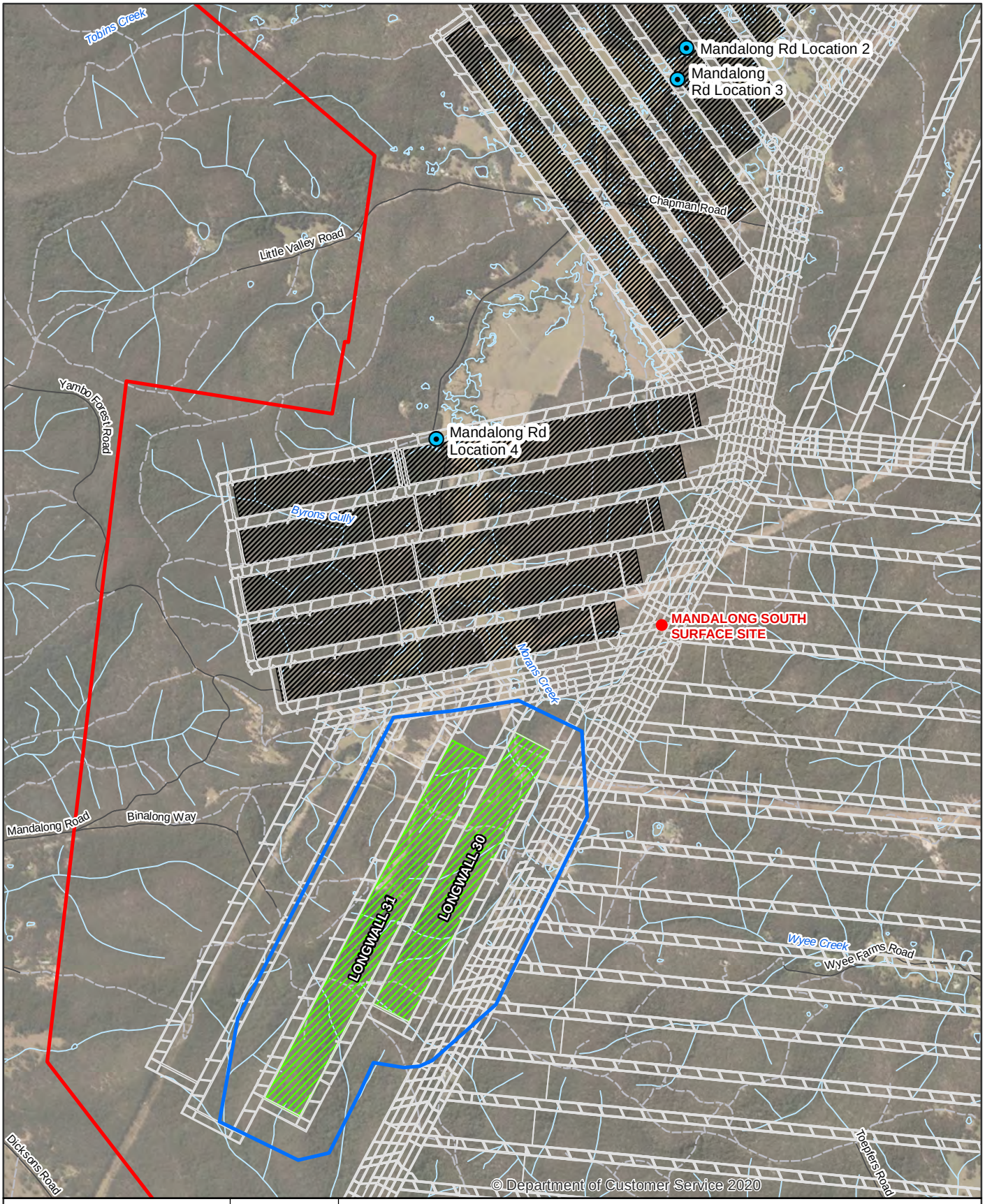
CENTENNIAL

DATE 11/06/2021

Figure 2-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP009_WatercourseStability_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba



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Metres

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

N

LEGEND

- Site location
- Development consent boundary
- Flood monitoring location
- Study area
- Road
- Track-Vehicular
- Existing extraction area
- Proposed extraction area
- Approved mine workings
- Waterway (field surveyed)

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

Flood Monitoring Locations

CENTENNIAL

DATE 16/06/2021

Figure 2-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP008_FloodMonitoring_0.mxd

Data source: LPI:DTDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba

2.2 Groundwater

2.2.1 Monitoring network

Monitoring of groundwater bores MSGW03A, MSGW03B, MSGW03C, MSGW04A, MSGW04B and MSGW04C will allow for the assessment of potential change during the mining of Longwalls 30 to 31 due to proximity (within 2 km) to the longwalls. Details of the groundwater bores are summarised in Table 2-3 and the locations shown in Figure 2-4. Bore casings are above ground level for all bores listed in Table 2-3.

Groundwater monitoring for water quality (pH, EC, major ions and dissolved metals including aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium and zinc) and water levels currently occurs on a quarterly basis, although monthly monitoring was undertaken for at least the first two years. Samples are collected using low flow pumps and sampling techniques.

Bores in the monitoring network that have been identified as being regularly inundated with surface water are purged prior to sampling to remove any influence of surface water on monitoring results. This does not include any bores listed in Table 2-3.

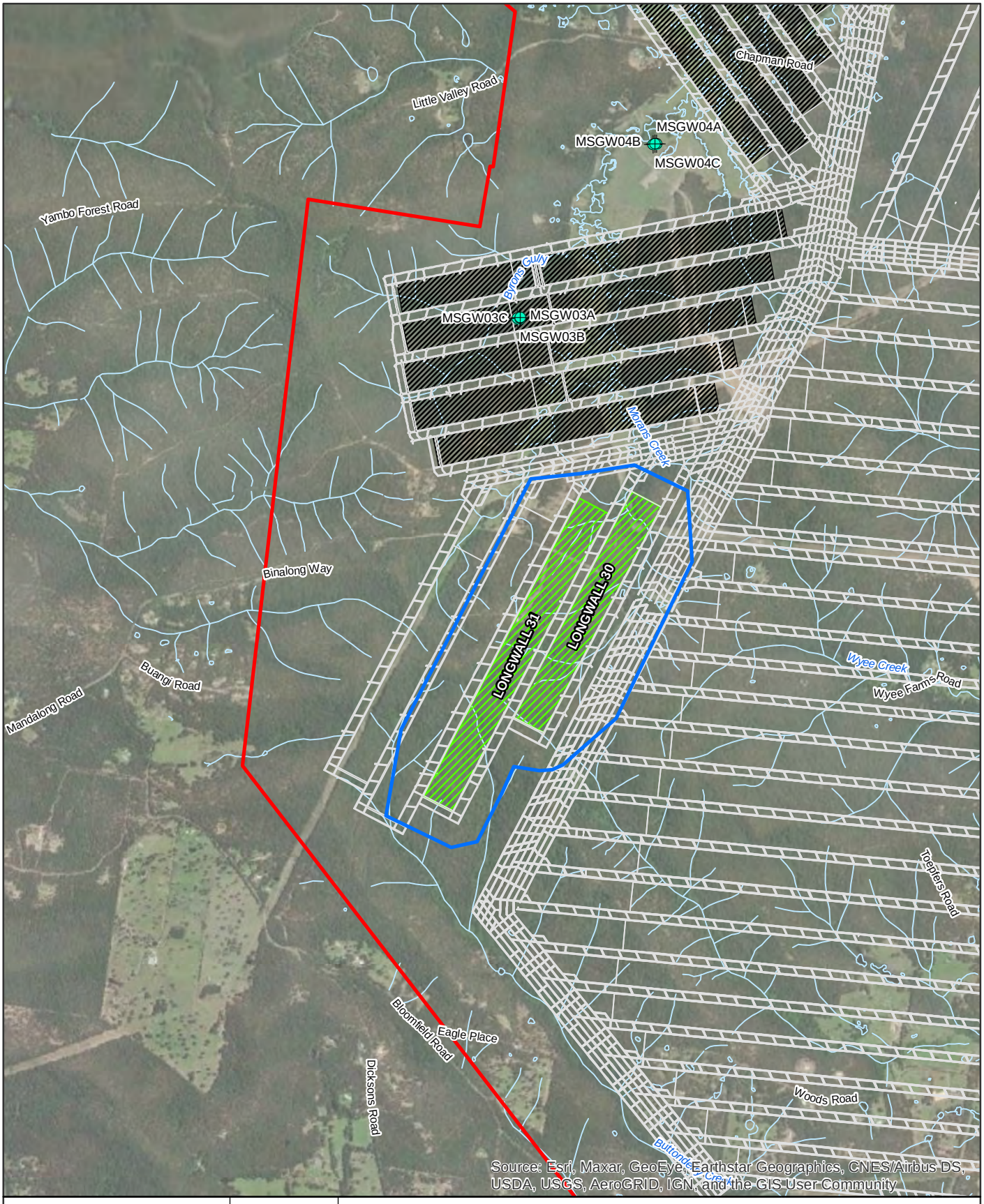
Table 2-3 Groundwater monitoring bore details

Bore	Monitoring period	Parameter	Lithology	Longwall area
MSGW03A	September 2011 – present	Level and quality	Morans Creek alluvium	LW26
MSGW03B	September 2011 – present	Level and quality	Sandstone (Tuggerah)	LW26
MSGW03C	September 2011 – present	Level only	Conglomerate (Munmorah)	LW26
MSGW04A	September 2011 – present	Level and quality	Morans Creek alluvium	–
MSGW04B	September 2011 – present	Level and quality	Sandstone (Tuggerah)	–
MSGW04C	September 2011 – present	Level only	Conglomerate (Munmorah)	–

Monitoring bores MSGW03C and MSGW04C are able to be monitored for groundwater level only. Blockages in these wells prevent sampling for groundwater quality.

Three landholder bores GW201651, GW201652, and GW201653 have been identified within 1 km of Longwalls 30 to 31 (refer Section 3.2.3). These bores are Mandalong Mine monitoring bores.

Depth of cover above Longwalls 30 to 31 is greater than 250 m. Therefore, in accordance with the Statement of Commitments made as part of the Mandalong Southern Extension Project (Table 1-2), no additional monitoring bores are proposed to be installed above Longwalls 30 to 31.



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0 125 250 500 750 1,000

Metres

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

N

LEGEND

- Groundwater monitoring location
- Development consent boundary
- Study area
- Existing extraction area
- Proposed extraction area
- Approved mine workings
- Waterway (field surveyed)

LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

Groundwater Monitoring Locations

CENTENNIAL

DATE 16/06/2021

Figure 2-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP006_GW_Monitoring_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba

2.2.2 Underground water transfers

An overview of underground water management is shown in Figure 2-5. Daily monitoring of the following underground water transfers is undertaken:

- Supply of potable water to mining equipment within the Mandalong workings
- Transfer of dirty mine water from the 69 c/t area to the Cooranbong Underground Storage area
- Transfer of water from the 151 c/t area to the Cooranbong Underground Storage area
- Transfer of surface water from Sediment Dams 1 and 2 at the CES to the Cooranbong Underground Storage
- Transfer of surface water from the 5 ML Dam at the CES to the Cooranbong Underground Storage
- Transfer of surface water from the gross pollutant trap at the CES (also referred to as Coal Handling Plant Settlement Tank) to the Cooranbong Underground Storage.
- Extraction of water from the Cooranbong Underground Storage area via licensed Cooranbong bore (works approval 20WA217077 and water access licence (WAL) 39767).
- Transfer of surface water from MMAS Sediment Dam to the Cooranbong Underground Storage

In addition, monthly monitoring of water levels within the Cooranbong Underground Storage is undertaken.

Transfer of surface water from the MSSS 10 ML Tank to the underground workings is currently unmetered.

2.2.3 Groundwater inflows into the mine

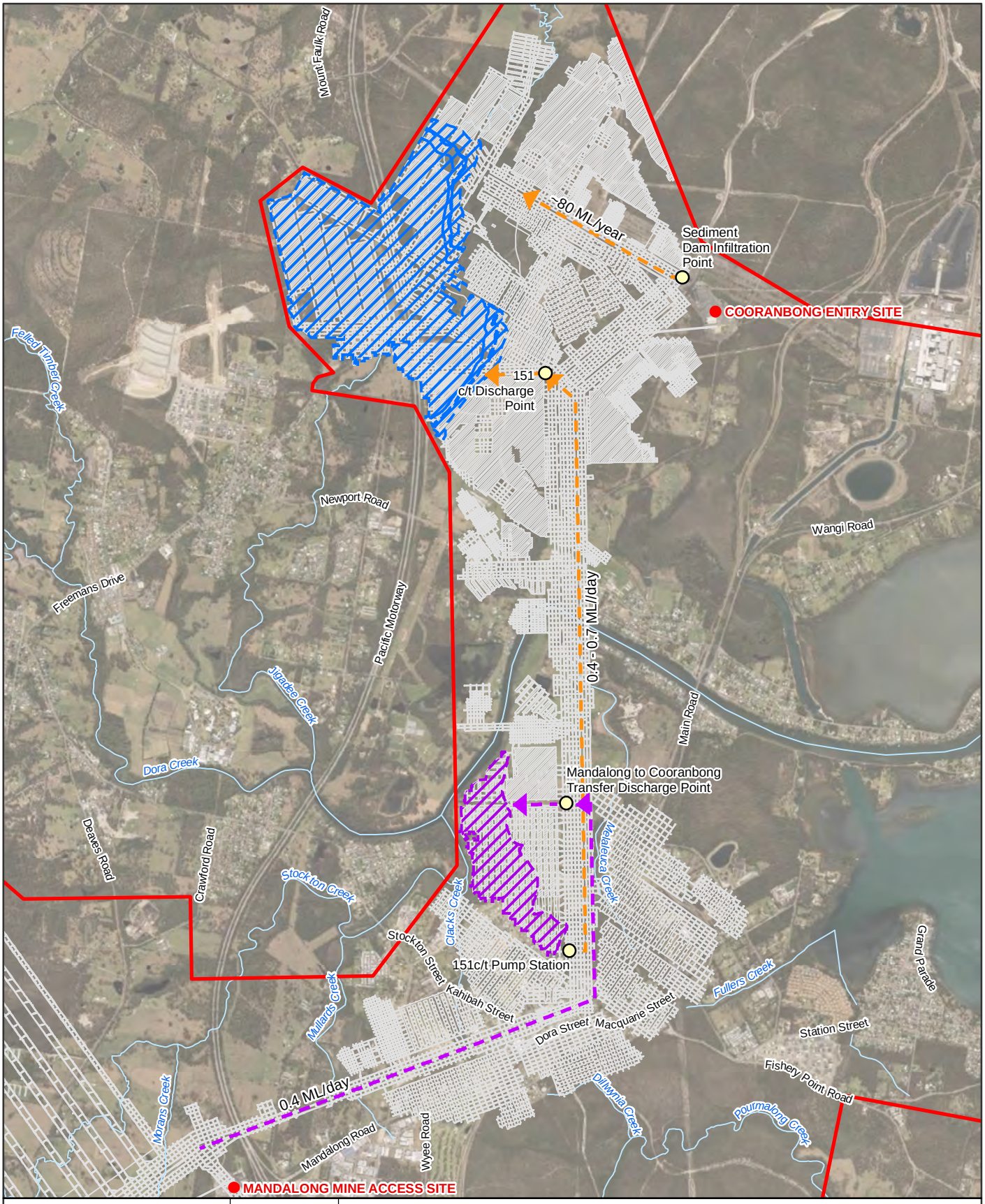
Groundwater inflows to the mine are dewatered to the Cooranbong Underground Storage area and subsequently discharged from licensed discharge point LDP001 at CES in accordance with EPL 365.

Annual calculation

Groundwater inflows from adjacent strata into the mine workings are calculated on an annual basis as part of the annual water balance review, in accordance with the requirements and methodology specified in the *Groundwater Monitoring and Contingency Plan* (GHD 2016a). This methodology specifies that the calculation of groundwater inflows into the mine involves converting the annual change in water level of the Cooranbong Underground Storage to a change in volumetric storage based on an assessment of floor contours of the underground workings. The actual annual volume of groundwater removed by the extraction bore is calculated using the following formula:

Groundwater inflow = Δ storage + extraction volume – inputs.

Where groundwater inflow is the seepage of groundwater from adjacent strata into the workings, the extraction volume is the annual sum of the daily measured volumes extracted by the bore and the inputs are the annual sum of transfers of potable water and mine water from the CES and Mandalong workings.



1:40,000 for A4

0 150 300 600 900 1,200

Metres

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

N

GHD

LEGEND

- Site location
- Development consent boundary
- Approved mine workings
- Cooranbong Transfer Locations
- Cooranbong Goaf
- Cooranbong Settling Area
- Mandalong Mine Dirty Water Pump Transfer
- Water Transfer
- Waterway

LOCATION	Mandalong
DRAWN	K.S.
CHECKED	T.D.
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

Current Cooranbong Underground Water Management

CENTENNIAL

DATE 22/12/2020

Figure 2-5

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP007_Cooranbong_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba

Hydrogeological model

Figure 2-6 shows the total predicted groundwater inflows into the drained workings from the existing numerical groundwater model, presented in the Modification 9 for the re-orientation of longwall panels at Mandalong Mine (GHD 2020a). Total groundwater inflows into the connected Cooranbong, Mandalong and Mandalong South workings are predicted to peak at approximately 2.1 ML/day in 2035. The peak predicted groundwater inflow is less than the peak groundwater inflow assessed as part of the approved Mandalong Southern Extension Project (GHD 2013), which is also presented in Figure 2-6. The predicted groundwater inflow is lower due to recalibration of the hydrogeological model (GHD 2016b).

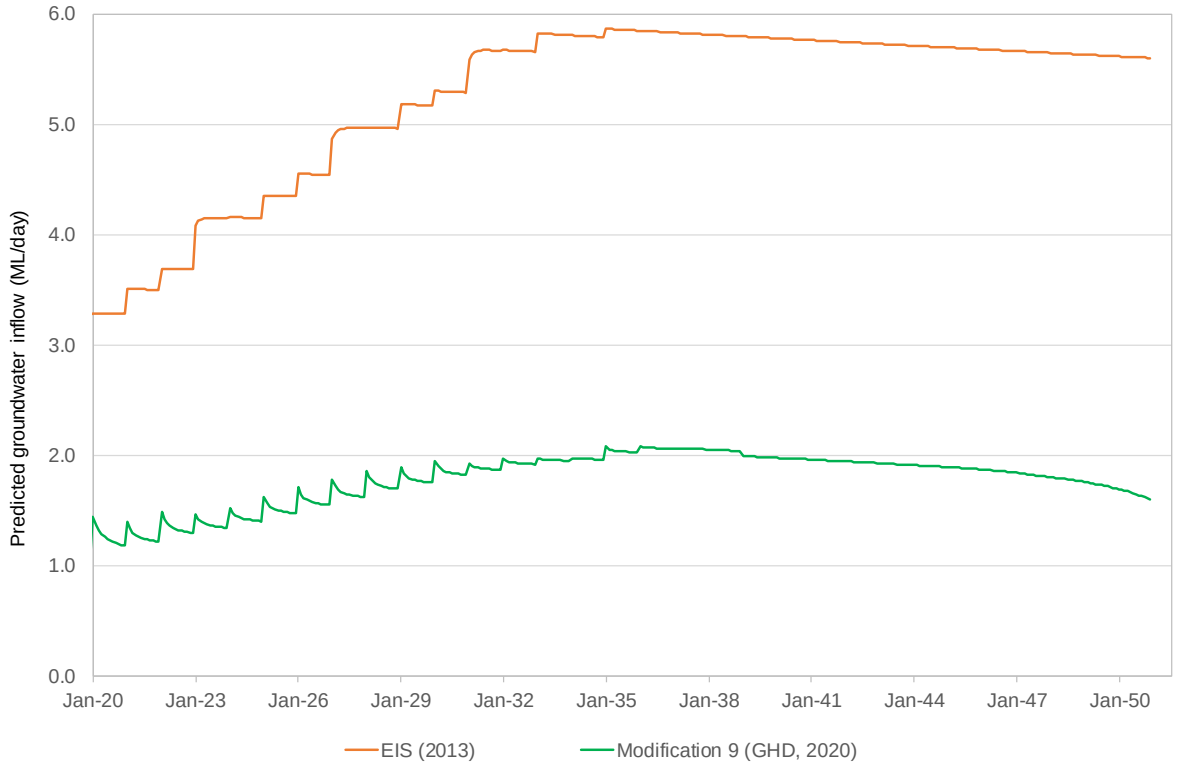


Figure 2-6 Modelled groundwater inflows into the Cooranbong, Mandalong and Mandalong South workings

3. Baseline data

3.1 Surface water

The study area is located within the upper reaches of Morans Creek and includes several unnamed tributaries. Morans Creek is a north-east flowing tributary of Stockton Creek, which discharges into the estuarine reach of Dora Creek approximately 9 km north east of the study area. Morans Creek is ephemeral, with periods of limited or no flow during low rainfall.

3.1.1 Surface water quality

Table 3-1 presents the extent of baseline watercourse quality data recorded within Morans Creek and Stockton Creek. Figure 2-1 presents the relevant surface water monitoring locations.

Table 3-1 Period of recorded water quality data

Surface water site	Facility	Period from	Period to	Number of points
SW003 – SW011	MMAS	March 2011	June 2020	55
SWMP06 – SWMP07	MSSS	June 2011	June 2020	48

Appendix C presents the baseline data for water quality within Stockton Creek and Morans Creek.

Baseline data for upstream Morans Creek presents a fresh water system with a near-neutral pH. Metals including arsenic, boron, cadmium, chromium, copper, mercury, lead, selenium and silver have concentrations below the limit of reporting.

Aluminium, cobalt and iron are naturally elevated within the catchment and this is supported by upstream monitoring results.

3.1.2 Flow monitoring

Figure 3-1 presents the level recorded by the flow gauge on Morans Creek between 2006 and 2008. Table 3-2 presents the statistics of the flow monitoring data.

Figure 3-2 and Figure 3-3 present the flow and level data recorded within Morans Creek since the new flow gauging station was installed (between October 2017 and May 2018).

Table 3-2 Flow monitoring data for Morans Creek

Statistic	Year		
	2006	2007	2008
Percentage of year monitored	100%	46.7%	69.6%
Annual rainfall total	828 mm	1508 mm	1577 mm
Volume recorded*	2542 ML	2296 ML	N/A

* Estimated from data provided. Gauge rating data to be confirmed.

Water levels within Morans Creek indicate a general creek response of up to 0.5 m to rainfall greater than 50 mm/day. Due to the inconsistent gauging recordings, it was not possible to determine a reliable correlation between rainfall and level.

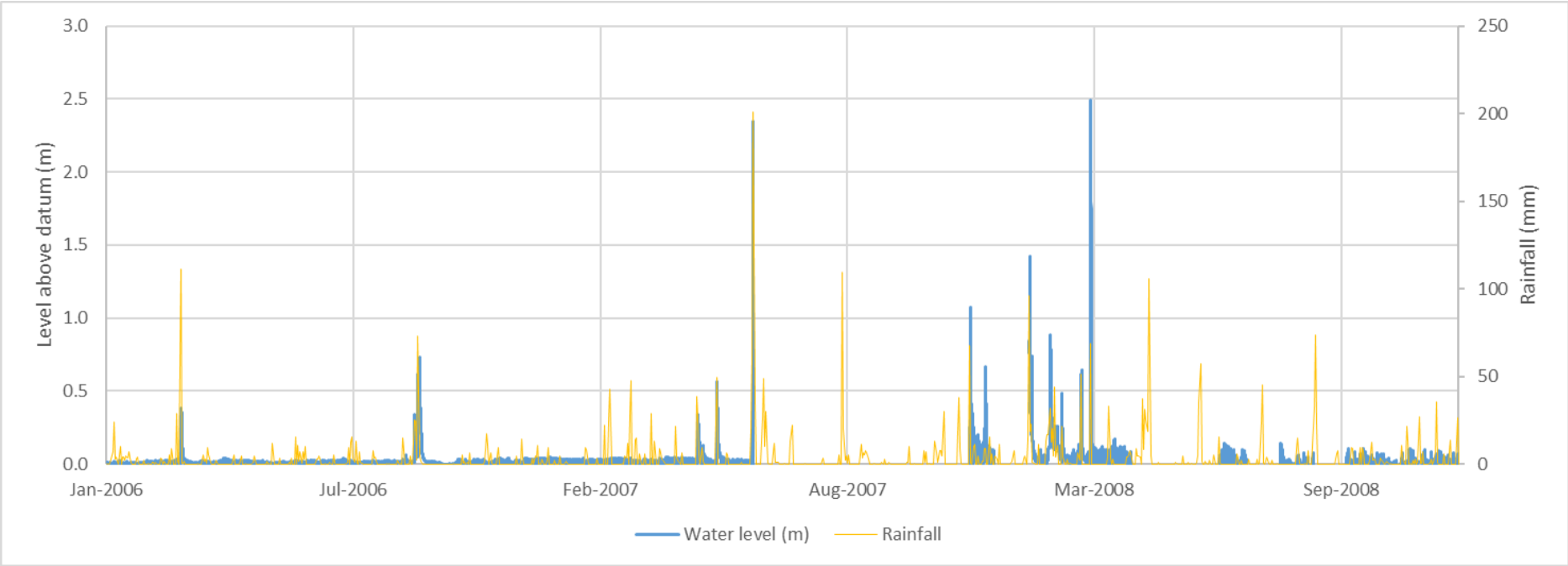


Figure 3-1 Level gauging within Morans Creek from 2006 to 2008

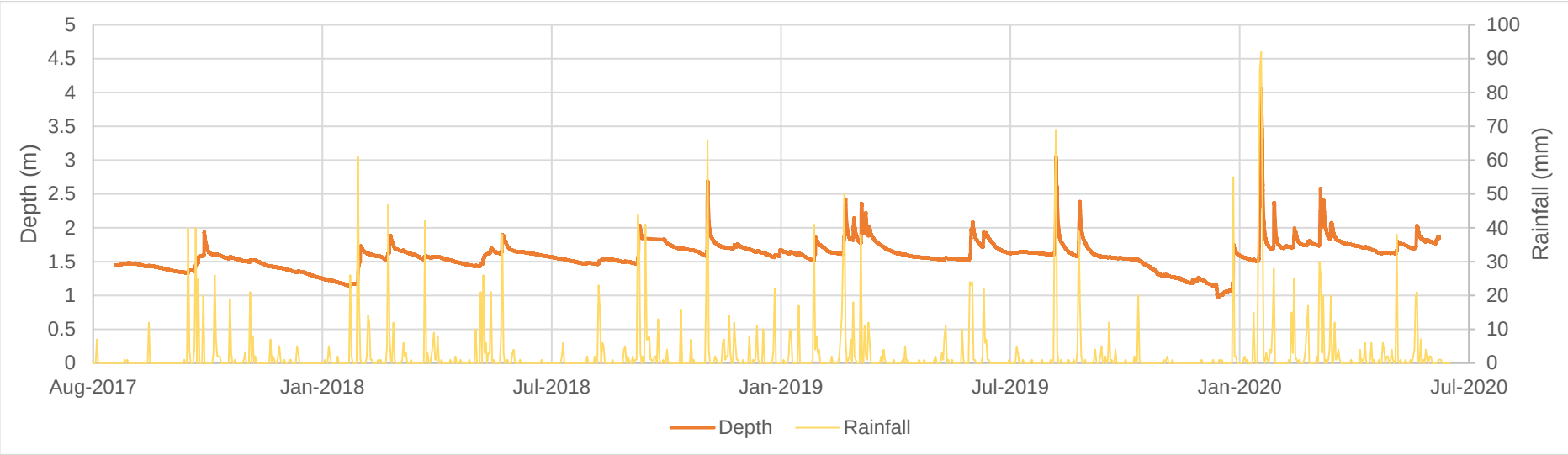


Figure 3-2 Level gauging within Morans Creek from October 2017 to July 2020

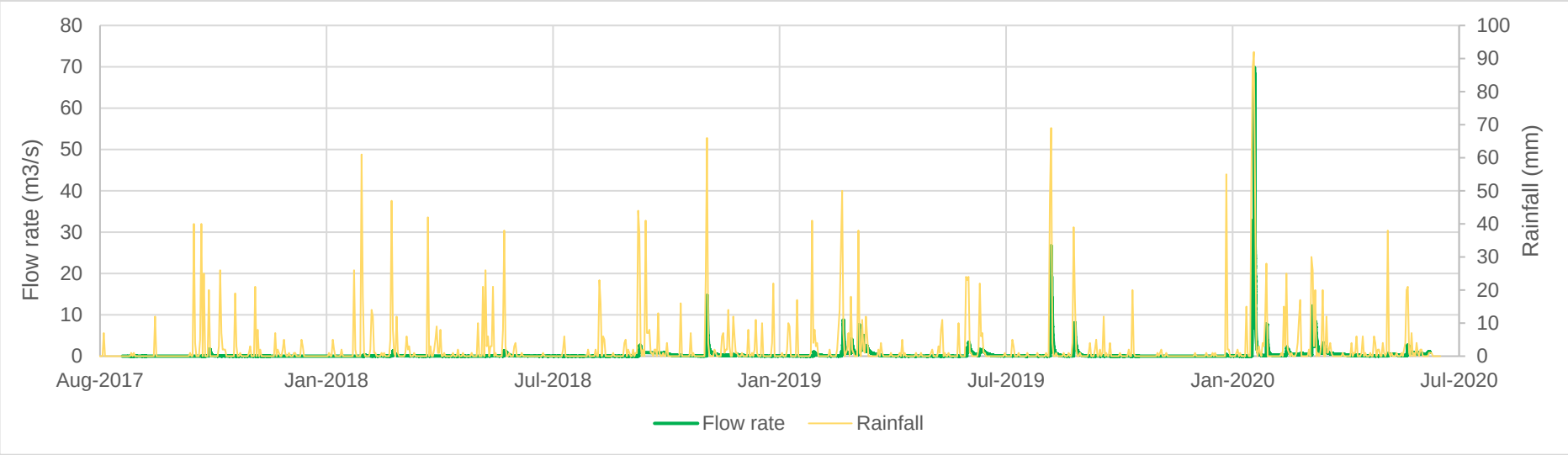


Figure 3-3 Flow gauging within Morans Creek from October 2017 to July 2020

3.2 Groundwater

The groundwater sources in the vicinity of the study area are generally low yielding and predominantly weathered and/or fractured sandstone, coal seams and clayey quaternary alluvium. Groundwater sources in the study area would be classified as 'less productive', in accordance with the NSW Aquifer Interference Policy (DPI 2012a).

3.2.1 Overview

Alluvial groundwater sources

The alluvium throughout the study area forms an unconfined shallow aquifer with a water table typically ranging in depth from less than 1 m up to about 3 m below ground level (bgl) and an aquifer thickness less than 20 m. The alluvial groundwater is moderately acidic to slightly alkaline, brackish to saline, extremely hard and of sodium chloride type (GHD 2013).

Due to the relatively high silt and clay content of the alluvium, the groundwater yields are relatively low (typically less than 1 L/s). As a result of the low yield and relatively poor water quality, there are very few registered private alluvial groundwater bores throughout the study area. The environmental value of the alluvial groundwater is considered to be generally 'primary industry' (specifically stock watering), with the saline groundwater generally only suitable for stock watering (GHD 2013). The review of registered private bores in Section 3.2.3 identified limited use of alluvial groundwater in the vicinity of Mandalong Mine for irrigation and domestic use.

Groundwater monitoring bores MSGW03A and MSGW04A, which are located within the alluvium, will allow for the assessment of potential change during the mining of Longwalls 30 to 31 due to proximity to the longwalls.

Porous and fractured rock water sources

Coal seam

The piezometric head within the Permian coal seams tends to reflect the natural topography and the orientation and dip of the seams, with reduced pressures at major surface drainage areas and in areas of coal extraction. Where coal seam groundwater has not been depressurised, the groundwater head generally tends to be in the order of 0 m Australian Height Datum (AHD) due to the coastal environment.

Permeability testing undertaken in 1996 and 1997 on the West Wallarah Seam and overburden strata in the existing Mandalong Mine area is reported in Pacific Power International (1997). Results indicate a variable hydraulic conductivity for the seam, ranging from 10^{-9} m/s to 10^{-5} m/s (0.03 m/year to 300 m/year). Areas of higher hydraulic conductivity coincide with areas where the coal is more intensively jointed or fractured, although the majority of the seam was generally found to be of lower hydraulic conductivity.

More recent permeability testing of the West Wallarah and Wallarah/Great Northern seams (at depths of 285 m to 300 m bgl) undertaken in 2011 as part of the Mandalong Southern Extension exploration program measured hydraulic conductivities ranging from approximately 0.75 m/year to 35 m/year (Sigra 2011).

Groundwater inflows into the existing Cooranbong and Mandalong workings from the coal seam and adjacent strata are reported by Centennial Mandalong to be relatively low. Further details on the underground water level management can be found in Section 4 of *Mandalong Southern Extension Project: Groundwater Impact Assessment* (GHD 2013).

Overburden rock

The overburden and interseam strata within the Newcastle Coalfield tend to have very low hydraulic conductivities (in the order of 0.0003 m/year to 0.03 m/year), unless joints or fracturing creates a secondary permeability (Pacific Power International 1997). Groundwater within the overburden rock above the West Wallarah Seam primarily occurs within weathered or fractured Triassic sandstone.

Permeability testing of the overburden rock was undertaken in 2011 as part of the Mandalong Southern Extension exploration program (Sigra 2011). The measured hydraulic conductivities and strata depths were as follows:

- 0.02 m/year (158.8–286.5 m bgl)
- 0.007 m/year (177.4–268.4 m bgl)
- 0.03 m/year (122.4–268.4 m bgl)

There has been a drop in relative groundwater level measured at most of the existing deeper monitoring bores screened within overburden rock above the existing Mandalong Mine longwalls, which has been attributed to mining.

Groundwater monitoring bores MSGW03B, MSGW03C, MSGW04B and MSGW04C, which are located within the overburden material, will allow for the assessment of potential change during the mining of Longwalls 30 to 31 due to proximity to the longwalls.

3.2.2 Groundwater levels and quality

A statistical summary of Mandalong Mine groundwater levels and quality is provided in Appendix C.

Note that bore MSGW04C is purged prior to sampling, resulting in anomalous water level results due to the recovery time.

Groundwater quality

At most alluvial bores groundwater pH is consistently within the range 5 to 8. Groundwater EC varies considerably within alluvium across the Mandalong mining area, ranging from less than 2000 µS/cm to over 10,000 µS/cm. The quality of the porous and fractured rock groundwater sources is slightly alkaline and brackish to saline. EC typically ranges from about 6000 µS/cm to over 10,000 µS/cm (GHD 2017).

As discussed in the Mandalong Southern Extension Project response to submissions, there was variability in groundwater EC at a number of monitoring bores at Mandalong Mine. As part of the response to submissions process it was identified that this variability in EC was attributable to sampling of bores by bailing. Note that monitoring bores included in this plan have been sampled using low flow techniques where possible (i.e. peristaltic pump or Micro-purge pump) since the commencement of monitoring in 2011. Monitoring bores not able to be sampled using low flow techniques have been purged prior to sampling.

Underground water levels within the mine workings

Centennial Mandalong has monitored water levels in the Cooranbong Underground Storage area since December 2011. The measured water levels (corrected to m AHD) between December 2011 and January 2020 are shown in Figure 3-4. The following observations have been made over this period:

- For the period prior to March 2013, the average rate of dewatering of the Cooranbong underground storage dam was 1.5 ML/day and the water level rose by approximately 5 m over this period.
- Over the period March to August 2013, the underground water level rose by a further 4 m since the pump was not in operation for most of this time.
- Between mid-August 2013 and February 2014, the average extraction rate was approximately 2.6 ML/day and the water level reduced by 6 m.
- Between February and September 2014, there was no extraction of water from the Cooranbong Underground Storage and the water level rose by approximately 11 m.
- Between October 2014 and January 2015, the average extraction rate was approximately 1.9 ML/day and the water level reduced by 1 m.
- Between January and March 2015 there was no pumping for most of this time and the water level rose 2 m.
- Between March and May 2015, the average extraction rate was approximately 2 ML/day and the water level dropped 0.15 m.
- Between June 2015 and November 2015, the average extraction rate was 3.0 ML/day and the water level reduced by 8.83 m.
- During December 2015 and January 2016, the average extraction rate was 2.7 ML/day and the water level reduced by 0.22 m.
- Between February 2016 and May 2016, the average extraction rate was 1.6 ML/day and the water level rose 1.6 m. This included a period where pumping ceased between April to May 2016 for LDP001 upgrade.
- During June 2016, the average extraction rate was 3.3 ML/day and the water level reduced by 1.12 m.
- Between July 2016 and October 2016, the average extraction rate was 2.8 ML/day and the water level reduced by 3 m.
- Between November 2016 and January 2017, the average extraction rate was 1.7 ML/day and the water level increased by 1.3 m.
- Between February and April 2017, the average extraction rate was 2.2 ML/day and the water level decreased by 2.5 m.
- For the remainder of 2017 water levels were relatively constant. Over this period the average extraction rate was 1.7 ML/day and water levels fluctuated by 1.1 m.
- Between January 2018 and May 2018, the average extraction rate was 2.1 ML/day and the water level decreased by 2.3 m.
- Between June 2018 and January 2019, the average extraction rate was 2.0 ML/day and the water level increased by 1.9 m.
- Between February 2019 and September 2019, the average extraction rate was 1.9 ML/day and the water level decreased by 5.6 m.
- Between October 2019 and January 2020, the average extraction rate was 1.4 ML/day and the water level increased by 1.6 m.

Based on an assessment of the floor contours of the Cooranbong workings, the underground water storage area has a capacity of approximately 4,200 ML (assuming void height of 3 m and void ratio of 0.4). Once the underground water storage reaches full capacity, the water spills to the south back towards the active Mandalong workings.

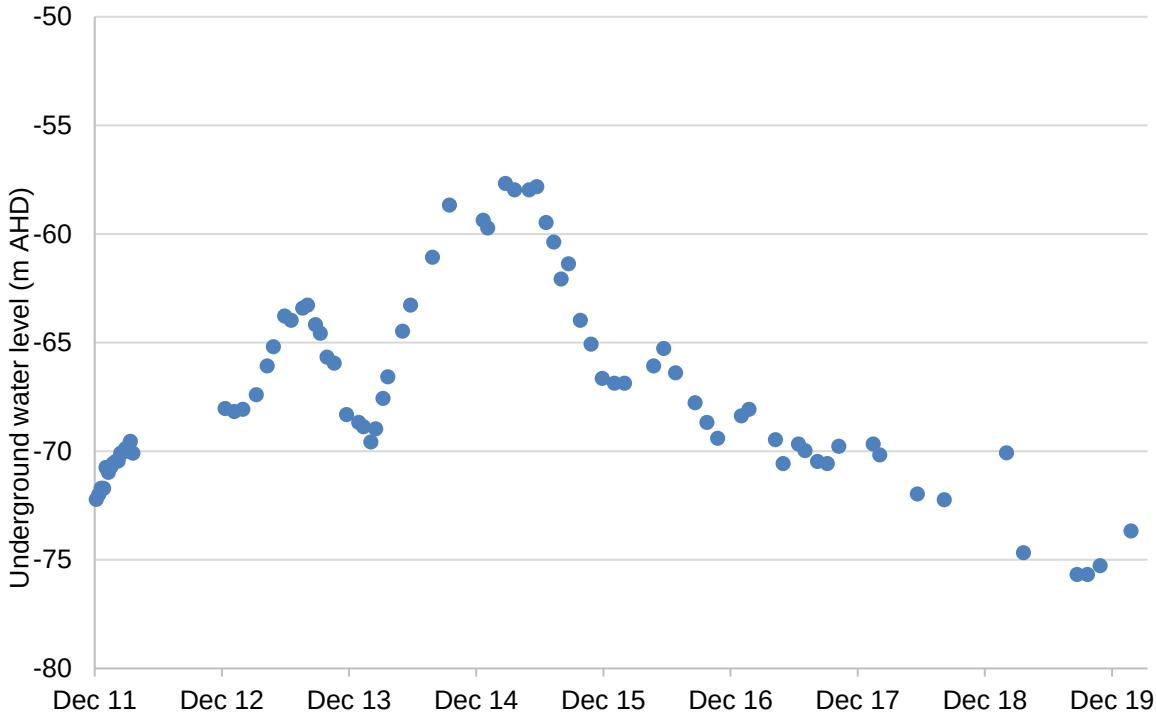


Figure 3-4 Cooranbong Underground Storage water levels

Groundwater levels

HARTT (Hydrograph Analysis: Rainfall and Time Trends) analysis was undertaken for each alluvial dataset as part of the development consent modification (Mod 5) for the extension of secondary extraction of Longwalls 24 and 24A (GHD 2017). The HARTT analysis was used to establish the relationship between groundwater levels and rainfall and detect underlying trends in groundwater level that are independent of rainfall. The HARTT analysis was again undertaken as part of the latest Annual Groundwater Monitoring Review (GHD 2020b).

Of the alluvial bores included in this plan, bore MSGW04A had statistically significant decreasing trends in groundwater level above the limit of reading of groundwater measurement (i.e. 0.1 m). Groundwater levels at MSGW04A have generally fluctuated between 23.2 m AHD and 25.2 m AHD. A decreasing time trend (independent of rainfall) in groundwater level has been observed at MSGW04A. The variation in groundwater level at MSGW04A may be a result of the development of shallow tensile and compressive cracks resulting in localised increases in hydraulic conductivity and porosity. It is expected that these cracks would fill over time and the hydraulic conductivity and porosity should return to pre-mining values. Groundwater levels at MSGW04A have remained within the typical range of groundwater levels and have continued to respond to periods of above average rainfall.

HARTT is only applicable to shallow groundwater monitoring bores (GHD 2017). Groundwater hydrographs have been visually reviewed to identify trends at the deeper monitoring bores and the VWPs. Hydrographs are presented in Appendix C. Reductions in groundwater levels at these locations are primarily attributable to purging prior to sampling.

3.2.3 Groundwater users

NSW bore database search

The search of the NSW groundwater bore database (DILW 2018) identified 140 bores in a 5 km radius of the existing, approved and proposed Mandalong Mine workings. The majority (64) are registered as monitoring/test bores, one bore registered for monitoring/town water supply, 13 did not have a registered use and the remainder (62) being registered for domestic, irrigation and/or stock use. Approximate bore locations are shown in Figure 3-5 and bore details are outlined in Appendix D.

The registered domestic and stock bores that were identified primarily extract groundwater from the Triassic sandstone and conglomerate formations with yields generally less than 1 L/s.

The search identified three private bores (GW201651, GW201652, GW201653) within 1 km of Longwalls 30 to 31. The bore search indicated that all three bores are Mandalong Mine monitoring bores, MSGW03A, MSGW03B and MSGW03C.

The predicted impacts on alluvial and fractured and porous rock groundwater sources as a result of mining at Mandalong Mine were found to be less than the Level 1 minimal impact considerations from the NSW Aquifer Interference Policy (GHD 2016b).

Groundwater dependent ecosystems and riparian vegetation

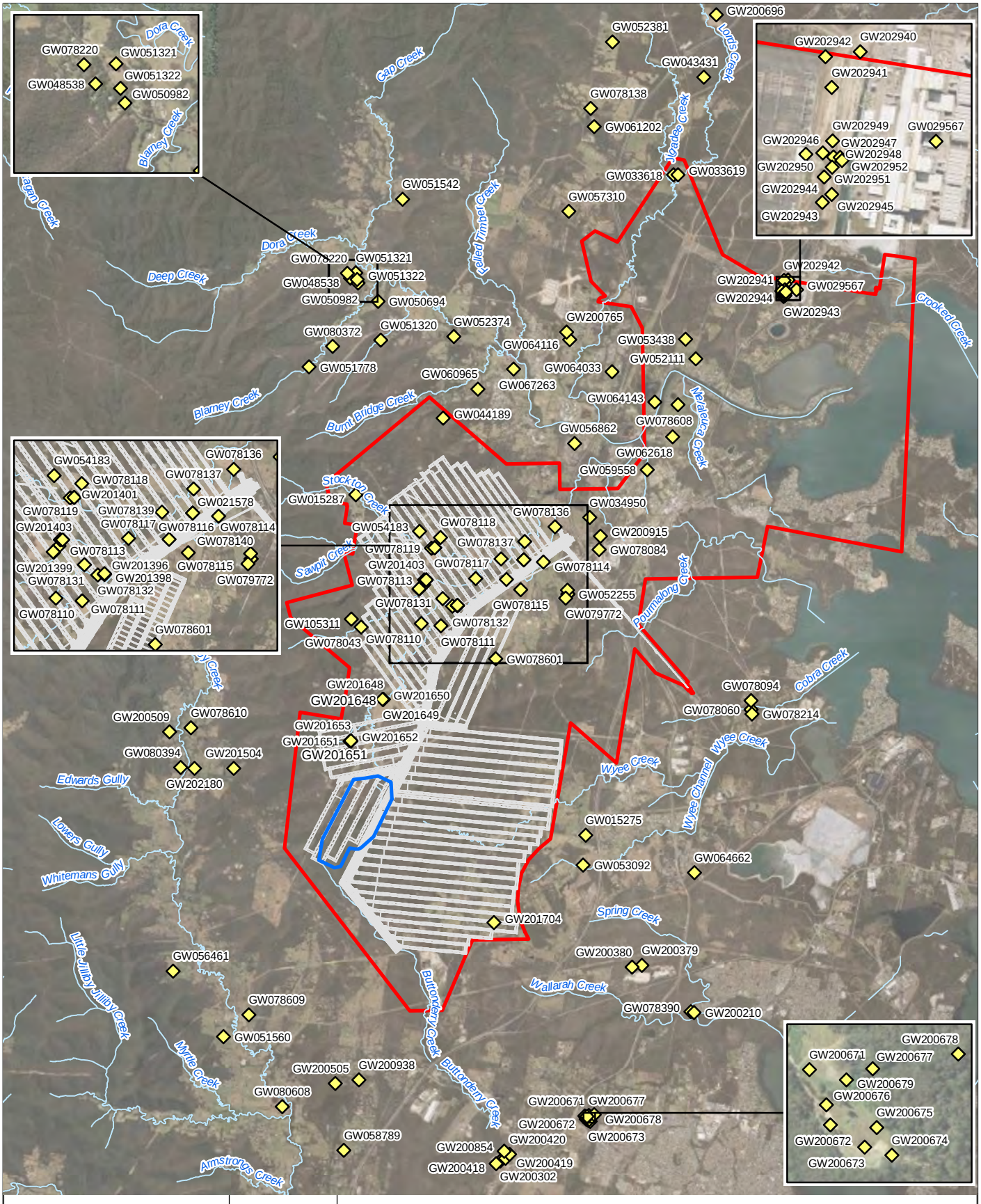
One potential groundwater dependent ecosystem (GDE), Alluvial Tall Moist Forest, has been identified within the study area (RPS 2013). This potential GDE generally coincides with the creeks and drainage lines within the study area. The watercourses identified within the study area are the upper reaches of Morans Creek. Shallow unconfined alluvium has been identified along this creek line.

Ecological communities within the study area are likely to be utilising shallow aquifers associated with ephemeral drainage lines and have therefore been considered as unlikely to be entirely groundwater dependent. This occurrence has been supported by the fact that the plant species within this vegetation community are not restricted to alluvial drainage lines; they can occur along moist sheltered gully areas, creek lines, as well as dry slopes. Therefore, they can be termed as facultative ecosystems.

Facultative ecosystems have been described as:

"a GDE that is not entirely dependent on groundwater, and may rely on groundwater on a seasonal basis or only during extended drought periods. At other times, water requirements may be met by soil or surface water" (DPI 2012b).

Impacts of mining Longwalls 30 to 31 on GDEs and riparian vegetation have been predicted to be minor (RPS 2013). The extents of these impacts are not expected to significantly alter the vegetation composition of GDEs or their habitat value for flora and fauna species (RPS 2013).



LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Extraction Plan LW30-31
Water Management Plan

NSW Bore Database Search Results

CENTENNIAL

DATE 16/06/2021

Figure 3-5

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12533794\EPWMP\12533794_EPWMP004_NSWBoreSearch_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. OOW: Pinneena, Registered Bore, 2010. Created by: smacdonald, kpsroba

4. Impact assessment criteria

4.1 Surface water quality

Site-specific guideline values (SSGVs) have been derived following ANZECC (2000) guidelines, now ANZG (2018), and are applied to watercourse monitoring within Morans Creek (GHD 2019). SSGVs have been selected based on a review of default guideline values (DGVs) presented by ANZECC (2000) and data collected at upstream monitoring locations SWMP06 and SWMP07. Table 4-1 presents the current SSGVs from GHD (2019), as well as the DGVs and results for SWMP06 and SWMP07.

Table 4-1 Site-specific guideline values for monitoring watercourse quality

Parameter	Units	DGV	SWMP06 80th percentile	SWMP07 80th percentile	Recommended SSGV
Physicochemical parameters					
EC	µS/cm	200	940	755	940
pH	pH units	6.5–9.0	6.2–6.7	6.5–7.0	6.2–9.0
TSS	mg/L	6	47	16	47
Turbidity	NTU	6	58	53	58
Nutrients					
Ammonia	mg/L	0.9	0.07	0.15	0.9
Total nitrogen	mg/L	0.35	1.18	1.52	1.52
Total phosphorus	mg/L	0.025	0.08	0.11	0.11
Dissolved metals					
Aluminium	mg/L	0.055	0.70	0.78	0.78
Arsenic	mg/L	0.024	0.001	0.001	0.024
Barium	mg/L	–	0.083	0.066	0.083
Boron	mg/L	0.37	0.05	0.05	0.37
Cadmium	mg/L	0.0002	0.0001	0.0001	0.0002
Chromium	mg/L	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.0025	0.009	0.001	0.009
Copper	mg/L	0.0014	0.001	0.002	0.002
Iron	mg/L	0.3	3.61	3.11	3.61
Lead	mg/L	0.0034	0.001	0.001	0.0034
Manganese	mg/L	1.9	0.828	1.744	1.9
Mercury	mg/L	0.0006	0.0001	0.0001	0.0006
Nickel	mg/L	0.011	0.006	0.004	0.011
Selenium	mg/L	0.0112	0.01	0.01	0.011
Silver	mg/L	0.00005	0.001	0.001	0.001
Zinc	mg/L	0.008	0.007	0.006	0.008
Other parameters					
Cyanide (total)	mg/L	0.004	0.004	0.004	0.004

1. 20th percentile value.

2. Guideline value for total selenium.

4.2 Groundwater

4.2.1 Groundwater levels

Based on the statistical analysis of alluvial groundwater levels, alluvial groundwater is highly responsive to rainfall and generally not impacted by mining.

No groundwater drawdown is predicted to occur in the alluvium (GHD 2017, 2020a). However, following undermining some short-term, temporary variation in alluvial groundwater level has been observed at Mandalong Mine (GHD 2017). The magnitude of this drawdown has generally been within 2 m. Therefore the groundwater trigger level for alluvial bore MSGW04A has been defined as 2 m below the minimum observed groundwater level. The minimum observed groundwater levels for this bore is shown in Appendix C. Alluvial monitoring bore MSGW03A is periodically dry following low or below average rainfall. Therefore no groundwater level trigger is recommended for MSGW03A, although responses in groundwater level to rainfall will be analysed annually.

Groundwater level trigger values for bores in the porous and fractured groundwater sources have been defined using predictions in the updated hydrogeological model (GHD 2017, 2020a). At monitoring bore MSGW04C, groundwater levels are predicted to fall below the base of the bore. Although this bore is not directly above any mine workings, it is within the zone of depressurisation predicted by the hydrogeological model. As MSGW04C is predicted to become dry due to mining related impacts, no groundwater trigger level is recommended for this bore.

At MSGW04B the hydrogeological model predicts no drawdown in groundwater level due to mining. However, observed groundwater levels at MSGW04B have shown a constant decreasing trend between 2014 and April 2018. This decreasing trend may be attributable to sampling of groundwater. Groundwater levels at MSGW04B have been relatively stable since April 2018. It is recommended that further groundwater level monitoring be undertaken at MSGW04B before a groundwater level trigger is specified for this bore.

At MSGW03B the hydrogeological model predicts no drawdown in groundwater level due to mining. Groundwater levels at MSGW03B have varied over the period of monitoring by approximately 3 m. The groundwater level hydrograph has been plotted with the CRD curve as shown in Appendix C. Comparison of the CRD curve and groundwater level hydrograph indicates that groundwater level at MSGW03B is responding to trends in rainfall. Therefore groundwater level trigger has been set as 2 m (typical variation in groundwater level) below the minimum observed groundwater level.

At monitoring bore MSGW03C, the hydrogeological model predicts groundwater levels will fall by approximately 128 m due to mining. The groundwater level hydrograph has been plotted with the CRD curve as shown in Appendix C. Prior to July 2014 the groundwater level at MSGW03C was relatively constant between 24.3 and 25.2 m AHD. The large drop in groundwater level following this period is due to purging of the bore for groundwater sampling. Due to the large predicted fall in groundwater level due to future mining, it is not considered that a groundwater level trigger value is appropriate for this monitoring bore. However, monitoring data obtained from this bore will be used in future calibration of the hydrogeological model.

Further investigations within these sources are triggered if an adjacent landholder complains about declining groundwater levels in their bore.

Triggers for groundwater levels are presented in Table 4-2 (i.e. if monitored level falls below trigger). Note that the trigger level in Table 4-2 differ slightly from the WMP (GHD 2019) as they have been recalculated using data collected since the WMP. Groundwater level triggers have been recalculated to detect impacts from upcoming Longwalls 30 to 31.

Table 4-2 Groundwater level trigger values

Bore	Lithology	Trigger (m AHD)
MSGW04A	Morans Creek alluvium	21.192
MSGW03B	Sandstone (Tuggerah)	24.62

4.2.2 Groundwater quality

Groundwater quality trigger values have been developed with reference to historical monitoring data. Groundwater quality trigger values have been developed for MSGW03A, MSGW03B, MSGW04A and MSGW04B. Groundwater level triggers have been recalculated to detect impacts from upcoming Longwalls 30 to 31. It is recommended that Stage 1 groundwater quality trigger values be based on an exceedance of 80th percentile for three consecutive monitoring rounds or an exceedance of the 100th percentile historical value, as shown in Table 4-3, Table 4-4, Table 4-5 and Table 4-6. Exceedance of the Stage 1 trigger value would launch an investigation. A Stage 2 trigger would occur if the outcome of this investigation indicated that the exceedance was attributable to mining related activities.

Monitoring bores MSGW03C and MSGW04C are no longer monitored for groundwater quality and therefore no triggers have been assigned for these bores.

It should be noted that, as outlined in Section 3.1, there is considerable natural variability in groundwater pH and EC in both alluvial and porous and fractured rock groundwater sources. In addition, the beneficial uses of this groundwater are limited due to the high EC.

Table 4-3 MSGW03A – groundwater quality trigger values

Parameter	Units	20/80th percentile trigger	0/100th percentile trigger
pH – upper level	pH units	6.0	6.4
pH – lower level	pH units	5.6	4.97
EC	µS/cm	4905	6370

Table 4-4 MSGW03B – groundwater quality trigger values

Parameter	Units	20/80th percentile trigger	0/100th percentile trigger
pH – upper level	pH units	7.5	8.0
pH – lower level	pH units	7.1	5.3
EC	µS/cm	6706	7250

Table 4-5 MSGW04A – groundwater quality trigger values

Parameter	Units	20/80th percentile trigger	0/100th percentile trigger
pH – upper level	pH units	6.5	7.2
pH – lower level	pH units	6.27	5.7
EC	µS/cm	9677	20,114

Table 4-6 MSGW04B – groundwater quality trigger values

Parameter	Units	20/80th percentile trigger	0/100th percentile trigger
pH – upper level	pH units	7.2	7.93
pH – lower level	pH units	6.67	6.56
EC	µS/cm	8310	8970

4.3 Performance criteria

4.3.1 Watercourses

Watercourses are to be managed for water quality and flow volume. Criteria for these aspects are provided in Table 4-7.

Table 4-7 Watercourse criteria

Aspect	Criteria	Performance criteria achieved
Watercourse quality	Within or below SSGVs provided in Table 4-1.	Likely
Watercourse flow	Above or within 50th percentile historical dry weather flow volume.	Likely

The stream flow monitoring station is located on Morans Creek, downstream of the study area. The location of the flow monitoring station is provided on Figure 2-1.

4.3.2 Stream health

To manage stream health, criteria have been developed based on geomorphic condition and waterway stability. The criteria are applicable to the watercourse stability of potentially impacted reaches of Morans Creek. Table 4-8 presents the criteria for stream health.

Table 4-8 Stream health criteria

Aspect	Criteria	Performance criteria achieved
Geomorphic condition and watercourse stability		
Incisional processes and instabilities Waterway bed condition	Occurrence of erosional processes does not occur as a result of subsidence.	Likely
Waterway cross sectional area	Change in cross sectional area does not vary beyond the predictions of the subsidence modelling undertaken as part of impact assessment.	Likely
Stream gradient	Change in stream gradient does not vary beyond the predictions of the subsidence modelling undertaken as part of impact assessment.	Likely
Watercourse subsidence		
3rd order and above streams GDEs	No connective cracking between the surface, or the base of the alluvium, and the underground workings. No subsidence impact or environmental consequence greater than minor.	Likely
1st and 2nd order streams	No subsidence impact or environmental consequences greater than predicted by impact assessment. No connective cracking between the surface and the underground workings.	Likely

Notes:

- Classification of streams in accordance with Strahler stream order system.
- Detailed performance indicators (including impact assessment criteria) for each of these performance measures will be detailed in the various management plans that are required under this consent.
- Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.

4.3.3 Groundwater environment

Table 4-9 below presents the groundwater environment management criteria for Mandalong Mine.

Table 4-9 Groundwater environment criteria

Aspect	Criteria	Performance criteria achieved
Groundwater level	Above trigger values provided in Table 4-2. No complaints regarding groundwater access.	Likely
Groundwater quality	Within or below trigger values provided in Table 4-3 to Table 4-6. No complaints regarding groundwater quality.	Likely

5. Mandalong Valley flood modelling

5.1 Flood modelling methodology

A flood model has been developed for the Mandalong Valley to identify and quantify the potential changes to the nature of flooding as a result of mining activities at Mandalong Mine. The model is a two dimensional hydrodynamic flood model implemented in RMA-2 and simulates the depth, velocity and shear (tractive) stress of flood flows, accounting for observed and predicted subsidence. The results of the model are used to estimate the potential impacts of mining on flooding, watercourse stability and ponding.

The model was updated to compare the potential impacts of the Modification 9 of SSD 5144 on flooding and watercourse stability to the approved SSD 5144 Modification 5 (Umwelt 2020). Modification 9 included the reorientation of renamed Longwalls 30 to 31.

5.2 Predicted changes to watercourse stability

Extraction of Longwalls 30 to 31 has the potential to change the physical characteristics or hydraulic response of overlying watercourses. The potential impact is quantified in terms of flow velocity and shear stresses, which indicate the potential for scouring, changes to channel geometry or changes to flow paths.

Analysis of flood modelling indicates that it is likely that scouring will occur near the south chain pillar of Longwall 29 (refer to Figure 2-2). Otherwise, no measureable impacts are expected, including along Buttonderry Creek.

Unwelt (2020) recommended that watercourse stabilisation works should be undertaken if increased bed and bank scouring is observed during monitoring of subsidence and watercourse stability.

5.3 Predicted changes to ponding

Extraction of Longwalls 30 to 31 has the potential to cause or increase ponding that occurs after prolonged rainfall or flooding with the area affected by subsidence.

Analysis of flood modelling results indicates that potential impacts are confined to existing flow paths, with no predicted impact on access routes to, or within, properties (and residences). Where modelling indicates the potential for increases to remnant ponding (refer to Figure 2-2), Umwelt (2020) recommended that local drainage works may be required to alleviate the increased ponding.

5.4 Predicted changes to flooding

Extraction of Longwalls 30 to 31 has the potential to change the flood regime in overlying watercourses.

Analysis of flood modelling results indicates that no adverse impacts are expected on flood subject dwellings relative to previous extraction.

6. Groundwater model validation program

6.1 Data review

The groundwater model validation program compares groundwater monitoring results with modelled groundwater level predictions. As specified in the *Mandalong Mine: Water Management Plan* (GHD 2019), the model will be reviewed against the monitoring data annually. Model re-calibration is undertaken as required or every three years.

Upon receipt of groundwater monitoring results, the following review processes will be undertaken:

- Data will be compared to the specified trigger values where applicable
- If result(s) do not meet specified trigger values further investigation will be required at the respective location

Centennial Mandalong undertakes an annual review of monitoring data to compare groundwater levels to rainfall and identify trends, and to assess statistically significant changes in groundwater quality.

6.2 Calculation of groundwater take

Centennial Mandalong currently holds works approval 20WA217077 and WAL 39767 under the North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan for the extraction of up to 1825 ML/year of underground mine water from the Cooranbong Underground Storage area into the Borehole Dam at the CES. A calculation of the groundwater take from the fractured and porous rock groundwater sources, as discussed is Section 2.2.3, will be undertaken annually as part of the annual water balance review, with the results reported in the Annual Review for Mandalong Mine.

6.3 Independent model review

Schedule 4, Condition 6A of development consent SSD-5144 requires an independent review of the groundwater model. An independent review of the groundwater model was undertaken in September 2017 and is provided in Appendix F. The independent groundwater model review found that the hydrogeological model is sufficiently fit for purpose.

7. Risks and mitigation plan

7.1 Trigger action response plans

Trigger action response plans (TARPs) are provided in Appendix G for:

- Watercourses
- Groundwater environment
- Stream health
- Flooding

7.2 Management plan review

This WMP will be reviewed as a result of:

- Any significant change to water management practices
- Continual exceedance of trigger values

A review of this WMP will be undertaken by a suitably qualified person and, where necessary, will consider consultation with the appropriate local and state government authorities.

Table 7-1 Summary of management actions and mitigation measures

Required action	Frequency
Undertake groundwater monitoring in accordance with Section 2.2.	Quarterly
Undertake surface water quality monitoring in accordance with Section 2.1.1	Quarterly
Undertake surface water flow monitoring in accordance with Section 2.1.2	Review continuous data annually
Stream and flow path monitoring specified in Section 2.1.3.	Biannually
Undertake flood monitoring in accordance with Section 2.1.4	In the event of significant rainfall events
Undertake daily monitoring of underground water transfers specified in Section 2.2	Daily, review daily data annually
Respond to exceedances of trigger values in accordance with the TARP presented in Appendix G.	Ongoing
Undertake an annual review and report on groundwater monitoring data as presented in Section 6.	Annually
Compare hydrogeological model predictions with monitoring data on an annual basis and re-calibrate the hydrogeological model as required as presented in Section 6.	Annually
Calculate annual groundwater take from the fractured and porous rock groundwater sources.	Annually

7.3 Reporting

Outcomes from the monitoring programs will be reported annually through the Annual Review. This reporting will cover outcomes such as results of floodpath, surface water and groundwater monitoring and assessment of monitoring results against relevant criteria.

8. References

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Governments and Australian state and territory governments, available from http://www.waterquality.gov.au/anz-guidelines/

DILW (2018) *Continuous water monitoring network,* Department of Industry – Lands and Water (site access: http://allwaterdata.water.nsw.gov.au/water.stm).

DPI (2012a) *NSW Aquifer Interference Policy: NSW Government policy for the licensing and assessment of aquifer interference activities*, NSW Department of Primary Industries.

DPI (2012b) *Risk assessment guidelines for groundwater dependent ecosystems*: *Volume 1 – The conceptual framework*, NSW Department of Primary Industries, Office of Water.

EMM (2020) Mandalong Mine: Modification report for modification to development consent SSD-5144. Report J200176 RP2 prepared for Centennial Mandalong Pty Ltd by EMM Consulting (May 2020)

GHD (2013) *Mandalong Southern Extension Project: Groundwater Impact Assessment,* prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

GHD (2016a) *Groundwater Monitoring and Contingency Plan, Cooranbong Entry Site,* prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

GHD (2016b) *Mandalong Tonnage Production Project – Groundwater and Water Balance Modelling Report,* prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

GHD (2016c) *Northern Operations: Regional Biodiversity Management Plan*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2019) *Mandalong Mine: Water Management Plan*, prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

GHD (2017) *Longwall 24 and 24A Modification, Water Resources Impact Assessment,* prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

GHD (2020a) *Mandalong Mine Longwall Reorientation Groundwater Model Update,* prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

GHD (2020b) *Mandalong Mine: Annual Groundwater Monitoring Review 2019,* prepared by GHD Pty Ltd for Centennial Mandalong Pty Limited.

Hunter Eco (2013) *Mandalong Mine: Wetlands Monitoring and Management Plan Revision 2013*, prepared by Hunter Eco for Centennial Mandalong Pty Limited.

Pacific Power International (1997) *Cooranbong Colliery Life Extension Project Overburden Strata Groundwater Study*, prepared by Pacific Power International.

RPS (2013) *Mandalong Southern Extension Project: Environmental Impact Statement – Flora and Fauna Impact Assessment*, prepared by RPS Australia East Pty Ltd for Centennial Mandalong Pty Limited.

Sigra (2011) *Permeability Testing at Borehole C050W650,* prepared by Sigra Pty Ltd for Centennial Coal Company Limited.

Umwelt (2013) *Mandalong Southern Extension Project: Surface Water Assessment*, prepared by Umwelt (Australia) Pty Limited for Centennial Mandalong Pty Limited.

Umwelt (2020) Flood Impact Assessment: Mandalong South Extension Project Modification. Report 20091/R01 prepared by Umwelt (Australia) Pty Limited for Centennial Mandalong Pty Limited.

Umwelt (2021) *Property MS0127 Flood Assessment (2nd Order Stream)*, prepared by Umwelt (Australia) Pty Limited for Centennial Mandalong Pty Limited.

Appendices

Appendix A – Correspondence with regulators

CENTENNIAL MANDALONG

23 December 2020

BY EMAIL

Water Regulation Officer (Newcastle)
Department of Industry – Lands & Water
PO Box 2213
Dangar NSW 2309

Dear Sir / Madam,

Centennial Mandalong – LW30-31 Extraction Plan – Water Management Plan for Review

In accordance with Condition 6(j) of Schedule 4 of SSD-5144, a copy of the Extraction Plan – LW30-31 Water Management Plan has been enclosed for your review and comment. This Water Management Plan has been prepared specifically as a component of the LW30-31 Extraction Plan.

Please provide any feedback or comments you may have on the Water Management Plan by 5pm on **Friday 29 January 2021** to:

Jeffrey Dunwoodie

Centennial Mandalong

PO Box 1000

Toronto NSW 2283

Or

Email: Jeffrey.Dunwoodie@centennialcoal.com.au

If you have any questions or require any further information in regard to this Water Management Plan, please contact me on 0448 490 023.

Yours sincerely

Jeffrey Dunwoodie

Environment & Community Coordinator

Enclosed

- Extraction Plan – LW30-31 Water Management Plan (December 2020).

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Planning, Industry & Environment

Mr James Wearne
Group Environment & Approvals Manager
Centennial Mandalong Pty Limited
PO Box 1000
TORONTO NSW 2283

07/06/2021

Dear Mr Wearne

Mandalong Southern Extension Project (SSD-5144)
Extraction Plan – Longwalls 30 - 31
Request for Information

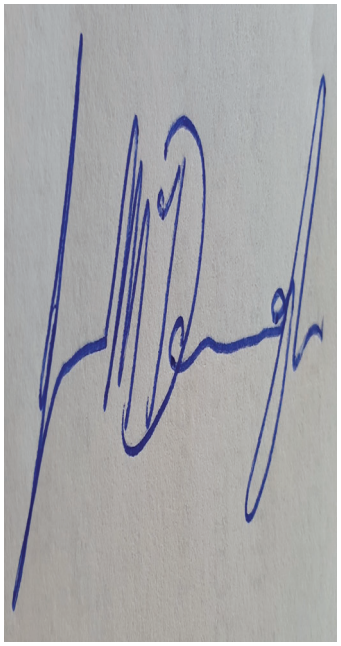
I refer to the Extraction Plan (EP) dated March 2021, and subsequent EP variation dated 26 May 2021, for Longwalls 30 and 31 at the Mandalong Mine, submitted in accordance with condition 6 of Schedule 4 of the Mandalong Southern Extension Project development consent (SSD-5144).

The Department has reviewed the EP in consultation with the Department of Planning, Industry and Environment's Biodiversity and Conservation Division (BCD) and Heritage NSW. Review comments for your attention are provided in Attachments A, B and C. The Department is satisfied that these matters can be addressed in a timely manner, however they are important to the effective management of impacts to the natural and built features within the proposed EP area.

The attached comments must be addressed to the satisfaction of the Secretary prior to the Department granting its final approval of the EP (as varied). Please upload revised versions of the EP and relevant sub-plans to the Major Projects portal at your earliest convenience.

If you have any questions, please contact James McDonough on 02 9585 6313.

Yours sincerely



James McDonough
Team Leader
Resource Assessments (Coal & Quarries)

Attachments:
Attachment A – DPIE Review Comments
Attachment B – Heritage NSW advice
Attachment C – Biodiversity and Conservation Division advice

Attachment A
Mandalong Southern Extension Project SSD5144
Extraction Plan Longwalls 30-31
Review Comments – 07 June 2021

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
6. The Applicant must prepare an Extraction Plan for all second workings on site, to the satisfaction of the Secretary. Each Extraction Plan must:	-	Extraction Plan (EP) for Longwalls 30-31 submitted to the Department on 21 April 2021.	Nil
(a) be prepared by suitably qualified and experienced persons whose appointment has been approved by the Secretary;	Yes	On 22 October 2020 the Secretary approved the appointment of Mr Phil Enright to prepare the Extraction Plan main document, Built Features MP, Property Subsidence MPs, Land MP, Public Safety MP, Subsidence Monitoring Program, TARPs and Contingency Plans. Also approved various specialists for WMP, BMP and HMP.	Nil
(b) be approved by the Secretary before the Applicant carries out any of the second workings covered by the plan;	Yes	Secondary extraction is scheduled to start in July 2021 for LW30 and complete LW31 in April 2022.	-
(c) include detailed plans of existing and proposed first and second workings and any associated surface development;	Yes	Graphical Plans of existing and proposed workings, as well as surface features, are included as attachments to the main Extraction Plan.	Nil
(d) include detailed performance indicators for each of the performance measures in Tables 6 and 7;	Yes	• Main EP - Section 3.5 - includes the performance measures and indicators and are high level and general. However, it is noted that the Trigger Action Response Plans (TARPs) for water, land, biodiversity, heritage, built features, public safety and properties are included in the Individual MPs, and are detailed and reflect the performance measures in Tables 6 and 7. See comments on triggers below. • Section 4.2 references the following key component plans and which have been submitted in support of the Main EP: o Built Features MP o Property Subsidence MP o Water MP o Biodiversity MP o Land MP o Heritage MP	Nil

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
		○ Public Safety MP ○ Subsidence Monitoring Program and ○ Trigger Action Response Plans. Each key component plan has been reviewed individually below.	
(e) provide revised predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed second workings, incorporating any relevant information obtained since the commencement date of this consent;	Yes	Subsidence predictions are provided as part of the main EP document. They are also provided as part of the EP variation dated 27 May 2021.	Update the main EP document to make reference to the most recent subsidence prediction report, as per the EP variation lodged 27 May 2021.
(f) describe the measures that would be implemented to ensure compliance with the performance measures in Tables 6 and 7, and manage or remediate any impacts and/or environmental consequences;	Yes	High-level subsidence management strategies (including avoidance, adaptive management and the use of TARPs) are described in Section 3.7 of the main EP document. More detailed subsidence management and remedial strategies for each natural and built feature are provided in the relevant management plans. Considered adequate.	Nil
(g) include a Built Features Management Plan, which has been prepared in consultation with RR and the owners of affected built features, to manage the potential subsidence impacts and/or environmental consequences of the proposed second workings, and which:	Partial	An Built Features Management Plan (BFMP) for LWs 30 to 31 is outlined in Section 4.7 of the main EP, and provided in Volume 3 of the EP. The BFMP includes the following sub-plans which have been provided in full: • Public Roads Management Plan – identifies two public roads and some unnamed Crown Roads and two private access roads to be impacted. Pre and post mining management measures adequate and Crown Lands and LMCC consulted. TARP satisfactory. • Communication Management Plan – Telstra has both overhead cables and underground pits and conduits through EP area. Adequate monitoring program accepted by Telstra. TARP satisfactory. • Powerline Management Plan – note: an Ausgrid 11kV line traverses the EP area, supplying a limited number of properties. Three power poles are predicted to be impacted with between 0.5 m to 1.2 m of vertical subsidence. Mitigation measures proposed by Ausgrid & Centennial committed to implementing. Ongoing monitoring of subsidence crosslines, and annual reporting. TARP satisfactory.	• Powerline MP – Figures 1, 2 and 3 do not label/number the individual Transgrid local powerlines to reference against subsidence impacts included in Table 9. Please update the figures accordingly.

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
		Section 4.2 and Table 4.2 of the main EP document summarises the consultation undertaken with the Resources Regulator, Crown Lands, Ausgrid, Telstra in relation to the BFMP. Consultation is further described in each respective management plan and copies of the correspondence is appended to the plans.	
• addresses in appropriate detail all items of key public infrastructure (with particular consideration to tension/angle/suspension towers on transmission lines), and other public infrastructure;	Yes	All key items of public infrastructure in the EP area appear to have been addressed.	Nil
• has been prepared following appropriate consultation with the owner/s of potentially affected feature/s;	Yes	Section 4.2 and Table 4.2 of the main EP document summarises the consultation undertaken with the Resources Regulator, Crown Lands, Ausgrid, Telstra in relation to the BFMP. Table 4.2 of the main EP indicates that the owners have endorsed and/or indicated satisfaction with the plans. Further discussion on consultation and copies of correspondence is provided in the appendices to the individual management plans.	Note: Main EP document - Section 8.1 contains an incorrect reference to Table 10, should be Table 9 – please amend.
• recommends appropriate remedial measures and includes commitments to mitigate, repair, replace or compensate all predicted impacts on potentially affected built features in a timely manner; and	Partial	Section 5.5 and Section 3.5.2 of the main EP document contains performance indicators and TARPs for each built feature, including remedial measures respectively. **Note:** It is not clear in the main EP document where the timeframes for notification to agencies and relevant stakeholders following the trigger of a relevant TARP and the implementation of actions required under the TARPs is mentioned or located.	Please include clear reporting timeframes and notification obligations relating to the TARPs in both the main EP document and cross check all individual TARPs for measurable notification timeframes. These should reflect the requirements in Schedule 5 of SSD-5144.
• in the case of all key public infrastructure, and other public infrastructure except roads, trails and associated structures, reports external auditing for compliance with ISO 31000 (or alternative standard agreed with the infrastructure owner), and provides for annual auditing of compliance and effectiveness during extraction which may impact the infrastructure;	Yes	• Section 7 of the BFMP confirms that Centennial Mandalong has adopted the Stature Risk Assessment Program which is consistent with ISO 31000. The company completed this risk assessment process for the built features affected by subsidence from extraction of LWs25 to 31, with the results summarised in Appendix 4 of the EP and Section 7 of the BFMP. • Section 15 provides a commitment to annual auditing of the requirements of the BFMP.	Nil

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
(h) include a Property Subsidence Management Plan for each privately-owned property affected by the proposed second workings, prepared in consultation with the landowner, which includes:	Partial	Electronic copies of the Property Subsidence Management Plans (PSMPs) for all nine properties located within the EP area have been provided in Volume 3 of the EP. Considered adequate. Section 4.2 (Table 4.2) of the main EP document summarises the consultation undertaken with the privately-owned property owners potentially affected. Further details of consultation are provided in Section 3 of each PSMP.	Update each PSMP to reflect the subsidence predictions that accompanied Centennial's EP variation request lodged on 27 May 2021. This includes updating the predicted subsidence set out in the figures within each PSMP. The figures should also be labelled to identify the individual property that is the subject of the relevant PSMP.
□ a detailed structural inspection of residences and all other structures on the property;	Yes	Structural assessment of properties confirmed in individual PSMPs (Section 3).	Nil
□ a detailed subsidence impact assessment for the property, including (where relevant): - a flood impact assessment, including a prediction of the minimum freeboard of the residence in a 1 in 100 year ARI flood event, and, where this prediction shows the minimum freeboard at the residence to be less than 0.5 m in a 1 in 100 year ARI flood event: □ recommends such works to raise, remediate or relocate the residence and/or provide suitable access to the property, prior to undermining the residence; or □ where these works are unable to be undertaken, offers to acquire the whole of the property, or such part of the property requested by the landowner where subdivision is approved, in accordance with conditions 3 and 4 of Schedule 5; - slope stability assessments at the properties shown in Figure 2 of Appendix 5, or at any other property as nominated by the Secretary, which must: □ be undertaken at least 12 months prior to undermining the property; □ be undertaken in consultation with RR, by a suitably qualified geotechnical expert; □ recommend measures to manage and/or mitigate the risks and impacts associated with slope instability and rock roll-out at the residence, and the	Yes	Section 3 of the PSMPs lists the subsidence, flooding, slope stability assessments undertaken for each property. Section 4 of the PSMPs summarises the predicted subsidence impact for each property. Section 5 of the PSMPs summarises the predicted flooding impact for each property. Section 6 of the PSMPs summarises the proposed mitigation requirement for each property. All PSMPs include a TARP. Section 6 of the PSMPs include mitigation, remedial and compensation measures applicable to each property. Refer to comment above in relation to the timing to implement individual action/responses and remedial measures.	Nil

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
risk to the safety of persons; and □ include a timeframe for the implementation of the recommended measures; - soil erosion assessment, which recommends measures to avoid, mitigate and otherwise respond to increased soil erosion (including tunnel erosion) impacts; and			
□ appropriate measures, commitments and timeframes to mitigate, repair, replace or otherwise compensate the impacts to the property;	Yes	Section 6 of the PSMPs include mitigation, remedial and compensation measures applicable to each property.	Nil
(i) include a Water Management Plan, which has been prepared in consultation with EPA and DPIE Water, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on watercourses and aquifers, including:	Partial	• Water Management Plan (WMP) dated December 2020 is included in Volume 3 of the EP. Table 4.2 of the main EP document summarises the consultation undertaken with the EPA and DPIE Water and NRAR on the EP, including the WMP. No response has been recorded from DPIE Water and NRAR, and Appendix A of the WMP does not provide evidence of consultation with DPIE Water and NRAR.	Please follow up the consultation with DPIE Water as it is a requirement of condition 6 of Schedule 4 of SSD-5144.
• detailed baseline data on groundwater levels, yield and quality in the region, and in privately owned groundwater bores that could be affected by the second workings;	Yes	• Baseline groundwater data is summarised in Section 3 and presented in detail in Appendix B and C of the WMP. • Only three bores were located within 1 km of LW30-13 and are mine-owned.	Nil
• surface water and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality;	Partial	• Impact assessment criteria and triggers for surface water and groundwater are included in Section 4 of the WMP. • Surface water criteria derived from both site-specific and default guideline values as presented in ANZECC (2000) guidelines. • Groundwater level values are derived from site-specific monitoring data and modelling. Trigger values for water levels are only provided for two bores, with several other bores cited to have no trigger values due to being dry and/or low water levels or insufficient data. • Section 4.2 - Groundwater quality triggers based on historic monitoring data and further investigations triggered if adjacent landowners complain about declining groundwater levels.	• WMP Section 4.2 - Please review groundwater trigger levels provided in Table 4-2 and update to be consistent with the approved Water Management Plan for SSD-5144 (GHD, 2019). • Section 4.2.2 - Please review Table 4-3 to Table 4-6 and update as necessary to address any inconsistencies with the approved WMP for SSD-5144 (GHD, 2019). • Please review and update criteria and triggers reflected in the TARP of the WMP.

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
• a program to monitor and report on stream morphology and stream flows, and assessment of any changes resulting from subsidence impacts, including scouring and ponding;	Partial	• Section 4.3.2 – Table 4-8 has been updated to reflect contemporary commitments to watercourse subsidence impacts following Mod 9. • Section 2.1.3 describes the monitoring of stream, flow path and ponding. Figure 2-2 shows the monitoring locations. However these do not reflect the additional two ponding locations identified following approval of Mod 9. • Section 4.3 – details performance criteria for watercourses, stream health (including geomorphic condition and waterway stability).	• Please update Section 2.1.3 and Figure 2-2 to reflect the two predicted additional ponding locations occurring above LW30 as identified in MOD 9. • Figure 2-2 - Please review and align monitoring points with Table 2-2. ie. is location C or G?
• a program to monitor flooding (including updated flood modelling); with recommendations to minimise, manage and mitigate (whether prospectively or retrospectively) flood impacts on residences, private properties, roads, other infrastructure and other built features;	Yes	• Section 5 - summarises the updated and revised flood model used to predict impacts on the flooding regime in the Mandalong Valley from mining in LWs 1 to 31. • Section 2.1.4 - The model was updated to compare the potential impacts of the MOD 9 of SSD 5144 on flooding and watercourse stability to the approved SSD 5144 MOD 5 (Umwelt 2020). MOD 9 included the reorientation of renamed Longwalls 30 to 31. • Section 5.2 - describes the predicted changes to flooding regimes for the changes to LW 30 – 31. • Section 5.3 – notes the predicted ponding impacts and proposed mitigation measures. Measures to minimise, manage and mitigate flooding impacts described in the LMP and BFMP, including the PSMPs.	Nil – see comments above.
• a groundwater monitoring program which: - includes a comprehensive monitoring bore network, ensuring all bore casings are above ground level and are purged before sampling; - samples on a monthly basis for the first two years of the development, and quarterly thereafter, unless directed by the Secretary; - monitors and reports on: □ groundwater inflows to the mine; □ background changes in groundwater yield/quality against mine-induced changes;	Yes	• Section 2.2 of the WMP describes the groundwater monitoring program. Figure 2-3 shows the groundwater bore monitoring locations. • Section 2 - describes indicates that monitoring will be undertaken on a quarterly basis and that the bores will be purged before sampling. • Section 2 - describes the monitoring procedures for groundwater inflows into the mine. • Section 3.2 describes monitoring to assess impacts to regional and local (alluvial) aquifers.	Nil

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
and □ impacts to: - regional and local (including alluvial) aquifers; - groundwater supply to private bores; and - groundwater dependent ecosystems and riparian vegetation;		• Section 4.2 and Table 4-2 provides groundwater level trigger values, including commitments to investigate if adjacent landowners complain about declining groundwater levels. See comments on trigger values in section above. • Section 3.2.3 - describes the GDE identified in the area. This has been further described and mapped in Section 6.1.1.3 and Figure 2 of the Biodiversity Management Plan (BMP). Potential impacts to and monitoring of GDEs and riparian vegetation is described in the BMP. Monitoring program considered adequate.	
• a program to validate the groundwater model for the development, and compare monitoring results with modelled predictions; and	Yes	Section 6 describes the groundwater model validation program (reviewed annually and re-calibrated every 3 years). Considered adequate.	Nil
• a plan to respond to any exceedances of the groundwater assessment criteria;	Yes	Mitigation plan included in Section 7. TARP included in Appendix F. Considered adequate.	Nil
(j) include a Biodiversity Management Plan, which has been prepared in consultation with BCD, which establishes baseline data for existing habitat, including water table depth, vegetation condition, stream morphology and threatened species habitat, and provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats; endangered ecological communities; and water dependent ecosystems;	Partial	Biodiversity Management Plan (BMP) dated December 2020 included in Volume 3 of the EP. Section 4.2 (Table 4.2) of the main EP document summarises the consultation undertaken with BCD on the EP, including the BMP. Appendix 1 of the BMP provides copies of correspondence. Table 4.2 indicates BCD declined to provide comment on the updated BMP. However, the Department provided a copy of the EP and BMP to BCD for review following Centennial's lodgement of the EP. BCD reviewed the BMP and provided a number of comments on the plan. It is recommended the BMP is updated to address BCD's comments. Baseline data is included in Section 6 of the BMP. Monitoring design based on Before-After, Control Impact methodology, which is considered adequate. Performance criteria, indicators and action response included in Table 8. TARP included in Appendix 2.	Update the BMP to address BCD's review comments (Attachment C), including: • updating the TARP to describe how condition 3 of Schedule 4 of the conditions of consent would be met, including how biodiversity values, and their offset requirements, would be quantified by use of the Biodiversity Assessment Method 2020 if any unexpected biodiversity impacts occur. • including measures to offset any unexpected biodiversity impacts.
(k) include a Land Management Plan, which has been prepared in consultation with any affected	Partial	Land Management Plan (LMP) dated March 2021 included in Volume 3, Appendix 2 of the EP.	Update the LMP to address Crown Lands' comments in relation to the

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
public authorities, to manage the potential impacts and/or environmental consequences of the proposed second workings on land in general;		Section 4.2 (Table 4.2) of the main EP document and Section 4 of the LMP summarises the consultation undertaken with potentially affected public authorities. Additional evidence of how the LMP has been updated in response to Crown Lands' comments is required. LMP focuses on managing potential impacts on steep slopes, rock outcrops and agricultural land. Includes monitoring and management ponding impacts.	Yambo Trig Station, as per the correspondence provided in Appendix 2 of the plan. Include a reference in Section 4 as to where within the LMP the comments have been addressed.
(l) include a Heritage Management Plan, which has been prepared in consultation with Heritage NSW and Registered Aboriginal Parties, to manage the potential environmental consequences of the proposed second workings on both Aboriginal and non-Aboriginal heritage items, and reflects the requirements of condition 22 of Schedule 3 (see below); (c) include: □ a description of the measures that would be implemented to: - protect, monitor and/or manage Aboriginal Cultural Heritage sites/items (including any proposed archaeological investigations and/or salvage measures); - manage the discovery of previously unidentified Aboriginal items; - maintaining and managing reasonable access for Aboriginal stakeholders to heritage items on the Applicant's land; - ongoing consultation with Aboriginal stakeholders in the conservation and management of Aboriginal cultural heritage; □ a short-term and long-term strategy for the storage of any Aboriginal Cultural Heritage items salvaged on site; and □ a protocol for the management of impacts to Historic Heritage sites/items, including previously unidentified sites/items, including archival recording where impacts to Historic Heritage	Partial	A report titled *Mandalong Mine LW 30-31 Extraction Plan Heritage Management Plan* (HMP), dated April 2021 and prepared by Umwelt, has been provided as a component of the EP. The HMP indicates that there are no non-Aboriginal heritage items in the extraction area. Section 4.2 (Table 4.2) of the main EP document summarises the consultation undertaken with Heritage NSW on the HMP. No evidence of consultation with Heritage NSW is provided in either the main EP document or the HMP. Notwithstanding, the Department provided a copy of the EP and HMP to Heritage NSW for comment. See Attachment B for detailed comments. Section 2 of the HMP summarises the consultation undertaken with Registered Aboriginal Parties (RAPs). Evidence of consultation with RAPs is provided in Appendix 1. Section 7 and Figure 7.2 identifies the 25 Aboriginal cultural heritage sites within the extraction area. Section 11.2 describes the 3-phase monitoring program. Section 11.1 includes a number of non-committal passages where 'should' is used in lieu of words such as 'will' or 'must'. The use of 'should' suggests that a recommendation, rather than a firm commitment to undertake the action, has been made.	Update the HMP to address Heritage NSW's review comments (Attachment B). • Update Section 11.1 to replace non-committal words such as 'should' with words that provide a firmer commitment to undertake the action. E.g. will, must.

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
sites/items cannot be avoided.		Section 11.2.1 Monitoring protocols for grinding groove and rock shelters frequently uses non-committal language such as 'should be'. Section 11.3 Identification of Previously Unknown Aboriginal Cultural Heritage Sites frequently uses non-committal language such as 'should'. Section 11.4 Consultation with Registered Aboriginal Parties uses non-committal language such as 'should'.	• Update Section 11.2.1 to replace non-committal words such as 'should' with words that provide a firmer commitment to undertake the action. E.g. will, must. • Update Section 11.3 to replace non-committal words such as 'should' with words that provide a firmer commitment to undertake the action. E.g. will, must. • Update Section 11.3 to replace 'should' with a word that provides a firmer commitment to undertake the action. E.g. will, must.
(m) include a Public Safety Management Plan, which has been prepared in consultation with RR, to ensure that the proposed second workings do not impact on public safety;	Partial	• Public Safety Management Plan (PSMP) included in Volume 3, Appendix 6 of the EP. • No evidence of consultation with the Resources Regulator has been included, although Section 4.2 (Table 4.2) of the main EP document summarises the consultation undertaken with RR on the EP, including the PSMP. • The PSMP includes appropriate monitoring, mitigation and management measures, which are in-line with the respective BFMPs. Considered adequate.	• Section 5 – Table 2 and Section 6.4 contains outdated references to DRE. Please review entire document and update to align with contemporary agency names and accurate consolidated consent conditions produced after approval of MOD 9. • Replace Figure 4 with an updated figure showing numbered powerlines to reference subsidence impacts accurately. See comments on BFMP above.
(n) include a Subsidence Monitoring Program, which has been prepared in consultation with RR to: □ provide data to assist with the management of the risks associated with conventional and nonconventional subsidence; □ validate the subsidence predictions; □ analyse the relationship between the predicted and resulting subsidence effects and predicted and resulting impacts under the plan and any ensuing environmental consequences; and □ inform the Contingency Plan and adaptive management process;	Yes	Subsidence Monitoring Program (SMP) is summarised in Section 4.9 of the main EP document and included in Volume 3, Appendix 8 of the EP. Section 4.2 (Table 4.2) of the main EP document summarises the consultation undertaken with the RR on the EP, including the SMP. No evidence of consultation with RR has been provided in either the main EP document or the SMP. Notwithstanding, the Department sought and received advice on the draft EP (including the SMP) from the RR. The RR did not have any specific comments regarding mine safety or mine rehabilitation matters in relation to the EP. The	Nil

Extraction Plan: ***Condition 6, Schedule 4***	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
		RR advised that the rehabilitation commitments outlined in any approved EP must be included in the Mining Operations Plan / Rehabilitation Management Plan regulated by the RR under the conditions of the mining lease and the *Mining Act 1992.* SMP includes baseline monitoring and a consolidated summary of subsidence movement and effects, built features and environmental monitoring.	
(o) Trigger Action Response Plans addressing all features in Tables 6 and 7, which contain: appropriate triggers to warn of the development of an increasing risk of exceedance of any performance measure; specific actions to respond to high risk exceedance of any performance measure to ensure that the measure is not exceeded; and an assessment of remediation measures that may be required if exceedances occur and the capacity to implement the measures;	Partial	Trigger Action Response Plans (TARPs) for water, land, biodiversity, heritage, built features, public safety and properties are included in Volume 1, Appendix 3 of the EP and are appended to the relevant individual plans. Triggers reviewed and considered adequate, with the exception of the groundwater triggers in the WMP (see earlier comments) Actions and remedial measures reviewed and considered adequate.	Update groundwater triggers as per comments above.
(p) include a Contingency Plan that expressly provides for; adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Tables 6 and 7, or where any such exceedance appears likely; and an assessment of the remediation measures that may be required if exceedances occur and the capacity to implement the measures;	Partial	Subsidence management strategies, including adaptive management framework, included in Section 3.6 of the main EP document. Considered adequate. Proposed remedial measures included in the TARPs and individual management plans.	Nil
(q) proposes appropriate revisions to the Rehabilitation Management Plan required under condition 33 of Schedule 3; and	Partial	Section 5.3 of the main EP document describes the updates and approvals of the Rehabilitation Management Plan (RMP), which was most recently approved by the Department on 23 December 2020.	Update Section 5.3 to include details of the MOP/RMP that was submitted to the Department for approval on 31 May 2021
(r) include a program to collect sufficient baseline data for future Extraction Plans.	Yes	Baseline data for future Eps is described in the various component sub-plans. Considered adequate.	Nil
General Comments			
1. Main EP document – Sections 4.7.1 and 4.7.2 – reference “the following figure”. Please amend to reference the relevant figure’s number. 2. If comments on the EP are received by Centennial from any agencies prior to approval of the EP, please forward then to the Department for consideration, particularly if consultation is a requirement of a condition of SSD-5144. (ie. DPIE Water or the RR).			

CENTENNIAL MANDALONG

23 December 2020

BY EMAIL

Ms. Lisa Potter
Operations Officer – Regulatory Operations
Environment Protection Authority
PO Box 488G
NEWCASTLE NSW 2300

Dear Lisa,

Centennial Mandalong – LW30-31 Extraction Plan – Water Management Plan for Review

In accordance with Condition 6(j) of Schedule 4 of SSD-5144, a copy of the Extraction Plan – LW30-31 Water Management Plan has been enclosed for your review and comment. This Water Management Plan has been prepared specifically as a component of the LW30-31 Extraction Plan.

Please provide any feedback or comments you may have on the Water Management Plan by 5pm on **Friday 29 January 2021** to:

Jeffrey Dunwoodie

Centennial Mandalong

PO Box 1000

Toronto NSW 2283

Or

Email: Jeffrey.Dunwoodie@centennialcoal.com.au

If you have any questions or require any further information in regard to this Water Management Plan, please contact me on 0448 490 023.

Yours sincerely

Jeffrey Dunwoodie

Environment & Community Coordinator

Enclosed

- Extraction Plan – LW30-31 Water Management Plan (December 2020).

Centennial Mandalong Pty Limited
ABN 74 101 508 892
PO Box 1000
Toronto NSW 2283
T. +61 02 4973 0900
E: info@centennialcoal.com.au
www.centennialcoal.com.au

RE: Centennial Mandalong LW30-31 Extraction Plan - Water Management PlanLisa Potter to: Jeffrey Dunwoodie 18/01/2021 10:31 AM
From: "Lisa Potter" <Lisa.Potter@epa.nsw.gov.au>
To: "Jeffrey Dunwoodie" <Jeffrey.Dunwoodie@centennialcoal.com.au>
Follow Up:
Normal Priority.
History:This message has been replied to.

Hi Jeff

Thank you for forwarding the Centennial Mandalong LW30-31 Extraction Plan - Water Management Plan. No further details are currently required.

Kind regards

Lisa Potter
Operations Officer
Regulatory Operations
NSW Environment Protection Authority
D 02 4908 6805 | **M** 0428 565 162

www.epa.nsw.gov.au @NSW_EPA

The EPA acknowledges the traditional custodians of the land and waters where we work. As part of the world's oldest surviving culture, we pay our respect to Aboriginal elders past, present and emerging.

Report pollution and environmental incidents 131 555 or +61 2 9995 5555

From: Jeffrey Dunwoodie <Jeffrey.Dunwoodie@centennialcoal.com.au>
Sent: Wednesday, 23 December 2020 7:29 AM
To: EPA RSD Hunter Region Mailbox <hunter.region@epa.nsw.gov.au>
Cc: Lisa Potter <Lisa.Potter@epa.nsw.gov.au>; Phil Enright <phil.enright@centennialcoal.com.au>
Subject: Centennial Mandalong LW30-31 Extraction Plan - Water Management Plan

Attention - Ms. Lisa Potter

Dear Lisa,

Please find attached a covering letter and an electronic version of the Centennial Mandalong LW30-31 Extraction Plan - Water Management Plan for review by the EPA as required by SSD-5144. Please contact me if you have any questions.

Regards

Jeff Dunwoodie
Environment and Community Coordinator

p: +61 (0) 2 4973 0947 | m: +61 (0) 448 490 023 | Internal: 3947

CENTENNIAL
Centennial Coal Company Pty Limited | Mandalong

12 Kerry Anderson Drive, Mandalong NSW 2264 Australia
centennialcoal.com.au

21 June 2021

BY EMAIL

Water Regulation Officer (Newcastle)
Natural Resources Access Regulator
Department of Planning, Industry & Environment – Lands & Water Division
PO Box 2213
Dangar NSW 2309

Dear Sir / Madam,

Centennial Mandalong – LW30-31 Extraction Plan – Water Management Plan for Review

In accordance with Condition 6(j) of Schedule 4 of SSD-5144, a copy of the updated Extraction Plan – LW30-31 Water Management Plan has been enclosed for your review and comment.

The Water Management Plan was originally provided to the Natural Resources Access Regulator on 23 December 2020 with no comments received and has recently been updated following a review by the Department of Planning, Industry & Environment.

Please provide any feedback or comments you may have on the updated Water Management Plan by 5pm on **Friday 2 July 2021** to:

Jeffrey Dunwoodie
Centennial Mandalong
PO Box 1000
Toronto NSW 2283
Or
Email: Jeffrey.Dunwoodie@centennialcoal.com.au

If you have any questions or require any further information in regard to this Water Management Plan, please contact me on 0448 490 023.

Yours sincerely

Jeffrey Dunwoodie

Jeffrey Dunwoodie

Environment & Community Coordinator

Enclosed

- Extraction Plan – LW30-31 Water Management Plan (June 2021).

Centennial Mandalong Pty Limited
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www.centennialcoal.com.au

Appendix B – Consultation outcomes

Comment	Response
Department of Planning, Industry and Environment (7 June 2021)	
Please follow up the consultation with DPIE Water as it is a requirement of condition 6 of Schedule 4 of SSD-5144.	Consultation with relevant regulators is documented in Appendix A. No response from DPIE Water has been received as of 9 June 2021. Centennial Mandalong is following up the consultation with DPIE Water.
WMP Section 4.2 - Please review groundwater trigger levels provided in Table 4-2 and update to be consistent with the approved Water Management Plan for SSD-5144 (GHD, 2019).	The groundwater level triggers in Table 4-2 differ slightly from the approved WMP (GHD 2019) as they have been recalculated using data collected since the approved WMP. Groundwater level triggers have been recalculated to detect impacts from upcoming Longwalls 30 to 31. Centennial Mandalong is currently in the process of updating the WMP.
Section 4.2.2 - Please review Table 4-3 to Table 4-6 and update as necessary to address any inconsistencies with the approved WMP for SSD-5144 (GHD, 2019).	The groundwater quality triggers in Table 4-3 to Table 4-6 differ slightly from the approved WMP (GHD 2019) as they have been recalculated using data collected since the approved WMP. Groundwater quality triggers have been recalculated to detect impacts from upcoming Longwalls 30 to 31. Centennial Mandalong is currently in the process of updating the WMP.
Please review and update criteria and triggers reflected in the TARP of the WMP.	The TARP has been updated to be consistent with TARP in the WMP (GHD 2019).
Please update Section 2.1.3 and Figure 2-2 to reflect the two predicted additional ponding locations occurring above LW30 as identified in MOD 9.	Table 2-2 and Figure 2-2 updated to include additional ponding location investigated following MOD 9. Review of flood modelling results (Umwelt, 2020) did not identify any new ponding locations.
Figure 2-2 - Please review and align monitoring points with Table 2-2. ie. location C or G	Monitoring points have been reviewed and updated to ensure consistency.

Appendix C – Baseline data

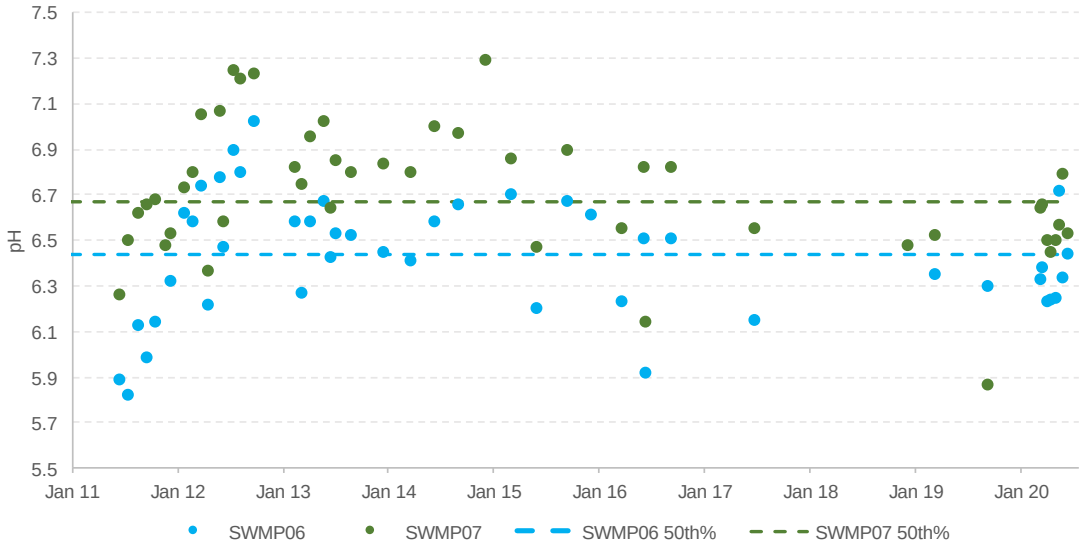
C.1 Surface water

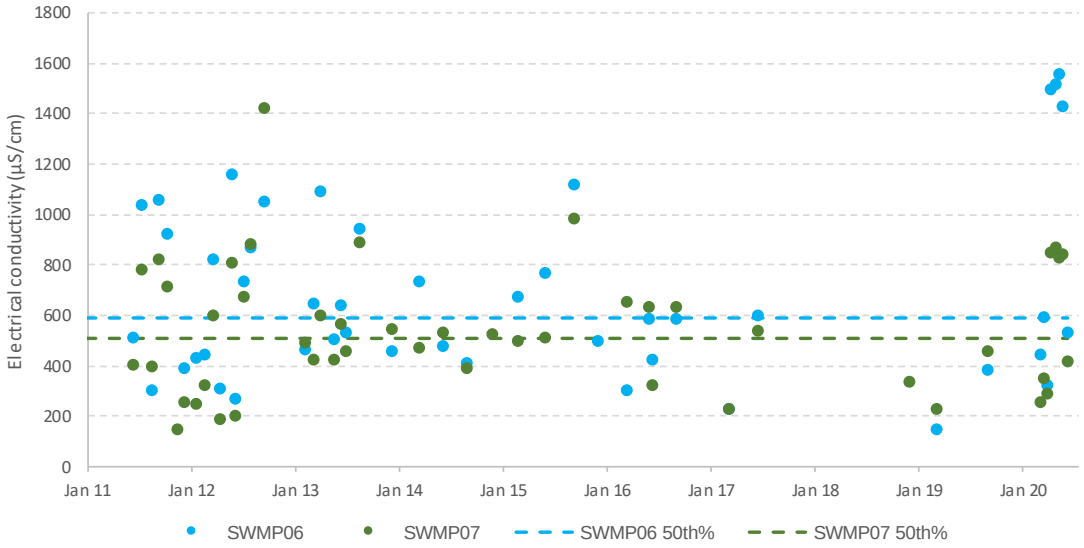
Median surface water quality results

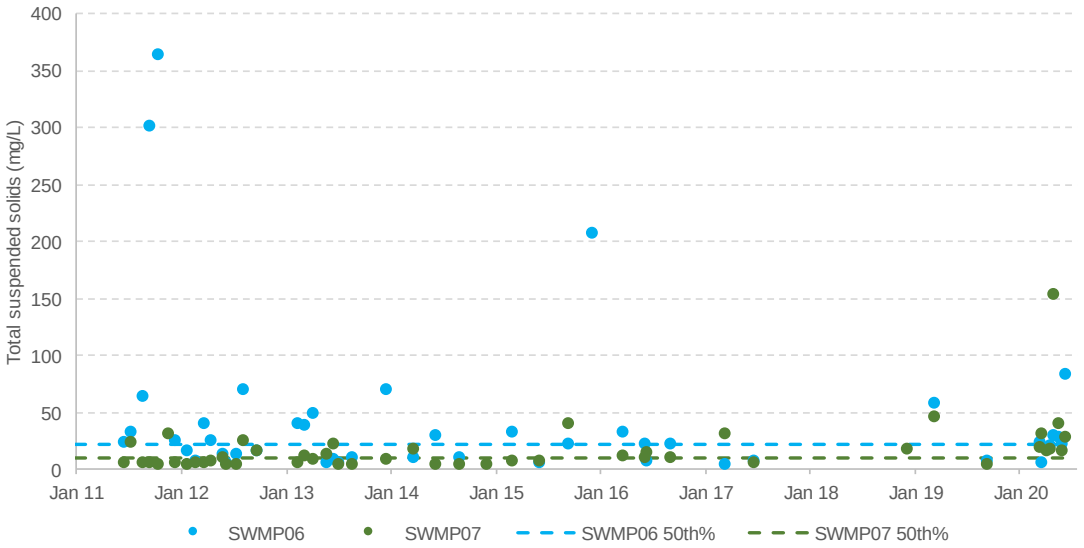
Parameter	Units	SW003	SW004	SW006	SW011	SWMP06	SWMP07
Physicochemical parameters							
EC	µS/cm	415	583	390	544	586	505.5
pH	pH units	6.47	6.88	6.52	6.68	6.44	6.67
TSS	mg/L	10	11	16	17	22	10.5
Turbidity	NTU	21.9	21.2	24.6	30.4	31.4	29.3
Nutrients							
Ammonia	mg/L	0.03	0.14	-	0.03	0.02	0.05
BOD	mg/L	-	-	-	-	2	2
TKN	mg/L	-	-	-	-	0.8	0.95
Total nitrogen	mg/L	-	-	-	-	0.8	0.95
Total phosphorus	mg/L	-	-	-	-	0.04	0.06
Anions							
Alkalinity (total)	mg/L	-	-	-	-	28	39
Chloride	mg/L	77	119	-	92	148	120
Sulfate	mg/L	12	10	-	4	13	10
Cations							
Calcium	mg/L	-	-	-	-	6	5
Magnesium	mg/L	-	-	-	-	12	10
Potassium	mg/L	-	-	-	-	3	4
Sodium	mg/L	-	-	-	-	76.5	75
Dissolved metals							
Aluminium	mg/L	-	-	-	-	0.29	0.28
Arsenic	mg/L	0.001	0.001	-	0.001	0.001	0.001
Barium	mg/L	0.045	-	-	0.03	0.068	0.047
Boron	mg/L	0.05	0.05	-	0.05	0.05	0.05
Cadmium	mg/L	0.0001	0.0001	-	0.0001	0.0001	0.0001
Chromium	mg/L	-	-	-	-	0.001	0.001
Cobalt	mg/L	-	-	-	-	0.004	0.0015
Copper	mg/L	0.001	0.001	-	0.001	0.001	0.001
Iron	mg/L	1.22	2.58	-	1.9	1.51	3.59
Lead	mg/L	0.001	-	-	0.001	0.001	0.001
Manganese	mg/L	0.16	0.90	-	0.82	0.33	0.46
Mercury	mg/L	0.0001	-	-	0.0001	0.0001	0.0001
Nickel	mg/L	-	-	-	-	0.005	0.003
Selenium	mg/L	0.01	0.01	-	0.01	0.01	0.01
Silver	mg/L	0.001	0.001	-	0.001	0.001	0.001
Zinc	mg/L	0.008	0.005	-	0.006	0.005	0.005
Total metals							
Aluminium	mg/L	-	-	-	-	0.80	0.79
Arsenic	mg/L	0.001	0.002	-	0.002	0.001	0.001
Barium	mg/L	0.058	0.067	-	0.078	0.078	0.058
Boron	mg/L	0.05	0.05	-	0.05	0.05	0.05
Cadmium	mg/L	0.0001	0.0001	-	0.0001	0.0001	0.0001
Chromium	mg/L	-	-	-	-	0.001	0.001
Cobalt	mg/L	-	-	-	-	0.007	0.0025

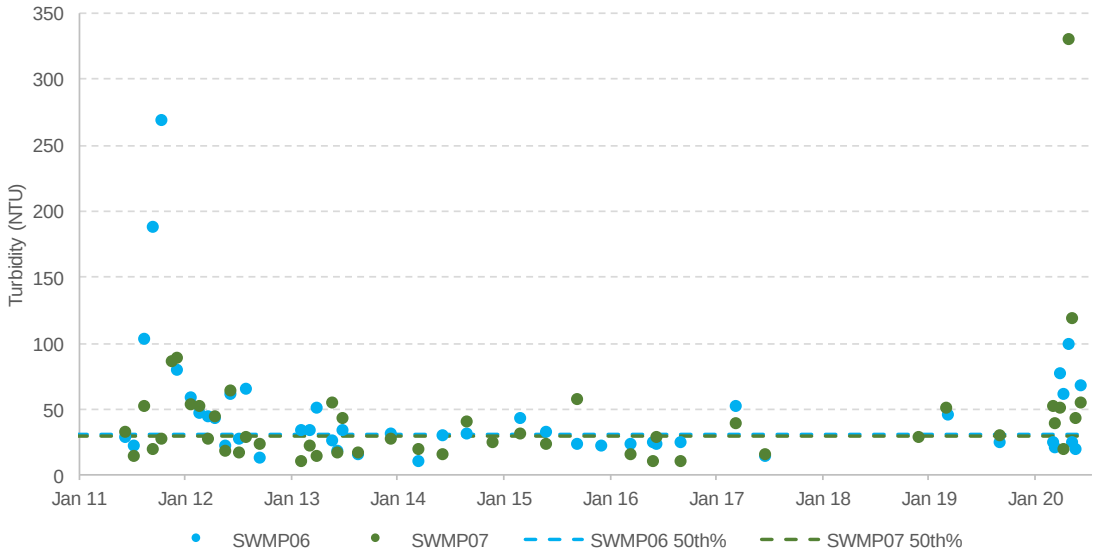
Parameter	Units	SW003	SW004	SW006	SW011	SWMP06	SWMP07
Copper	mg/L	0.002	0.002	-	0.002	0.001	0.002
Iron	mg/L	2.83	5.11	-	6.86	5.65	4.72
Lead	mg/L	0.001	0.001	-	0.001	0.001	0.001
Manganese	mg/L	0.26	0.63	-	1.05	0.45	0.51
Mercury	mg/L	0.0001	0.0001	-	0.0001	0.0001	0.0001
Nickel	mg/L	-	-	-	-	0.006	0.004
Selenium	mg/L	0.01	0.01	-	0.01	0.01	0.01
Silver	mg/L	0.001	0.001	-	0.001	0.001	0.001
Zinc	mg/L	0.019	0.014	-	0.012	0.0085	0.008
Other parameters							
Cyanide	mg/L	0.004	0.004	-	0.004	0.004	0.004
Fluoride	mg/L	0.1	0.1	-	0.1	0.10	0.10
Oil and grease	mg/L	2	2	2	2	2	2

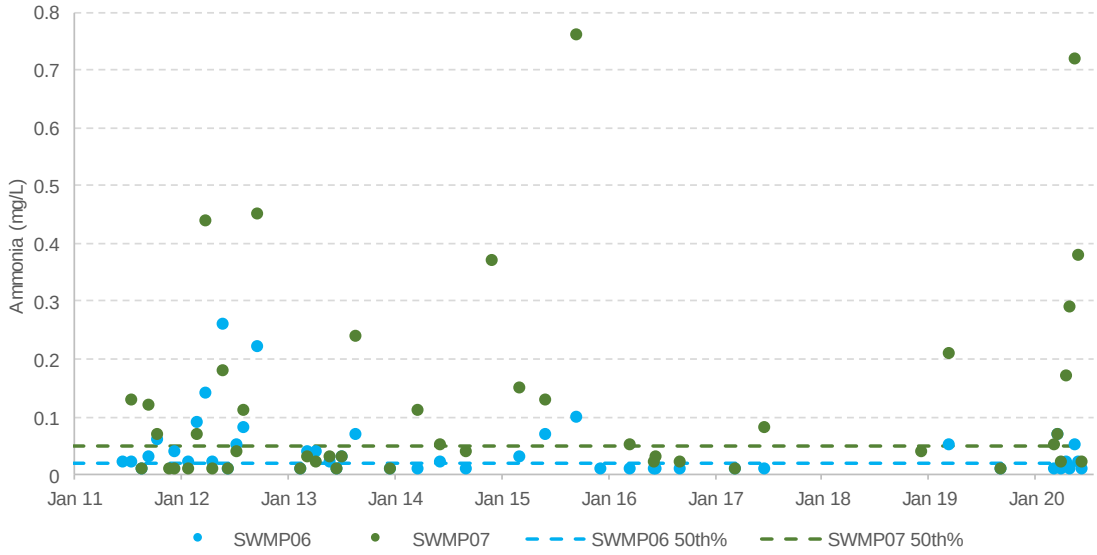
Morans Creek upstream

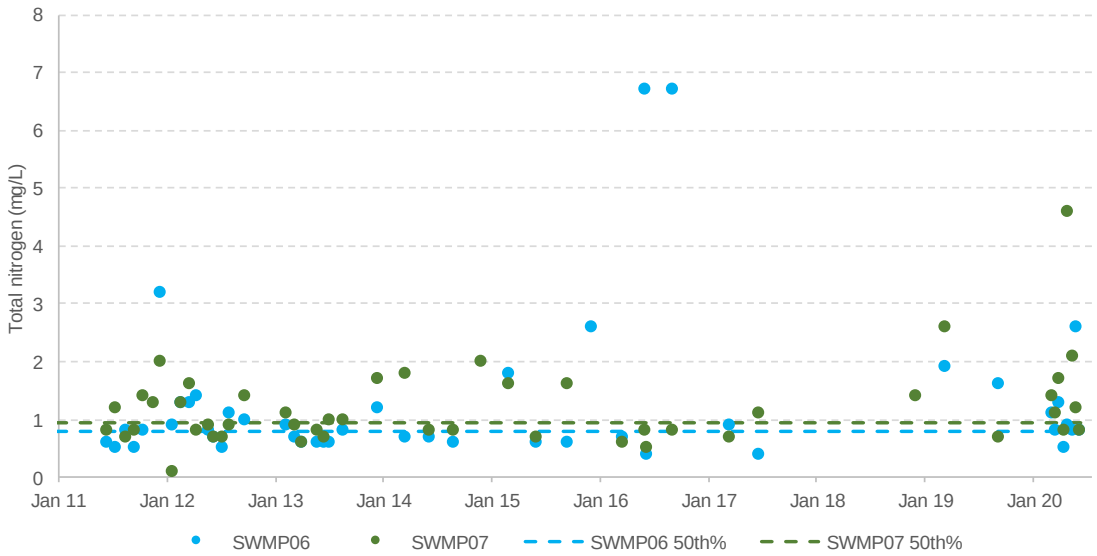


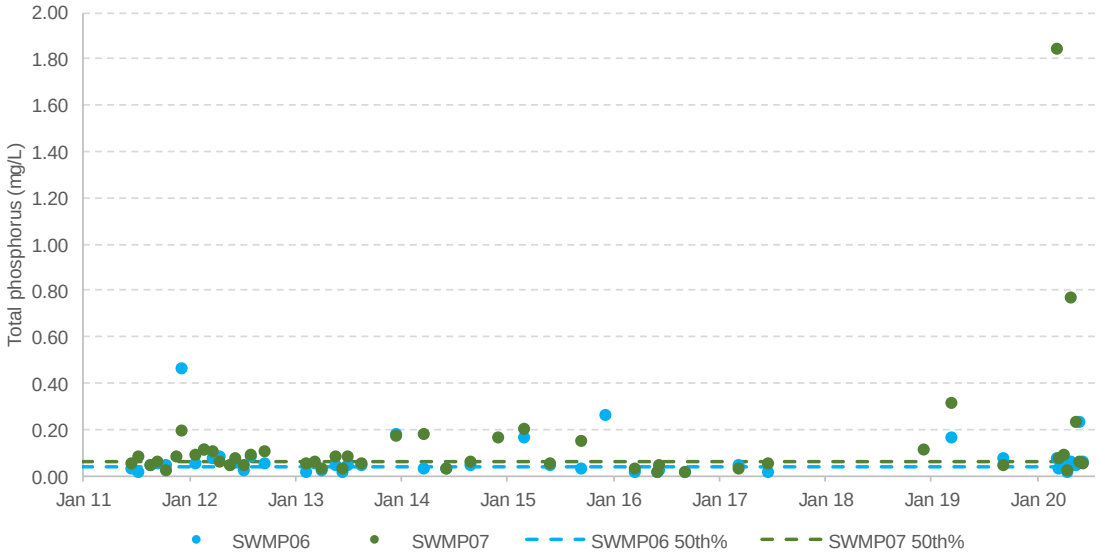


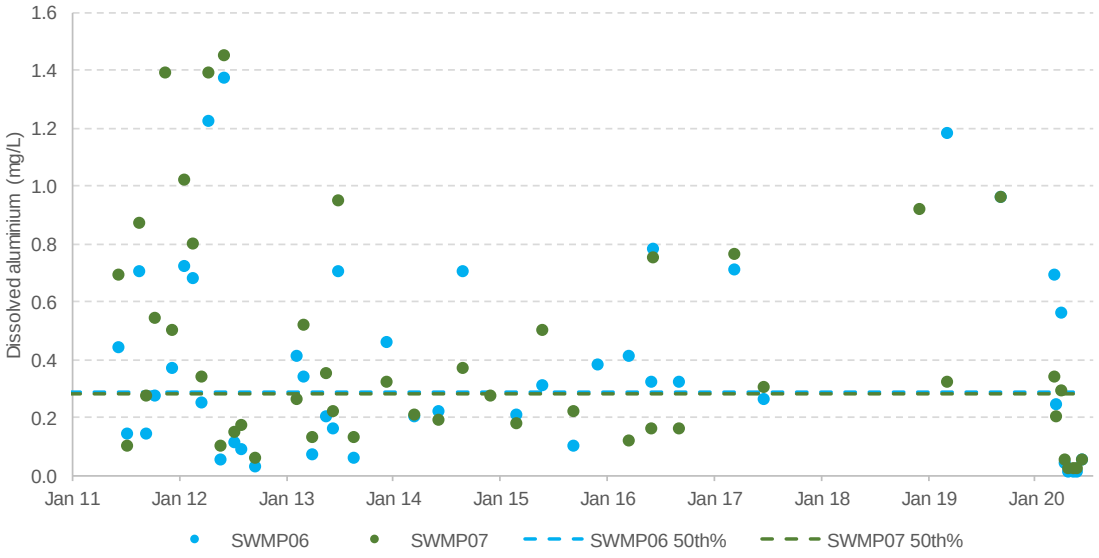


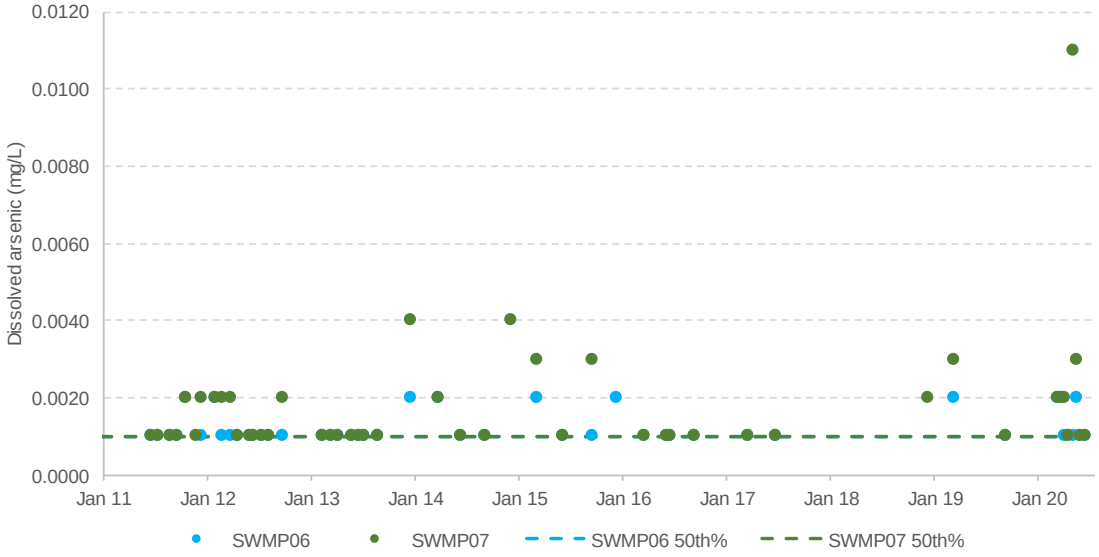

Turbidity (NTU)
350
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

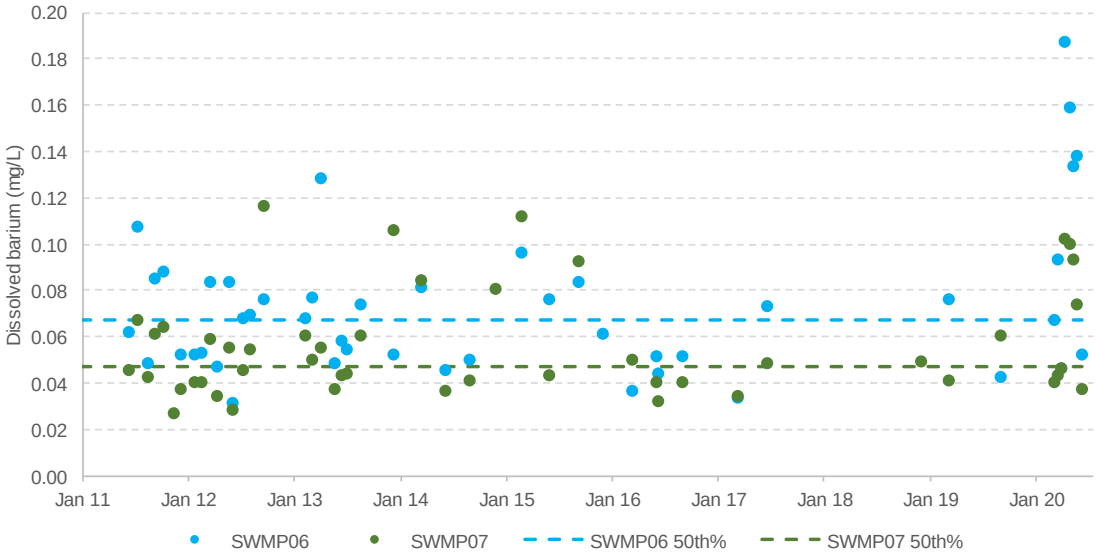

Ammonia (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

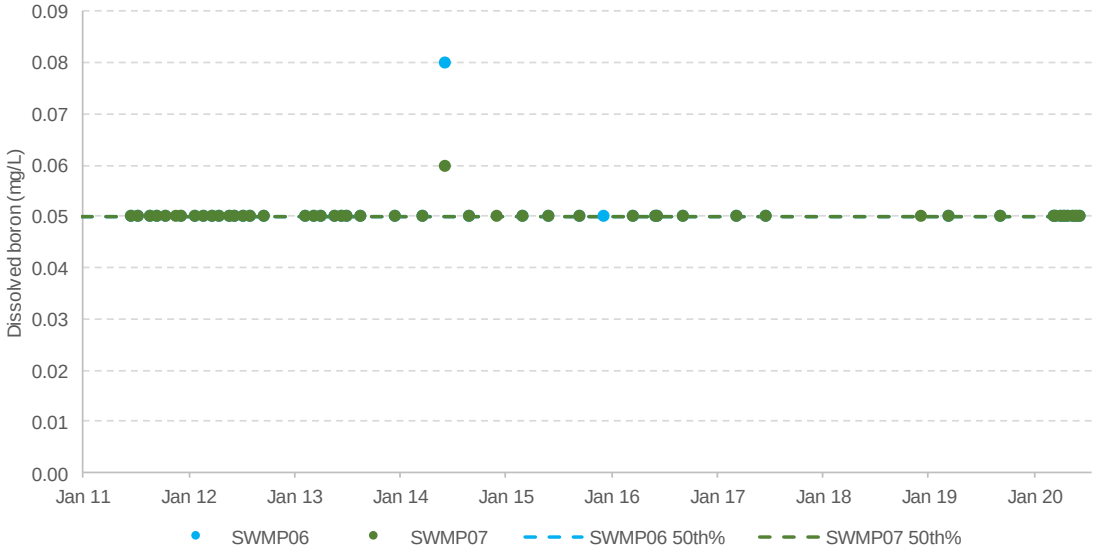

Total nitrogen (mg/L)
8
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

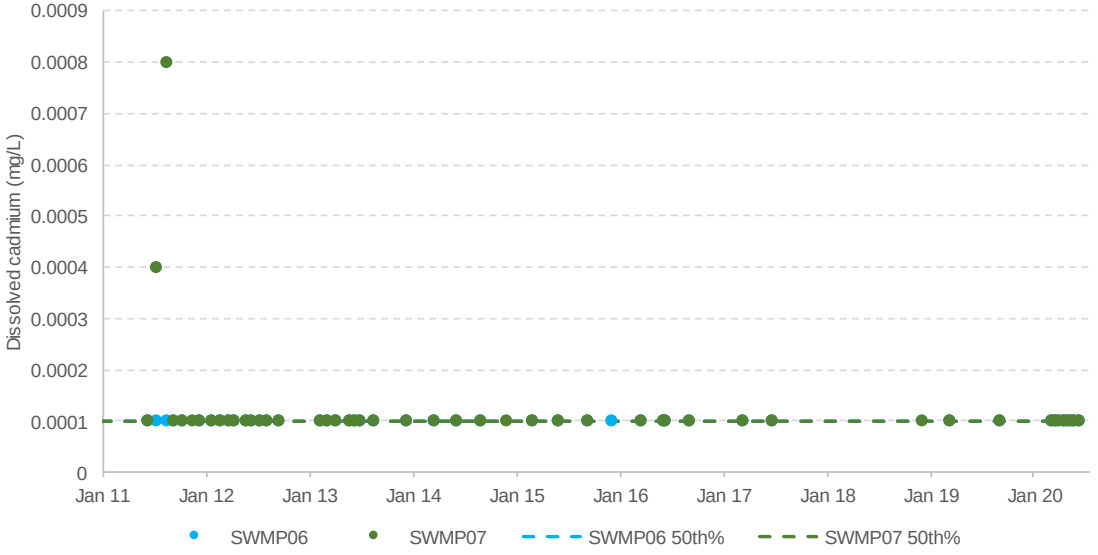

Total phosphorus (mg/L)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

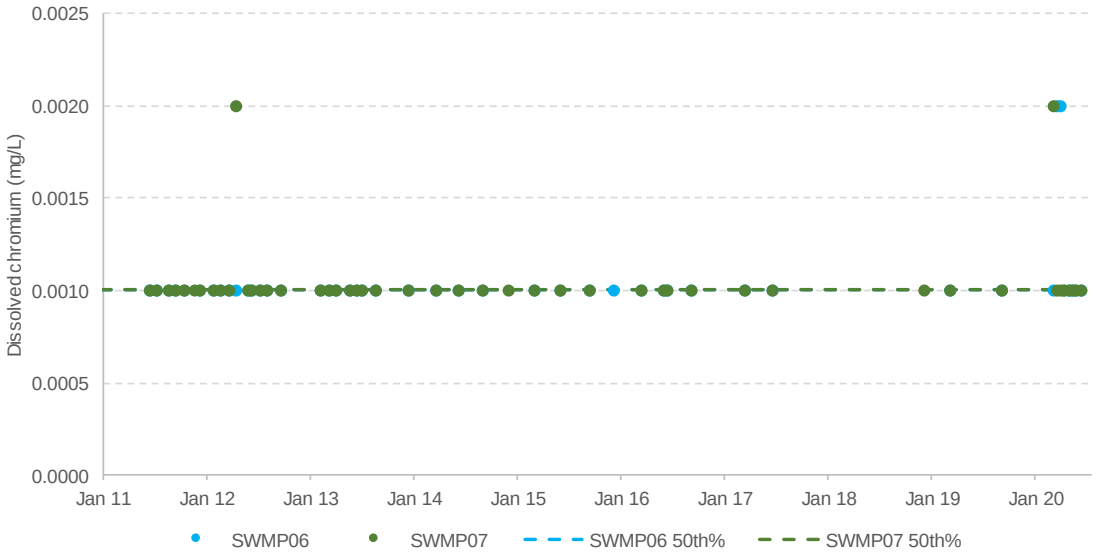

Dissolved aluminium (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

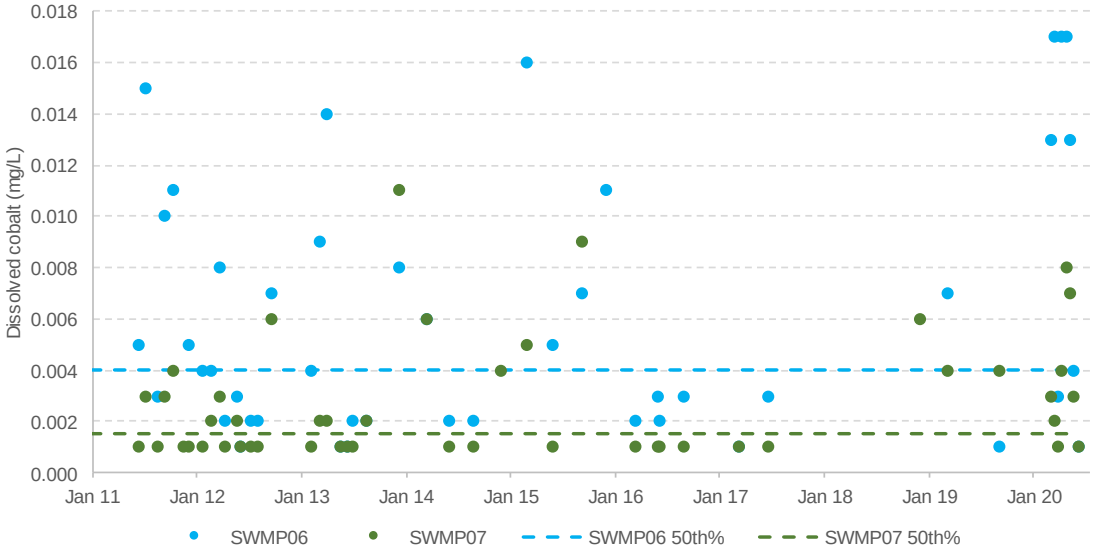

Dissolved arsenic (mg/L)
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

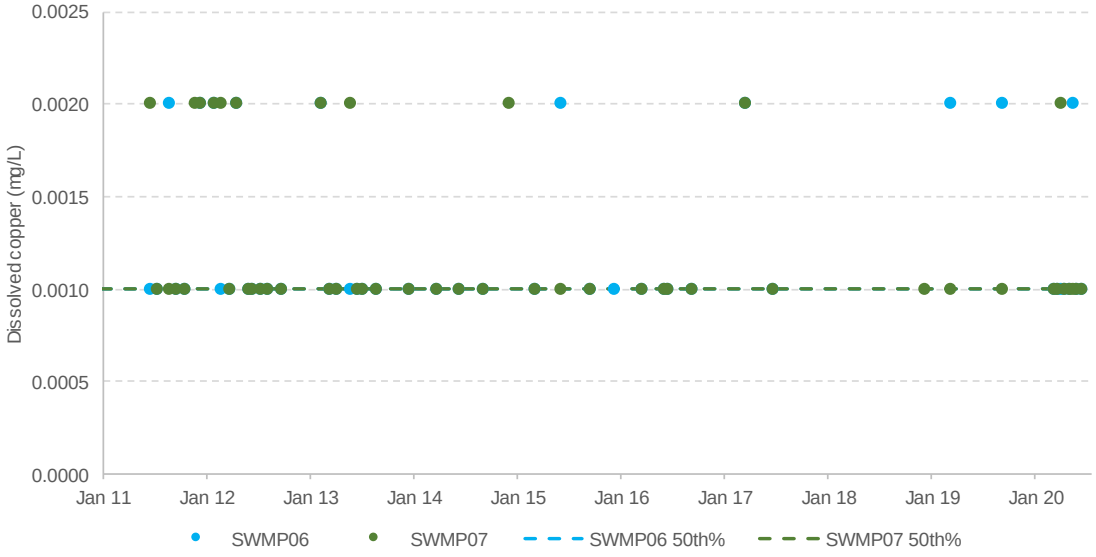

Dissolved barium (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

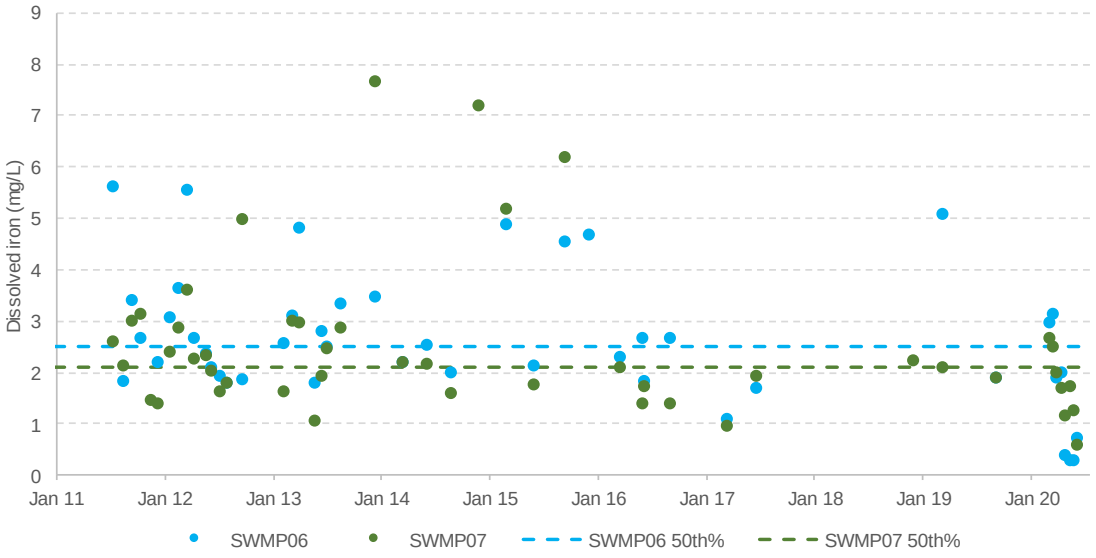

Dissolved boron (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

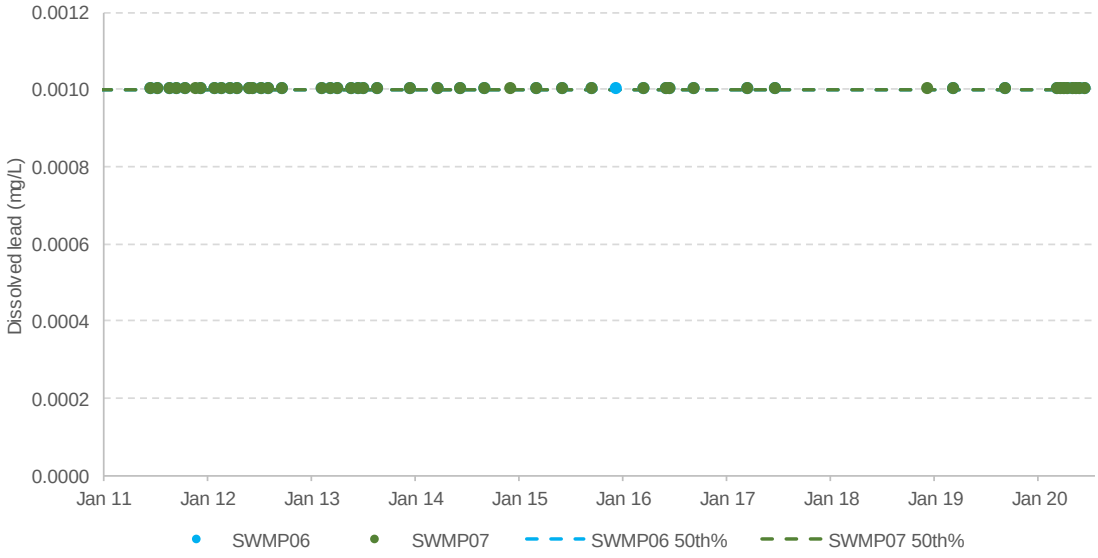

Dissolved cadmium (mg/L)
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

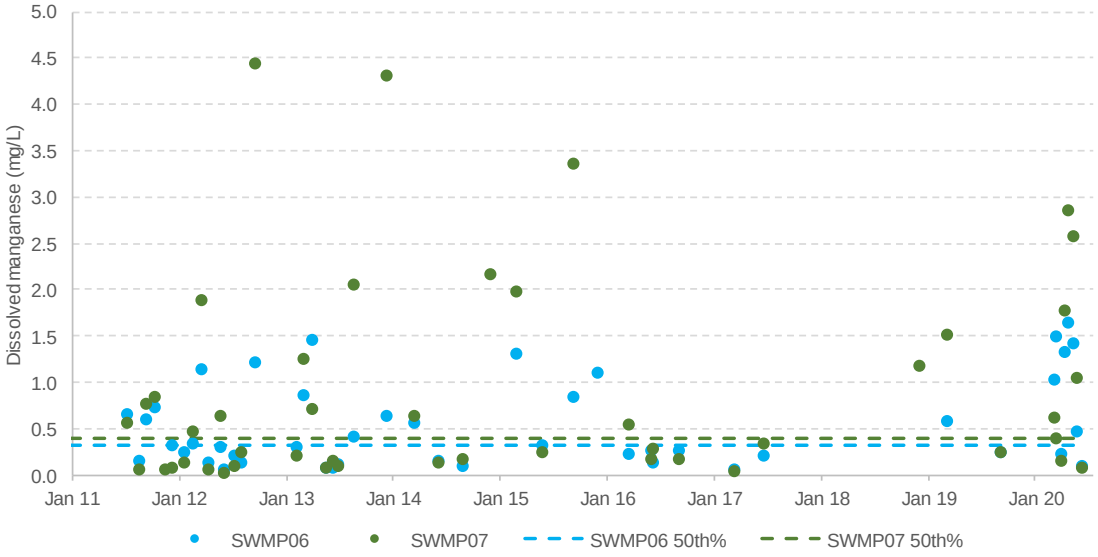

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved chromium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

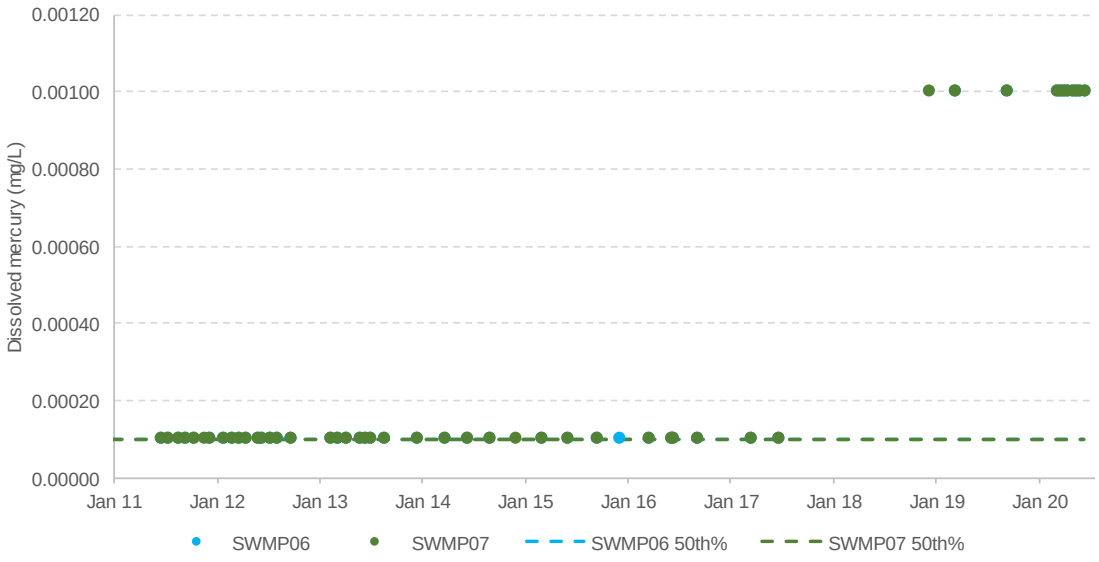

0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved cobalt (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

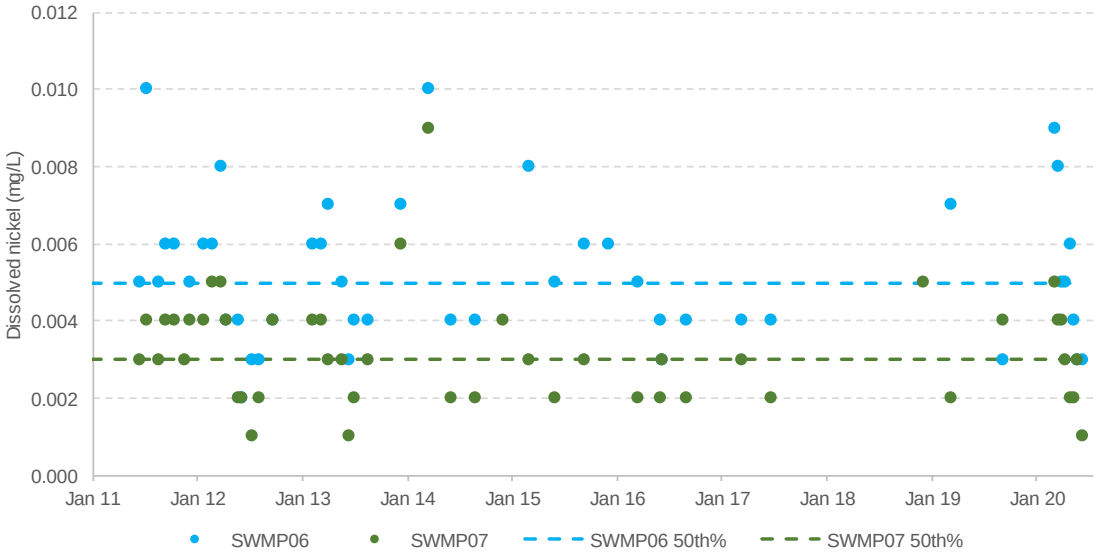

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

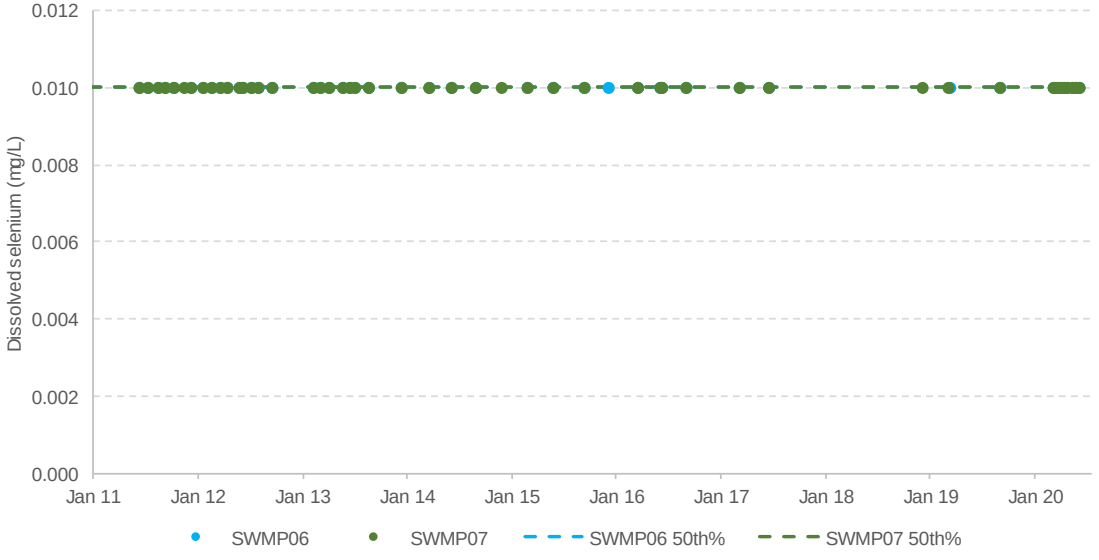

Dissolved iron (mg/L)
9
8
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

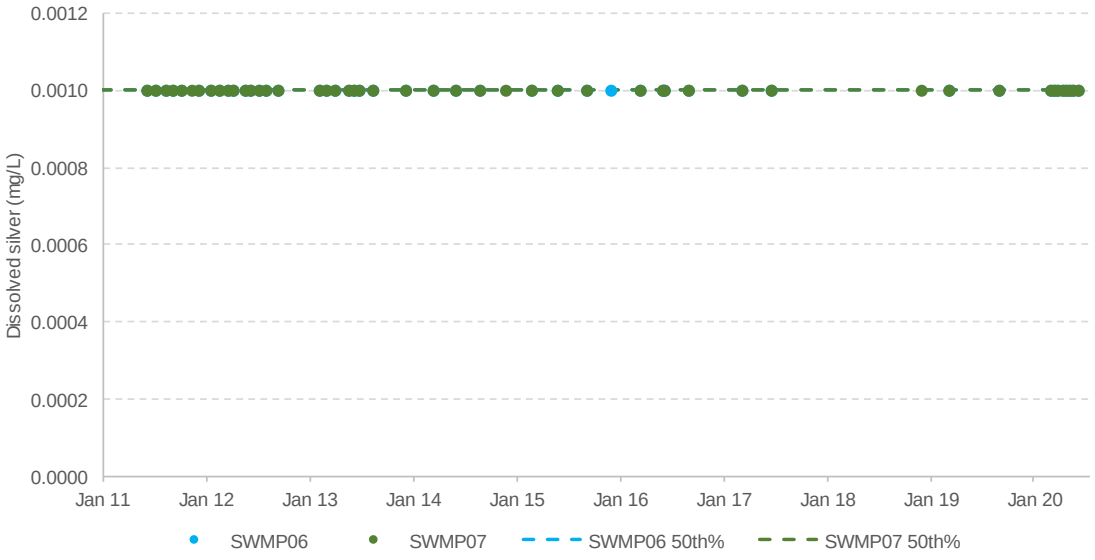

Dissolved lead (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

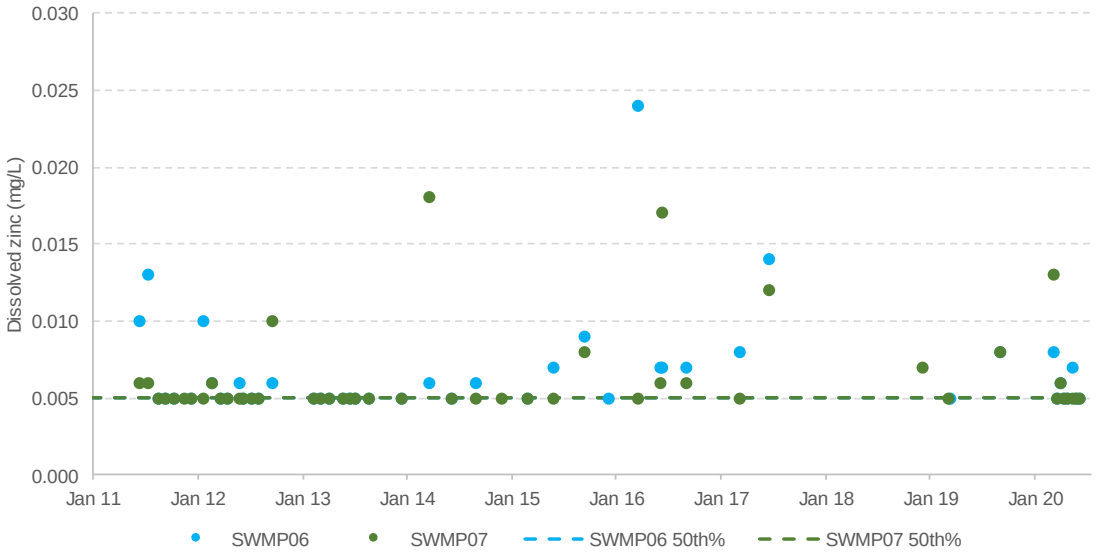

Dissolved manganese (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%


0.00120
0.00100
0.00080
0.00060
0.00040
0.00020
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

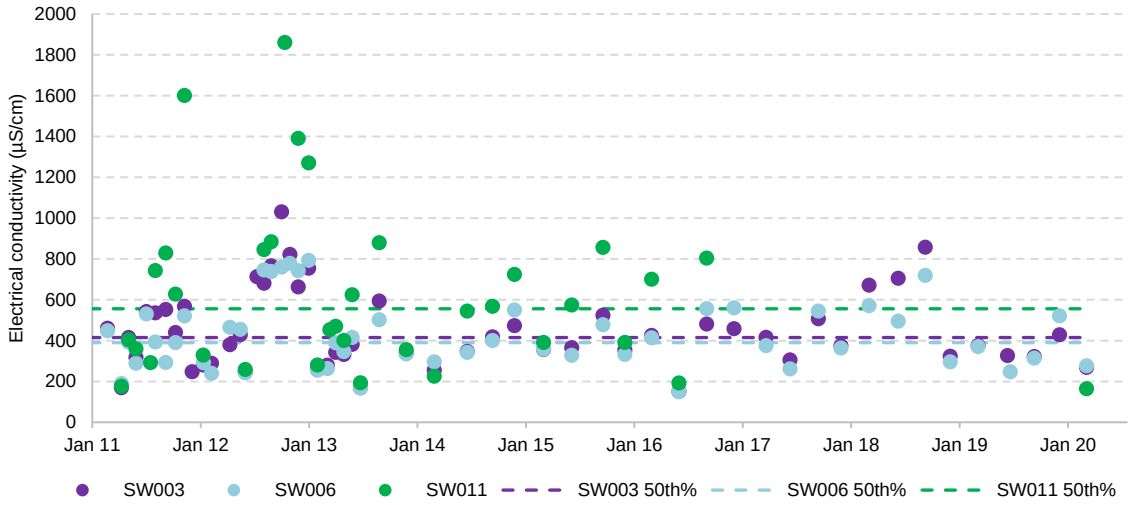

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved nickel (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

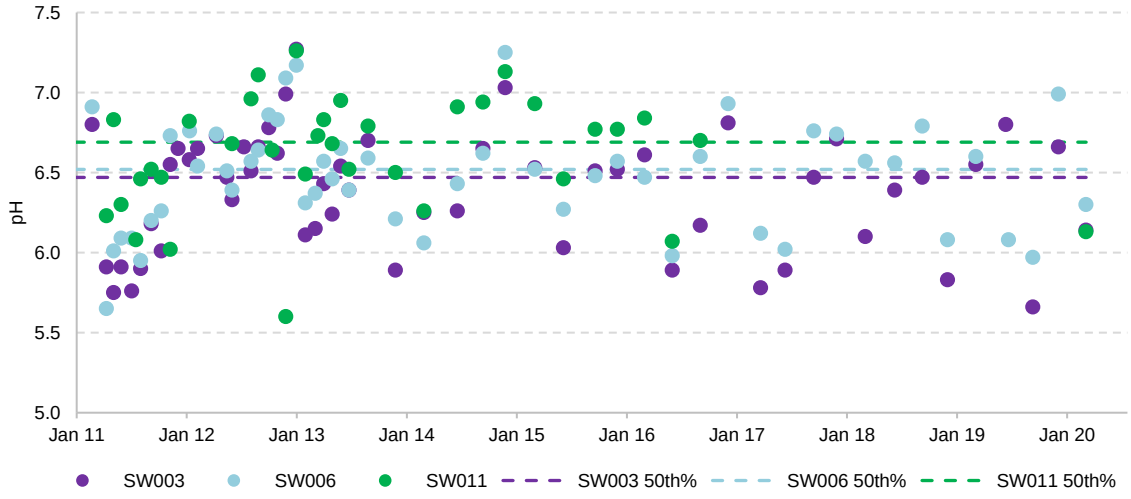

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

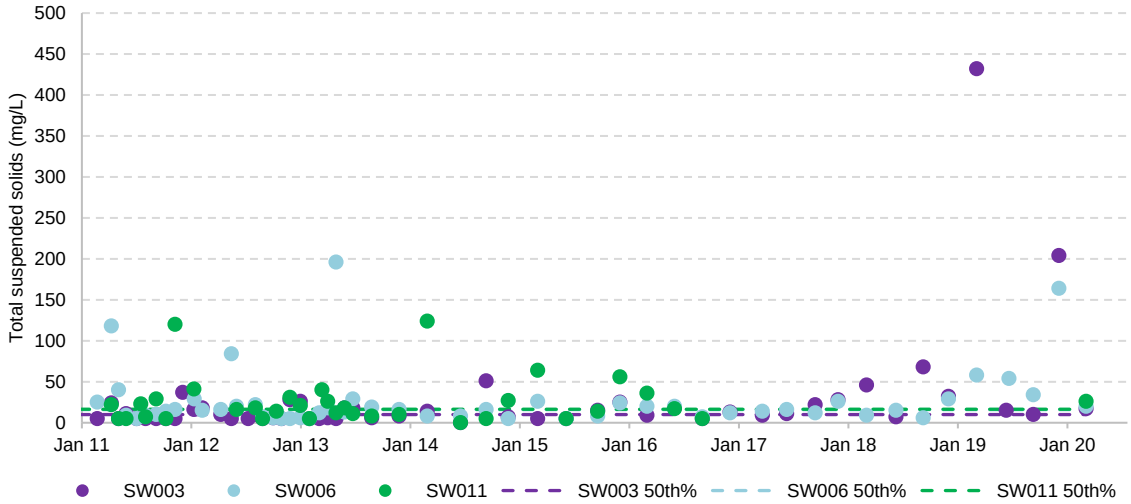

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

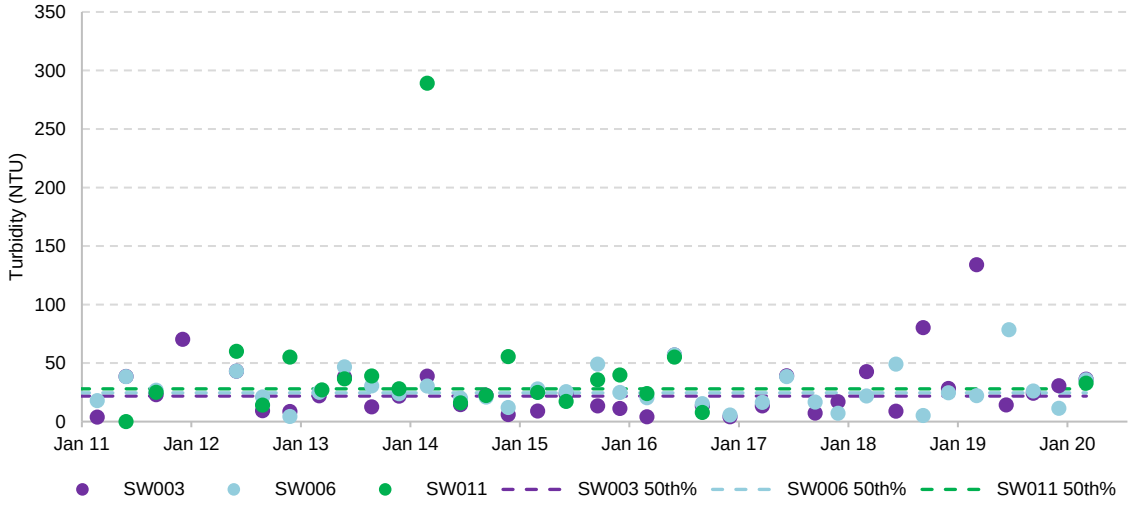

0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SWMP06
SWMP07
SWMP06 50th%
SWMP07 50th%

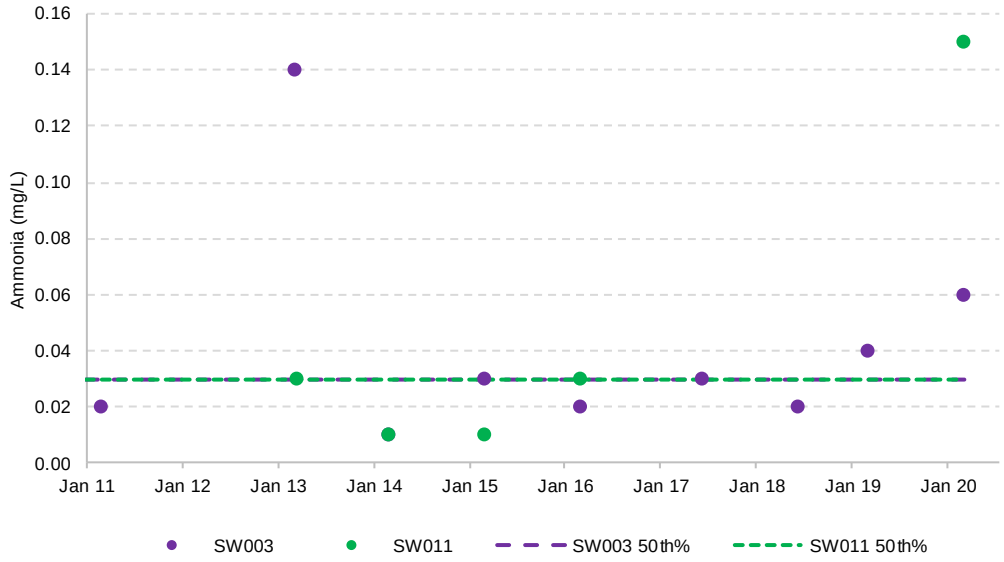
Morans Creek downstream

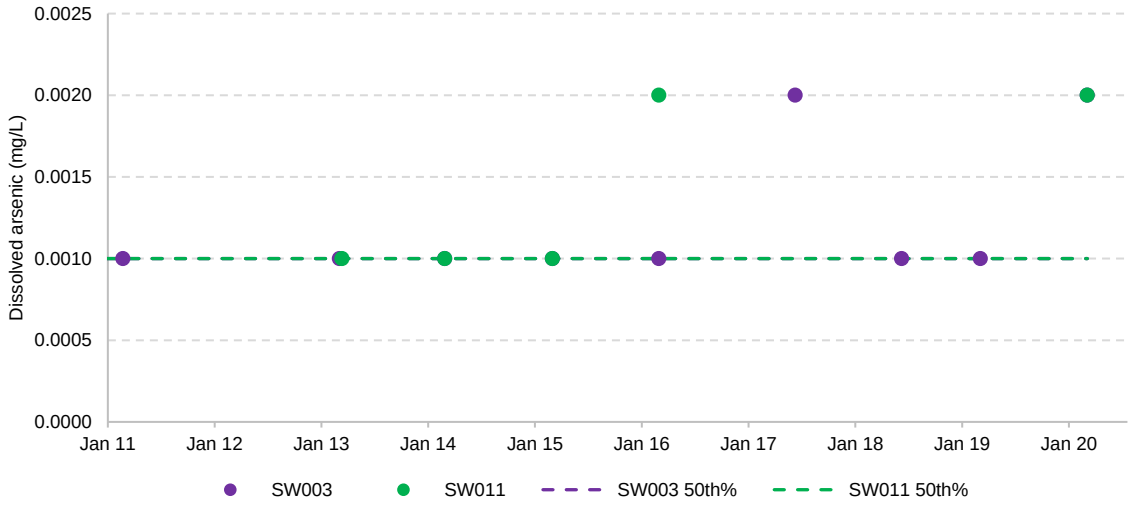


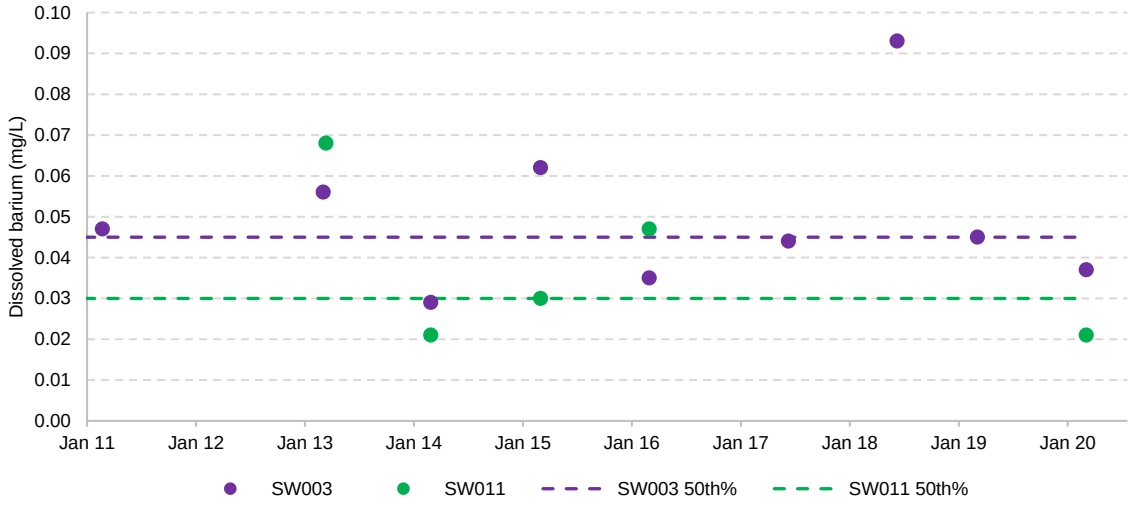


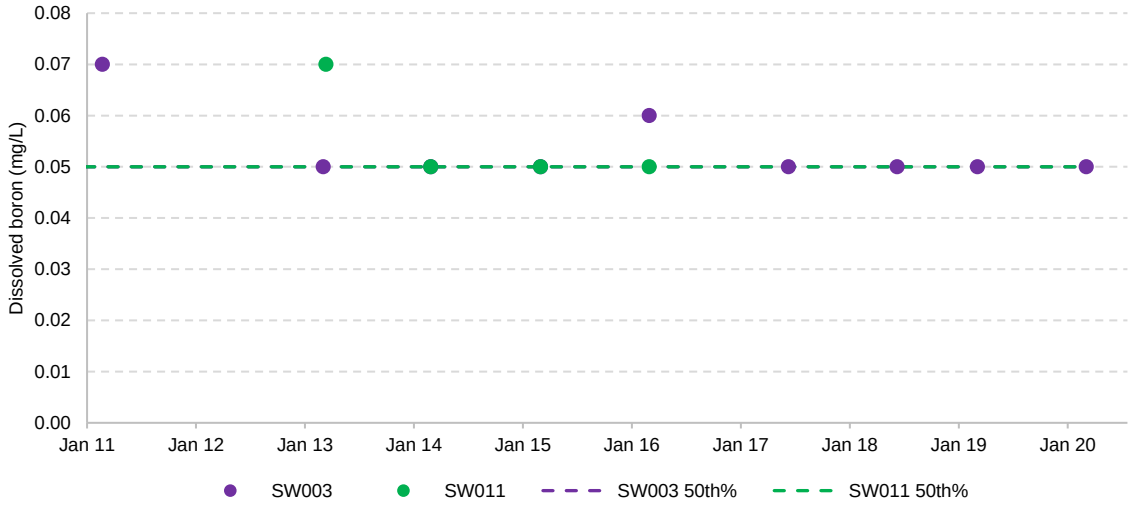


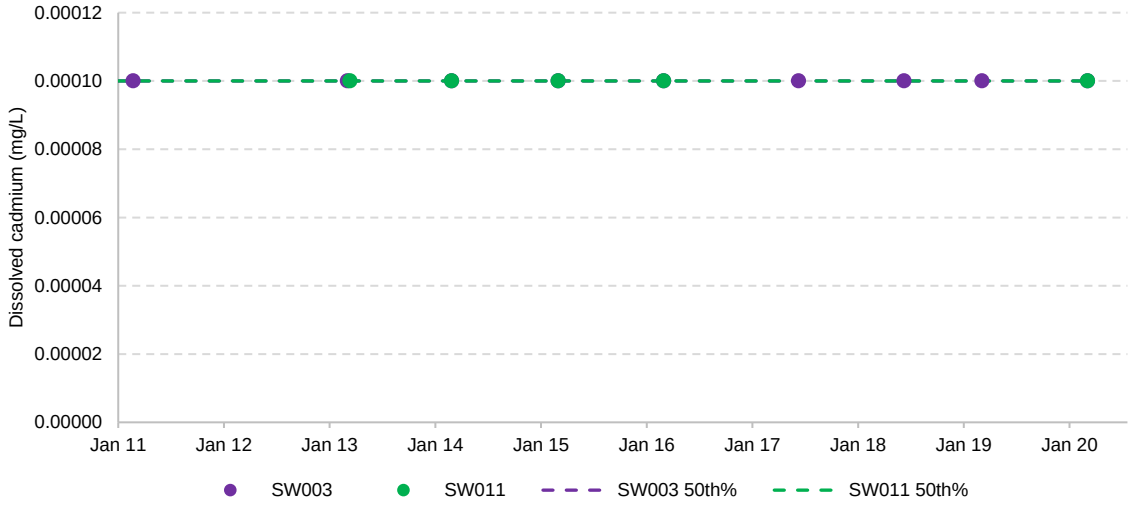

Turbidity (NTU)
350
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW006
SW011
SW003 50th%
SW006 50th%
SW011 50th%

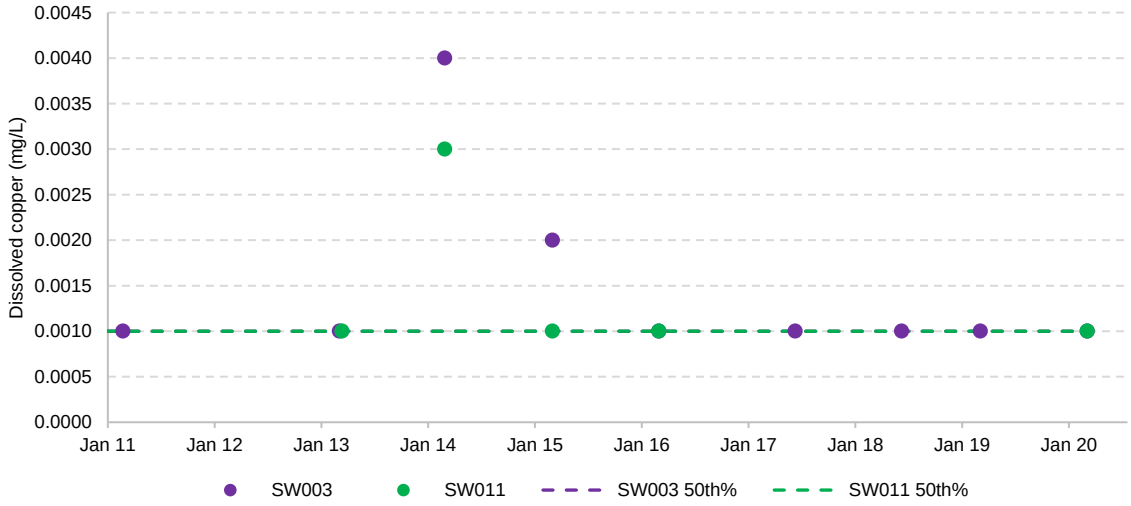

Ammonia (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

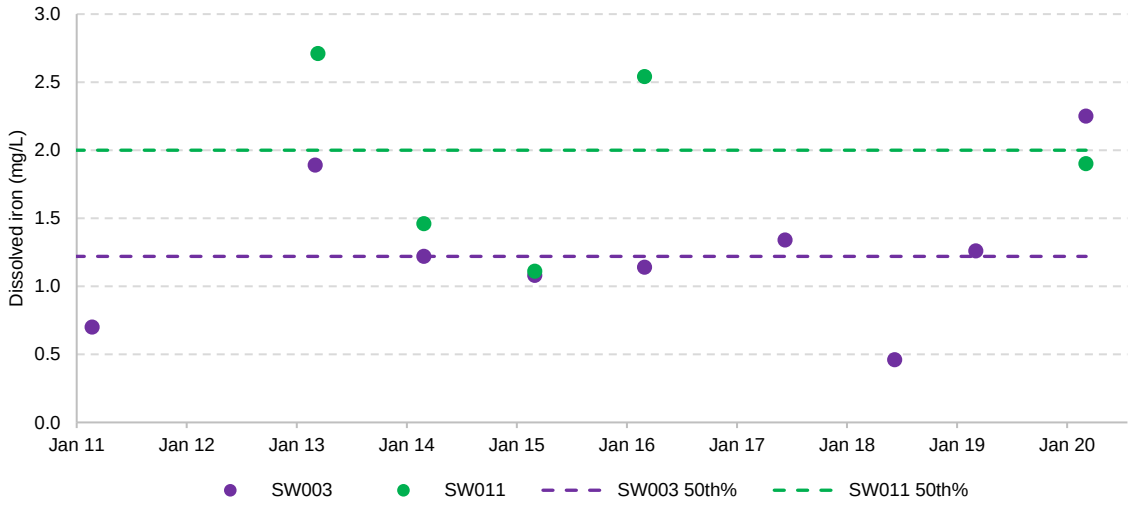

Dissolved arsenic (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

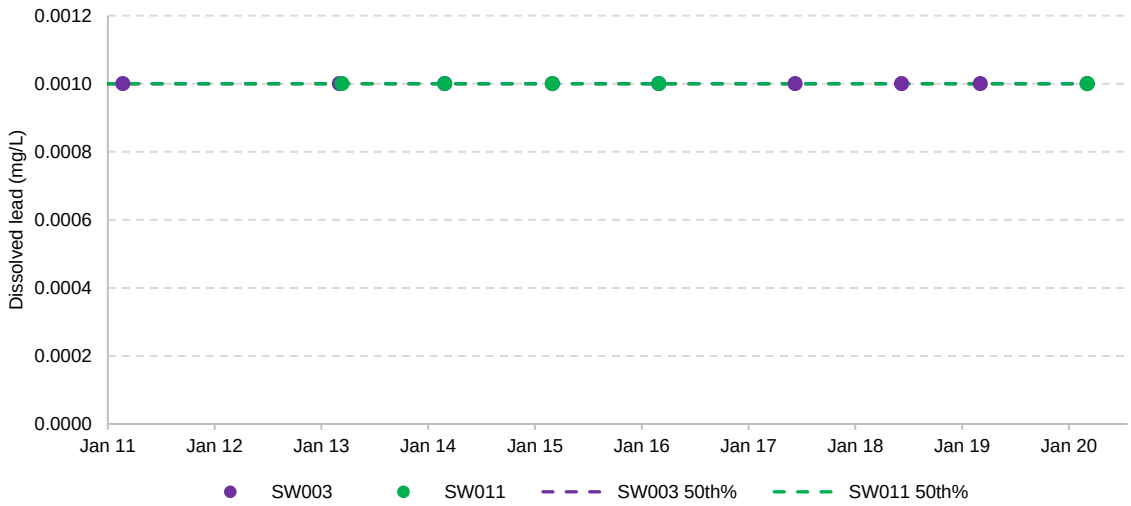

Dissolved barium (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

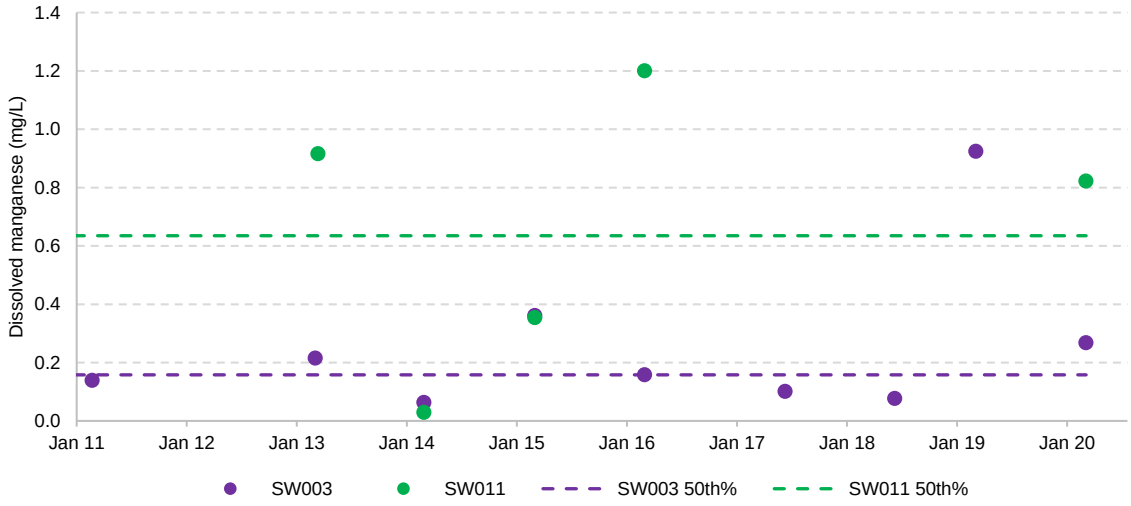

Dissolved boron (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

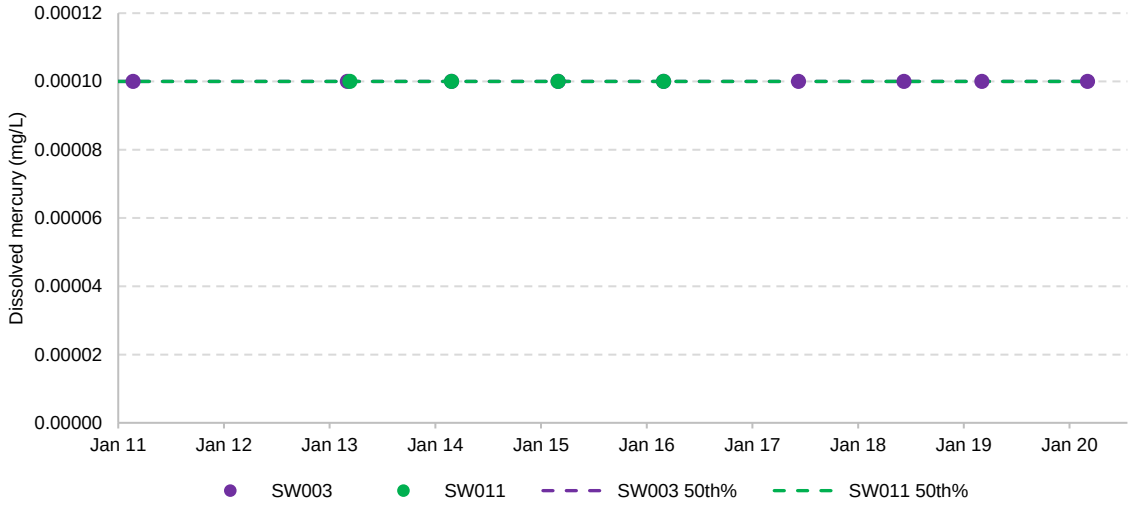

Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

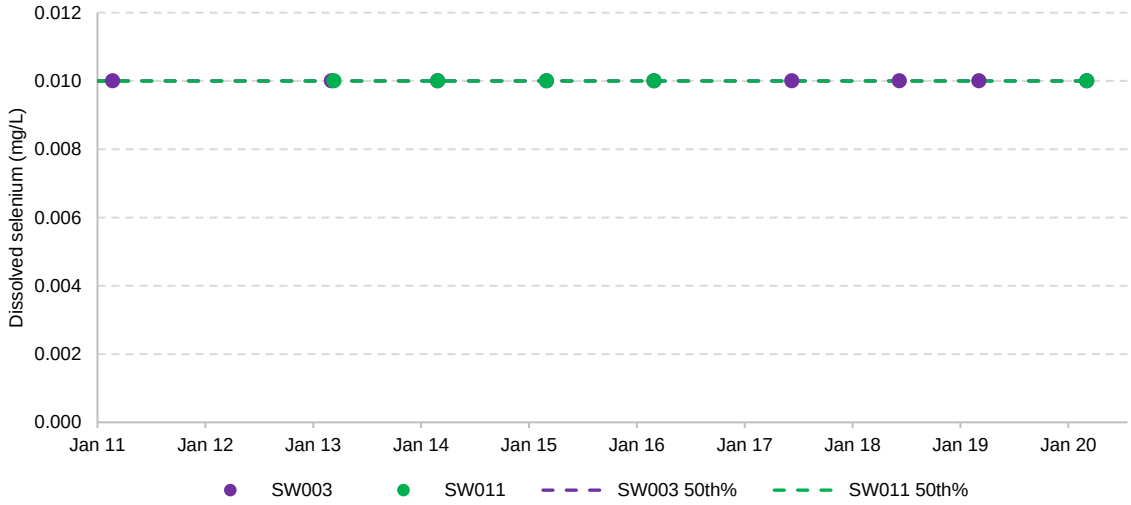

Dissolved copper (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

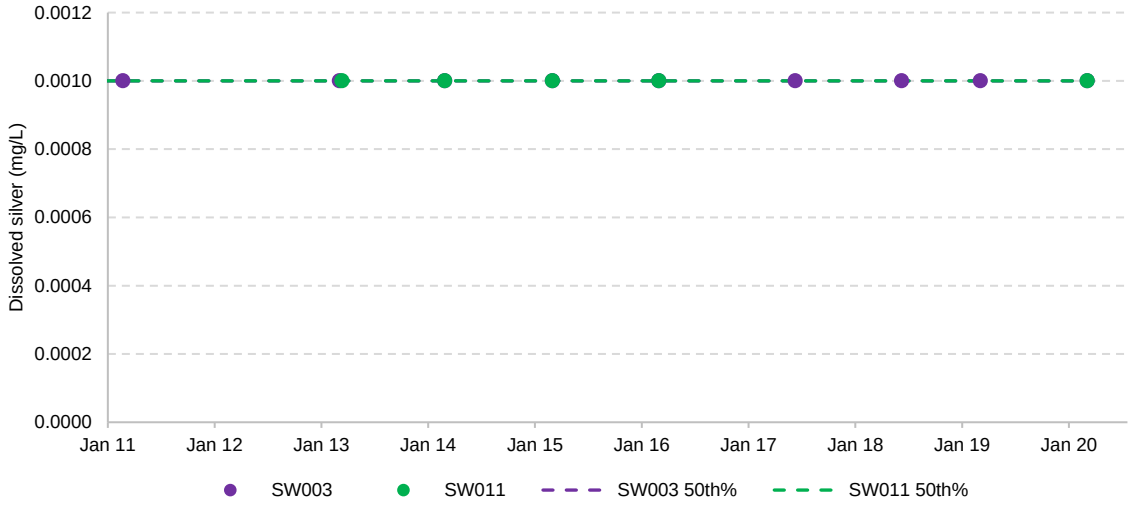

Dissolved iron (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

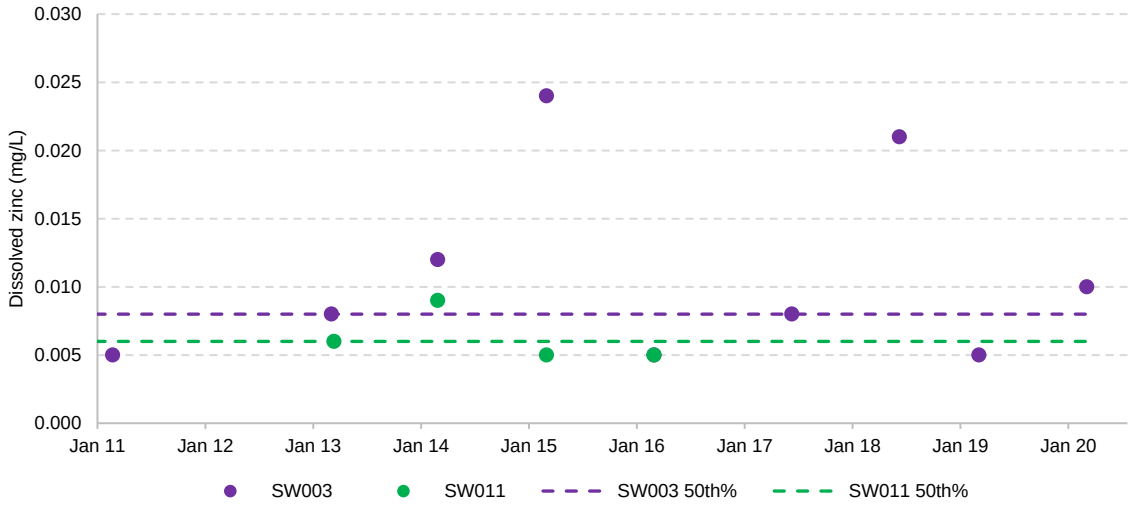

Dissolved lead (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%


Dissolved manganese (mg/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

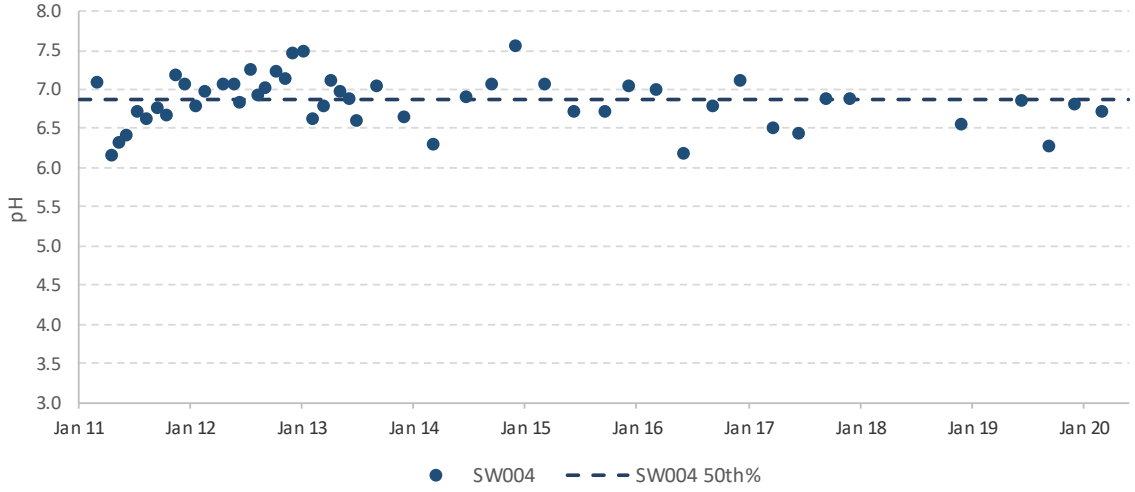

Dissolved mercury (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

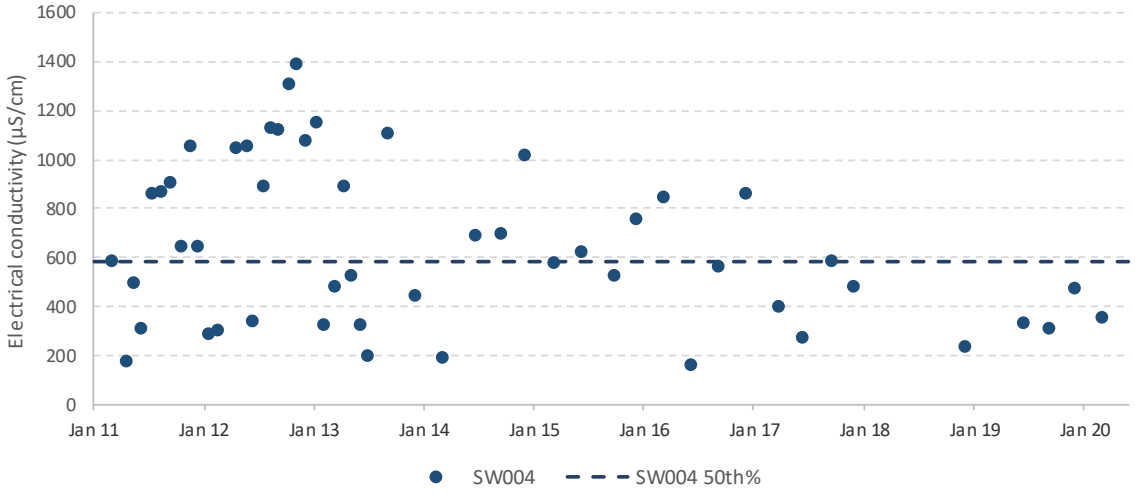

Dissolved selenium (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

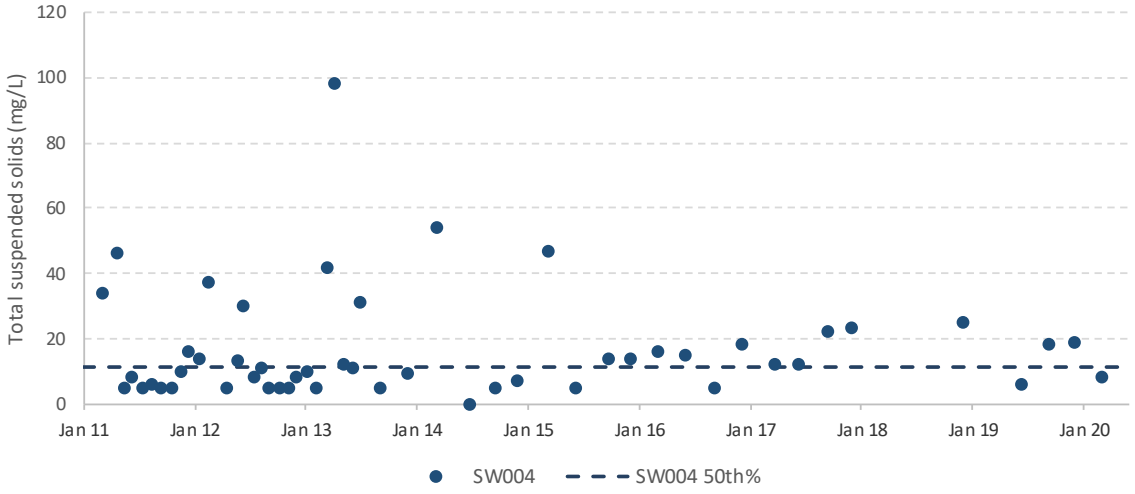

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

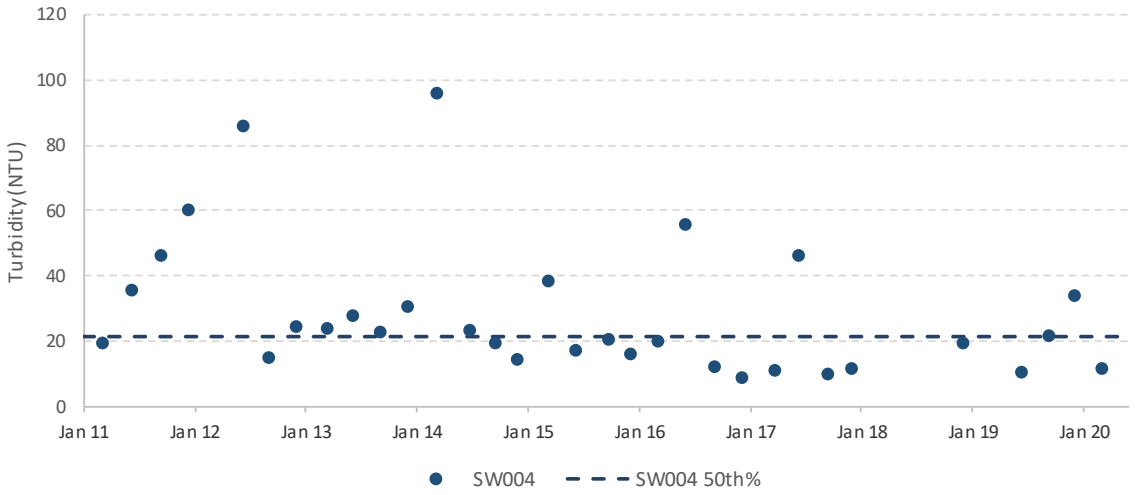

0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW003
SW011
SW003 50th%
SW011 50th%

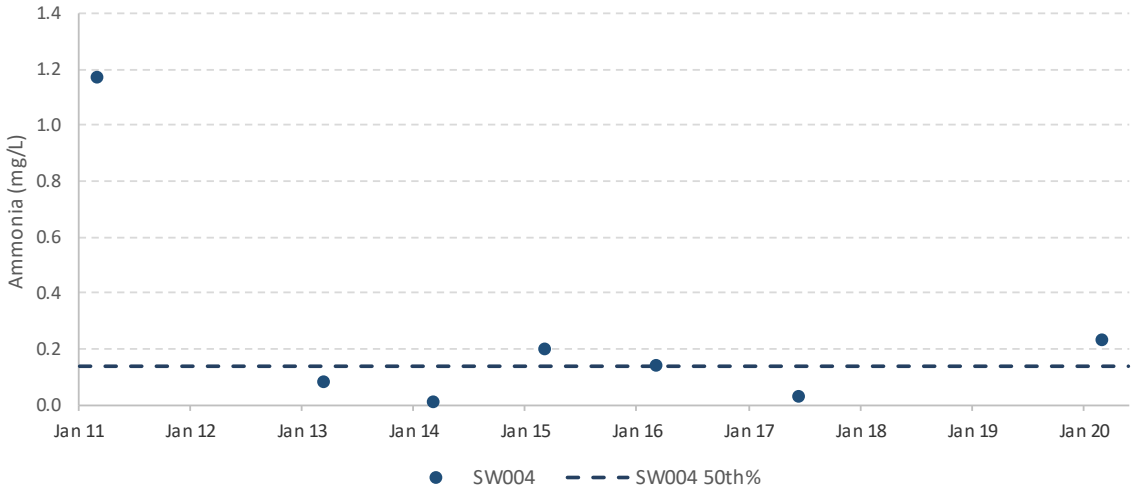
Stockton Creek Upstream

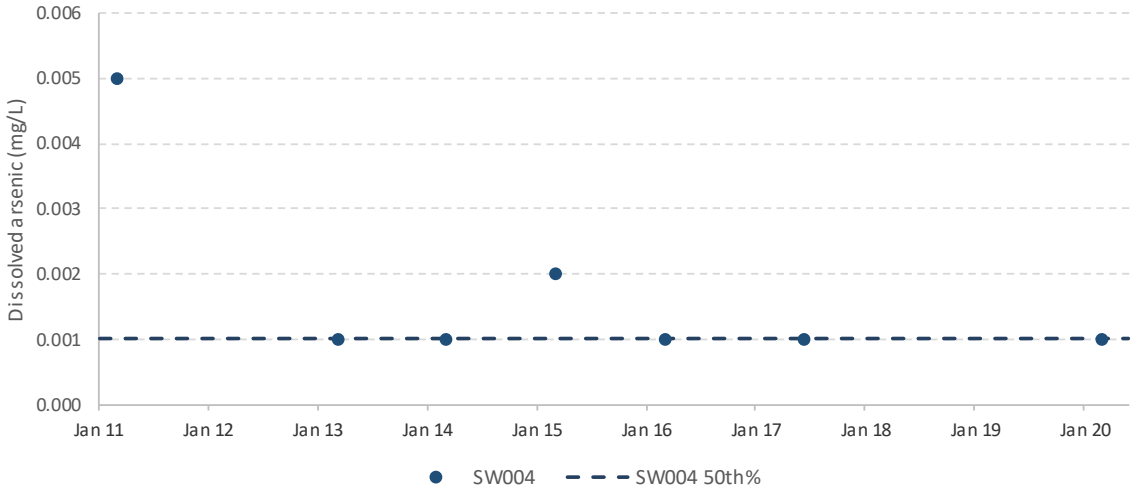


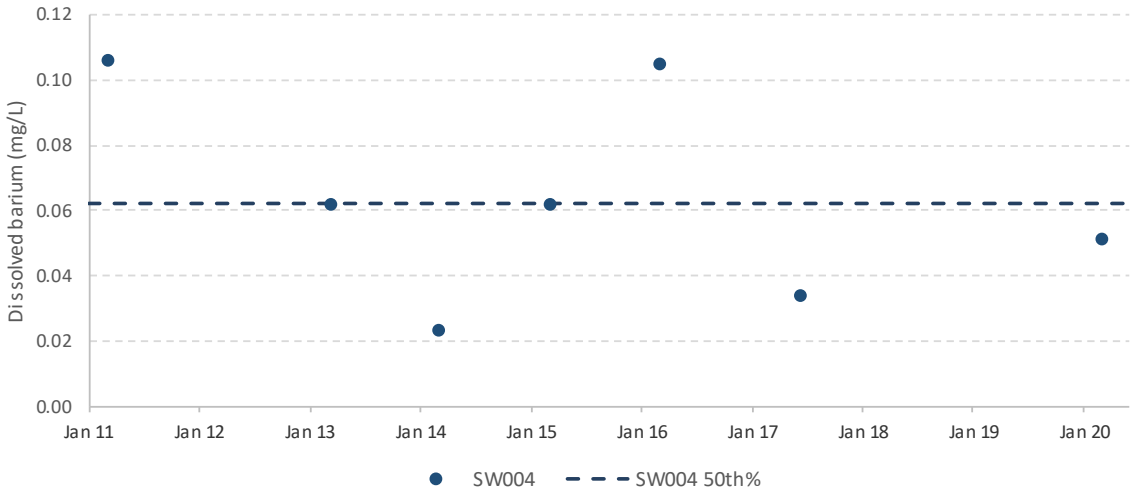


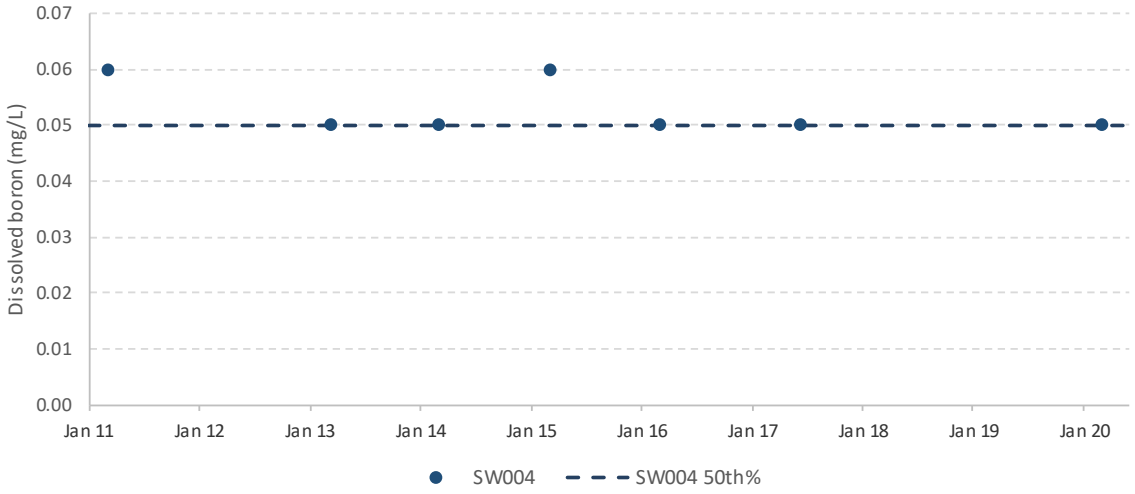


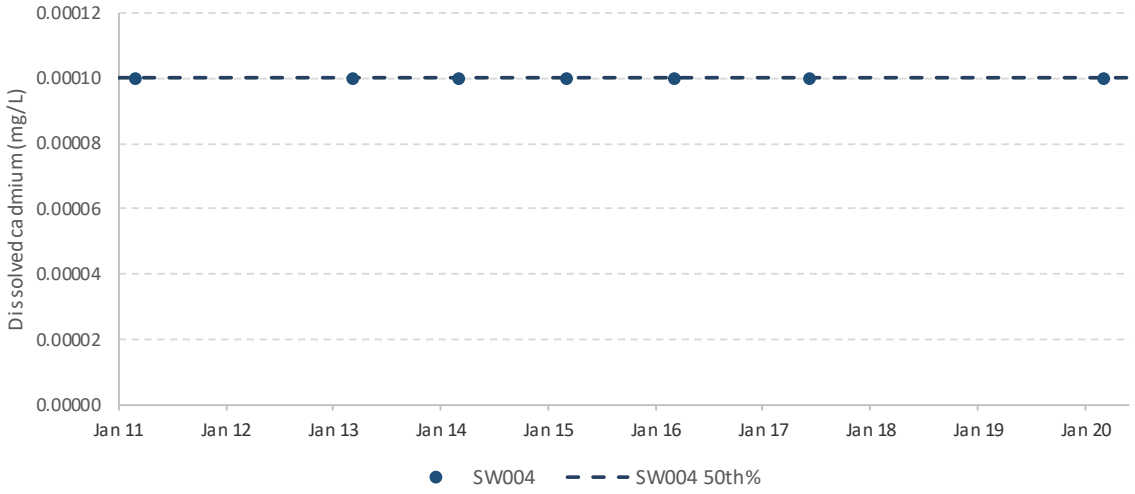

120
100
80
60
40
20
0
Turbidity (NTU)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

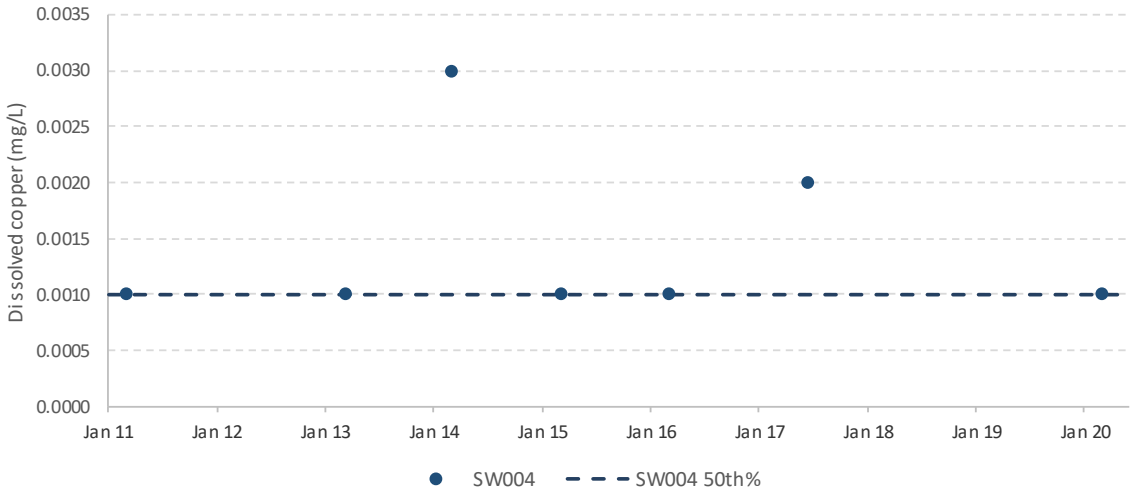

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Ammonia (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

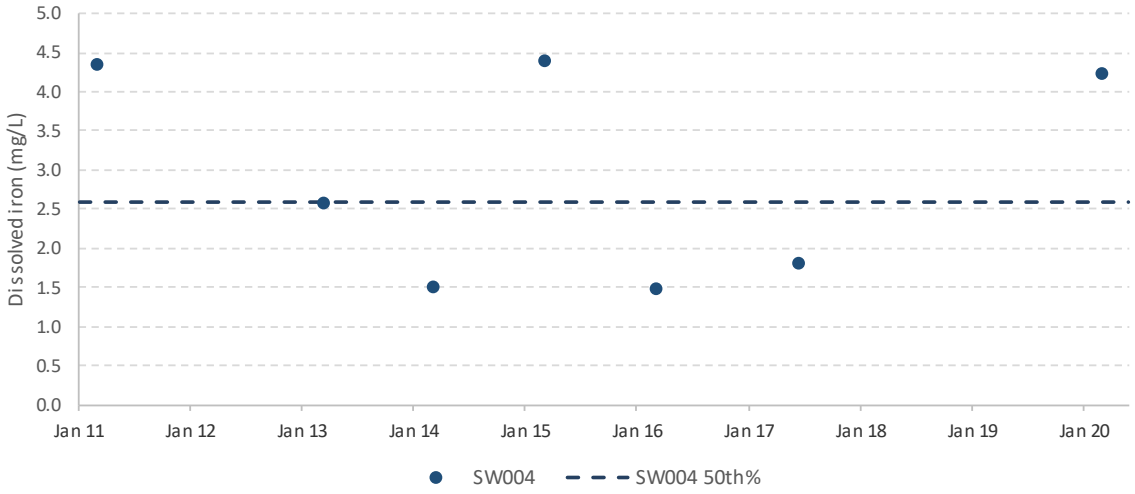

0.006
0.005
0.004
0.003
0.002
0.001
0.000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

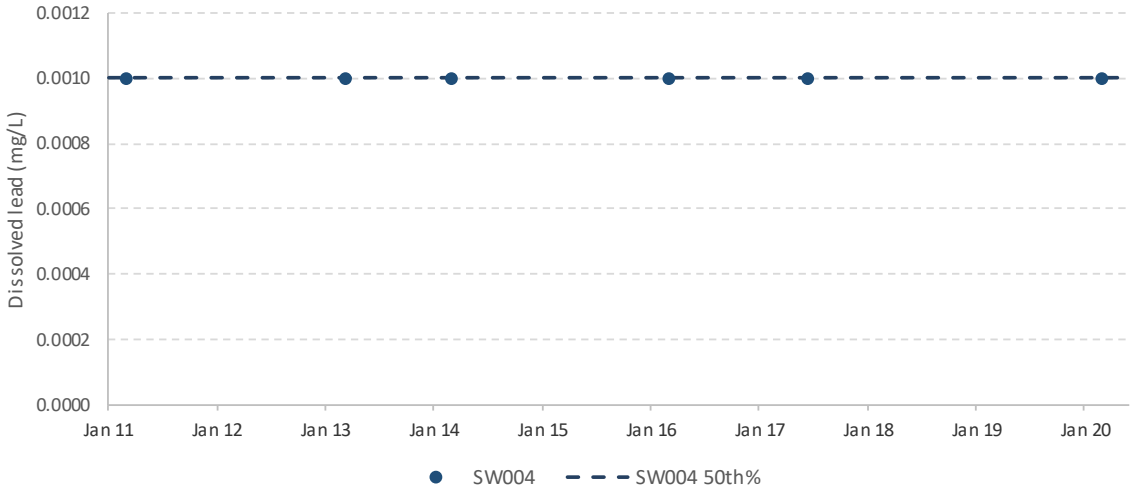

0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

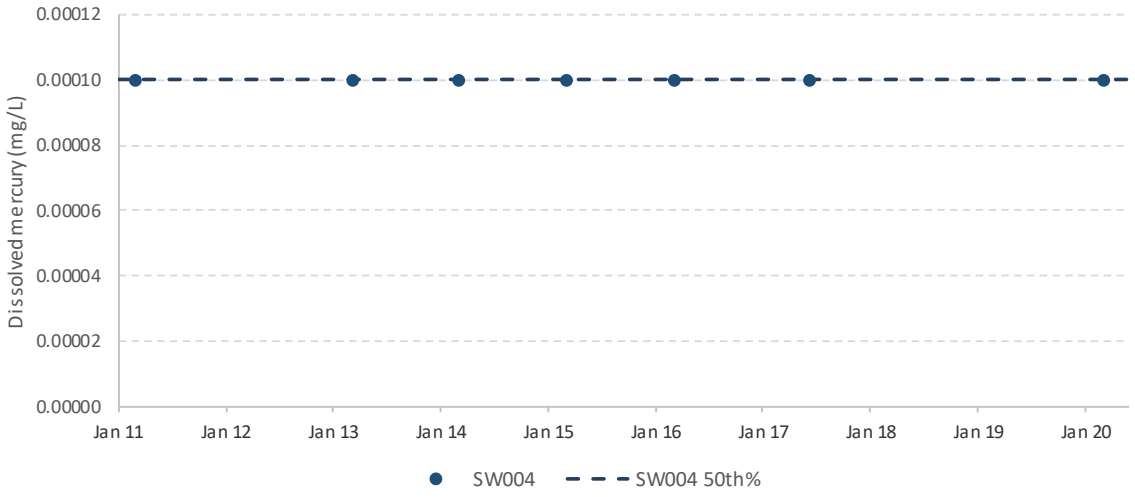

0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved boron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

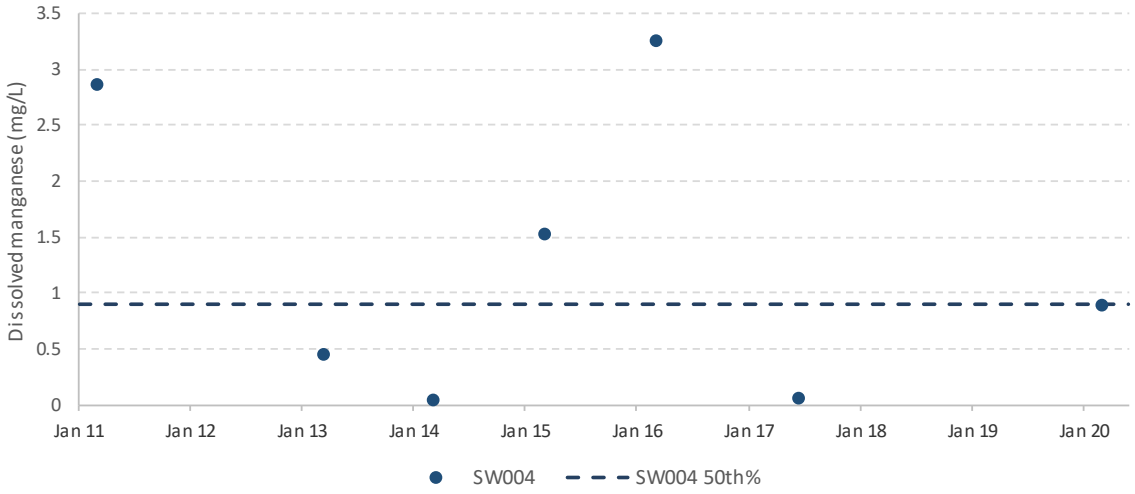

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved cadmium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

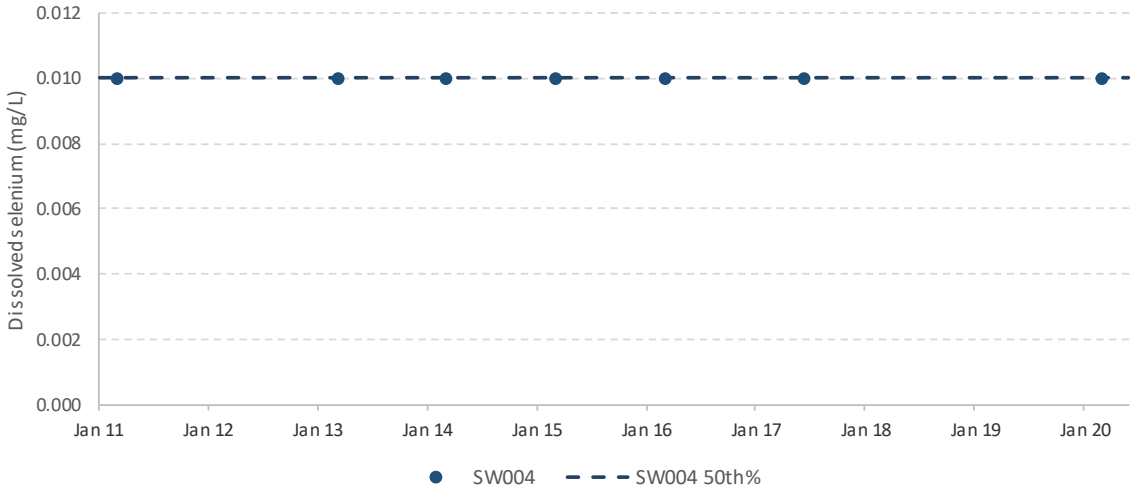

0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

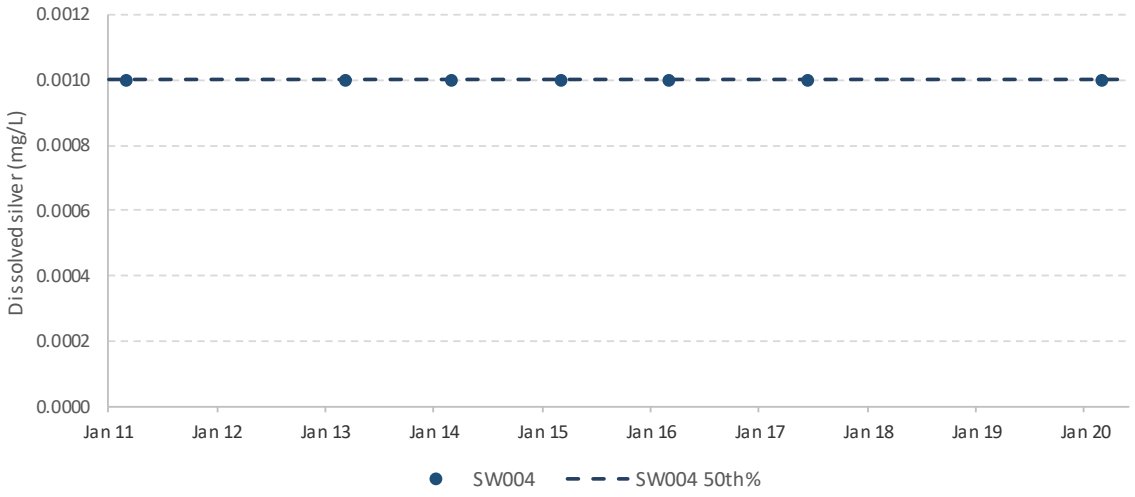

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dissolved iron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

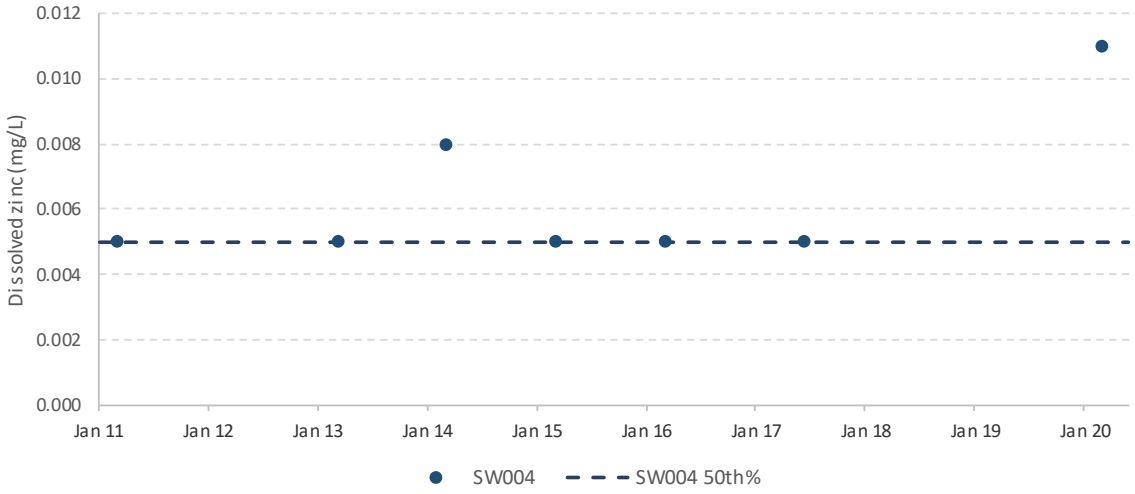

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved lead (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

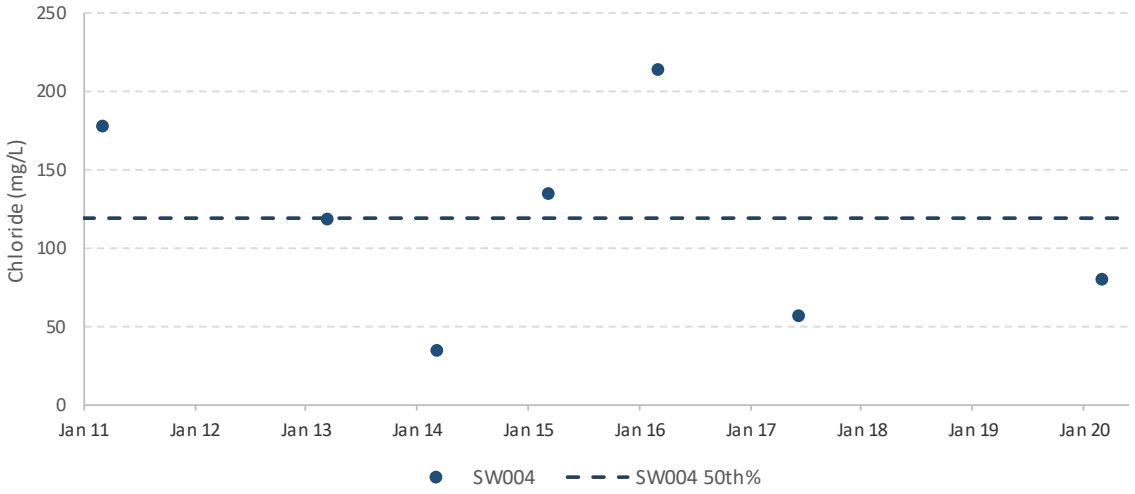

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

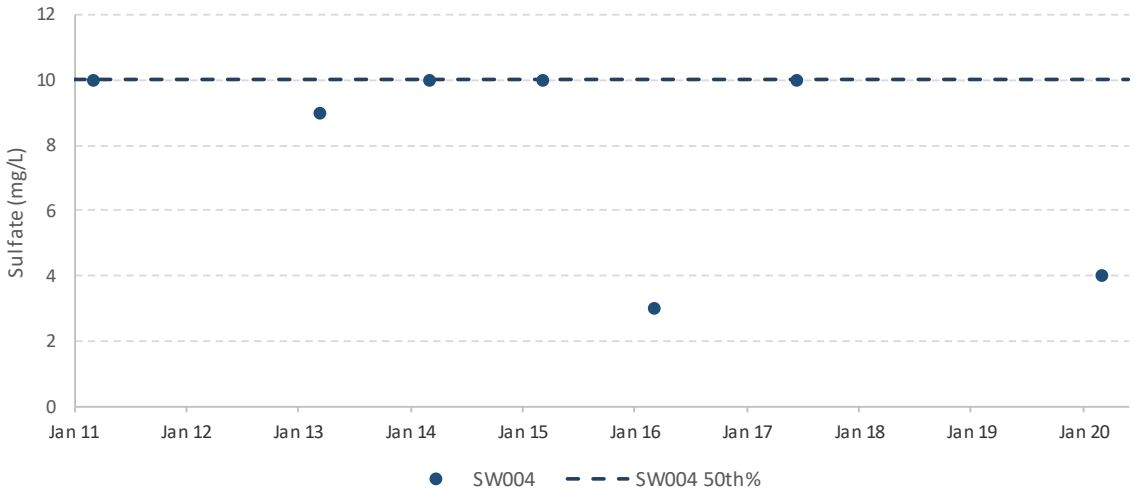

3.5
3
2.5
2
1.5
1
0.5
0
Dissolved manganese (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

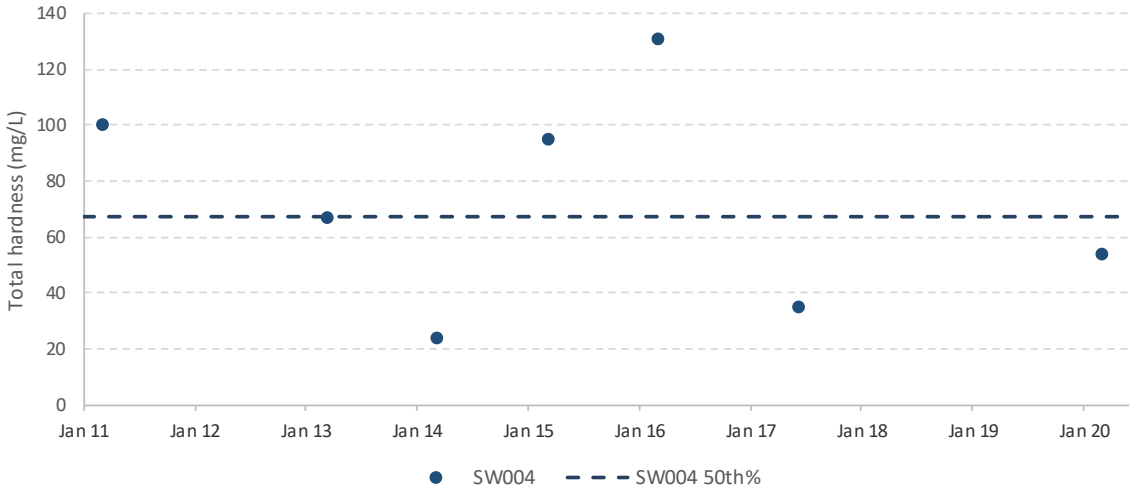

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

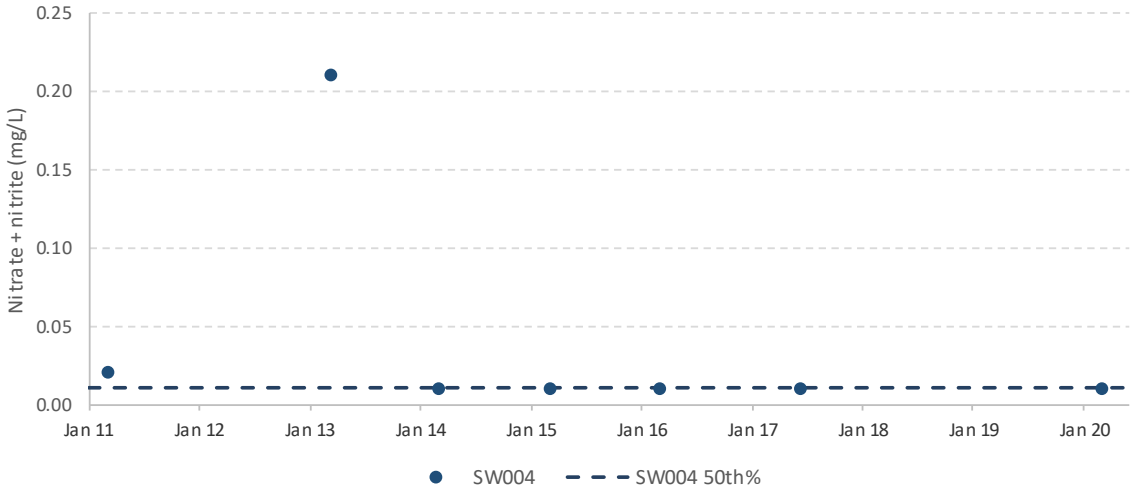

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

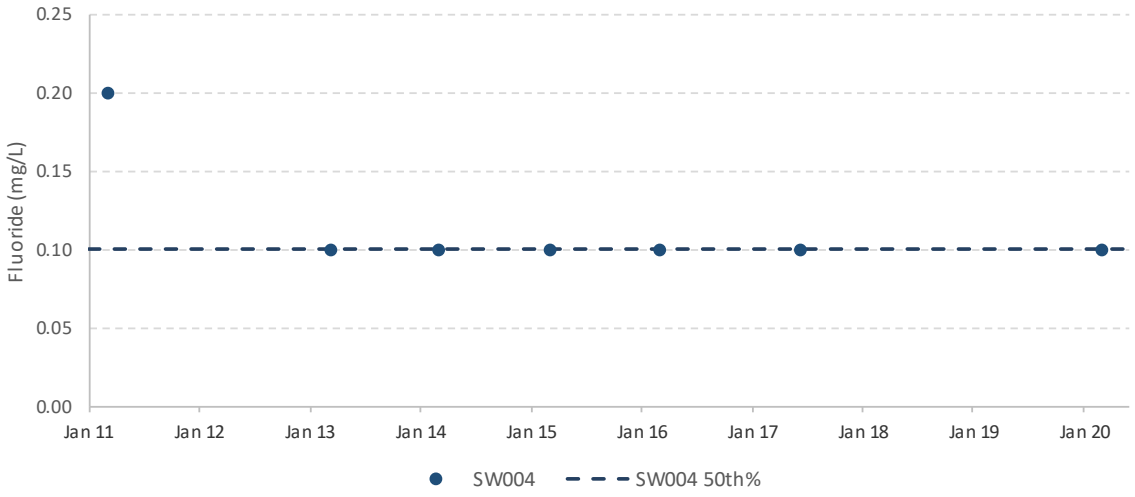

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%


250
200
150
100
50
0
Chloride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%


12
10
8
6
4
2
0
Sulfate (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%


140
120
100
80
60
40
20
0
Total hardness (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%


0.25
0.20
0.15
0.10
0.05
0.00
Nitrate + nitrite (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%


0.25
0.20
0.15
0.10
0.05
0.00
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
Jan 20
SW004
SW004 50th%

C.2 Groundwater

Baseline groundwater level data

Bore	Groundwater level (m AHD)					
	Count [3]	Minimum	20th percentile	Median	80th percentile	Maximum
MSGW03A	28 [1]	–	31.50	32.53	34.06	36.05
MSGW03B	71	28.63	29.50	29.82	30.14	30.50
MSGW03C	72	-3.72 [2]	21.43	23.78	24.76	25.17
MSGW04A	77	23.192	23.622	23.952	24.124	25.007
MSGW04B	75	-0.50	9.86	17.70	20.96	21.94
MSGW04C	63	-71.53 [2]	-9.55	7.22	18.24	21.79

1. Bore regularly dry due to natural variation in rainfall.
2. Attributable to purging of bore for sampling.
3. Manual readings.

MSGW03A – Baseline groundwater quality

Parameter	Units	20th percentile	Median	80th percentile	Maximum
Physicochemical parameters					
pH	pH units	5.64	5.81	6.01	6.35
EC	µS/cm	3100	3730	4905	6370
Dissolved metals					
Aluminium	mg/L	0.13	0.21	0.35	0.54
Arsenic	mg/L	0.004	0.006	0.01	0.018
Cadmium	mg/L	0.0001	0.0001	0.0001	0.0002
Chromium (III + IV)	mg/L	0.0026	0.004	0.007	0.008
Cobalt	mg/L	0.011	0.017	0.022	0.033
Copper	mg/L	0.001	0.001	0.0034	0.007
Iron	mg/L	2.92	6.30	8.84	19.1
Lead	mg/L	0.001	0.001	0.001	0.007
Manganese	mg/L	0.020	0.030	0.045	0.087
Mercury	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Nickel	mg/L	0.018	0.022	0.029	0.04
Selenium	mg/L	0.01[1]	0.01[1]	0.01[1]	0.01[1]
Zinc	mg/L	0.009	0.015	0.026	0.034

1. All values less than limit of reporting (LOR).

MSGW03B – Baseline groundwater quality

Parameter	Units	20th percentile	Median	80th percentile	Maximum
Physicochemical parameters					
pH	pH units	7.08	7.27	7.50	8
EC	µS/cm	5930	6420	6706	7250
Dissolved metals					
Aluminium	mg/L	0.01	0.01	0.03	0.3
Arsenic	mg/L	0.0036	0.01	0.0164	0.04
Cadmium	mg/L	0.0001	0.0001	0.0001	0.001
Chromium (III + IV)	mg/L	0.001[1]	0.001	0.002	0.005
Cobalt	mg/L	0.001	0.001	0.001	0.007
Copper	mg/L	0.001	0.001	0.0014	0.006
Iron	mg/L	0.11	0.33	0.71	2.06
Lead	mg/L	0.001	0.001[1]	0.001	0.014
Manganese	mg/L	0.058	0.088	0.136	0.401
Mercury	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Nickel	mg/L	0.005	0.059	0.095	0.202
Selenium	mg/L	0.01	0.011	0.01	0.01
Zinc	mg/L	0.005	0.0055	0.011	0.636

1. All values less than LOR.

MSGW03C – Baseline groundwater quality

Parameter	Units	20th percentile	Median	80th percentile	Maximum
Physicochemical parameters					
pH	pH units	7.03	7.22	9.12	12.01
EC	µS/cm	5872	6430	7422	8570
Dissolved metals					
Aluminium	mg/L	0.04	0.1	0.53	0.87
Arsenic	mg/L	0.002	0.003	0.009	0.01
Cadmium	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Chromium (III + IV)	mg/L	0.001	0.001	0.003	0.005
Cobalt	mg/L	0.001	0.001	0.001	0.002
Copper	mg/L	0.001	0.001	0.001	0.002
Iron	mg/L	0.06	0.23	0.67	0.96
Lead	mg/L	0.001	0.001	0.001	0.002
Manganese	mg/L	0.038	0.519	0.632	0.699
Mercury	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Nickel	mg/L	0.002	0.002	0.003	0.005
Selenium	mg/L	0.01[1]	0.01[1]	0.01[1]	0.01[1]
Zinc	mg/L	0.005	0.016	0.027	0.061

1. All values less than LOR.

MSGW04A – Baseline groundwater quality

Parameter	Units	20th percentile	Median	80th percentile	Maximum
Physicochemical parameters					
pH	pH units	6.29	6.39	6.51	7.19
EC	µS/cm	8580	9288	9677	20,114
Dissolved metals					
Aluminium	mg/L	0.01	0.01	0.02	0.27
Arsenic	mg/L	0.001	0.001	0.001	0.003
Cadmium	mg/L	0.0001	0.0001	0.0001	0.0002
Chromium (III + IV)	mg/L	0.001	0.001	0.001	0.054
Cobalt	mg/L	0.001	0.001	0.001	0.002
Copper	mg/L	0.001	0.001	0.001	0.003
Iron	mg/L	2.26	2.4	2.67	5.94
Lead	mg/L	0.001	0.001	0.001	0.004
Manganese	mg/L	0.455	0.494	0.535	0.7
Mercury	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Nickel	mg/L	0.001	0.001	0.001	0.002
Selenium	mg/L	0.01[1]	0.01[1]	0.01[1]	0.01[1]
Zinc	mg/L	0.005	0.005	0.01	0.792

1. All values less than LOR.

MSGW04B – Baseline groundwater quality

Parameter	Units	20th percentile	Median	80th percentile	Maximum
Physicochemical parameters					
pH	pH units	6.68	6.89	7.18	7.93
EC	µS/cm	7270	7910	8310	8970
Dissolved metals					
Aluminium	mg/L	0.01	0.01	0.02	0.27
Arsenic	mg/L	0.001	0.001	0.002	0.008
Cadmium	mg/L	0.0001	0.0001	0.0001	0.0003
Chromium (III + IV)	mg/L	0.001[1]	0.001[1]	0.001[1]	0.001[1]
Cobalt	mg/L	0.001[1]	0.001[1]	0.001[1]	0.001[1]
Copper	mg/L	0.001	0.001	0.001	0.006
Iron	mg/L	0.91	1.38	2.08	2.8
Lead	mg/L	0.001	0.001	0.001	0.002
Manganese	mg/L	0.1824	0.208	0.251	0.311
Mercury	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Nickel	mg/L	0.007	0.036	0.095	0.302
Selenium	mg/L	0.01[1]	0.01[1]	0.01[1]	0.01[1]
Zinc	mg/L	0.005	0.017	0.034	1.61

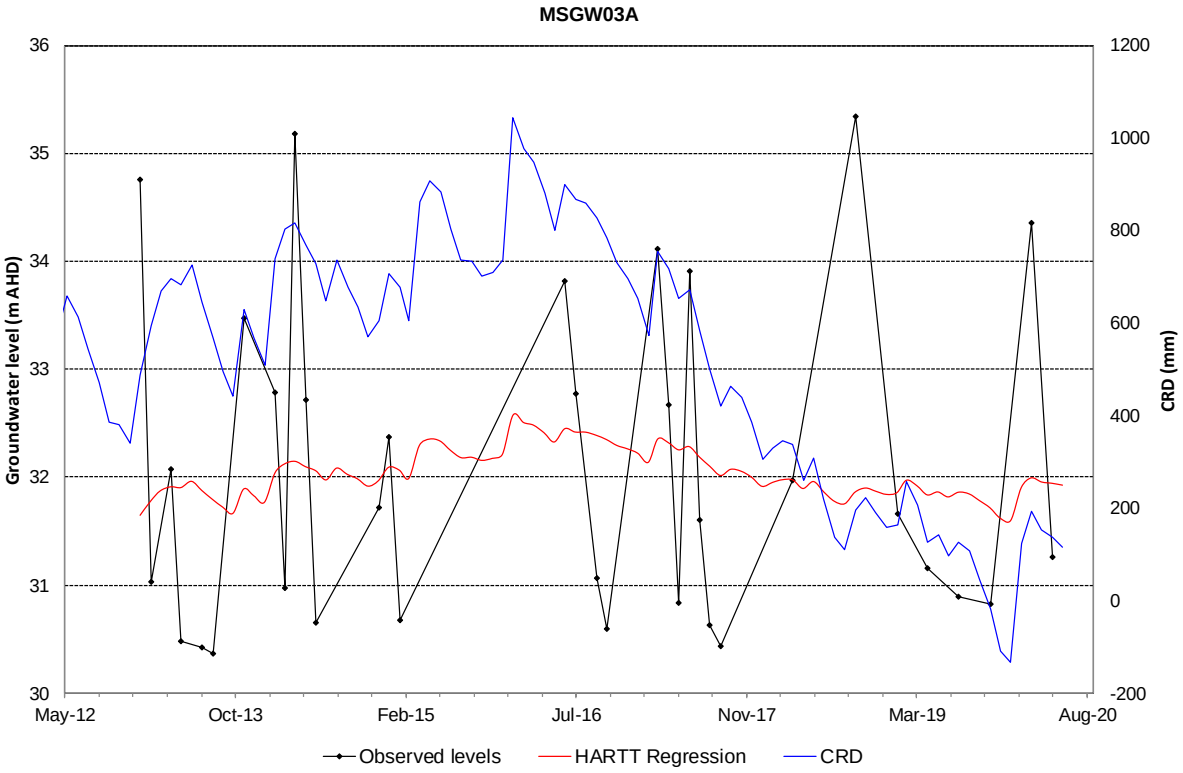
1. All values less than LOR.

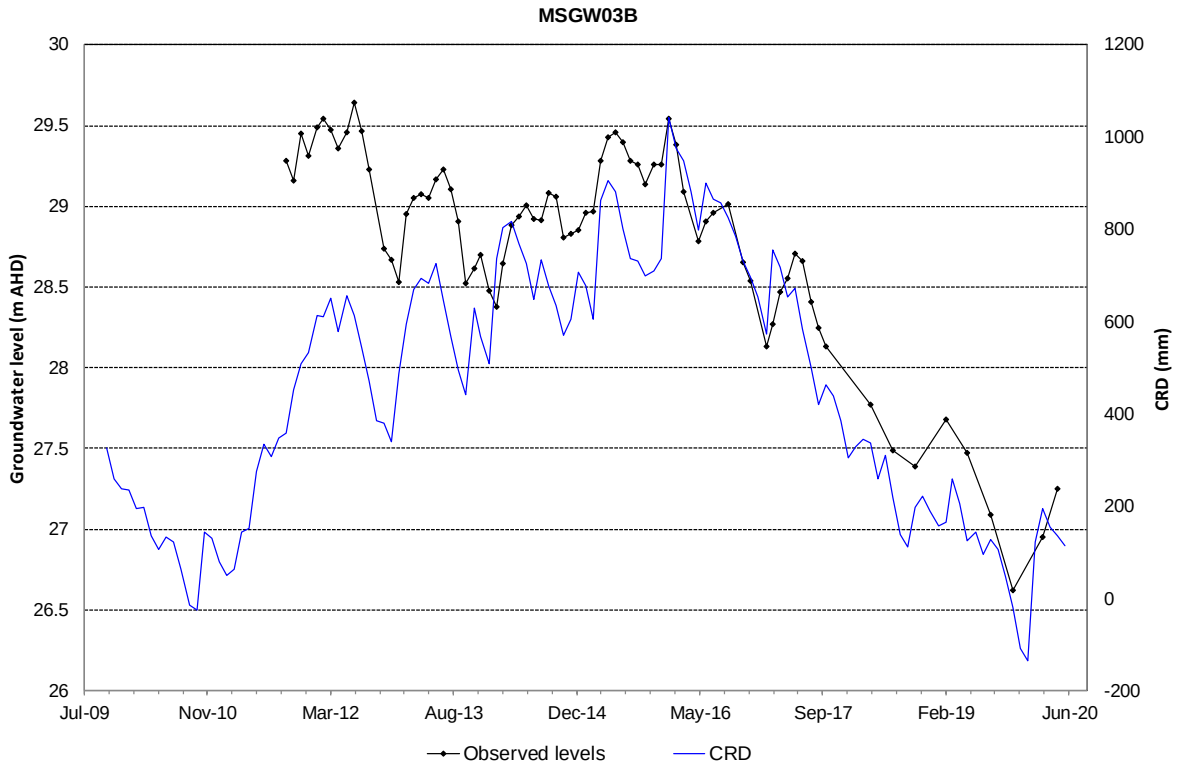
MSGW04C – Baseline groundwater quality

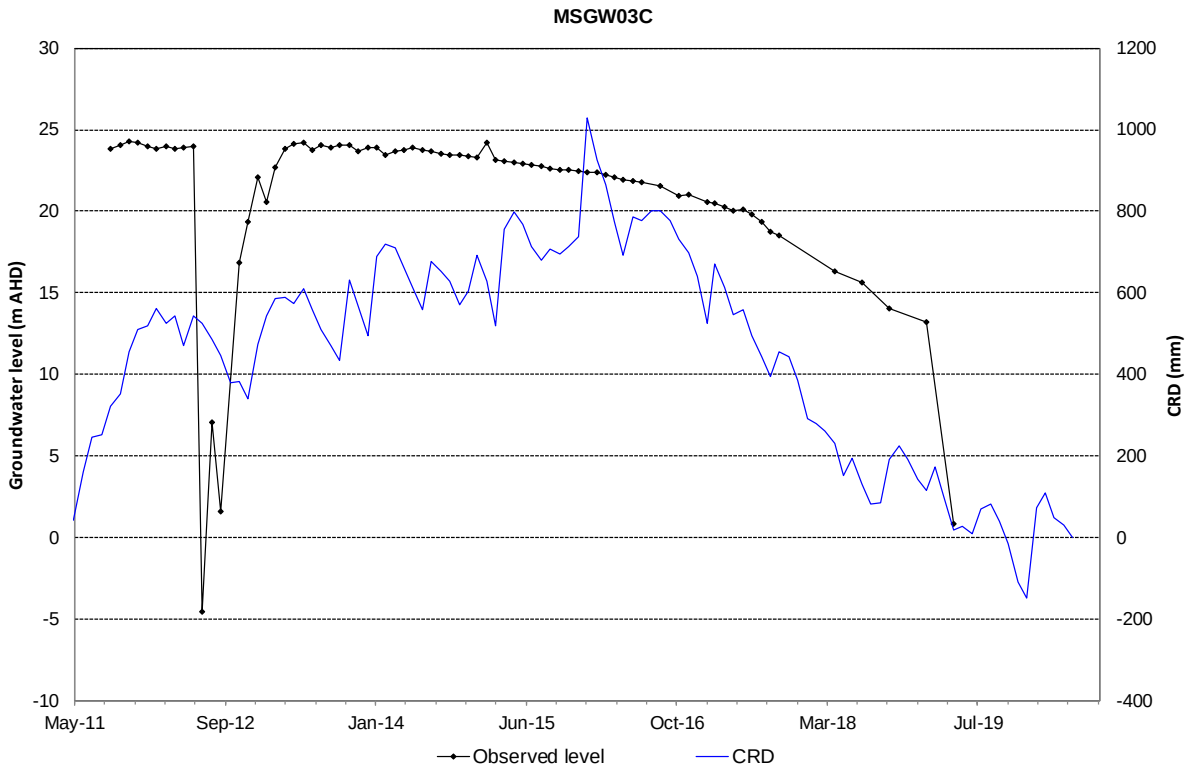
Parameter	Units	20th percentile	Median	80th percentile	Maximum
Physicochemical parameters					
pH	pH units	7.25	8	11.19	12.67
EC	µS/cm	5222	6460	7772	9960
Dissolved metals					
Aluminium	mg/L	0.024	0.1	0.208	0.72
Arsenic	mg/L	0.003	0.005	0.007	0.008
Cadmium	mg/L	0.0001	0.0001	0.0002	0.0006
Chromium (III + IV)	mg/L	0.001	0.002	0.004	0.005
Cobalt	mg/L	0.001	0.001	0.001	0.004
Copper	mg/L	0.001	0.001	0.002	0.004
Iron	mg/L	0.106	0.18	0.368	0.54
Lead	mg/L	0.001	0.001	0.0016	0.003
Manganese	mg/L	0.007	0.063	0.214	0.356
Mercury	mg/L	0.0001[1]	0.0001[1]	0.0001[1]	0.0001[1]
Nickel	mg/L	0.001	0.002	0.004	0.011
Selenium	mg/L	0.01[1]	0.01[1]	0.01[1]	0.01[1]
Zinc	mg/L	0.005	0.005	0.027	0.103

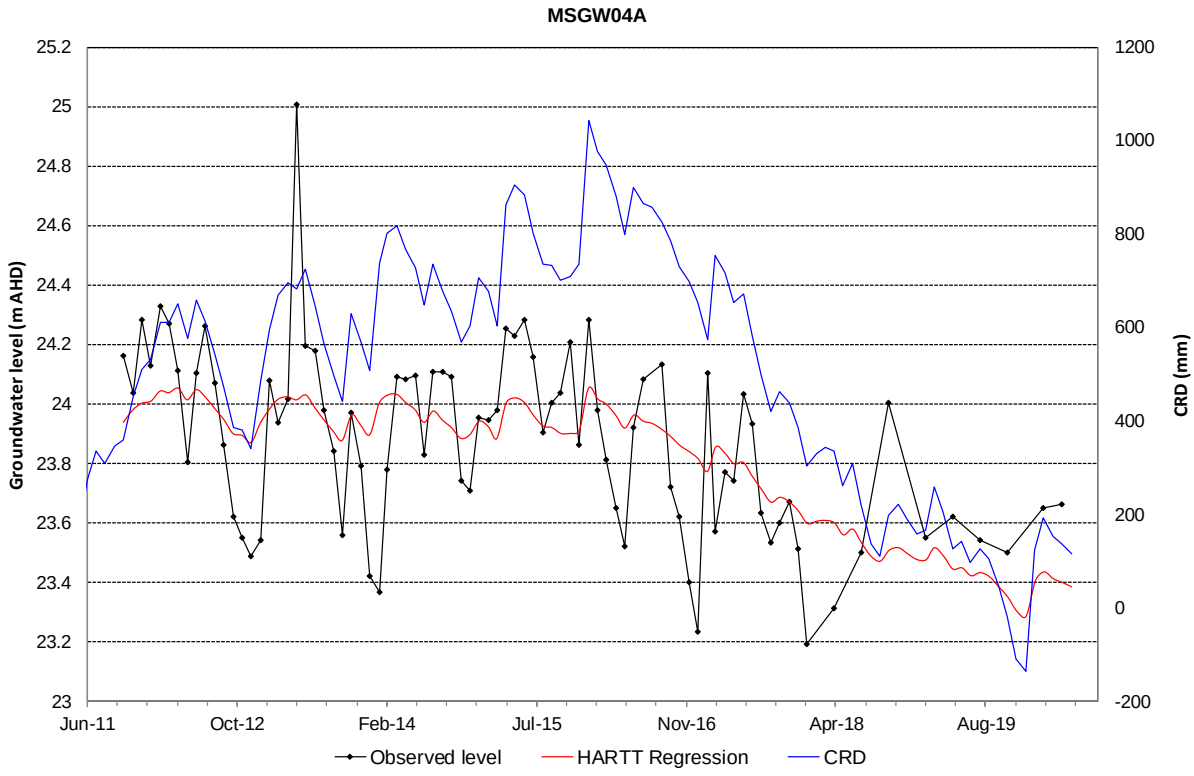
1. All values less than LOR.

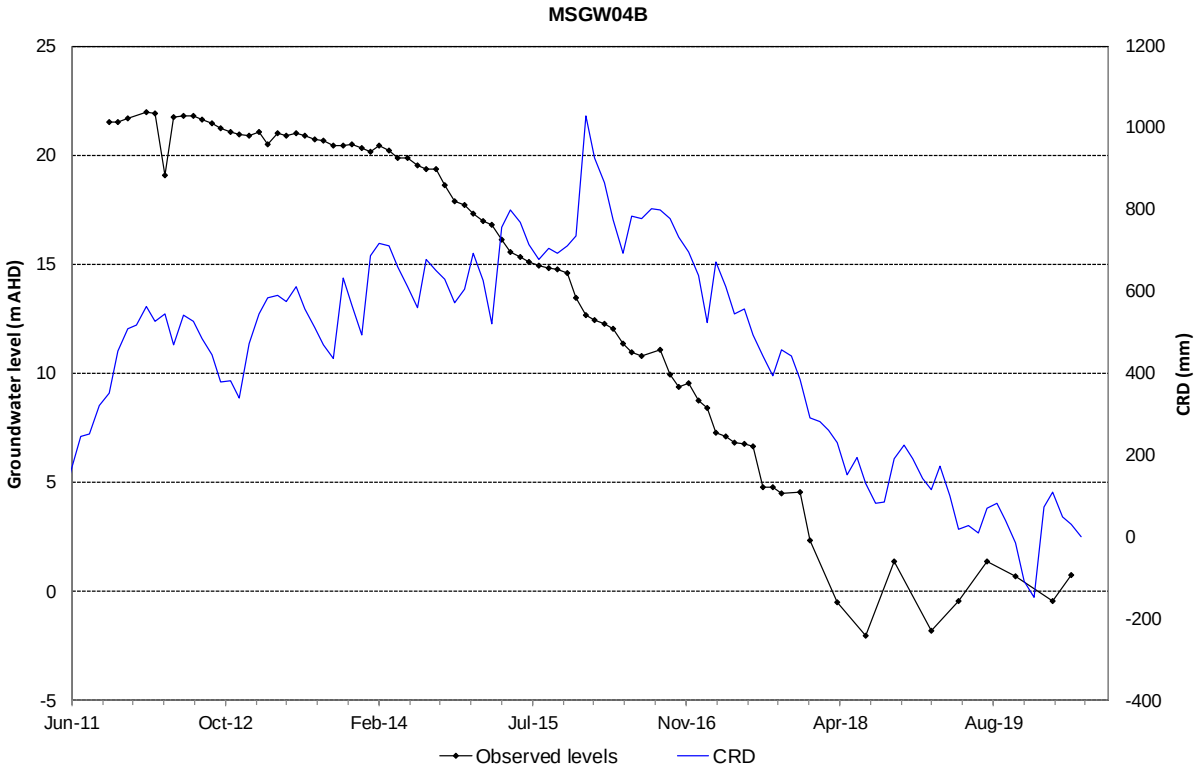
Groundwater level/pressure hydrographs

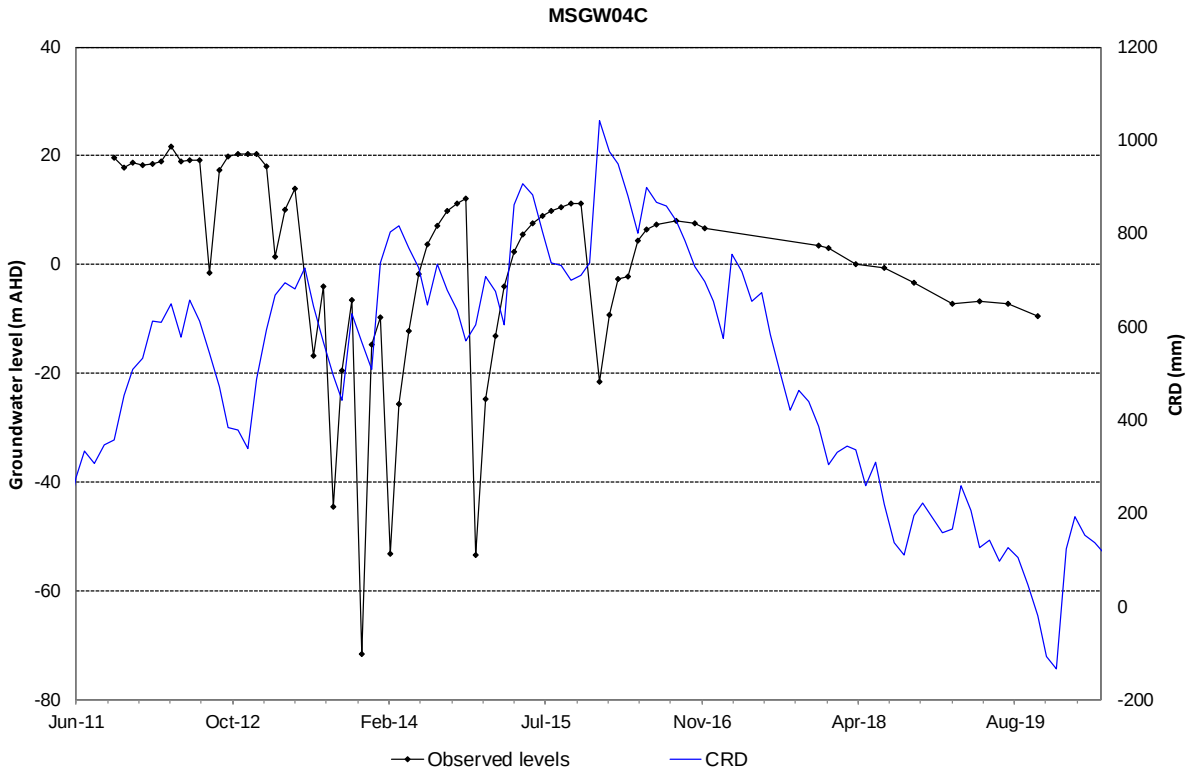




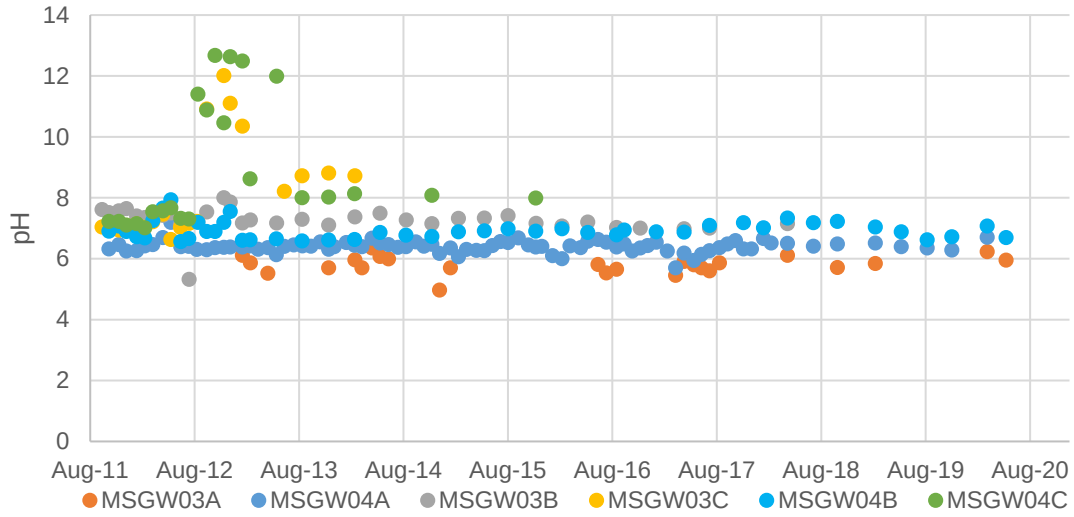

MSGW03C
Groundwater level (m AHD)
CRD (mm)
30
25
20
15
10
5
0
-5
-10
1200
1000
800
600
400
200
0
-200
-400
May-11
Sep-12
Jan-14
Jun-15
Oct-16
Mar-18
Jul-19
Observed level
CRD

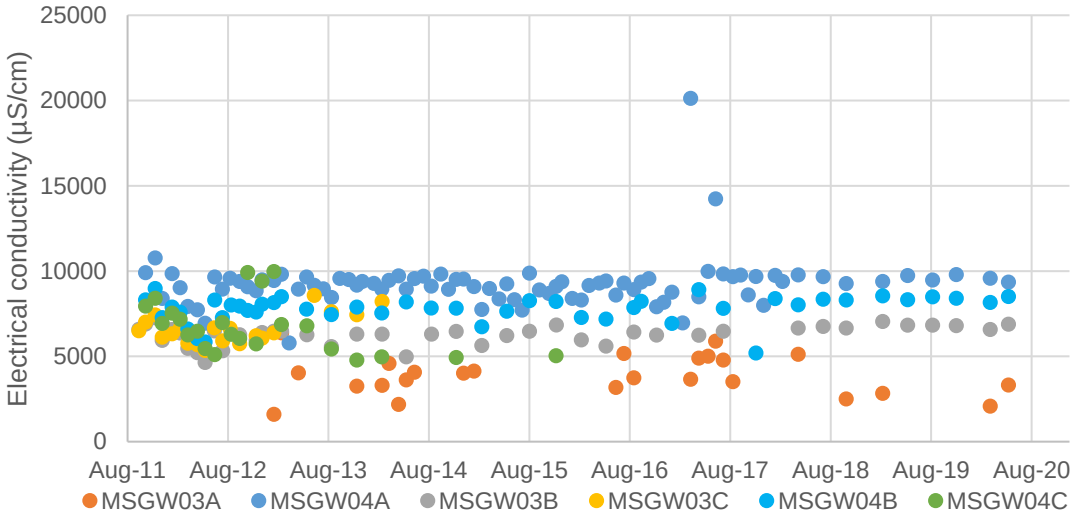

MSGW04A
Groundwater level (m AHD)
CRD (mm)
25.2
25
24.8
24.6
24.4
24.2
24
23.8
23.6
23.4
23.2
23
1200
1000
800
600
400
200
0
-200
Jun-11
Oct-12
Feb-14
Jul-15
Nov-16
Apr-18
Aug-19
Observed level
HARTT Regression
CRD

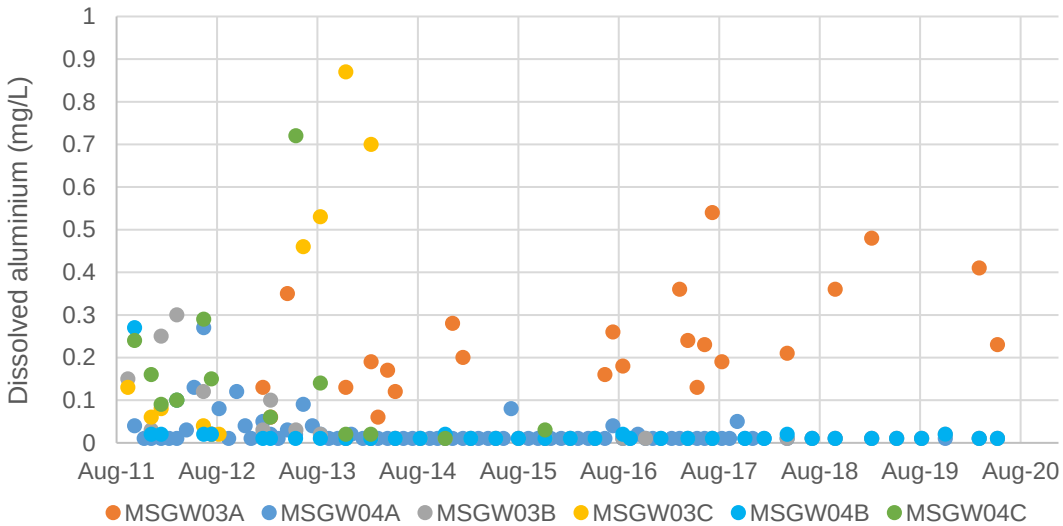

MSGW04B
Groundwater level (m AHD)
CRD (mm)
25
20
15
10
5
0
-5
1200
1000
800
600
400
200
0
-200
-400
Jun-11
Oct-12
Feb-14
Jul-15
Nov-16
Apr-18
Aug-19
Observed levels
CRD

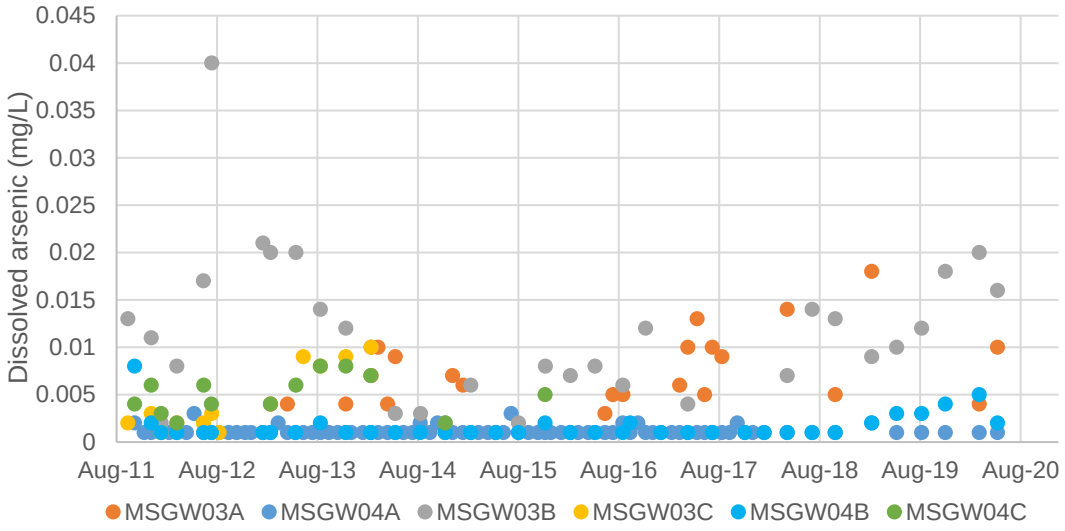

MSGW04C
Groundwater level (m AHD)
CRD (mm)
40
20
0
-20
-40
-60
-80
1200
1000
800
600
400
200
0
-200
Jun-11
Oct-12
Feb-14
Jul-15
Nov-16
Apr-18
Aug-19
Observed levels
CRD

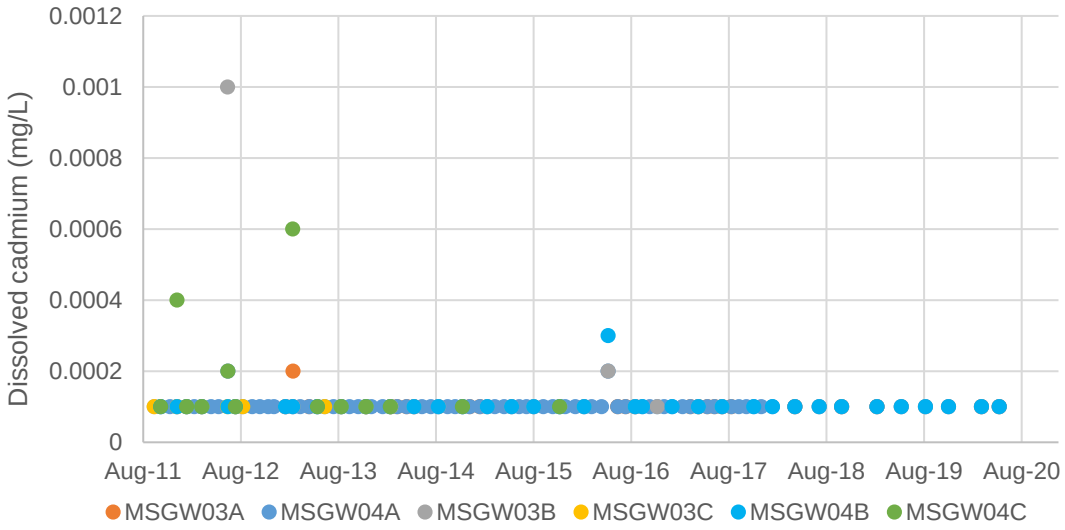
Groundwater quality plots

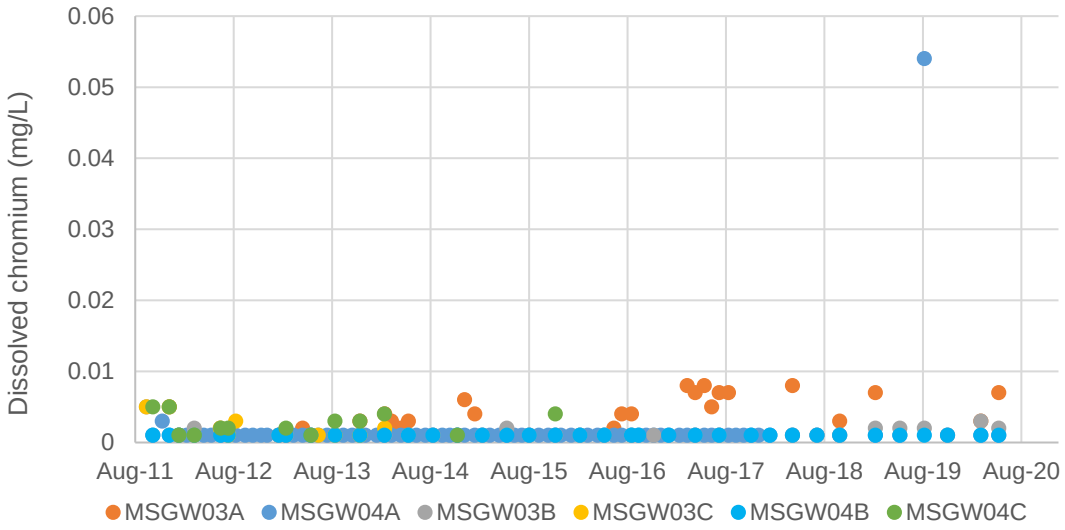


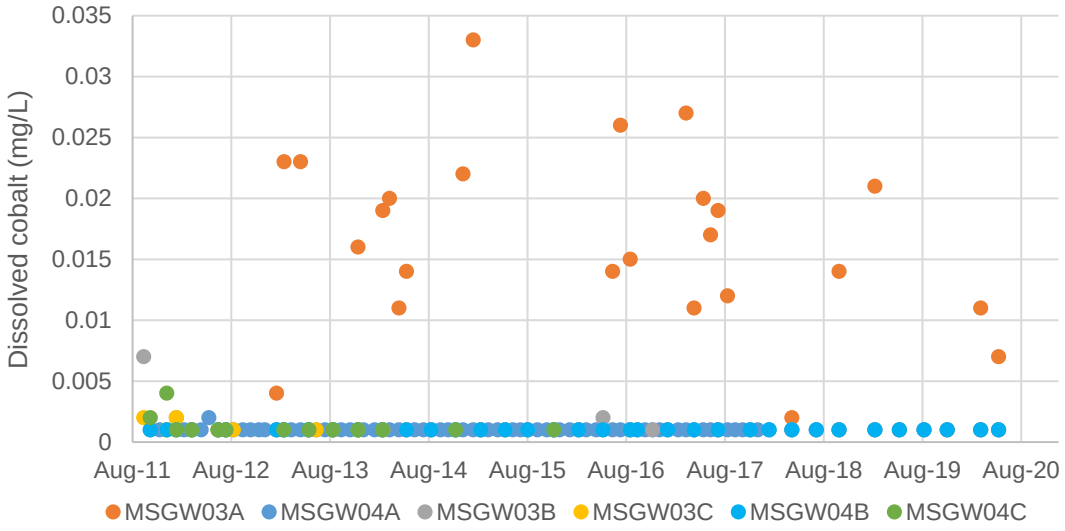


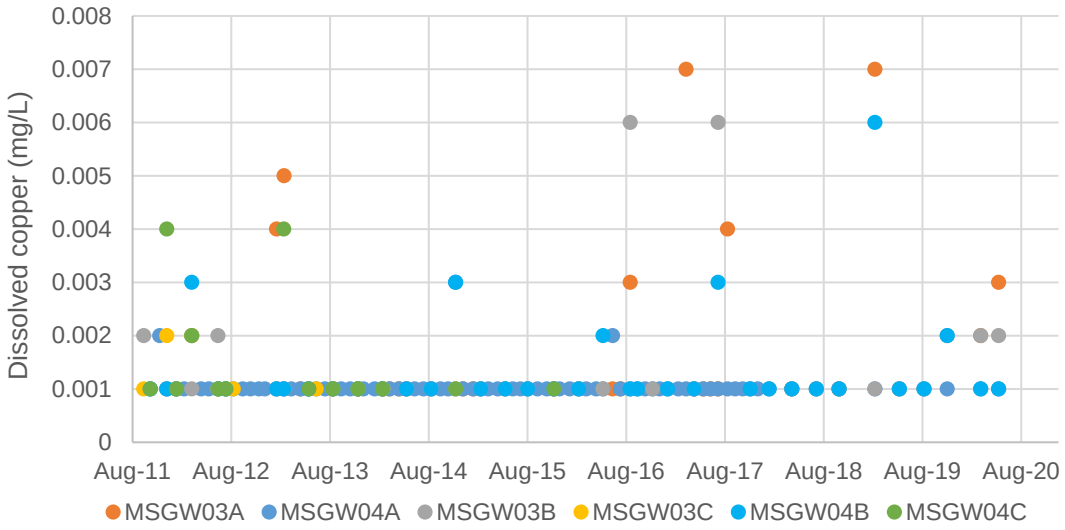


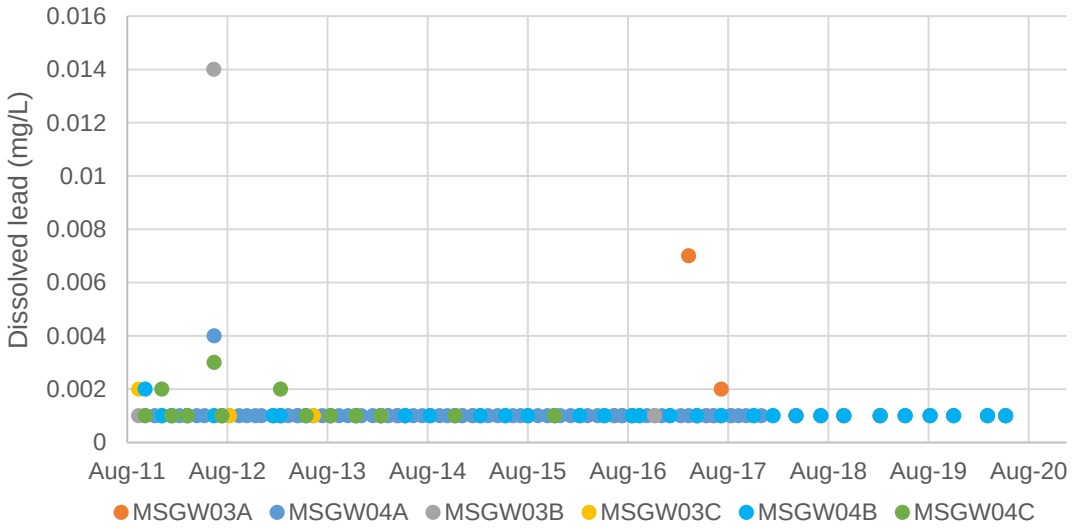

Dissolved arsenic (mg/L)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Aug-11 Aug-12 Aug-13 Aug-14 Aug-15 Aug-16 Aug-17 Aug-18 Aug-19 Aug-20
MSGW03A MSGW04A MSGW03B MSGW03C MSGW04B MSGW04C

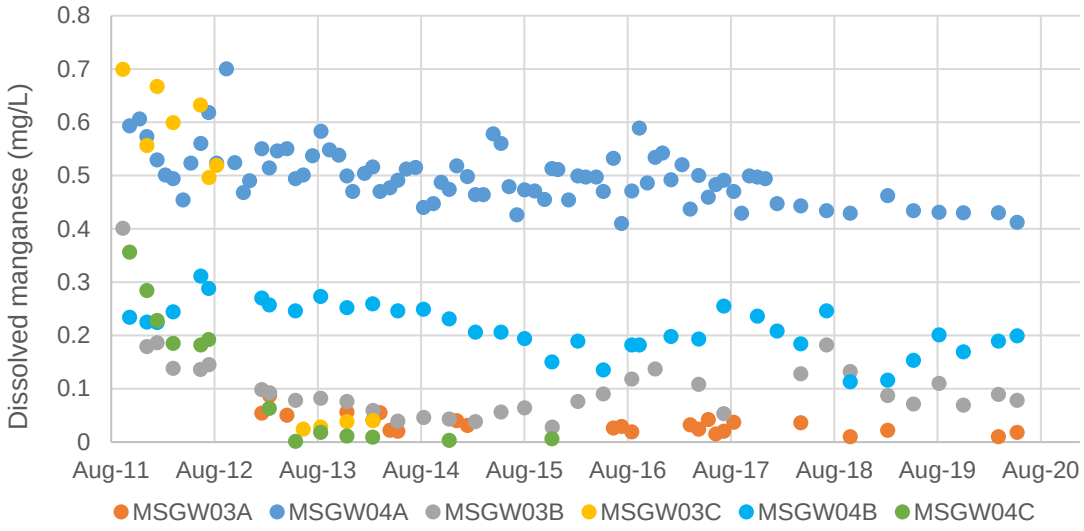

Dissolved cadmium (mg/L)
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
Aug-11 Aug-12 Aug-13 Aug-14 Aug-15 Aug-16 Aug-17 Aug-18 Aug-19 Aug-20
MSGW03A MSGW04A MSGW03B MSGW03C MSGW04B MSGW04C

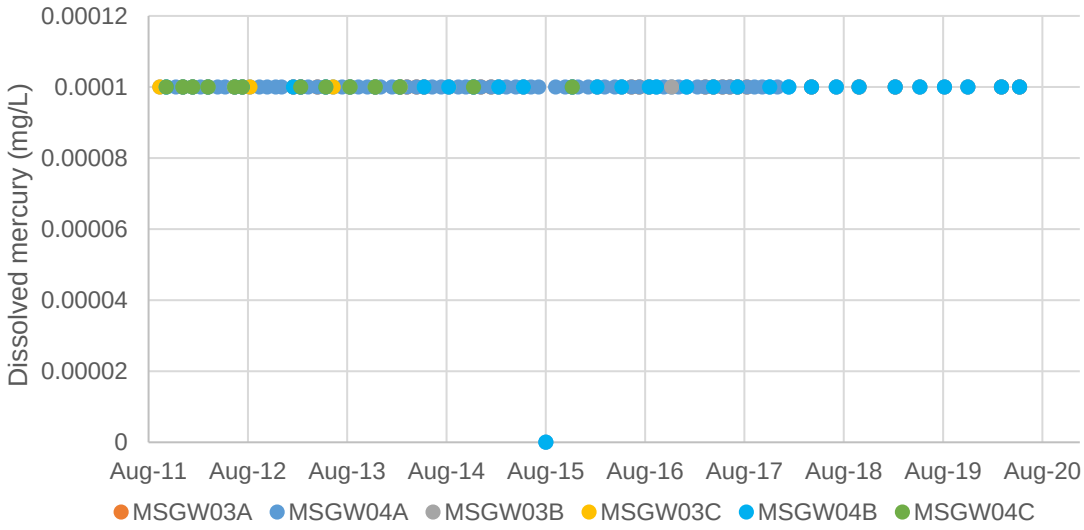

Dissolved chromium (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Aug-11 Aug-12 Aug-13 Aug-14 Aug-15 Aug-16 Aug-17 Aug-18 Aug-19 Aug-20
MSGW03A MSGW04A MSGW03B MSGW03C MSGW04B MSGW04C

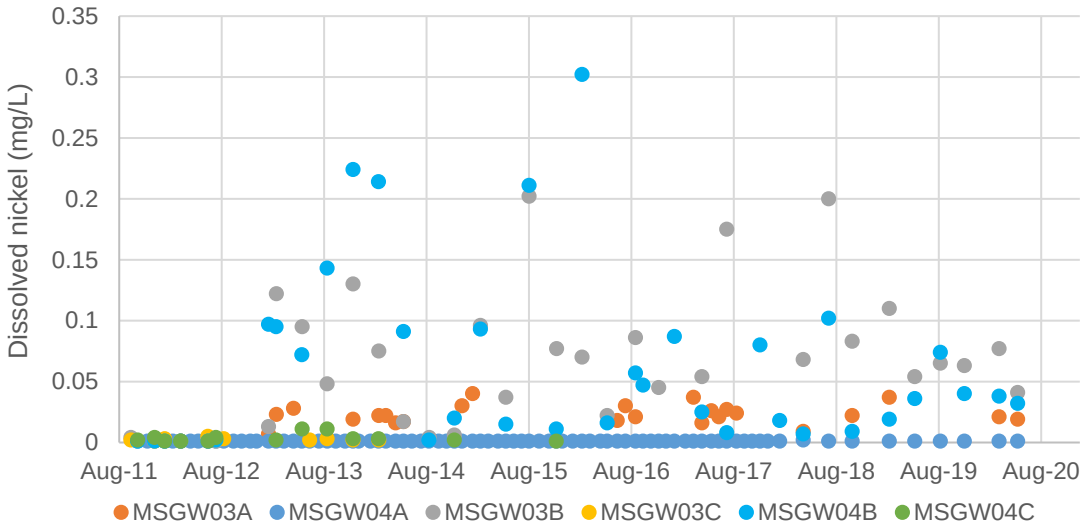

Dissolved cobalt (mg/L)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Aug-11 Aug-12 Aug-13 Aug-14 Aug-15 Aug-16 Aug-17 Aug-18 Aug-19 Aug-20
MSGW03A MSGW04A MSGW03B MSGW03C MSGW04B MSGW04C

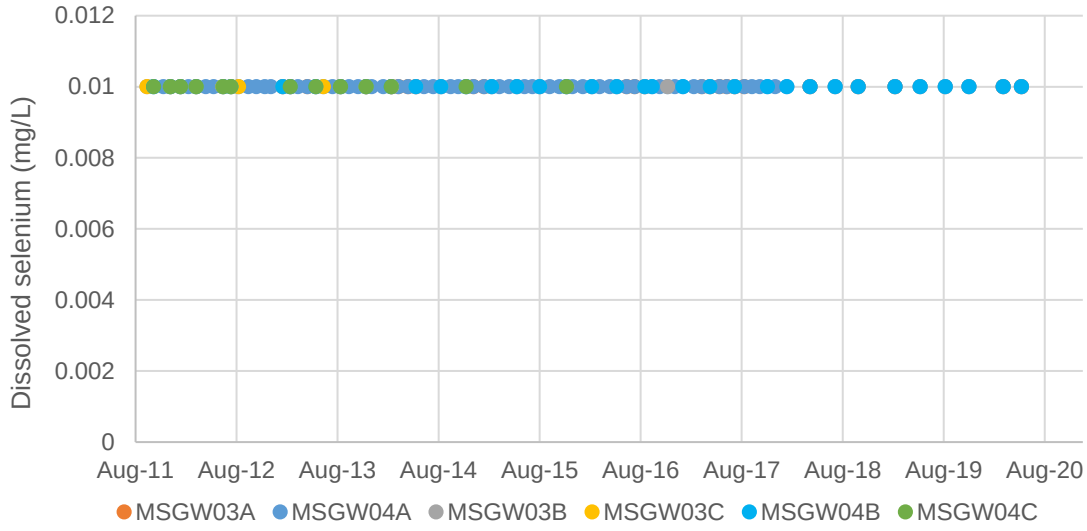

Dissolved copper (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Aug-11 Aug-12 Aug-13 Aug-14 Aug-15 Aug-16 Aug-17 Aug-18 Aug-19 Aug-20
MSGW03A MSGW04A MSGW03B MSGW03C MSGW04B MSGW04C

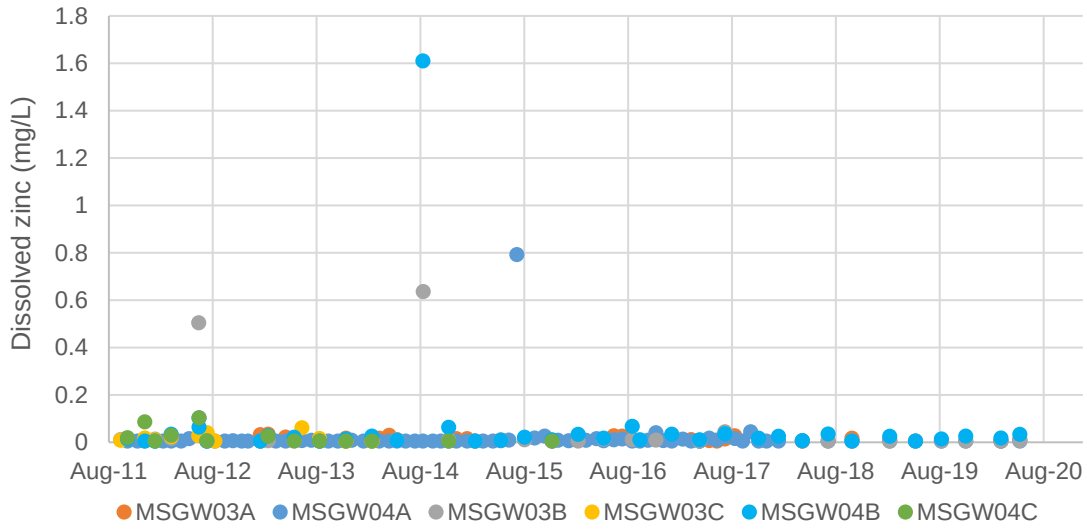

Dissolved lead (mg/L)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Aug-11 Aug-12 Aug-13 Aug-14 Aug-15 Aug-16 Aug-17 Aug-18 Aug-19 Aug-20
MSGW03A MSGW04A MSGW03B MSGW03C MSGW04B MSGW04C


Dissolved manganese (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Aug-19
Aug-20
MSGW03A
MSGW04A
MSGW03B
MSGW03C
MSGW04B
MSGW04C


Dissolved mercury (mg/L)
0.00012
0.0001
0.00008
0.00006
0.00004
0.00002
0
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Aug-19
Aug-20
MSGW03A
MSGW04A
MSGW03B
MSGW03C
MSGW04B
MSGW04C


Dissolved nickel (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Aug-19
Aug-20
MSGW03A
MSGW04A
MSGW03B
MSGW03C
MSGW04B
MSGW04C


Dissolved selenium (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Aug-19
Aug-20
MSGW03A
MSGW04A
MSGW03B
MSGW03C
MSGW04B
MSGW04C


Dissolved zinc (mg/L)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Aug-19
Aug-20
MSGW03A
MSGW04A
MSGW03B
MSGW03C
MSGW04B
MSGW04C

Appendix D – Registered groundwater bores

Bore	Easting	Northing	Depth (m)	Licence status	Authorised use	Surface water level (m bgl)	Yield (L/s)	Salinity (mg/L)	Aquifer
GW015275	356866	6327914	4.5	Active	Stock, irrigation, domestic	3.9	0.15	Fresh	Clay, sand
GW015287	351406	6335997	44.1	Active	Stock, irrigation	–	–	3,001–7,000	–
GW021578	355396	6334454	3.6	Active	Stock, domestic	2.4	0.13	Fair	Sand
GW029567	361864	6340863	3	Active	Stock, irrigation, domestic, farming	2.1	–	–	Sandstone, gravel
GW033618	358945	6343594	30.4	Active	Stock	–	–	–	Sandstone, shale
GW033619	359049	6343596	21.3	Active	Stock	–	1.52	–	Sandstone, shale
GW034950	356963	6335463	76.2	Active	Stock, domestic	14.9	0.25	Poor	Conglomerate
GW043431	359665	6345915	38.1	Active	Stock	1.8	–	–	–
GW044189	353479	6337815	3.6	Active	Stock, domestic	–	–	0–500	–
GW048538	351276	6341139	26	Active	Domestic	7	0.13, 0.63	–	–
GW050694	351933	6340595	30	Active	Stock, domestic	12	1.5	Good	Shale
GW050982	351460	6341019	24.4	Active	Domestic	–	–	–	–
GW051320	351999	6339672	46	Active	Stock, domestic	9	0.38	Good	Conglomerate
GW051321	351404	6341265	46	Active	Stock, domestic	–	1.89	–	Shale
GW051322	351432	6341111	53	Active	Stock, domestic	9	0.13	–	Shale
GW051542	352519	6343007	38	Active	Stock, domestic	12.2	1.7	Good	Sandstone
GW051560	348262	6323132	33	Active	Stock, farming	13	5	–	Sandstone
GW051778	350297	6339030	41	Active	Stock, domestic	10	0.13, 1.13, 0.5	–	Conglomerate, shale, sandstone
GW052111	359475	6339227	49	Active	Stock	10.5	0.1, 0.27	Good	Conglomerate, sandstone
GW052255	356445	6333638	114	Active	Stock	8.7	0.07, 0.1, 0.23	–	Shale, Conglomerate
GW052374	353735	6339759	38	Active	Stock, domestic	18	2.52	–	Sandstone
GW052381	357498	6346746	35	Withdrawn	Stock, domestic	13	0.76	Good	Coal
GW053092	356798	6327205	0	Cancelled	Irrigation, stock, domestic	–	–	–	Sand
GW053438	359235	6339686	53	Lapsed	Stock, irrigation, domestic	–	0.44	1,001–3,000	Shale

Bore	Easting	Northing	Depth (m)	Licence status	Authorised use	Surface water level (m bgl)	Yield (L/s)	Salinity (mg/L)	Aquifer
GW054183	352923	6335126	18.3	Active	Domestic	–	–	Fair	–
GW056461	347072	6324685	23	Active	Domestic, stock	9	2.52	–	Unknown
GW056862	356600	6337214	45	Active	Stock, domestic	–	–	–	–
GW057310	356467	6342726	61	Active	Stock, domestic, farming	6	0.07	–	Shale
GW058789	351125	6320435	29	Withdrawn	Stock, domestic	–	–	Salty	Ironstone
GW059558	358320	6336592	5	Active	Stock, domestic, farming	–	–	–	–
GW060965	354299	6338505	33.6	Active	Stock, domestic	29	0.38	Salty	Shale
GW061202	357061	6344737	50.3	Active	Stock, domestic	21.9	0.1, 0.2	1,001–3,000	Siltstone, Coal
GW061226	356445	6333638	117.3	Active	Stock, domestic	24.4, 83	3, 0.1, 0.1	3,001–7,000	Sandstone, shale
GW062618	358931	6337371	34.5	Active	Domestic	16.4	34, 53	–	–
GW064033	357483	6338921	49.4	Active	Stock, domestic	12.2	0.06, 0.1, 0.15	501–1,000	Sandstone
GW064116	356486	6339677	21.3	Active	Stock, domestic	–	0.3, 0.6	0–500	Sandstone
GW064143	358504	6338197	24.3	Active	Stock, domestic	–	–	1,001–3,000	Gravel
GW064662	359443	6327028	24	Active	Domestic	7	–	–	Sandstone
GW067263	355148	6338979	10	Active	Stock, domestic	3	0.15	–	–
GW078043	351532	6332856	33	Active	Stock, domestic	16, 18	–	–	Sandstone
GW078060	360787	6330898	28	Active	Domestic	15	1.25	Fresh	Conglomerate
GW078084	357181	6334696	62	Active	Stock, domestic	5	0.05, 0.1	Fresh	Sandstone
GW078094	360784	6331113	30.4	Active	Domestic, stock	5	0.2, 0.3	480, 500	Sandstone
GW078110	352956	6332939	7.3	Active	Monitoring bore	–	–	5,100	Sand
GW078111	353423	6332885	12.2	Active	Monitoring bore	–	–	–	–
GW078113	353009	6333865	12.2	Active	Monitoring bore	2.35	–	1,630	Silt, sand
GW078114	355863	6334400	12	Active	Monitoring bore	3.48	–	650	Sand
GW078115	355319	6333746	10.4	Active	Monitoring bore	0.99	–	5,370	Sand
GW078116	354978	6333987	8.5	Active	Monitoring bore	1.74	–	10,880	Sand
GW078117	354252	6334007	13.7	Active	Monitoring bore	1.68	–	2,380	Sand

Bore	Easting	Northing	Depth (m)	Licence status	Authorised use	Surface water level (m bgl)	Yield (L/s)	Salinity (mg/L)	Aquifer
GW078118	353418	6334980	15.8	Active	Monitoring bore	2.38	–	820	Sand
GW078119	353204	6334731	9.1	Active	Monitoring bore	2.66	–	230	Sand
GW078131	353466	6333532	12.5	Active	Monitoring bore	1.58	–	310	Sand
GW078132	353702	6333351	14.6	Active	Monitoring bore	1.65	–	5,100	Sand
GW078136	356136	6335236	9	Active	Monitoring bore	4.5	–	370	Sand
GW078137	355416	6334886	5.5	Active	Monitoring bore	5.35	–	2,720	Sand
GW078138	356976	6345167	120	Cancelled	Test bore	35	0.2, 0.6	320, 470	Sandstone
GW078139	354851	6334477	9.1	Active	Monitoring bore	2.9	–	1,560	Sand
GW078140	356434	6333731	180	Cancelled	Test bore	16	0.2	634	Coal
GW078214	360811	6330799	36	Active	Stock, domestic	12, 9	0.63, 2	Fresh	Sandy clay, sandstone
GW078220	351203	6341259	23	Active	Stock, domestic	10	7	1,280	Clay
GW078390	359361	6323730	3	Active	Domestic	–	–	–	–
GW078601	354731	6332103	18.85	Active	Stock, domestic	4.5	1.1	1,600	Weathered sandstone
GW078608	359054	6338132	60	Active	Stock, domestic	–	–	–	–
GW078609	348866	6323656	70	Active	Stock, domestic	–	–	–	Sandstone, mudstone
GW078610	347495	6330465	316.2	Active	Stock, domestic	–	–	–	–
GW079772	356385	6333546	234	Cancelled	Test bore	–	0.1, 0.2	2,900, 1,500	Sandstone, coal
GW080372	350851	6339519	75	Active	Stock, domestic	3	0.15	–	Sandstone, siltstone
GW080394	347251	6329529	42	Active	Stock, domestic	18	2.6	6,230	Sandstone
GW080608	349661	6321471	48	Active	Stock, domestic	3.2	0.4	–	Shale
GW105311	351296	6333045	198	Abandoned	Stock, domestic	–	–	–	–
GW200210	359439	6323706	4.5	Active	Domestic	3.5	1	–	–
GW200302	354830	6320184	180	Active	Test bore	–	0.35	7,750	Sandstone
GW200379	358197	6324827	6	Active	Monitoring bore	5.6	–	–	Clay
GW200380	357960	6324782	6	Active	Monitoring bore	5	–	–	Clay
GW200419	354958	6320242	4.2	Active	Test bore	–	–	–	Clay, sand
GW200420	355056	6320343	4.25	Active	Test bore	–	–	–	–
GW200505	350914	6322022	54	Active	Stock, domestic	15, 18.5	0.1, 0.25	Fresh	gravel, conglomerate
GW200509	346985	6330372	100	Active	Stock, domestic	–	0.01	–	Sandstone
GW200671	356845	6321257	5.5	Active	Monitoring bore	–	–	–	–

Bore	Easting	Northing	Depth (m)	Licence status	Authorised use	Surface water level (m bgl)	Yield (L/s)	Salinity (mg/L)	Aquifer
GW200672	356876	6321175	4.5	Active	Monitoring bore	–	–	–	–
GW200673	356927	6321142	4.5	Active	Monitoring bore	–	–	–	–
GW200674	356967	6321130	4.5	Active	Monitoring bore	–	–	–	–
GW200675	356945	6321171	3	Active	Monitoring bore	–	–	–	–
GW200676	356870	6321205	4.5	Active	Monitoring bore	–	–	–	–
GW200677	356939	6321258	3	Active	Monitoring bore	–	–	–	–
GW200678	357066	6321280	3	Active	Monitoring bore, town water supply	–	–	–	–
GW200679	356900	6321242	4.8	Active	Monitoring bore	–	–	–	–
GW200696	359964	6347393	66	Cancelled	Test bore	–	–	–	–
GW200765	356404	6339855	8	Active	Domestic	–	–	–	-
GW200854	354927	6320417	2.9	Active	Monitoring bore	2.3	–	–	Clay
GW200915	357208	6335014	60	Active	Stock, domestic	–	–	–	–
GW200938	351483	6322112	36	Active	Stock, domestic	14	0.1, 0.5	–	Conglomerate
GW201396	353820	6333360	9	Active	Monitoring bore	2.5	–	–	Clayey sand, sand
GW201397	353821	6333365	30.5	Active	Monitoring bore	20	–	–	Sandstone
GW201398	353822	6333372	58	Active	Monitoring bore	51	–	–	Sandstone, mudstone
GW201399	352912	6333760	30.1	Active	Monitoring bore	27	–	–	Sandstone, mudstone
GW201400	352906	6333763	63	Active	Monitoring bore	54	–	–	Sandstone, mudstone
GW201401	353283	6334737	32.85	Active	Monitoring bore	29.5	–	–	Sandstone, mudstone
GW201402	353281	6334735	60	Active	Monitoring bore	55	–	–	Sandstone
GW201403	353034	6333976	21	Active	Monitoring bore	16	–	–	Sandstone, mudstone
GW201404	353073	6333977	34.1	Active	Monitoring bore	24	–	–	Sandstone
GW201405	353073	6333978	60	Active	Monitoring bore	56	–	–	Sandstone
GW201504	348505	6329500	205	Active	Test bore	11	0.5	3610	Clay, shale
GW202940	361666	6341097	4.5	Active	Monitoring bore	1.6	–	–	Clayey sand
GW202941	361591	6341004	5.5	Active	Monitoring bore	2.03	–	–	Sand, sandy clay
GW202942	361575	6341085	6	Active	Monitoring bore	1.81	–	–	Silty clay, gravelly sandy clay
GW202943	361566	6340704	8	Active	Monitoring bore	4.68	–	–	Gravel, conglomerate

Bore	Easting	Northing	Depth (m)	Licence status	Authorised use	Surface water level (m bgl)	Yield (L/s)	Salinity (mg/L)	Aquifer
GW202944	361571	6340770	8.5	Active	Monitoring bore	5.3	–	–	Weathered conglomerate
GW202945	361591	6340725		Active	Monitoring bore	5.11	–	–	Conglmerate, coal
GW202946	361568	6340833	8.4	Active	Monitoring bore	4.79	–	–	Conglomerate
GW202947	361596	6340822	9	Active	Monitoring bore	3.94	–	–	Silty clay
GW202948	361613	6340821	9.5	Active	Monitoring bore	2.9	–	–	Silty sand, sandy gravelly clay
GW202949	361593	6340864	9	Active	Monitoring bore	4.09	–	–	Sandy, silty clay
GW202950	361523	6340829	9	Active	Monitoring bore	1.17	–	–	Clay
GW202951	361592	6340796	9	Active	Monitoring bore	5.82	–	–	Fill
GW202952	361618	6340813	19	Active	Monitoring bore	5.35	–	–	Clay
GW201578	355396	6334454	3.6	Active	Stock, domestic	2.4	0.13	–	Sand
GW201648	352065	6331146	19.4	Active	Monitoring bore	1.4	–	–	Silty clay, sandy clay
GW201649	352055	6331144	150	Active	Monitoring bore	6.3	0.3, 1.6	3,800, 4,600	Sandstone
GW201650	352045	6331143	48.1	Active	Monitoring bore	5.5	1.5, 0.4	4,100, 3,200	Sandstone
GW201651	351273	6330153	6.5	Active	Monitoring bore	–	–	–	Sandstone
GW201652	351288	6330152	48	Active	Monitoring bore	6.3	0.2	5,000	Sandstone
GW201653	351291	6330161	156	Active	Monitoring bore	5	0.25	4,350	Sandstone
GW202180	347573	6329504	30	Active	Stock, domestic	–	4.5, 8	1,000	Sandstone
GW201704	354686	6325840	7.2	Active	Monitoring bore	1.9	–	–	Sandy clay, sandstone
GW200418	354740	6320120	4.45	Active	Test bore	–	–	–	Clay
GW203089	349313	6321480	–	–	–	–	–	–	–
GW203090	349313	6321485	–	–	–	–	–	–	–
GW203091	349313	6321490	–	–	–	–	–	–	–
GW203092	349038	6321529	–	–	–	–	–	–	–
GW203087	349593	6321423	–	–	–	–	–	–	–
GW203093	349038	6321534	–	–	–	–	–	–	–
GW203088	349593	6321432	–	–	–	–	–	–	–
GW203094	349038	6321539	–	–	–	–	–	–	–
GW203099	353010	6323601	–	–	–	–	–	–	–

Bore	Easting	Northing	Depth (m)	Licence status	Authorised use	Surface water level (m bgl)	Yield (L/s)	Salinity (mg/L)	Aquifer
GW203098	353010	6323596	–	–	–	–	–	–	–
GW203101	352940	6323294	–	–	–	–	–	–	–
GW203100	352948	6323292	–	–	–	–	–	–	–
GW203084	352503	6322830	–	–	–	–	–	–	–

Appendix E – Surface and groundwater remediation measures

Remedial strategies have been conceptualised for Mandalong Mine as part of previous extraction management plans. Strategies can take one of two forms:

- **Soft engineering solutions** which comprise of elements such as coir logs, jute matting, geotextile, rock armouring, timber log dissipaters and a range of other options that are generally designed to repair cracks and erosion and prevent recurrence by regulating the flow of surface and subsurface water. These solutions are generally biodegradable and therefore integrate into the riparian systems.
- **Hard engineering solutions** comprise the use of concrete and various grouting techniques as well as earthworks. These solutions are used where either subsidence is persistent and results in water losses from waterways or areas of remanent ponding are impacting on waterway hydraulics or impacting on property.

A hierarchy of control will be used when implementing remediation works. Soft engineering solutions will be used initially to remediate any impacts that may occur. These soft engineering works will be monitored and maintained to ensure design performance. Hard engineering solutions will be used if monitoring demonstrates that the soft engineering solutions require additional works.

Potential engineering solutions may include but not limited to the following seven typical mitigation measures, discussed in Sections E.1 to E.6 below. To accommodate for improvements in technology and research, a detailed investigation into the remediation measure will need to be conducted prior to the implementation of any engineering solution.

E.1 Surface water drainage to mitigate ponding

Where subsidence has resulted in a significant increase in remnant ponding, surface or sub-surface water drains can be constructed to improve water carriage on a property. These drains need to be designed so they have sufficient capacity to drain areas affected by ponding. These drains are typically of a shallow design depending on existing surface gradients and direct surface water to established drainage lines. Any drainage works on private property are undertaken in consultation with the landowner and facilitated by and access agreement.

E.2 Infilling of surface cracks to prevent surface water loss

In the unlikely event that subsidence causes significant surface cracks, these may be in filled to prevent the loss of surface water. Surface cracks are typically remediated by backfilling these with surrounding surface material then re-grading to create a level surface. Disturbed areas are then rehabilitated by planting native endemic species to prevent soil erosion.

E.3 Creek realignment measures to improve flows

If sections of the creek bed become hydrologically isolated or have significant areas of additional pooling caused by changes in bed gradients, then these bed sections may need to be realigned to improve flows. Realignments need to be designed based on surveyed long sections to best suit existing creek grades. This remediation measure typical involves excavating to regrade a creek bed section or removing elevated sections causing a constriction to flow. Upstream water would need to be contained to allow excavation and following realignment similar soil material would be re-instated to stabilise the creek bed. Permits to work within a waterway would need to be obtained from the relevant government department prior to commencing works. Where remediation is required on private property, any remediation will be undertaken in consultation with the landowner and facilitated by land access agreements.

E.4 Creek bed stabilisation measures to reduce erosion

Where creek gradient changes result in a significant increase in erosion, it may be necessary to reduce flow velocities in the creek bed to prevent further scouring and the resultant erosion. This can be achieved by a number of methods ranging from constructing bends in the creek line to establishing weir pools. These methods would require specific design to quantify the amount of flow reduction to stabilise the creek. It may also be necessary to stabilise banks. This may be done by re-grading bank areas to reduce incised sections and stabilising the soil by re-vegetating banks.

E.5 Measures to control out of channel erosion

Contour bunds can be used to redirect surface flows from areas at risk of increased erosion particularly, where exposed soils are subject to out of channel flood flows. These contour bunds act to reduce the flow path and redirect water away from areas of erosion. The contour bunds are typically constructed on a low gradient following an existing contour level redirecting surface water into existing drainage channels or water structures. Areas at risk of erosion can then be rehabilitated by establishing vegetation cover using native endemic species.

E.6 Bentonite cut off trenches to control groundwater flows

If near-surface cracking results in drainage of groundwater from the alluvial creek system, this may be remediated by constructing bentonite-filled cut of trenches. These trenches can be constructed to prevent lateral drainage of the groundwater and redirect this back into the existing groundwater dependent system. The trenches need to be positioned and design based on site specific information however, they generally consist of subsurface trench excavations filled with bentonite at the limit of a groundwater system to redirect lateral groundwater flows back into an existing groundwater system.

E.7 Grouting of rock bars

If rock bars are present in creek beds and these are affected by subsidence cracking this may lead to a loss of surface water from a creek. Ongoing monitoring of water loss should be undertaken to determine if long-term effects are evident. Where it is possible, grouting of cracks in rock bars may be effective in reducing water loss and returning surface water flows.

Appendix F – Independent groundwater model review

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DATE: 4 October 2017

TO: Jeff Dunwoodie
Environment and Community Coordinator Mandalong Southern Extension
Centennial Coal Company Limited
12 Kerry Anderson Drive
Mandalong NSW 2264
Tel: (02) 4973 0947

Email: Jeffrey.Dunwoodie@centennialcoal.com.au

FROM: Dr Noel Merrick

RE: Mandalong Longwalls 24 and 24A – Groundwater Model Review

OUR REF: HA2017/2

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1. Introduction

This review is provided in response to your email request of 17 August 2017, following approval for a Modification for the extension of Longwall 24 and the addition of Longwall 24A. This Project is an extension of the existing underground Mandalong Coal Mine in the Newcastle Coalfield about 50 km south-west of Newcastle.

Modification 5 of development consent SSD-5144 was approved by the NSW Department of Planning and Environment (DP&E) in August 2017. Condition 6A of Schedule 4 of the Development Consent states:

The Applicant must commission an independent expert whose appointment has been endorsed by the Secretary, to carry out a review of the groundwater model for the development. This review must include a:
(a) review of all available monitoring data;
(b) comparison of predicted and actual groundwater impacts; and
(c) review of the effectiveness of the groundwater model.

The review must be undertaken and reported to the satisfaction of the Secretary. The report must be submitted to the Secretary and DPI Water prior to the approval of any Extraction Plan relating to Longwalls 24 and/or 24A.

DP&E has endorsed Dr Noel Merrick of HydroAlgorithmics Pty Ltd as the independent expert. Previously in 2014, he conducted a peer review of the groundwater assessment prepared by GHD for the development application for the Mandalong Southern Extension Project.

2. Documentation

The review is based on the following reports:

1. GHD, 2017, Mandalong Longwall Panel 24 to 24A Modification Water Resources Impact Assessment. Report 2218510-22653 prepared for Centennial Mandalong Pty Ltd. Revision 0 (28 April 2017), 113p + 5 Appendices (68p).

2. GHD, 2016, Mandalong Production Tonnage Project Groundwater and Water Balance Modelling Report. Report 2218387-54841 prepared for Centennial Mandalong Pty Ltd. Revision 1 (19 September 2016), 24p.

3. GHD, 2017, Mandalong Groundwater Model Additional Information for Peer Review. Letter Report 2219127-92376 prepared for Centennial Mandalong Pty Ltd. 24 September 2017, 12p.

An earlier review is documented in:

4. HydroAlgorithmics, 2014, Mandalong Southern Extension Project – Groundwater Model Review. Letter Report HA2014/4, 18 March 2014, 14p.

That review relied primarily upon:

5. GHD, 2013, Mandalong Southern Extension Project Groundwater Impact Assessment. Report 22\16168\100113 prepared for Centennial Mandalong Pty Ltd. Revision 1 (August 2013), 60p + 6 Appendices (114p). EIS Appendix H.

6. [Doc #1] Appendix F. Mandalong Southern Extension Project Hydrogeological Model Report. Report 22\16168\100113 prepared for Centennial Mandalong Pty Ltd. Revision 1 (August 2013), 46p + 1 Annexure (8p).

7. GHD, 2014, Mandalong Southern Extension Project Response to Comments on the Groundwater Impact Assessment. Letter of 6 March 2014 to Mr James Wearne, Environmental Coordinator, Centennial Coal.

Document #1 has the following sections:

1. Introduction
2. Legislation, policies and guidelines
3. Site description
4. Methodology
5. Existing conditions
6. Impact assessment
7. Mitigation, management and monitoring
8. Summary
9. References.

The Appendices are:

A. Flooding assessment
B. Groundwater hydrographs
C. Groundwater quality data
D. Surface water quality
E. Registered groundwater bores

Document #2 includes a summary of groundwater model refinements and predictive results. It has the following sections:

1. Introduction
2. Hydrogeological model
3. Water balance
4. Conclusions
5. References.

Document #3 includes a summary of groundwater model calibration. It has the following sections:

1. Chronology of model development and review
2. Data
3. Conceptual model
4. Model construction
5. Calibration and sensitivity analysis
6. Model predictions and uncertainty analysis
7. References.

3. Review Methodology

The previous review [Document #4], which covered groundwater modelling and the full groundwater assessment for the Mandalong Southern Extension Project, was guided by the two accepted guides to the review of groundwater models: (A) the Murray-Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline[1], issued in 2001, and (B) guidelines issued by the National Water Commission in June 2012 (Barnett *et al*., 2012[2]). The review also considered compliance with the Director General's Requirements and NSW Office of Water requirements at that time. For the groundwater assessment, particular attention was given to whether the minimal harm considerations of the *NSW Aquifer Interference Policy* (NSW Government, 2012[3]) were addressed adequately.

On this occasion, the review is more targeted in terms of three aspects of the approval condition:

(a) review of all available monitoring data;
(b) comparison of predicted and actual groundwater impacts; and
(c) review of the effectiveness of the groundwater model.

As the groundwater model has undergone some revision since it was last reviewed, comments are offered on model revision as well.

4. Previous Review [Document #4]

The main findings of the previous review were:

1. There are shortcomings in the modelling that has been done for this groundwater assessment. Fortunately, the groundwater assessment is based not only on numerical modelling but also on a cause-and-effect analysis of hydrographs that have responded to a long period of climatic variation and mining.
2. An effective HARTT analysis is used to tease out the causative factors, and that shows negligible effect on alluvium but an expected depressurisation within the Triassic formations and Permian coal measures. The hydrographic datasets contain a wealth of information on climatic response and mining effects.
3. As the numerical model has some deficiencies, more exploration of the uncertainty in mine inflow estimates was recommended; this was undertaken and reported in a "Response to Comments".
4. The estimates for mine inflows, drawdown magnitudes and drawdown extent have low confidence.
5. The fractured zone is not well represented in the model.

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1 MDBC (2001). Groundwater flow modelling guideline. Murray-Darling Basin Commission. URL: www.mdbc.gov.au/nrm/water_management/groundwater/groundwater_guides

2 Barnett, B, Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A. (2012). *Australian Groundwater Modelling Guidelines*. Waterlines report 82, National Water Commission, Canberra.

3 NSW Government, 2012, NSW Aquifer Interference Policy – NSW Government policy for the licensing and assessment of aquifer interference activities. Office of Water, NSW Department of Primary Industries, September 2012.

6. It appears that all existing mines are kept dewatered through to 2036, whereas many would be in recovery mode by then. A table of stress periods and active mine drains though the calibration and prediction periods would clarify the assumptions.
7. Further sensitivity analysis of the transient model was recommended, with a focus on the hydraulic conductivity of the Munmorah Conglomerate and the specific storage of the deeper hydrogeological units (considered to be too high in the model).
8. There are six model layers. In hindsight, it might have been better to have an extra layer or two to allow better representation of the fractured zone (Layer 4) with enhanced permeability[4] decaying with height above the mined seam.
9. MODFLOW-NWT does not have the feature of time-varying material properties required for proper simulation of the evolving fractured zone as mining progresses. MODFLOW-SURFACT is the only version with this feature[5].
10. Transient calibration of groundwater hydrographs was rudimentary. *"While trends and absolute magnitudes can be checked, amplitudes of the groundwater response cannot be checked because rainfall was not varied in time. Hydrographic performance is patchy - some hydrographs are matched reasonably well, others not at all, and those that agree well are not always with the same model."*

At point 3, the sensitivity analysis resulted in a range of peak mine inflows varying from about 2 ML/day to about 10 ML/day. The base case model predicted about 6 ML/day at the peak.

5. Groundwater Model Refinements

Document #3 provides a useful chronology of the evolution of the groundwater model. The original model has been found to have over-estimated the mine inflow since 2013 by a factor of about three, although one of the earlier sensitivity runs predicted an inflow of the right magnitude. The mine inflow for May 2014 to June 2015 has been back-calculated (from a water balance) to have averaged 0.79 ML/day, while the base case model predicted about 2.1 ML/day at that time.

Recalibration of the model has been necessary to better replicate the observed mine inflow. The refinements are:

A. Extending the model from 6 to 8 layers by representing the fracture zone with 3 layers. *[A peer review recommendation.]*
B. Applying a ramp function for permeability in the fracture zone. *[A peer review recommendation.]*
C. Reduction of specific storage by 3 orders of magnitude. *[A peer review recommendation.]*
D. Reduction in most host layer permeabilities.
E. More rapid extraction at 6.5 Mtpa.

The revised model now replicates "observed" mine inflows.

New performance statistics for calibration to groundwater hydrographs have not been provided, although visual comparisons are given in Document #3 for 13 sites that have a demonstrated mining effect. The hydrographic matches are generally poor, although some give the trends that are expected.

The many hydrographs that are not mining-affected, but have a strong rainfall signature, are presumed to not match well because time-varying rainfall recharge has not been incorporated in the model. This deficiency in the model was highlighted in the previous peer review.

It is still unclear how the time-varying changes in fracture zone permeability have been incorporated unless MODFLOW-SURFACT software is being used, but there is no statement

[4] Here used interchangeably with the more correct hydraulic conductivity term.
[5] Since the review, MODFLOW-USG has been released and a beta version allows time-varying properties.

that the previous MODFLOW-NWT software has been replaced. This means that the fracture zone has to be activated prematurely at the start of the simulation prior to mining.

6. Monitoring Data

The approval conditions call for a review of all monitoring data.

The groundwater monitoring network is discussed in Section 5.2 of Document #1. The network is very substantial, with groundwater level records back as far as 1997. There are 64 standpipes listed in Table 5-1 of Document #1 plus one site with five vibrating wire piezometers (VWPs).

A comprehensive cause-and-effect analysis has been performed on the groundwater hydrographs. For 29 alluvial bores, an objective HARTT analysis has been done. Non-alluvial bore responses are addressed qualitatively.

The HARTT analysis (Table 5-2) suggests that four alluvial bores demonstrate a mining effect: BH24A, BH26A, BH27A and MSGW03A. The reviewer considers the findings to be erroneous for all but BH24A which shows a definite mining effect (**Figure 1**); this bore is over Longwall (LW) 15. Two bores (BH26A and MSGW03A) are distant from mining and have poor quality observations; hence the HARTT findings are not reliable. The remaining bore (BH27A over LW18) has insufficient observation points (only four); hence the HARTT findings are not reliable.

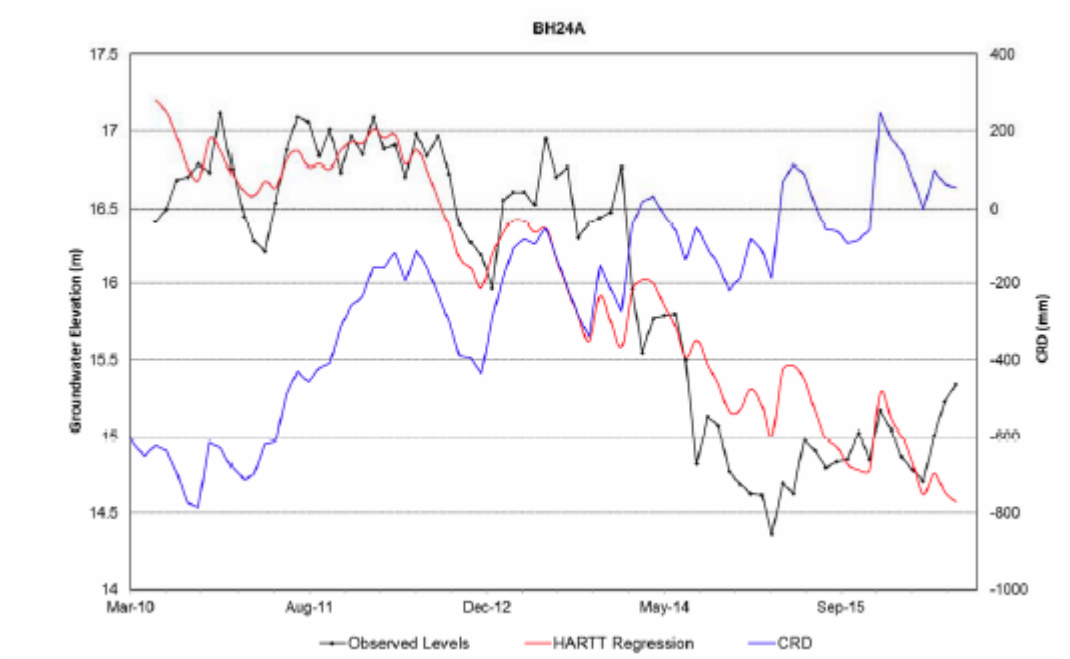


Figure 1. A demonstrated mining effect on an alluvial bore (BH24A over LW15)

One criticism is that the hydrographic plots (such as Figure 1) should show “mAHD” as the groundwater elevation unit (not “m”). Often, for shallow bores with rapid response time, a better correlation would be found with rainfall residuals rather than cumulative residuals (CRD).

The non-alluvium hydrographs show many definite mining effects, indicated by non-correlation with the CRD (rainfall trend) curve. However, the analysis is hindered by the plots not showing the commencement date of each longwall, or the date at which the monitoring bore was undermined. In the reviewer’s opinion, definite mining effects are evident at the following bores:

- BH02A (LW3) – sandstone;
- BH03B (mains) – sandstone;

- BH06A (LW7) – sandstone;
- BH07A (LW10) – conglomerate; BH07B (LW11) – siltstone;
- BH08A (LW11) – ?;
- BH09A/B (LW12) – mudstone;
- BH010A (LW16) – mudstone; BH10B (LW16) – siltstone;
- BH23A (LW4) – mudstone – see **Figure 2**;
- BH24B (LW15) – sandstone;
- BH025B (LW14) – sandstone; BH25C (LW14) – mudstone;
- MSGW04B (south of LW24) – sandstone.

An example of a definite mining effect is shown in Figure 2.

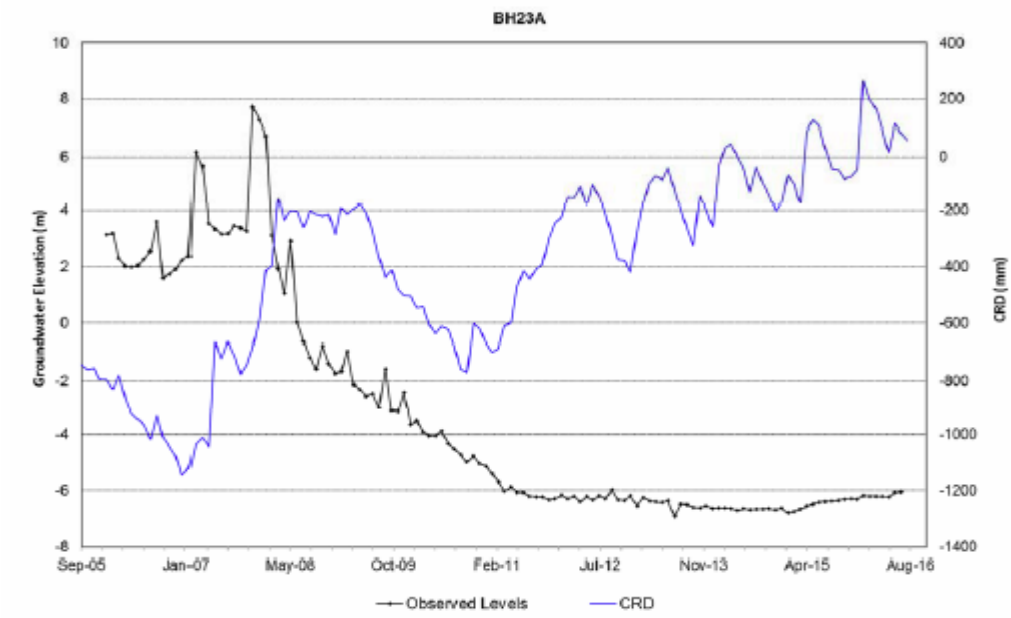


Figure 2. A demonstrated mining effect on a porous rock bore (BH23A over LW4)

One piezometer in presumably shallow coal shows very strong correlation with the rainfall trend, as shown in **Figure 3**. The depths of the monitoring bores should be stated in Table 5-1 of Document #1.

Figure 3. Strong evidence of rainfall recharge at a shallow coal monitoring site (BH15)

Document #1 notes that “depressurisation of fractured and porous rock groundwater sources (by greater than 2 m) occurs up to 230 m above the Mandalong longwall panels”, and the “greatest depressurisation tends to occur up to 120 m above the longwalls”. This supports the assumption of a constant 140 m thick fracture zone in the groundwater model.

Document #1 notes that, at a few “monitoring locations that have shown depressurisation due to mining, groundwater levels have stabilised or started to gradually increase towards pre-mining levels approximately three to five years after undermining occurring”. The groundwater model is not showing this behaviour. Based on review of earlier reports, it is likely that the model does not deactivate any older longwall “drains” until all mining is finished; this prevents recovery from occurring. If active pumping is occurring in the older panels, this is the correct modelling procedure.

Groundwater quality statistics for pH and electrical conductivity (EC) are summarised in Appendix C of Document #1 for 29 alluvial bores and 35 non-alluvial bores. This is a substantial dataset, but it plays no direct role in the development of a groundwater flow model.

7. Model Predictions

The approval conditions call for a comparison of predicted and actual groundwater impacts.

The first comparison of substance is that of mine inflow. **Figure 4** shows the range of predicted mine inflows for a number of sensitivity analysis models in 2014, while **Figure 5** shows a comparison of one of those models (“Model 7”) with current predictions for Run 24 (being the favoured realisation of several tested alternatives).

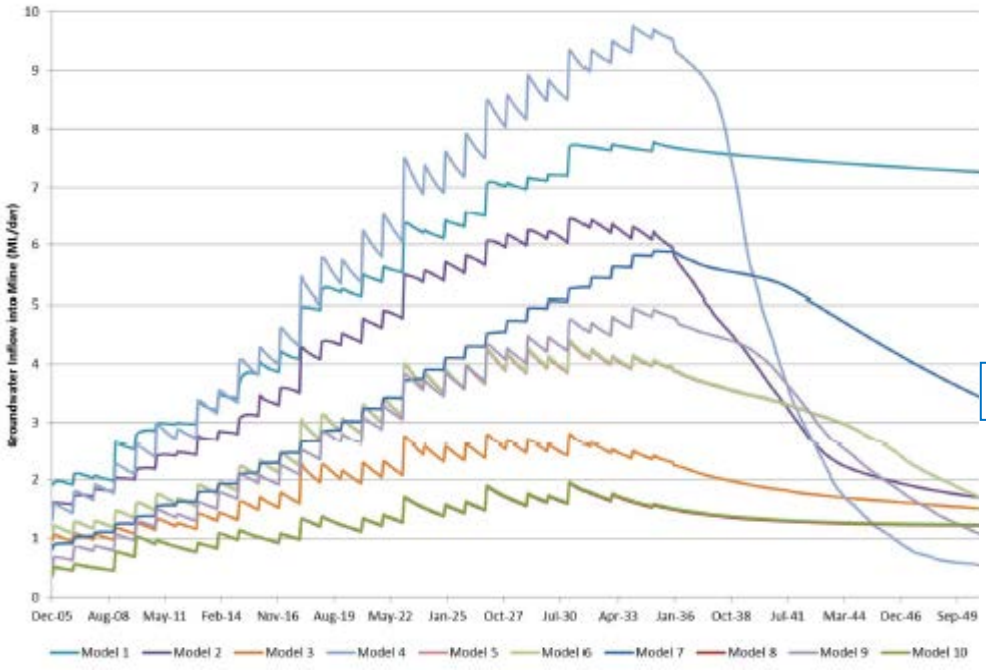


Figure 4. Sensitivity analysis predictions of mine inflow for model runs in 2014

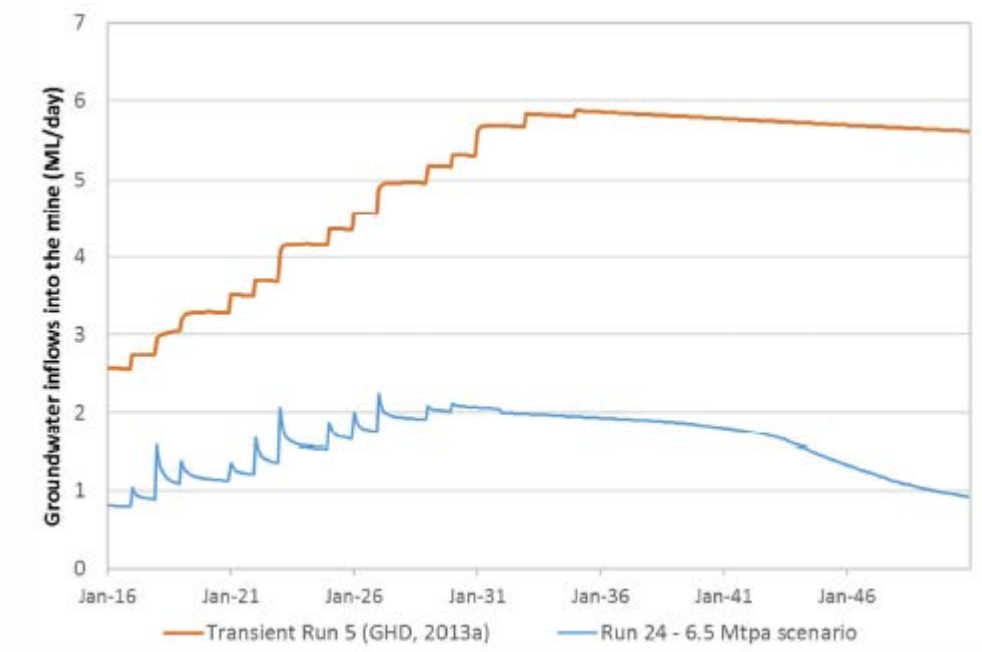


Figure 5. Comparison of the 2014 base case model predicted mine inflow with current Run 24 model [the actual mine inflow at January 2016 was about 0.8 ML/day]

It is clear from **Figure 5** that the predicted mine inflow is now much lower than previously reported. It follows that any environmental impacts or drawdown effects at private bores would now be much less. The new model predicts no more than 10 cm drawdown on the water table in alluvium or outcropping Triassic sandstone. In the Permian overburden, however, the 2 m drawdown extent is predicted to be wider due to the incorporation of lower storage properties in the model. Section 6.4.1 in Document #1 examines the potential impact on 31 registered private bores (Table 6-6) and concludes that only four bores lie within the 2 m drawdown extent and, due to their elevations or operational status, none is likely to be affected by more than 2 m drawdown.

As the previous assessment in 2014 did not offer predicted drawdowns at individual bores, and no measurements of water levels are undertaken at private bores, it is not possible to conduct a comparison of predicted with actual drawdown effects.

8. Model Effectiveness

The approval conditions call for a review of the effectiveness of the groundwater model.

Now that the model gives a good replication of actual mine inflows from 2013 to 2015, confidence is much improved as to the likelihood of predicted environmental impacts.

There are still issues with the model that should be addressed at the next revision. The calibration of transient groundwater levels, in the form of hydrographs, really should be better. **Figure 6** shows a good calibration, while **Figure 7** shows a poor comparison in which the actual mining effect, if there is one, is short-lived. The latter shows some rainfall correlation (shown in **Figure 8**) which should be tested in the model by introducing time-varying rainfall recharge. In general, the alluvial hydrographs have a strong rainfall signature. The reason they should be replicated by the model is that they provide the best control over assumed rainfall recharge fractions and assumed specific yield in the upper model layers.

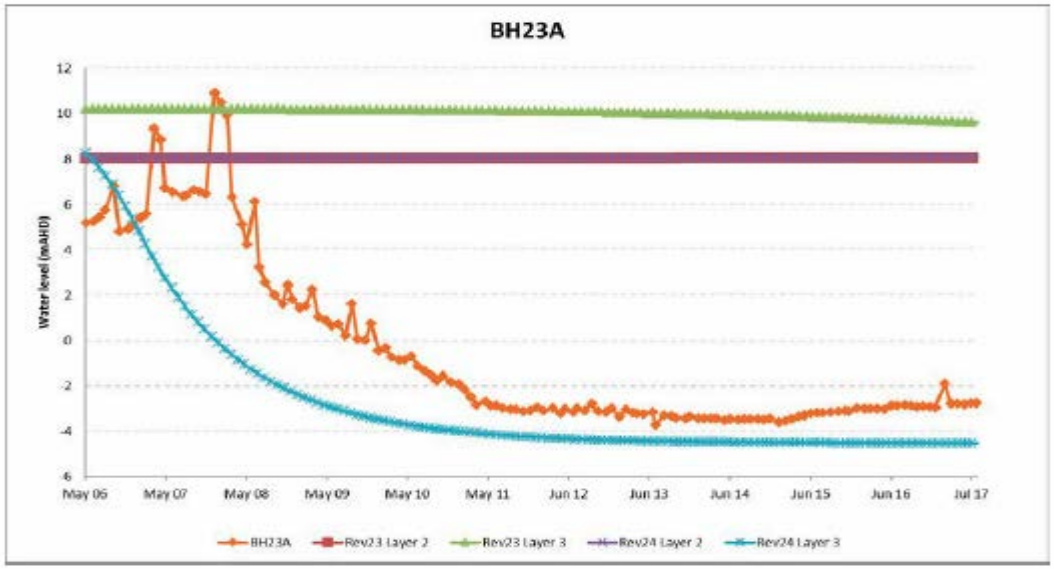


Figure 6. Good hydrographic correlation at BH23A (over LW14)

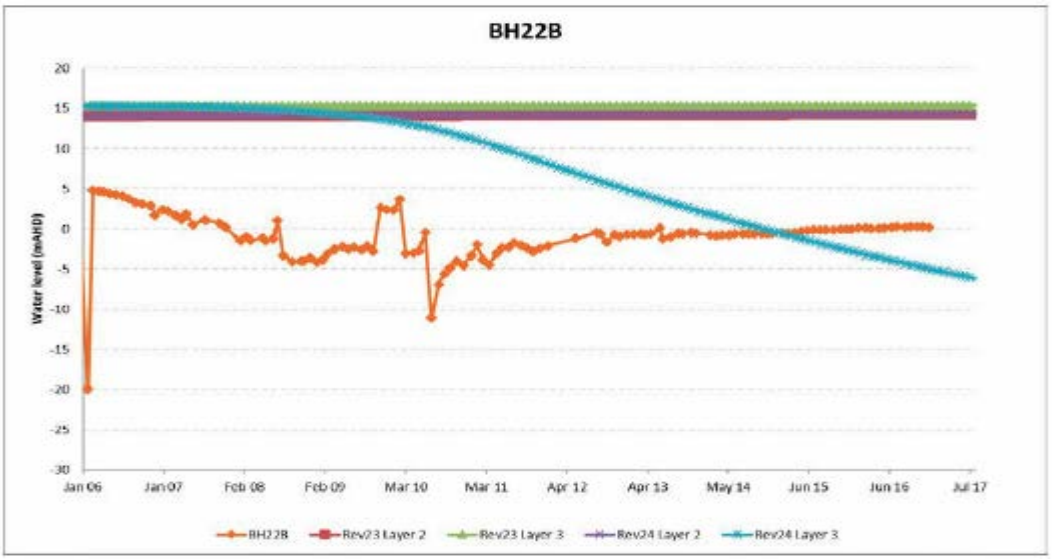


Figure 7. Poor hydrographic correlation at BH22B (over LW4/5)

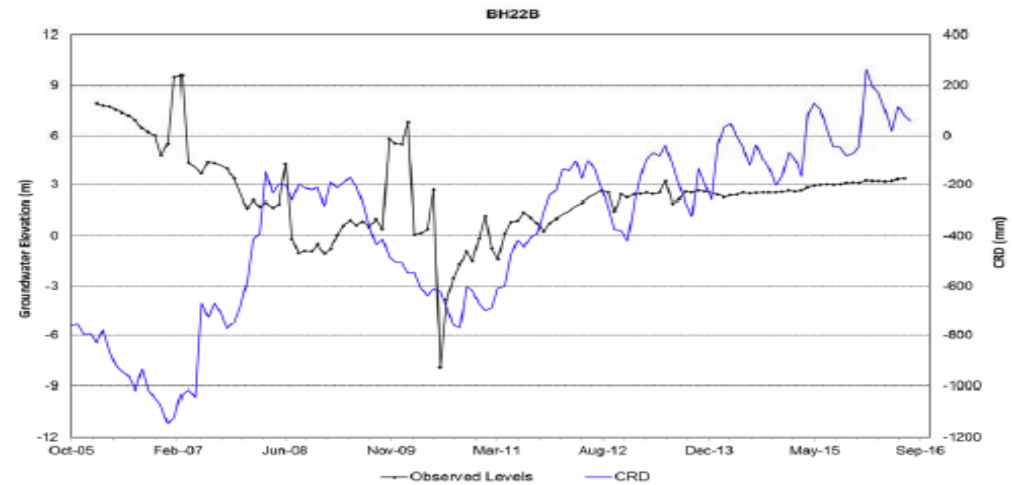


Figure 8. Hydrographic correlation at BH22B (over LW4/5) initially with mining and then with rainfall

There is a concern that there is too much rainfall recharge in the model. The evidence for this is provided in Table 6-1 of Document #1 [**Table 1** in this report], which reports the water balance components at 2018 and 2036. During 2018 and 2036, respectively, there is a net gain of 1,474 ML/year (that is, 1,859-385) and 869 ML/year (that is, 1,611-742) in groundwater held in storage despite the continuation of mining. The storage reduces by 605 ML/year (that is, 1,474-869) while the mine inflow increases by 364 ML/year (that is, 760-396). The baseflow to streams increases from 2018 to 2036, from 3,606 to 3,835 ML/year, contrary to expectations (unless depressurised groundwater levels are recovering). As the mining drains are still active at all longwall panels until the end of mining, recovery in the model is not able to happen. A contour map of positive and negative water level changes from 2018 to 2036 is required to shed light on the reason for these unexpected results.

	Proposed conditions			
	2018		2036	
	Alluvium and outcropping rock [2] (ML/year)	Rock (ML/year)	Alluvium and outcropping rock [2] (ML/year)	Rock (ML/year)
INPUTS				
Recharge	4,055	0	4,055	0
GHB [3]	1,326	351	1,323	349
Storage	5	380	1	741
Other zones	537	574	554	576
TOTAL INPUTS	5,923	1,305	5,933	1,666
OUTPUTS				
Drains [4]	3,606	396	3,835	760
GHB [3]	229	27	232	30
Storage	1,514	345	1,290	321
Other zones	574	537	576	555
TOTAL OUTPUTS	5,923	1,305	5,933	1,666

Table 1. Water balance for 2018 and 2036 (part Table 6-1 of Document #1))

The simulated hydrograph for bore BH06A in Document #3 (page 6) clearly shows an increasing water level for three of the four plots.

At Section 6.2.3 in Document #1, there is a statement “that there would not be an increase in the vertical migration of alluvial groundwater to underlying groundwater sources as a result of the proposed extension of Longwall 24 and the addition of Longwall 24A”. While this is likely, it has not been demonstrated. Rather, Table 6-1 of Document #1 [**Table 1** in this report] has demonstrated that there is a quantified take of an extra 15 ML/year [that is, (574-537)-(576-554) for “other zones”] in 2036, compared to the take in 2018. The extra take over the duration of LW24-24A could be quantified.

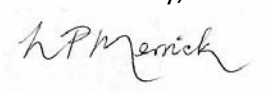
Another statement in Document #1 at page 63 (paragraph 1) should be corrected: “*The gradual drop in groundwater pressure suggests that discontinuous fractures may have developed in the rock overlying the mine workings at these locations*”. A drop in groundwater pressure provides no indication of fracturing, as groundwater pressures must decline from the effect of an underlying sink even if the intervening rock is compact. This erroneous view has surfaced lately in other documents and is giving lay readers a false impression of the facts.

9. Conclusion

As a concluding remark, the groundwater model should be regarded as a work in progress, as are all groundwater models. The current model is a significant improvement over the previously reviewed model but there should be a commitment to ongoing model improvement as mining proceeds.

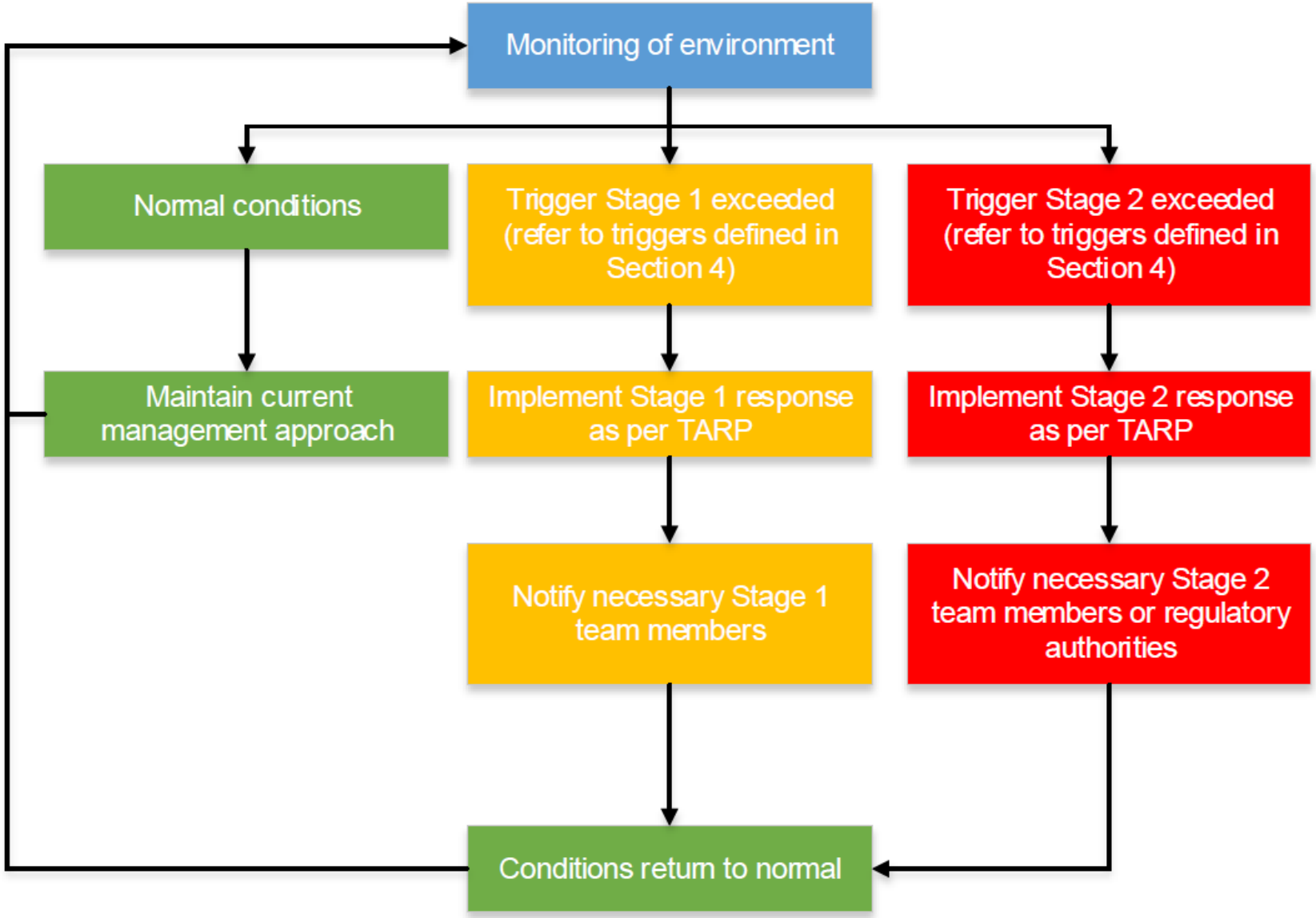
Although more work could have been done to improve transient calibration, the model is considered sufficiently *fit for purpose*, as required by the Aquifer Interference Policy, on the strength of the corresponding cause-and-effect analysis of effects observed during prior and current mining, and good replication of recent mine inflows.

Yours sincerely,



Dr Noel Merrick

Appendix G – Trigger action response plans


Monitoring of environment
Normal conditions
Trigger Stage 1 exceeded (refer to triggers defined in Section 4)
Trigger Stage 2 exceeded (refer to triggers defined in Section 4)
Maintain current management approach
Implement Stage 1 response as per TARP
Implement Stage 2 response as per TARP
Notify necessary Stage 1 team members
Notify necessary Stage 2 team members or regulatory authorities
Conditions return to normal

Aspect	Normal	Trigger 1	Trigger 2	Response
Groundwater environment				
Groundwater quality	Monitored groundwater quality within or below values presented in Table 4-3, Table 4-4, Table 4-5 and Table 4-6.	Monitored groundwater quality is outside or above the Stage 1 values presented in Table 4-3, Table 4-4, Table 4-5 and Table 4-6 for three consecutive monitoring rounds. Monitored groundwater quality is outside or above the Stage 2 values. **Action: Review recent monitoring results and any relevant operational data (e.g. mining activities, meteorological data).** **Undertake investigation to determine if the change in groundwater quality is due to mining-related activities.**	Investigation into Stage 1 trigger identified that change in groundwater quality is due to mining related activity. Community complaint to Centennial Mandalong regarding groundwater quality. **Action: If environmental impacts are unacceptable and/or if the beneficial use of the groundwater changes, remediation options will be considered as per Appendix D.** **Loss of water supply from an adjacent landholder will need to be replaced by Centennial Mandalong.**	**Trigger 1: Notify Environment and Community Coordinator/ Mine Manager as soon as non-conformance is detected.** **Trigger 2: Notify relevant agencies in accordance with Pollution Incident Response Management Plan (PIRMP) requirements or if material harm has occurred.** **Notify Department of Planning, Industry and Environment (DPIE-Water) and any potentially affected landowners as soon as practicable if the investigation into the Stage 1 trigger identifies that change in groundwater quality is due to mining related activities.**

Aspect	Normal	Trigger 1	Trigger 2	Response
Groundwater level	Monitored groundwater levels are greater than values presented in Table 4-2.	Monitored groundwater levels are below the values presented in Table 4-2. **Action: Review recent monitoring results and any relevant operational data (e.g. mining activities, meteorological data).** **Investigate the source of the exceedance.**	Investigation into Stage 1 trigger identifies that trigger exceedance is due to mining-related activity. Community complaint to Centennial Mandalong regarding groundwater levels. Drawdown at any water supply work exceeds 2 m. **Action: Verify whether monitoring results are consistent with hydrogeological model predictions and consider recalibration.** **Loss of alluvial groundwater may need to be licensed under the water sharing plan.** **If predicted environmental impacts are unacceptable, develop and implement corrective/preventative actions based on the outcomes of the investigation, as per Appendix E.**	**Trigger 1: Notify Environment and Community Coordinator/ Mine Manager as soon as non-conformance is detected.** **Trigger 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.** **Notify DPIE-Water and any potentially affected landholders as soon as practicable if the investigation into the Stage 1 trigger identifies that change in groundwater levels is due to mining related activities.**

Aspect	Normal	Trigger 1	Trigger 2	Response
Watercourse and flooding				
Flooding	Subsidence levels are within predictions. No increase in post mining out of channel flood levels identified by flood model. Increase in ponding consistent with flood modelling predictions (Umwelt 2020). **Action: Continue flood monitoring and modelling for each Extraction Plan.**	Subsidence levels are 1.5 times greater than predicted Increase in post mining out of channel flood depths causing ponding above predicted. Remnant ponding area exceeds the extent of predictions by the flood model. **Action: Determine extent of increase in flood depths and if any potential loss of vegetation or land area due to inundation.** **Consult with ecologist, landowners and government departments on whether mitigation measures are required to improve water drainage.**	Subsidence levels two times greater than predicted Significant increase in post mining out of channel flood depths causing ponding. Significant increase in remnant ponding area which exceeds the extent of predictions by the flood model. **Action: Verify whether monitoring results are consistent with flood model predictions and consider recalibration.** **Refer to Appendix E for potential engineering solutions.** **Consult with ecologist, landowner and government departments on flood drainage remediation measures and implement/report effectiveness of measures.**	**Trigger 1: Notify Environment and Community Coordinator/ Mine Manager as soon as practicable.** **Trigger 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.** **Notify DPIE-Water as soon as practicable.**

Aspect	Normal	Trigger 1	Trigger 2	Response
Water quality	Water quality at monitoring locations are within or below SSGVs provided in Table 4-1 (for Morans Creek) or consistent with historical baseline (for other watercourses).	Water quality is outside or above SSGVs provided in Table 4-1 (for Morans Creek) or not consistent with historical baseline for at least one parameter for two consecutive sampling events. **Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors.** **Investigate the source of the exceedance and .**	Investigation into Stage 1 trigger identifies that trigger exceedance is due to operational activity. Community complaint to Centennial Mandalong regarding surface water quality. **Action: determine if an incident has potentially occurred.** **Increase monitoring frequency and undertake additional monitoring where relevant.** **Develop and implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and additional monitoring, as per Appendix E.**	**Trigger 1: Notify Environment and Community Coordinator/ Mine Manager as soon as exceedance is detected.** **Trigger 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.** **Notify DPIE-Water as soon as practicable if Stage 2 exceedance is found to be mining related.**

Aspect	Normal	Trigger 1	Trigger 2	Response
Water flow	Creek flow rates and relationships with rainfall are consistent with historical baseline results.	Reduction in flow compared with historical baseline results and reference sites. **Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors.** **Investigate the source of the reduction in flow and develop corrective/ preventative actions based on outcomes.**	Loss of flow compared with historical baseline results and reference sites. Community complaint to Centennial Mandalong regarding surface water flow. **Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors.** **Determine if an incident has potentially occurred and investigate the sources of the loss of flow.** **Develop and implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and additional monitoring, as per Appendix E.** **Loss of water supply from an adjacent landholder will need to be replaced by Centennial Mandalong.**	**Trigger 1: Notify Environment and Community Coordinator/ Mine Manager as soon as non-conformance is detected.** **Trigger 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.** **Notify DPIE-Water as soon as practicable if loss in flow is mining related.**

Aspect	Normal	Trigger 1	Trigger 2	Response
Geomorphic condition and watercourse stability				
Watercourse instabilities	Watercourse monitoring indicates no areas of instabilities due to subsidence. **Action: Continue site inspections in accordance with the monitoring program.**	Watercourse monitoring indicates one or more areas of instabilities in watercourses possibly as a result of subsidence impacts. **Action: Review historical monitoring records.** **Investigate the factors contributing to the instability, which may include advice from technical specialists.** **Implement corrective actions as required as soon as practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation.** **Increase monitoring frequency and undertake additional monitoring where relevant.**	Watercourse monitoring indicates one or more areas of instabilities in watercourses possibly as a result of subsidence impacts. Causing sediment loads to migrate and/or impact to riparian vegetation. **Action: Immediately isolate areas of instability and implement remediation measures to stabilise surface and/or watercourse.** **Investigate the factors contributing to the instability, which may include advice from technical specialists.** **Implement corrective/preventative actions based on the outcomes of the investigation and/or additional monitoring. Prioritise actions based on the risk to the environment and likelihood of further impact.** **Increase monitoring frequency and undertake additional monitoring where relevant.**	**Trigger 1: Notify Environment and Community Coordinator/ Mine Manager as soon as practicable.** **Trigger 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.** **Notify DPIE-Water as soon as practicable.**

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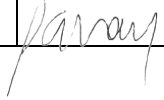
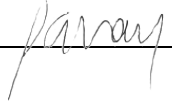
12533794-90933-1/https://projectsportal.ghd.com/sites/pp01_01/mandalongminelw3033e/ProjectDocs/12533794-REP-ExtractionPlan_WMP_LW30-31.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	I Gilmore T Tinkler	S Gray		S Gray		2/12/2020
1	I Gilmore T Tinkler	S Gray		S Gray		22/12/2020
2	I Gilmore T Tinkler	S Gray		S Gray		10/06/2021
3	I Gilmore T Tinkler	S Gray		S Gray		21/06/2021

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