

MANGOOLA OPEN CUT

GLENORE



Groundwater Management Plan



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Document History

Version	Date Reviewed	Review Team	Nature of the Amendment
0	November 2008	Mangoola Coal, GSS	Initial Mangoola Coal GWMP approved by DoP on 5 th January 2009
1	July 2010	Mangoola Coal, Umwelt	Reviewed for operational phase and submitted for approval (no further comment from DoP).
2	December 2010	Mangoola Coal	Addressed comments from DoP and re-submitted in December 2010. DoP had no further comments on this version.
3	February 2013	Mangoola Coal, Susan Shield (Umwelt)	3-yearly review and Modification 4 update – submitted for approval in Feb 2013.
4	September 2013	Mangoola Coal, Susan Shield (Umwelt)	Defined monitoring frequency at private bores (as per DP&I feedback). Added GW26/ GW078396 (existing EPL monitoring site missing from plan). Approved 11/09/2013.
5	July 2014	Mangoola Coal/DP&E	Modification 6, licence and monitoring location update. Approved by DP&E 22 nd December 2014.
6	January 2017	Mangoola Coal NSW EPA DPI Water 10/02/2017	Revised monitoring program; and revised impact assessment criteria for flow/no flow conditions. Removed duplication with Water Management Plan. Updated monitoring data. Incorporated findings of AGE Groundwater review 2016.
7	May 2017	Mangoola Coal	Updated following consultation with DPI Water.
8	November 2017	Mangoola Coal	Updated following DPE review.
9	May 2018	Mangoola Coal	Updated following groundwater trigger level review in consultation with CLWD (formerly DPI Water). Revision included groundwater level and quality trigger review completed by AGE in May 2018.
10	August 2018	Mangoola Coal	Updated following consultation with NRAR (formerly CLWD) and subsequent recommendations.
11	January 2019	Mangoola Coal	Updated following further consultation with NRAR.
12	November 2019 March 2020 July 2020	Mangoola Coal	Updated following comments and recommendations from NRAR dated 13 August 2019. Updated following comments and recommendations from NRAR dated 2 March 2020. Updated following comments and recommendations from NRAR dated 17 June 2020.
13	April 2022	Mangoola Coal	Overall updated GWMP to include MCCO, updated baseline data and trigger approach to align with Development Consent (SSD 8642) and RTS.
14	October 2022	Mangoola Coal	Updated following comments and recommendations from DPE Water dated 23 September 2022.
15	October 2024	Mangoola Coal	Full review of Management plan Update to reflect the 3-year numerical groundwater model calibration. Section 1.3 provides a list of the changes/updates.

Number: MANOC-1276546935-7

Status: [Document Status (Office)] **Effective:** [Effective Date]

Owner: Coordinator – Environment & Community

Version: [Document Version (Office)] **Review:** [Planned Review Date]

Page 2 of 120

Table of Contents

1.	Introduction	5
1.1	Project Description.....	5
1.2	Purpose and Scope.....	5
1.3	Updates in this version.....	5
1.4	Roles and Responsibilities	6
1.5	Definitions and acronyms.....	6
2.	Statutory Obligations.....	8
3.	Summary of the Groundwater Regime	9
4.	Groundwater Infrastructure.....	11
4.1	Existing monitoring network	11
4.2	Additional Monitoring Sites.....	13
4.3	Private groundwater users	13
4.4	Cumulative Impacts and Monitoring Locations.....	14
5.	Summary of Baseline Data	15
5.1	Groundwater Level.....	15
5.1.1	Climate influence	15
5.2	Groundwater Quality	16
5.2.1	Colluvium and weathered bedrock along Big Flat Creek	16
5.2.2	Permian strata	16
5.2.3	Beneficial use.....	16
5.3	Predicted Impacts	17
6.	Data Collection Methodology	18
6.1	Monitoring Standards	18
6.2	Groundwater Levels.....	18
6.3	Groundwater Quality	19
6.4	Additional baseline monitoring	19
6.5	Groundwater Dependent Ecosystems	19
6.6	Groundwater Quantity.....	21
6.6.1	Groundwater Licencing.....	23
6.7	Groundwater Seepage.....	23
7.	Data analysis Methods	25
7.1	Groundwater Level.....	25
7.2	Groundwater Quality	27
7.3	Groundwater Quantity	30
8.	Trigger Action Response Plans	32

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: Coordinator – Environment & Community

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 3 of 120

8.1	Performance Measures	32
8.2	Groundwater triggers values	33
8.2.1	Background.....	33
8.2.2	Groundwater Levels.....	34
8.2.3	Groundwater Quality	38
8.3	Trigger Action Response Plans.....	41
8.4	Compensatory Water Supply guiding principles, complaint management and reporting protocol	51
8.4.1	Compensatory water supply guiding principles	51
8.4.2	Community Complaints.....	52
8.4.3	Dispute resolution	52
9.	Environmental Performance Review and Improvement Program	53
9.1	Annual Review	53
9.2	Monitoring Equipment	53
9.3	Reporting of groundwater take for exploration activities.....	53
9.4	Groundwater Model.....	53
9.5	GWMP review and revision	53
9.6	Privately owned groundwater bores.....	54
10.	Contingency Plan	55
10.1	Contingency measures	55
10.1.1	Big Flat Creek.....	55
10.2	Unforeseen impacts protocol	57
11.	References	58
	Appendix A - Regulatory requirements	60
	Appendix B - Groundwater Monitoring Network	65
	Appendix C - Summary of Baseline Data.....	75
	Appendix D - Graphical Summary.....	85
	Appendix E - Trigger Charts	94

1. Introduction

Mangoola Coal Operations Pty Limited (Mangoola Coal) operates Mangoola Open Cut, which is an open cut coal mine located in the Muswellbrook Local Government Area, approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman (refer to Figure 1-1 in the Water Management Plan (WMP)).

1.1 Project Description

Project Approval 06_0014 was granted in June 2007 for the construction of the open cut coal mine and associated infrastructure, with mining commencing in September 2010. In April 2021, State significant development (SSD) consent SSD 8642 was granted for the Mangoola Coal Continued Operations (MCCO) Project (refer to the WMP for the detailed Project description). On 21 November 2022, Mangoola surrendered MP 06_0014 in accordance with Schedule 2, Condition A15 of SSD-8642.

1.2 Purpose and Scope

This Groundwater Management Plan (GWMP) has been prepared to fulfil the requirements of SSD 8642, under which Mangoola Open Cut operates, and to satisfy other relevant statutory requirements that are applicable to Mangoola Open Cut (refer to Section 1.5 of the WMP and Section 2 of this GWMP).

The GWMP outlines the groundwater data collection/analysis methods, baseline data, performance measures, trigger thresholds and Trigger Action Response Plans (TARPs).

1.3 Updates in this version

Table 1-1 provides an overview of the changes made in this updated version of the Mangoola GWMP.

Table 1-1 Changes in this updated GWMP version

GWMP Section	Section Title	Change
4.1	Existing monitoring network	All newly drilled groundwater monitoring bores (which was in progress during the period of the last GWMP update in 2022) are now included in the monitoring network. No additional monitoring locations are proposed and will be reviewed during the next update.
4.2	Additional monitoring sites	Update section to acknowledge that all recently drilled monitoring location are added to Section 4.1 and no additional sites planned
4.3	Private groundwater users	Update Table 4.2 with updated predicted drawdown from the 2023/2024 model calibration (AGE, 2024b)
5.3	Predicted Impacts	Align section with the recent numerical groundwater model calibration
6.4	Additional baseline monitoring	Mangoola Coal completed this monitoring in line with the commitments in section 6.4.

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: Coordinator – Environment & Community

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 5 of 120

GWMP Section	Section Title	Change
6.6	Groundwater Quantity	Update to reflect the recent numerical groundwater model update
6.6.1	Groundwater Licencing	Update to reflect the recent numerical groundwater model update
8.1	Performance Measures	Review Table 8-1 and align with model update if necessary.
8.2.2	Groundwater Level Triggers	Hydrographs, in Appendix E Apply the most recent calibrated numerical groundwater model (AGE, 2024b). Adjust the Tier 1 Triggers and calculate triggers for the bores indicated with 'tbd' in Table 8-2. Recalculate Tier 2 Triggers based on the calibrated model. Reset the baseline where required (as a result of rainfall patterns).
8.2.3	Groundwater Quality Triggers	Review trigger locations. Apply approved groundwater quality trigger methodology and add quality triggers for all new bores in Table 8-3. Review existing trigger levels and update if needed.
8.3	Trigger Action Response Plans	Review the TARP tables and update where find necessary to align with updated triggers and most recent numerical groundwater model calibration (AGE, July 2024).
9.3	Groundwater Model	Indicate that model has been validated and calibrated in 2023/2024.
Appendixes	Hydrographs	Update hydrographs and plot against updated triggers
All		Update to aerial images General administrative and formatting update

1.4 Roles and Responsibilities

Refer to Section 1.6 of the WMP.

1.5 Definitions and acronyms

The terminology utilised within this GWMP is defined in Table 1.3 of the WMP and Table 1-2 below.

Table 1-2 Terminology Utilised Within the GWMP

Term	Definition
µs/cm	microSiemens per centimetre - the standard measure of electrical conductivity and is used to indicate the salinity level of water
Annual Review (AR)	Annual Review as per SSD8642 Schedule 2, Part D, Condition D11.
AGE	Australasian Groundwater and Environmental Consultants Pty Ltd

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: Coordinator – Environment & Community

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 6 of 120

Term	Definition
AHD	Australia Height Datum. Used to indicate elevation.
Alluvium	Sediment consisting of silt, sand, clay and/or gravel deposited by a flowing stream or floods in a valley.
Aquifer	A water bearing sediment or rock formation.
ANZECC	Australia and New Zealand Environment Conservation Council
Bore/Borehole	A hole formed by boring or auguring
Colluvium	Soil or debris that accumulates at the base of a slope by mass-wasting or sheet erosion typically comprising of unsorted angular fragments close to the source.
CRD	Cumulative rainfall departure
EA	Environmental Assessment
EC	Electrical Conductivity
EIS	Environmental Impact Statement
ECM	Mangoola Environmental and Community Manager
EPL	Environmental Protection License
GWMP	Groundwater Management Plan
Groundwater	Sub-surface water which is within the saturated zone. The upper surface of this saturated zone is called the water table.
Incident	A set of circumstances that: causes or threatens to cause material harm to the environment; and/or breaches or exceed the limits or performance measures/criteria in this plan or associated approval
MCCO	Mangoola Coal Continued Operations
ML	Megalitres or millions of litres, e.g. 5 ML is the same as 5,000,000 litres.
NRAR	NSW Natural Resources Access Regulator
pH	A measure of acidity.
Piezometer	A small diameter bore lined with a slotted tube used for determining the standing water level for groundwater.
PIRMP	Pollution Incident Response Management Plan
Saline Water	Water from the project's saline water management system as described in the Environmental Assessment.
SWMP	Surface Water Monitoring Plan
Tailings	Fine residual waste material separated during the coal preparation process.
TARP	Trigger Action Response Plan
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WMP	Water Management Plan

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: Coordinator – Environment & Community

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 7 of 120

2. Statutory Obligations

This GWMP has been prepared in accordance with the development consent, SSD 8642. Appendix A - presents the consent conditions relevant to the GWMP and identifies where each condition has been addressed in this plan. Refer to Section 1.5 of the Mangoola WMP for the detailed regulatory framework and obligations.

3. Summary of the Groundwater Regime

The regional groundwater regime is comprised of; a shallow unconfined aquifer associated with alluvial deposits along the main drainages of Wybong Creek and Sandy Creek, a shallow colluvial and weathered zone minor aquifer along Big Flat Creek, and a deeper confined system primarily associated with the coal seams. The wider coal measures strata provide limited groundwater storage and transmission capacity, and the interburden and overburden lithologies possess very low hydraulic conductivities.

Groundwater recharge to the Permian strata occurs via rainfall to the ground surface infiltrating into the formations through the soil cover and weathered profile. The alluvial and colluvial sediments are also recharged by seepage through creek beds when these are flowing. Groundwater-surface water interactions occur along Wybong Creek and Sandy Creek, but not along Big Flat Creek where the water table is below the bed of the creeks and the colluvium is largely unsaturated occurring as a surficial capping of limited thickness (AGE, 2019a). Groundwater flow directions prior to mining were a subdued reflection of topography and aligned with the major drainage lines in the area (Umwelt 2006) (refer to Figure 3-1).

Groundwater is typically brackish to saline in quality in all areas except within the alluvium along Wybong Creek and Sandy Creek. The salinity is the main constraint to beneficial use of groundwater in the region with all bedrock geological units having a water quality that is often unsuitable for aquatic ecosystems, irrigation, or potable consumption (AGE 2019a).

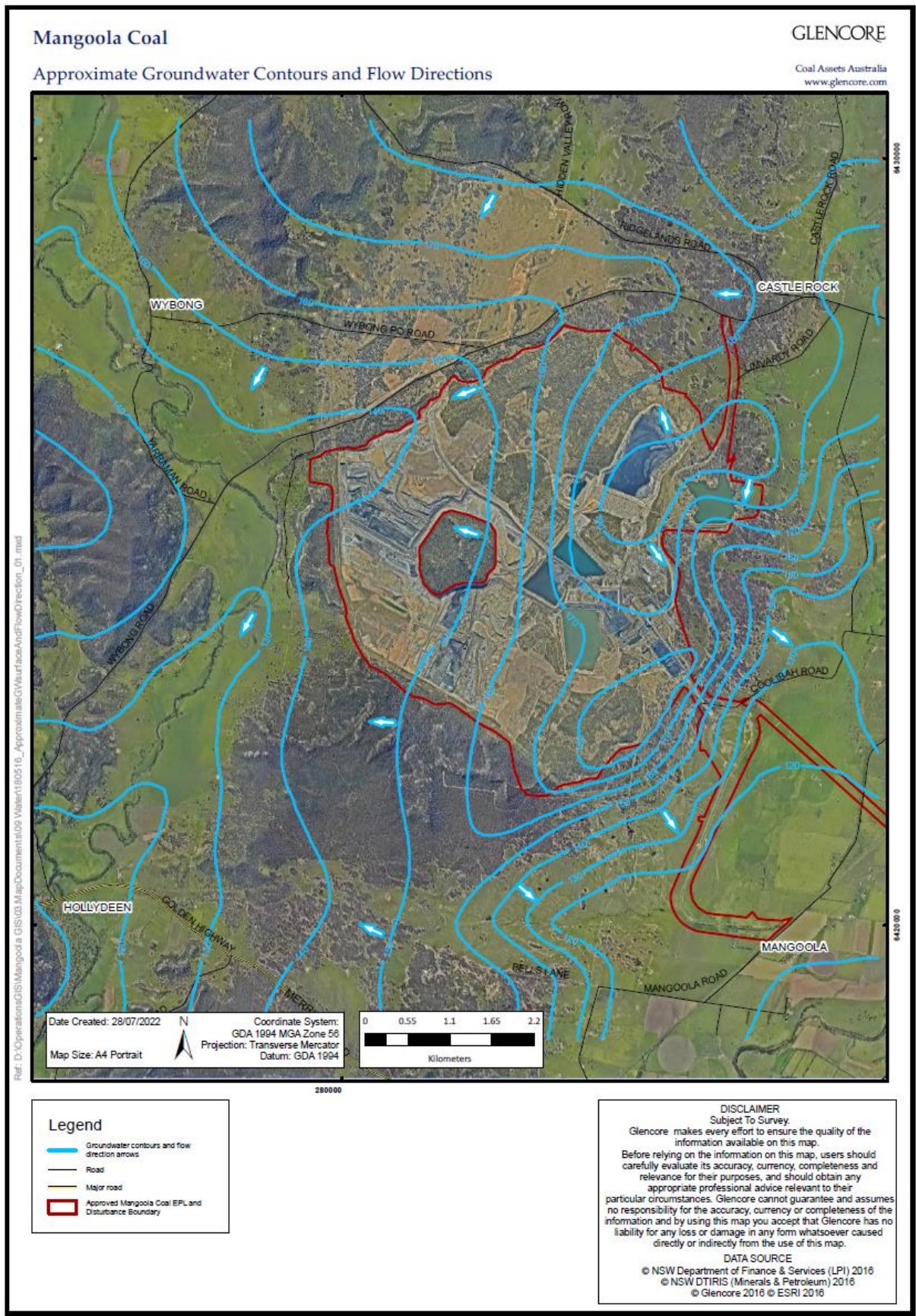


Figure 3-1 Approximate Groundwater Contours and Flow Directions

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: Coordinator – Environment & Community

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 10 of 120

4. Groundwater Infrastructure

4.1 Existing monitoring network

A network of uPVC groundwater monitoring bores and vibrating wire piezometers (VWPs) has been installed at Mangoola to monitor the influence of approved mining activities on the groundwater regime. The number of monitoring bores utilised at the site changes over time as new monitoring bores are installed to collect data in future mining areas, and sites within the approved mining footprint go dry, and/or are gradually removed as mining passes through. The location and target geology for the monitoring sites are shown on Figure 4-1.

Currently groundwater monitoring is undertaken at 65 monitoring locations. Figure 4-1 shows the location of the monitoring sites, with the details (including the monitoring frequency) for each monitoring site are summarised in Appendix B. The monitoring frequency adopted is:

A subset of monitoring points is used as compliance bores and have had trigger thresholds calculated for water levels and/or water quality, as discussed in Section 8.2. Groundwater monitoring points GW04 and GW26 are monitoring points 10 and 11 under the site's Environmental Protection Licence (EPL) 12894.

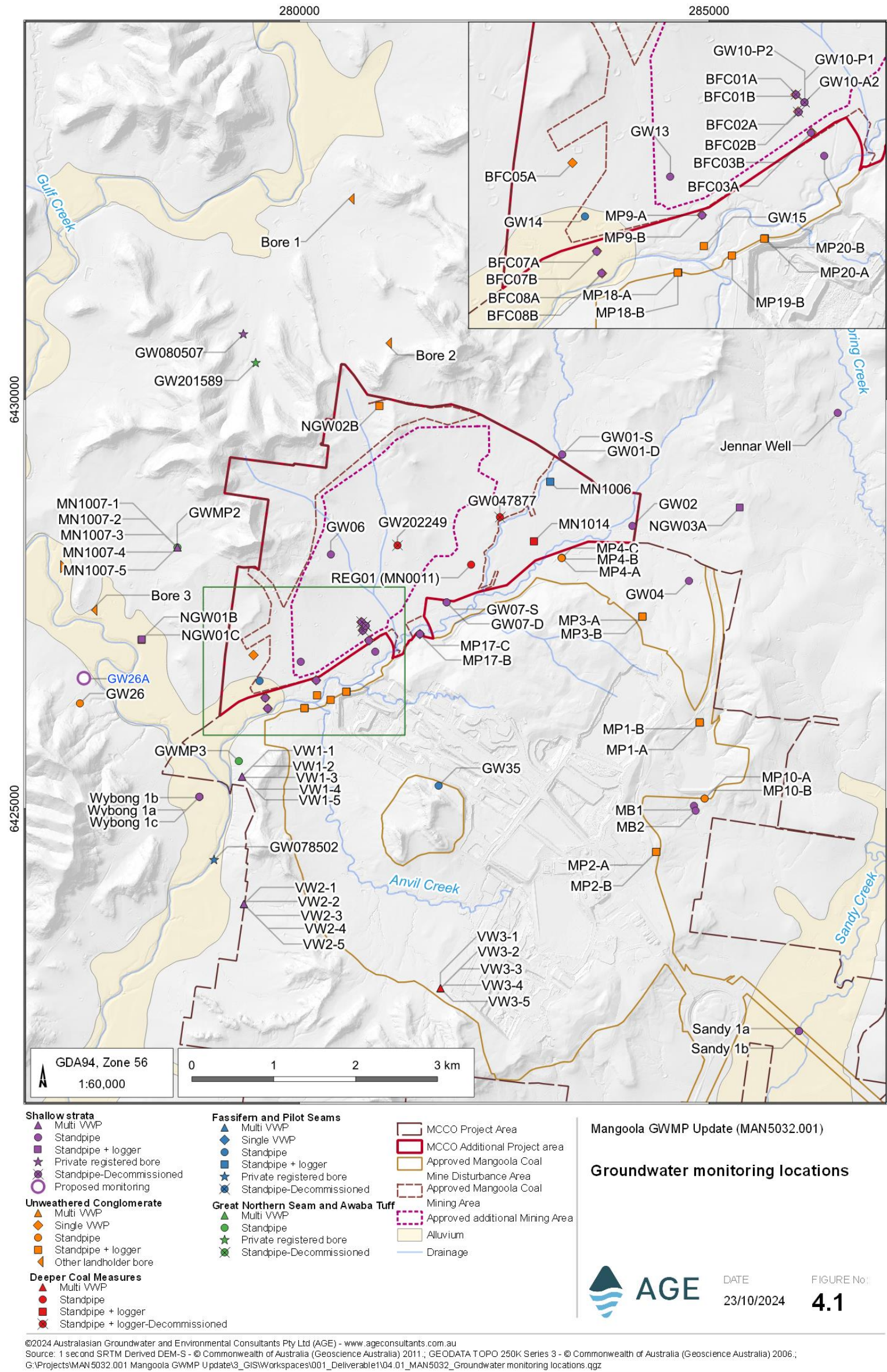


Figure 4-1 Groundwater monitoring locations

4.2 Additional Monitoring Sites

The groundwater impact assessment prepared for MCCO concluded that a number of additional groundwater monitoring locations should be added to the monitoring network to assess baseline conditions as per the MCCO EIS (Umwelt 2019a). The locations of the newly installed groundwater monitoring sites are shown Figure 4-1 with a summary of the construction details for each site provided in Table 4-1. These bores were installed between late 2022 and mid 2023. No additional monitoring bores are proposed for the 2024/2025 period.

Table 4-1 Additional monitoring bores installed between late 2022 and mid 2023 and added to the groundwater monitoring program

Bore ID	Easting (m)	Northing (m)	Target geology	Nominal Depth (m)
Wybong1a *	278777	6425143	Alluvium	20
Wybong1b *	278777	6425143	Unweathered conglomerate	40
Wybong1c *	278777	6425143	Great Northern Seam	50
Sandy 1a *	286099	6422280	Alluvium	20
Sandy 1b *	286099	6422280	Permian non-coal inter-burden	70
GWMP1a	277913	6422707	Alluvium	20
GWMP1b	277913	6422707	Great Northern Seam	30
GWMP2	278509	6428191	Great Northern Seam	140
GWMP3	279259	6425580	Great Northern Seam	69
GW26A **	277367	6426593	Weathered rock or alluvium	25
NGW01_D **	278062	6427044	Conglomerate	33
NGW01_E **	278060	6427042	Conglomerate	112

Notes: Coordinates GDA94/MGA Zone 56.

* Groundwater level trigger and quality triggers derived for these bores.

** The additional sites above (GW26A and NGW01_D and NGW01_E) have been added to ensure the monitoring network provides sufficient data to determine if the project performance measures are being met.

4.3 Private groundwater users

The majority of registered bores and wells within the predicted groundwater impact zone are situated on Mangoola Coal landholdings. There are a small number of water supply bores located on private properties at the locations on Figure 4-1.

Condition B39 of SSD 8642 requires that prior to commencing construction of the MCCO Project, the owners of the private water supply bores listed in

Table 4-2 may request Mangoola Coal monitor the groundwater level within their bore to determine if there are any impacts from mining activities over time. If monitoring records drawdown of more than 2 m as a result of mining, Mangoola Coal must provide compensatory water in accordance with SSD 8642 conditions B41 to B45.

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 13 of 120

On 17 May 2021 Mangoola Coal offered monitoring to owners of the bores listed in

Table 4-2 in accordance with the requirements of SSD 8642. Bore-specific monitoring plans have been developed according to the time frames provided in

Table 4-2.

Table 4-2 – Private Bore Monitoring

Bore ID*	Receiver ID*	Predicted Groundwater Drawdown (m) [#]	Bore inspected and monitoring plan developed **
Bore 1	R261	0.3	Non-responsive landholder.
Bore 2	R157	5.9	Non-responsive landholder
Bore 3~	R130	1.5	Yes, Aug 2021
GW080507	R144	0.05	Yes, May 2022
GW201589	R144	0.1	Yes, May 2022
GW078502	R83	24.1	Non-responsive landholder.

Notes: * The receiver IDs and bore locations are presented in SSD 8642 Appendix 3.
 [#] Originally outlined in the MCCO Project EIS (Umwelt 2019a) and as updated in the MCCO Project RTS (Umwelt 2019b). The drawdown predictions were updated after the 3-year model calibration in 2024 (AGE, 2024b).
 ** As per SSD 8642.
 ~Private agreement in place with landowner

4.4 Cumulative Impacts and Monitoring Locations

No other mining operations exist within the numerical groundwater domain and the cumulative drawdown for both the existing Mangoola operations and MCCO Project is covered by this GWMP.

Number: MANOC-1276546935-7

Status: [Document Status (Office)] **Effective:** [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] **Review:** [Planned Review Date]

Page 14 of 120

5. Summary of Baseline Data

5.1 Groundwater Level

Groundwater level monitoring data indicates that pre-mining groundwater levels in the deeper hard rock and coal measure aquifers in the area were relatively consistent, with water levels fluctuating according to climatic conditions at the time. Monitoring bores close to the active mining area within the mining footprint or along Big Flat Creek have recorded falling water levels from around late 2014 when the mine floor advanced below the water table. Drawdown in these areas was predicted in groundwater modelling and was not unexpected (refer to Appendix D - for the summary graphs). A summary of the baseline groundwater data is provided in Appendix C.

5.1.1 Climate influence

The cumulative rainfall departure (CRD) statistics graph (Figure 5-1) is plotted with groundwater level hydrographs (as indicated in Section 7). The baseline groundwater level data period will be adjusted and statistical data recalculated after extreme weather periods and climate influences are considered for any trigger events. For example, Figure 5-1 shows a prolonged dry period occurred between 2017 and 2024 with above average rainfall in 2021 and 2022. Recently the 2023 period indicated below average rainfall with above average rainfall again in YTD 2024.

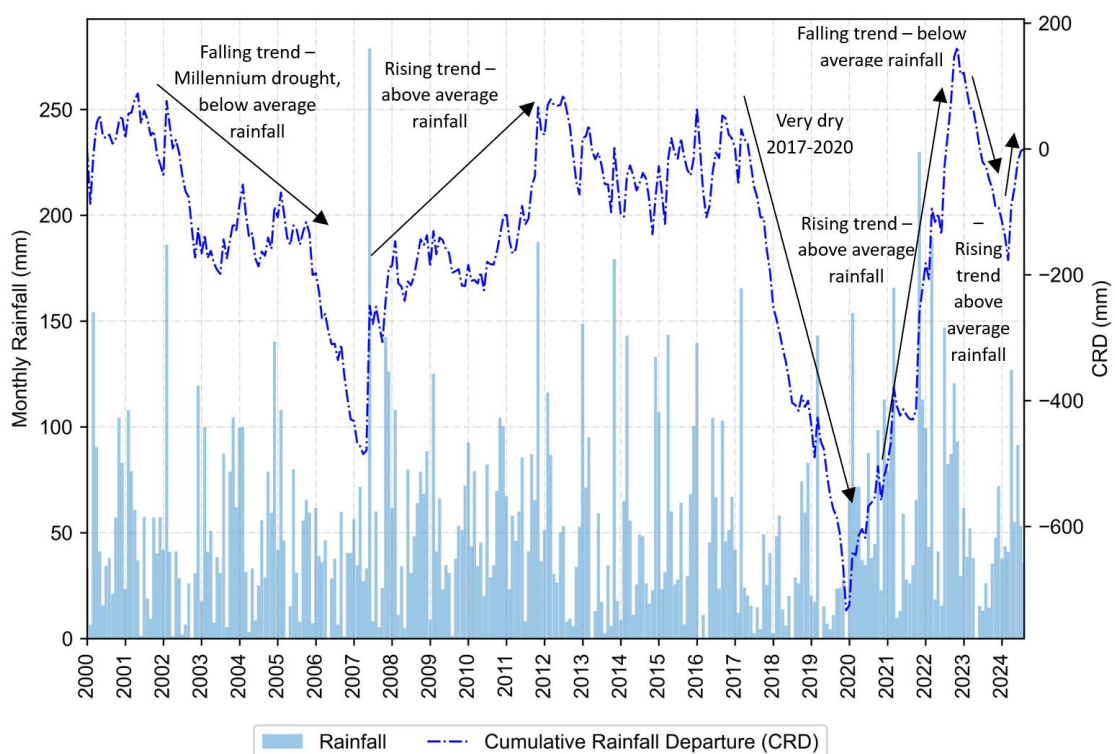


Figure 5-1 CRD

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 15 of 120

5.2 Groundwater Quality

Statistical data for EC and pH is provided in Appendix C - and trend graphs in Appendix D -.

5.2.1 Colluvium and weathered bedrock along Big Flat Creek

The highest EC levels generally occur in the colluvium and weathered bedrock along Big Flat Creek and the lower reaches of Anvil Creek. pH values range from 5.4 to 9.2 with a median of approximately 7.2. EC values have a very wide range from ~1,000 $\mu\text{S}/\text{cm}$ to 36,300 $\mu\text{S}/\text{cm}$, with a median bore EC of approximately 12,870 $\mu\text{S}/\text{cm}$, indicating a typically brackish water quality.

5.2.2 Permian strata

The monitoring bores in the surrounding unweathered Triassic and Permian bedrock typically return pH readings of between pH 6 and pH 9.5. Median bore pH is approximately 7.2, which is the same as for the weathered bedrock.

EC results are highly variable and individual values range from <1,000 $\mu\text{S}/\text{cm}$ to >30,000 $\mu\text{S}/\text{cm}$, with a median bore EC of approximately 8,000 $\mu\text{S}/\text{cm}$. This median bore value is approximately half of that typically seen in the weathered zone along Big Flat Creek.

5.2.3 Beneficial use

Salinity is the key constraint to groundwater beneficial use and can be classified on a scale ranging from fresh to extremely saline according to concentrations of total dissolved solid (TDS). FAO (2013) provide categories for salinity based on TDS concentrations as summarised in Table 5-1 below. There is one monitoring bore that can be classified as fresh water and two more sites which are brackish, with the majority classified as moderately saline to brine.

Table 5-1 Salinity classifications (AGE, 2019a)

Category	TDS	Number of Mangoola monitoring bores within this range
Fresh water	<500 mg/L	1
Brackish (slightly saline)	500 to 1,500 mg/L	2
Moderately saline *	1,500 to 7,000 mg/L	21
Saline	7,000 to 15,000 mg/L	37
Highly saline	15,000 to 35,000 mg/L	38
Brine	>35,000 mg/L	2

Note: ANZECC (2000) Stock Water Guidelines: Maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, **5,000 mg/L for beef cattle (EC 7500 $\mu\text{S}/\text{cm}$)**, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.

Bores located in the Permian bedrock typically yield low volumes of water. Therefore, conglomerate and coal measures bores could only support low intensity uses such as stock watering. The colluvial material along Big Flat Creek is typically shallow, clay rich, and of higher salinity than the bedrock, which will also limit the beneficial use of this groundwater. Where bores abstract less saline water, this would be expected to become more saline over time as the water is replenished by more saline water from the surrounding strata. A higher number of bores have a salinity suitable for beef cattle watering.

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 16 of 120

5.3 Predicted Impacts

The Environmental Assessment for PA06_0014 (Umwelt, 2006) includes the modelled prediction for the depressurisation of the water table and coal seams. This has since been updated by a number of modifications to PA 06_0014.

In April 2021, State significant development (SSD) consent SSD 8642 was granted for the Mangoola Coal Continued Operations (MCCO) Project. This approval included the predicted groundwater drawdown captured in the MCCO EIS. A review of the site groundwater model by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (AGE 2022) concluded that the numerical model developed for the MCCO EIS (AGE 2019) generally replicated drawdown trends induced by mining in close proximity to the mining area. However further model calibration was required for the areas further west of the mine and the newly installed monitoring bore data was applied. The most recent update to the groundwater model was undertaken by AGE (2024b).

Groundwater levels have generally declined around the mining area as predicted by groundwater models. A number of model updates have provided the opportunity to refine the model predictions over time as more water level records became available from the site monitoring program. The drawdown estimates have changed over time as more monitoring data has become available to calibrate the models and the estimated hydraulic properties of the different geological units are able to be better defined at the regional scale.

Predicted inflows from the AGE, 2024b model is shown in Figure 6-2. As discussed in Section 6.6, predicted groundwater inflows are below the 700 ML/annum licence held by Mangoola to take from the porous rock aquifers and 254 ML/annum of licenses held by Mangoola to take water from the Wybong Creek Alluvium.

6. Data Collection Methodology

6.1 Monitoring Standards

Groundwater monitoring at Mangoola Coal is undertaken in accordance with the following standards and guidelines:

- Approved Methods for the Sampling and Analysis of Water pollutants in NSW (Department of Environment and Conservation 2004); and
- AS/NZS 5667.11:1998 Water Quality – Sampling – Guidance on Sampling of Groundwater’s.

All groundwater monitoring data is retained on site (in the Environmental Monitoring Database referred to as EMD) and is compared to predicted impacts and trigger thresholds on an ongoing basis. Monitoring records for EPL 12894 groundwater monitoring points are retained in accordance with EPL 12894.

6.2 Groundwater Levels

Natural fluctuations in groundwater levels occur in response to a range of stresses. These stresses can range from short term events, such as rainfall recharge events, or long-term events, such as multi-year drought. To capture the range of stresses, groundwater levels/pressures are measured both manually over longer time frames, and automatically over shorter time frames with pressure transducers and data loggers. The monitoring frequency is:

- **Daily** at VWP sites are equipped with data loggers to continuously monitor groundwater pressure at intervals which is converted to an equivalent water level (these sites are cemented into the borehole and do not allow measurement of groundwater quality). Downloads of these locations occurs monthly;

Daily using electronic water level loggers at private land holder properties that have agreed to the installation of measuring infrastructure and program - data is download on a quarterly basis (refer to

- Table 4-2); and
- **Monthly or bimonthly** (every two months) for the remainder of the monitoring bore network.

Groundwater level loggers have been installed at three of the six landholder bores (refer to

Table 4-2), where landholders approved the installation of measuring infrastructure to continuous monitoring levels and to download the data quarterly. In addition to the monitoring above, Mangoola also installed the following bores (also refer to Section 4.2) to further verify drawdown impacts;

- one standpipe cluster (three individual bores, Wybong 1a, b and c) in the Wybong Creek alluvial and shallow coal measures; and
- one standpipe cluster (two individual bores, Sandy 1a and b) into Sandy Creek alluvium and underlying coal measures.

Water levels in these bores have been monitored on a monthly basis since early 2023 to collect baseline data before transitioning to a bimonthly frequency.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 18 of 120

6.3 Groundwater Quality

The standpipe sites allow collection of water samples for field and laboratory determination of water quality. Samples are collected on bimonthly, six monthly and annual cycles. The water quality suites implemented are:

- bi-monthly - groundwater level, pH, Electrical Conductivity (EC) and nutrients (NOx);
- six monthly - as above plus ion speciation; and
- annually - as above plus TDS, major ions and heavy metals.

Details of monitoring parameters for each monitoring site are provided in Appendix B -.

6.4 Additional baseline monitoring

A requirement of the Statement of Commitment, Mangoola Coal committed to complete additional baseline monitoring along Big Flat Creek in the area adjacent the eastern flank of the out-of-pit emplacement area for a minimum of 12 months prior to the commencement of mining as requested. Mangoola Coal has completed this monitoring in line with these commitments. Monitoring at these sites will continue as per the I monitoring frequency outlined in Appendix B.

6.5 Groundwater Dependent Ecosystems

Vegetation potentially dependent on groundwater was considered as part of the MOCO EIS. Figure 6-1 shows the potential groundwater dependent ecosystems located in riparian zones along Wybong Creek and Big Flat Creek. Mangoola Coal undertake floristic monitoring of GDE's and riparian vegetation along Big Flat Creek in accordance with the Mangoola Coal stream health monitoring program outlined in the SWMP (Appendix D of the WMP).

The retained vegetation monitoring program includes a permanent monitoring plot within riparian ecosystems on Big Flat Creek. The monitoring locations are shown in Figure 6-1. The condition of the vegetation is assessed on an annual basis to identify any deterioration or improvement in condition.

The vegetation characteristics that are assessed and recorded as part of this monitoring include:

- floristic composition;
- general health of vegetation;
- evidence of natural regeneration;
- occurrence and abundance of weed species;
- presence of threatened or other significant species;

Groundwater level monitoring will be continued at sites MP17B and MP17C for the Big Flat Creek site and proposed Wybong1C along the Wybong Creek. If there is a deterioration in GDE health the process outlined in the TARP (Section 8.3) will be followed.

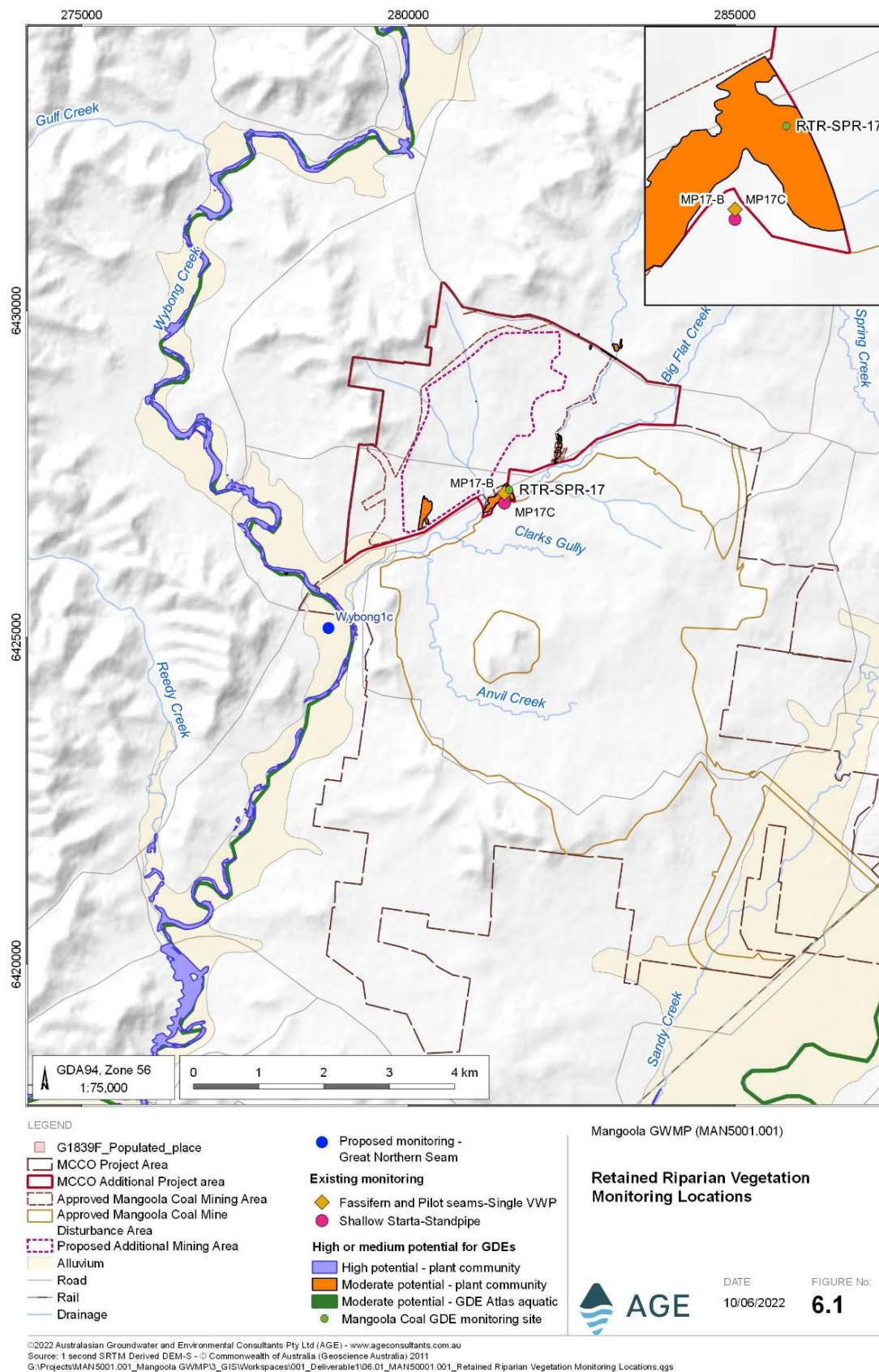


Figure 6-1 Retained Riparian Vegetation Monitoring Locations

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 20 of 120

6.6 Groundwater Quantity

Mangoola Coal record the volume of water extracted from the open cut pits during pit dewatering and compare the recorded volume with relevant water license limits. The volumes of water pumped from within the mine are measured via approved flow meters (or calculated by pump hours) as per the conditions of WAL 41561. The volume of groundwater inflow cannot be directly measured as it mixes with surface water. Therefore, the volume of groundwater is estimated using a water balance model that includes estimates of water from all other sources including pit dewatering, rainfall, and surface run-off. This is undertaken on a quarterly basis. The estimate of groundwater inflow into the mine water management system is included in the site water balance (Section 5 of WMP).

Proponents of aquifer interference activities are required to provide predictions of the volume of water to be taken from a water source as a result of the activity. Groundwater levels have declined in a zone adjacent to the mining areas as predicted prior to mining (as predicted by AGE, 2019a and EIS and approved by DPHI). The volume of groundwater entering the mine has been relatively low and well below the volumes predicted in the 2006 EIS. Estimates of groundwater inflow from the most recent groundwater model are shown in Figure 6-2 (AGE 2024b). The modelling indicates the peak groundwater inflow will occur in 2030 at approximately 170 ML and will be between 72 and 142 ML between 2024 and 2029.

Figure 6-3 shows the change in flux predicted by the numerical model within Wybong Creek alluvium due to the approved mining at the Mangoola Coal Mine. The modelling indicates the peak cumulative take will occur in 2030 at approximately 23 ML (AGE, 2024b), generally lower than the 2019 predictions (AGE, 2019a).

The estimated groundwater inflows are less than the 700 ML/annum of water units held by Mangoola to take from the porous rock aquifers. The estimated take from the Wybong Creek alluvium is less than the 254 ML/annum of water licenses units held by Mangoola to take from the alluvial aquifers. Refer to Section 6.6.1 below for the groundwater licence information.

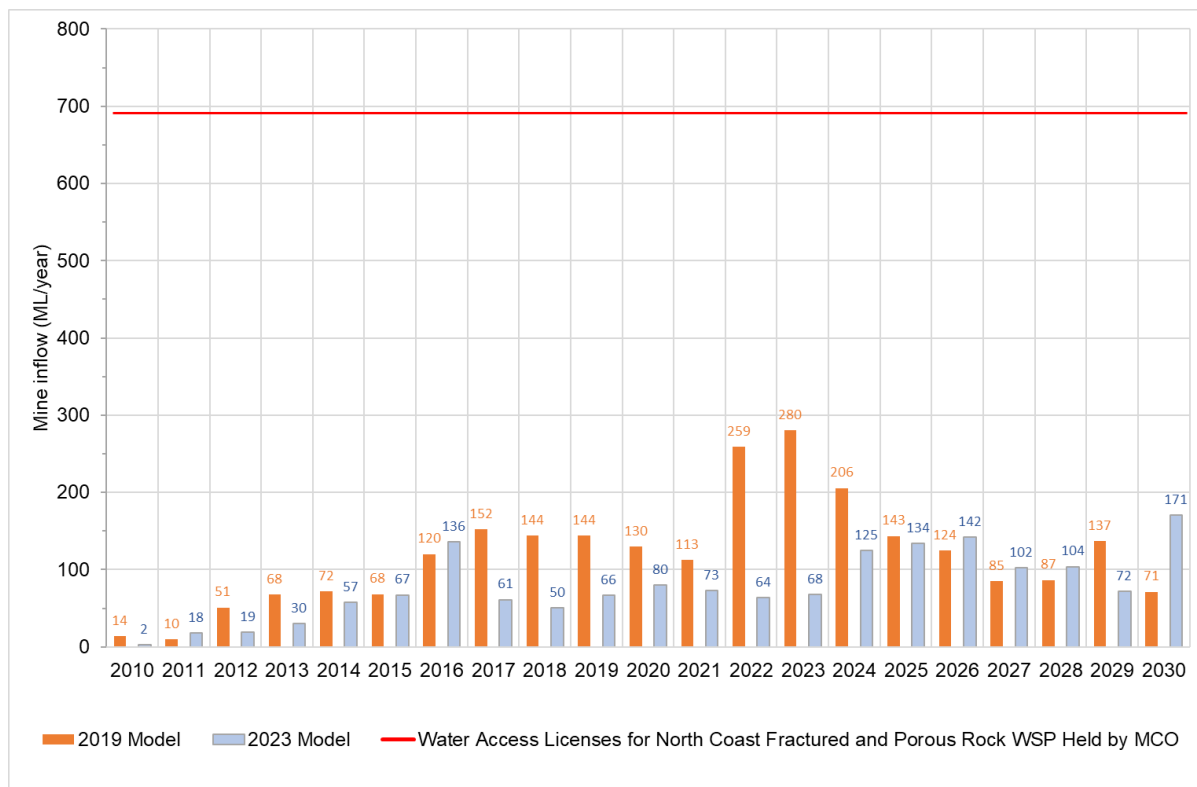


Figure 6-2 Predicted direct take of groundwater by approved mining (AGE, 2024b)

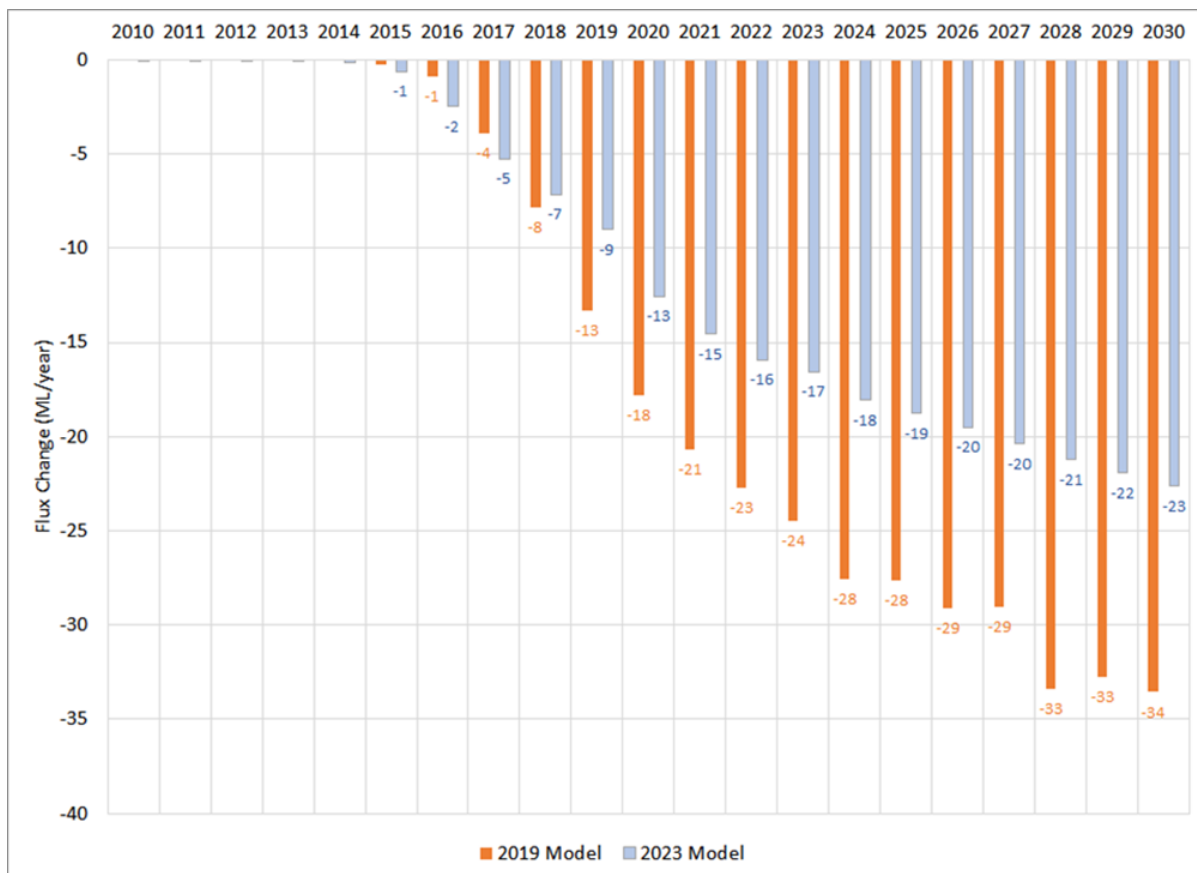


Figure 6-3 Change in influx to Wybong Creek alluvium from approved mining (AGE, 2024b)

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 22 of 120

6.6.1 Groundwater Licencing

The Aquifer Interference Policy (AIP) states that a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. In the case of the mining and the MCCO Project the take of water occurs incidentally during the mining process. This incidental¹ take of groundwater can induce flow from adjacent groundwater sources or connected surface water, which constitutes take of water under the New South Wales AIP. In all cases, separate access licences are required to account for the take from all individual water sources.

Groundwater is extracted from the open cut pit at Mangoola Coal. Mangoola Coal holds four water licences (refer to Table 6-1) for the extraction of groundwater. The licence details are included in Section 1.5.7 and Appendix F of the WMP. Mangoola Coal has water licences for the extraction of:

- 700 ML/annum groundwater from the porous rock aquifers which include the Permian Newcastle Coal Measures and Triassic Narrabeen Group sandstones and conglomerates; and
- 254 ML/annum incidental groundwater take from the alluvial aquifer associated with Wybong Creek².

Table 6-1 Water management Act 2000 Water Access Licences related to groundwater inflow

WAL	Share Component (units or ML)	Category	Water Source
11085	128	Aquifer	Wybong Creek
37027	30	Aquifer	Wybong Creek
37028	96	Aquifer	Wybong Creek
41561	700	Aquifer	Sydney Basin-North Coast Groundwater Source

As outlined in Section 1.5.6 and Section 1.5.7 of the WMP all groundwater associated with Mangoola Coal is managed under the Water Management Act 2000 with the commencement of the North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan on the 1 July 2016. The former Part 5 water licence was transferred to water access licences under the Water Management Act 2000.

6.7 Groundwater Seepage

The overburden and saline water storages are located up dip of the active mining areas which means that all seepage from these areas reports to the in-pit sumps which are actively dewatered. Therefore, seepage off site from the onsite water management system is not likely to occur due to secondary containment within the main storages of the active mine.

¹ Incidental water is defined in the Aquifer Interference Policy 2012 as “Water that is taken by an aquifer interference activity that is incidental to the activity; including water that is encountered within and extracted from mine workings, tunnels, basements or other aquifer interference structures that must be dewatered to maintain access, serviceability and/or safe operating conditions. This water is not actually required to be used as part of the process of carrying out that activity”.

² Condition B37 of request The Applicant must not use any licensable water from the Wybong Creek Water Source for mining purposes. This restriction does not apply to water used outside the project disturbance area for revegetation purposes associated with the implementation of the Biodiversity Offset Strategy, or to any licensable water within the project disturbance area that is collected as an incidental result of approved mining activities.”. This water is collected incidentally and satisfies this condition.

The Seepage Collection Sump (SCS) is constructed hydraulically downgradient of the Raw Water Dam (RWD) to collect seepages from the RWD. The hydraulic head pressure from the RWD causes saline groundwater seepage expression which is captured in the Sandy Creek Farm Dams (SCFD 1 and 2) and pumped back up to RWD for re-use. Figure 6-4 shows the conceptual model of the RWD seepage interception system (Engeny, 2020).

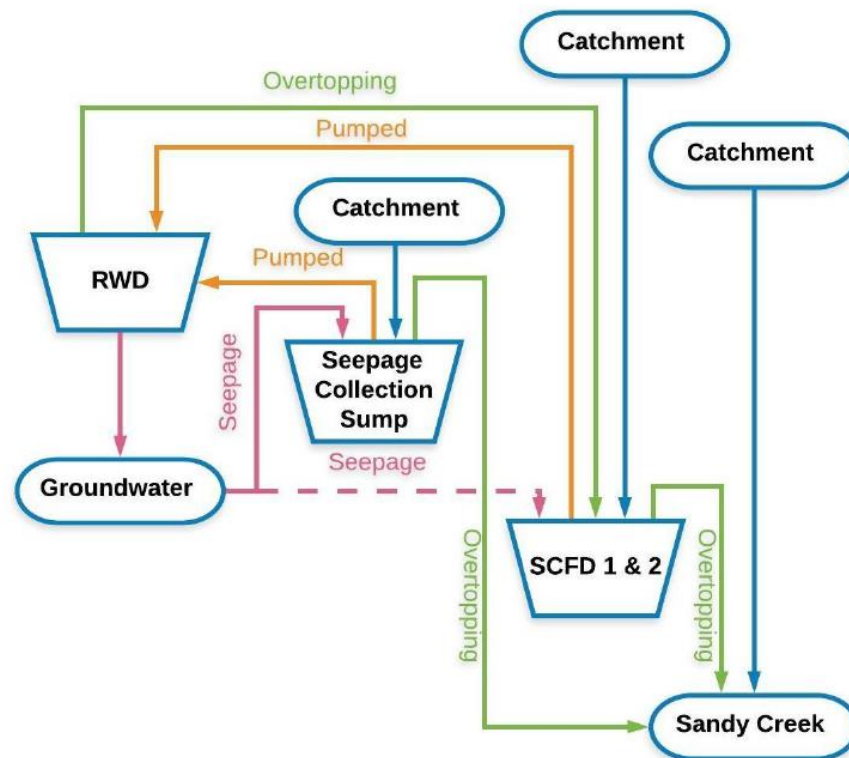


Figure 6-4 Conceptual model of the RWD seepage interception system (Engeny, 2020)

7. Data analysis Methods

7.1 Groundwater Level

The methods for analysis of groundwater level data are summarised in a flowchart in Figure 7-1. The flowchart outlines the pre-processing steps, including quality assurance/quality control (QA/QC), undertaken for groundwater level data analysis.

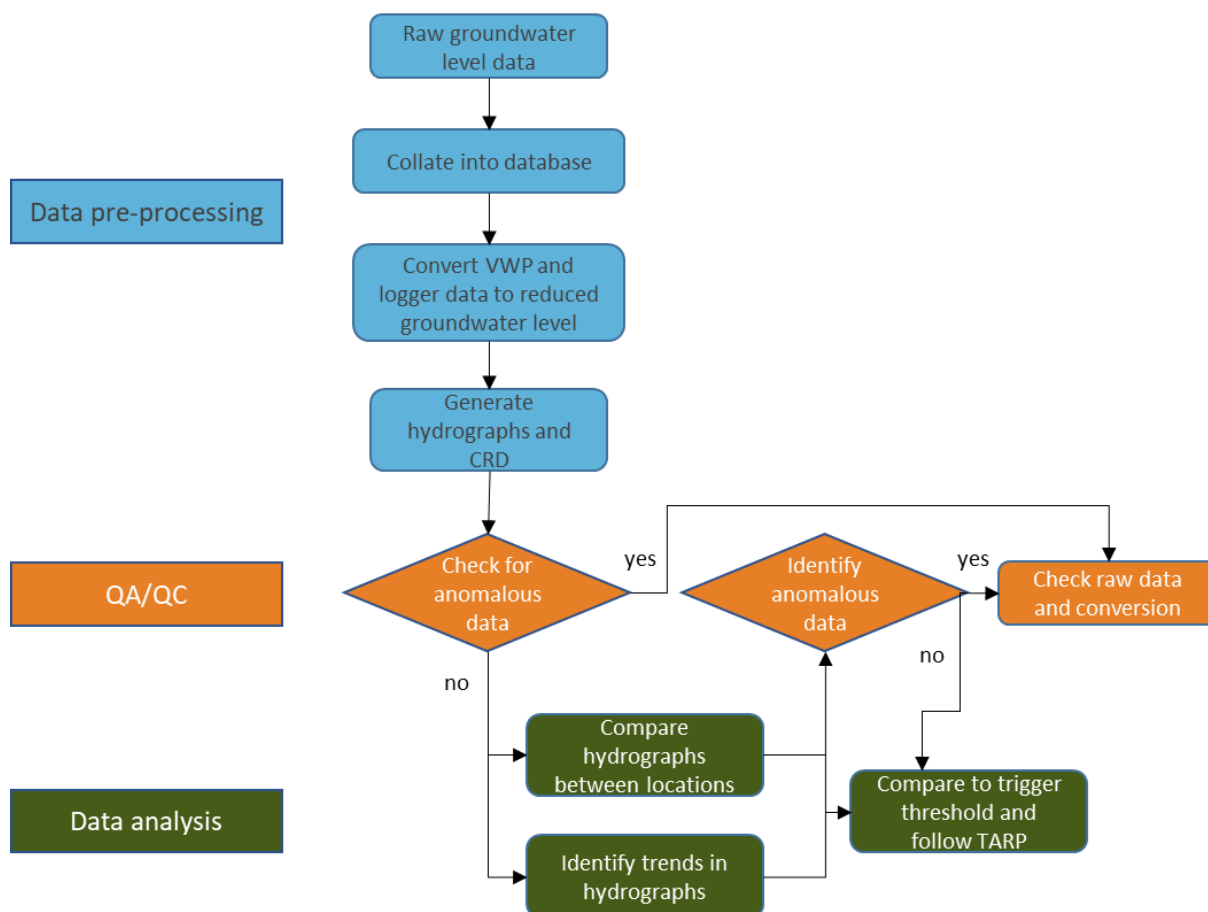


Figure 7-1 Groundwater level data pre-processing and analysis flowchart

As indicated in the flowchart, manual standing water levels and electronic pressure logger/VWP data will be converted to a reduced water level with respect to Australian height datum (m AHD). Pressure logger data will be adjusted to remove the effects of barometric pressure changes where required.

The water level data will be visualised as time series charts (hydrographs). An example hydrograph is provided in Figure 7-2. Hydrographs will be utilised as a tool to identify occurrence of anomalous data points, which can form part of the QA/QC process.

Once anomalous data points are rectified or removed³, the hydrographs will be used to understand the behaviour of water in the groundwater regime including:

- recharge/discharge events as indicated by the relationship to the Cumulative Rainfall Departure from mean (CRD);
- vertical hydraulic gradients at nested locations monitoring water levels in alluvial and Permian strata; and
- any depressurisation effects from Mangoola.

Hydrographs will be compared between monitoring locations to reveal more significant water level changes that could be a result of Mangoola activities. Where water level measurements are outside the trigger threshold the TARP process (as outlined in Section 8.3) will be initiated.

Horizontal flow directions within key hydrostratigraphic units with sufficient spatial data will be illustrated by piezometric contour maps prepared annually. These contour maps will be generated from monitoring data by connecting areas of equal groundwater elevation to create a two-dimensional representation of the piezometric surface. Comparisons of contour maps (Refer to the example in Figure 3-1) with previous time periods will provide information about changes in groundwater flow directions over time.

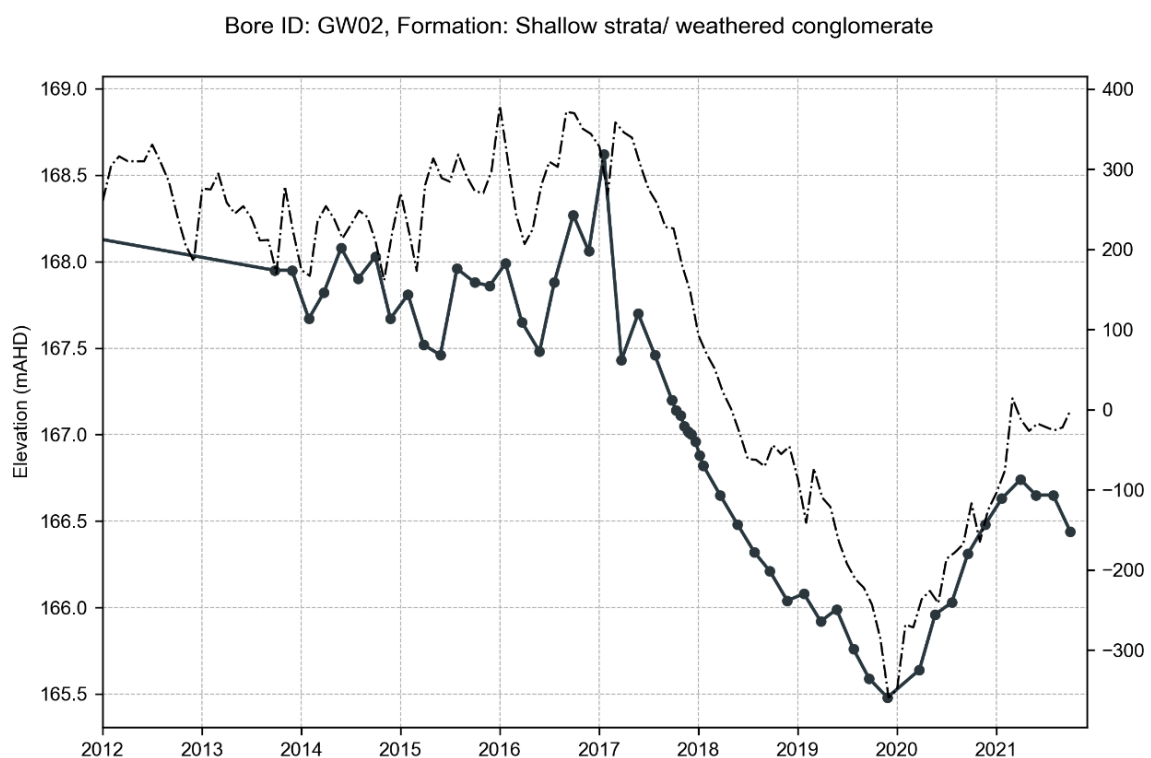


Figure 7-2 Example hydrograph with CRD (dotted line) for GW02, for analysis

³ Outliers or single point anomalies will be assessed. Outliers have the potential to skew statistics an outlier is a measured data point that is distant from other data points and normally identified based on four standard deviations from the mean and should be removed from the dataset used to calculate baseline statistics.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 26 of 120

7.2 Groundwater Quality

The selected groundwater monitoring bores will have water samples collected for water quality analysis and field pH and EC measurements. The methodology for analysis of groundwater quality data is summarised in the flowchart in Figure 7-3. Similar to the water level flowchart in Figure 7-1, this flowchart outlines the pre-processing, including QA/QC, as well as the steps that will be undertaken for groundwater quality data analysis.

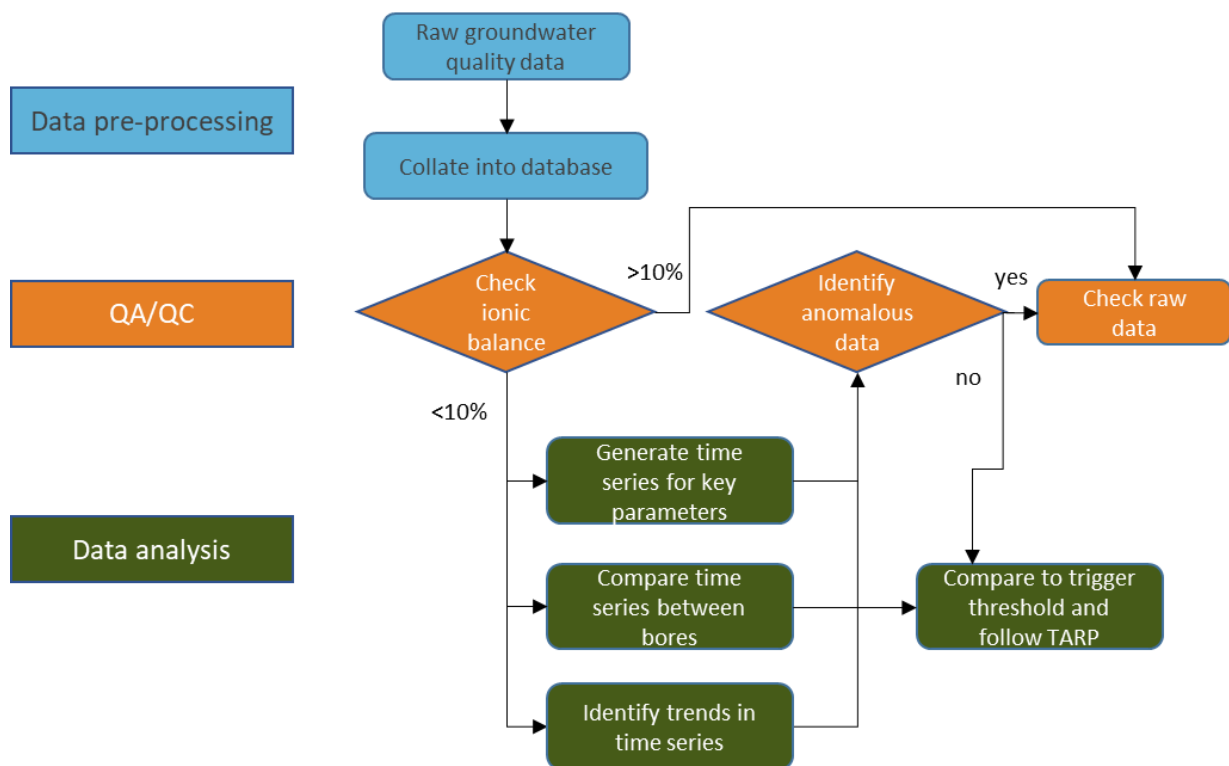


Figure 7-3 Groundwater quality data pre-processing and analysis procedures

Groundwater quality data will be pre-processed for analysis in a similar approach as the method adopted for groundwater levels. Field and laboratory results will be collated and tabulated in the database.

Groundwater samples with ionic balance beyond the $\pm 10\%$ range will be identified and the cause determined. If necessary, an additional sample will be collected for laboratory analysis within seven to 21 days of original sample (depending on urgency). Samples that are determined not to be representative will be flagged and removed in subsequent data analysis. Records of sampling method, sample transportation and laboratory consistency of reporting limits are also factors that could influence the occurrence of nonrepresentative values.

Similar to ionic balance, any outliers will be assessed in the same manner as the groundwater level data assessment.

Time series plots will be generated and included in the Annual Review for water quality indicators pH and EC that have trigger values as discussed in Section 8.2. The water quality trends will be compared with short-term and long-term water level trends.

For datasets with non-normal distribution, a rolling median will be calculated from the eight most recent data points and plotted on the time series charts (control chart).

Figure 7-4 shows an example of the stacked charts that will be generated and included in the Annual Review for each monitoring bore, and the trigger thresholds based on baseline data.

In addition, in identifying location-specific trigger thresholds for pH and EC, all field and laboratory analytes will be tabulated and compared against historical and recent trends in the Annual Review. Assessment of the water quality trigger thresholds discussed in Section 8.2; will provide information on existing and evolving conditions of the monitored hydrostratigraphy in the Annual Review..

A Piper diagram will be generated and reported within the Annul Review as a visualisation tool to understand the relative major ion abundance and water chemistry at each monitoring location. Piper diagrams are useful in identifying differing, or mixing, chemistry signatures between hydrostratigraphic units, and how signatures change over with time. An example Piper diagram prepared using major ion data from selected monitoring bores is provided in Figure 7-5.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

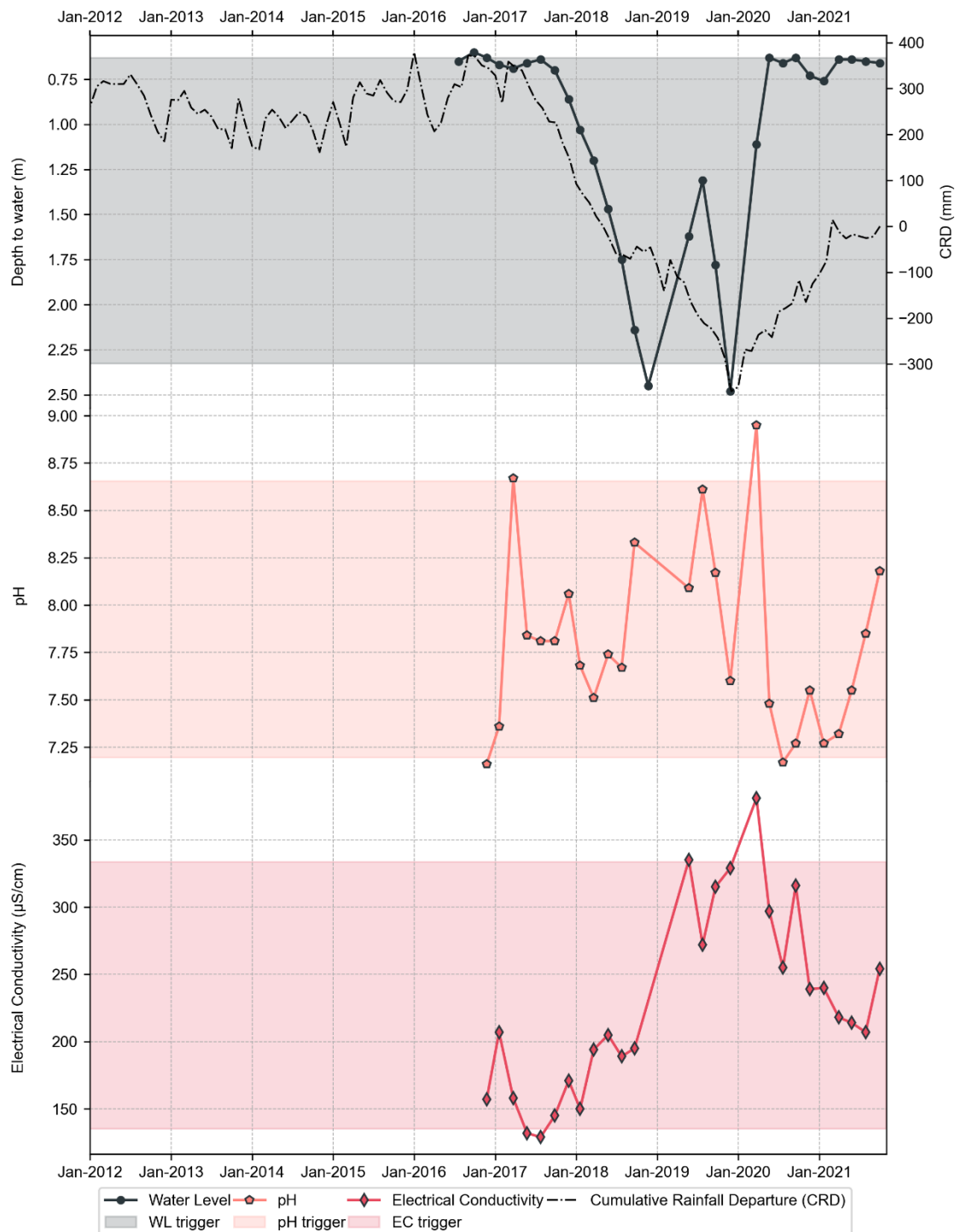
Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 28 of 120

Monitoring bore: GW06, Formation: unknown



Notes: Filled and unfilled symbology indicates concentration above and below limit of reporting respectively.

Figure 7-4 Example stacked water quality and water level charts

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 29 of 120

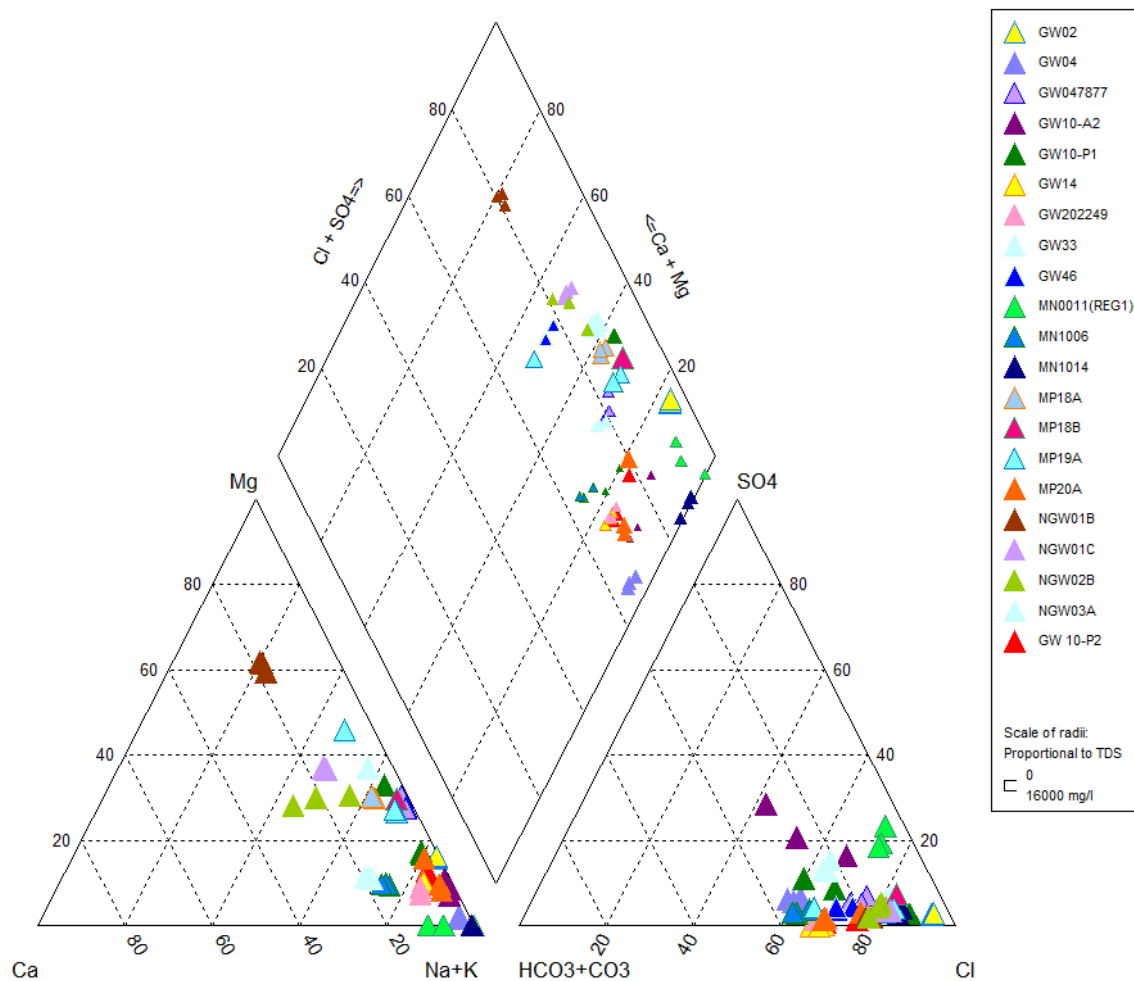


Figure 7-5 Example Piper Diagram (2017 water samples)

7.3 Groundwater Quantity

The volume of incidental groundwater take to the mining areas will be estimated each calendar year using the site water balance model. The site water balance method compares rainfall and runoff inputs to the pits with pumping outputs and storage changes to provide an estimate of pumpable incidental groundwater take from the mining areas. The site water balance model is updated at the end of each calendar year with the results provided in the annual review (refer to Section 5 of the WMP).

The development consent requires “a program to validate the groundwater model for the project, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions”. Every three years the numerical groundwater flow model will be reviewed, validated and if necessary calibrated (also refer to Section 9.4 of this GWMP). The numerical model simulates the subsurface flow of groundwater and provides estimates of incidental water take from the Mangoola pits and passive take from the surrounding alluvial aquifers.

These water takes will be reviewed as part of the annual review and be used as the basis for determining entitlements required to account for groundwater taken by the mine each calendar year.

The total volume of incidental (pit inflow) and passive (alluvial take) groundwater take will be tabulated each year and compared quantitatively with the licenced entitlements in the annual review.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 30 of 120

Different incidental take estimated by the site water balance method and groundwater modelling is not uncommon due to different underlying methodologies and assumptions. Where the water balance model and the numerical model provide differing estimates of groundwater inflow commentary on the potential cause will be provided within the annual review. A conservative approach will be undertaken utilising the highest estimates of groundwater inflow to the mining area to ensure adequate water licenses are held to account for the groundwater intercepted.

8. Trigger Action Response Plans

8.1 Performance Measures

Mining activities that intercept the water table or interfere with groundwater systems are considered aquifer interference activities under the AIP. The AIP describes minimal impact considerations for aquifer interference activities and includes a series of acceptable thresholds for water level and quality changes. The minimal impact consideration thresholds depend upon whether the water source is highly productive or less productive and whether the water source is alluvial or porous/fractured rock in nature. The minimal impact considerations described in the AIP have been adopted as the groundwater performance measures.

As indicated in Section 6.6, all groundwater associated with Mangoola Coal is now governed under the Water Management Act 2000 with the commencement of the North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan on the 1 July 2016. The alluvium along Wybong Creek and Sandy Creek has been classified as highly productive. Both of these highly productive groundwater areas are located outside of the MCCO Additional Project Area. The Permian coal measures (porous and fractured rock) are categorised as “less productive” (DPHI-Water, 2012).

The performance measures of each monitored groundwater system with respect to groundwater receptors and the appropriate monitoring locations are presented in Table 8-1. Refer to Figure 8-1 and Figure 8-2 for the bore locations.

Table 8-1 Groundwater performance measures

Potential mining issue or impact	Receptor	Water source type	Applicable to	Performance measures / Required Action
Water level changes due to water take, drawdown and aquifer interconnectivity	Water supply bore	Highly productive alluvial Less productive porous rock	Bore 1 Bore 2 Bore 3 GW080507 GW201589 GW078502 #	No more than 2 m drawdown attributable to mining activities
	Standpipe monitoring bore within 40 m of high priority groundwater dependent system (GDE)	Highly productive alluvial Less productive porous rock	Wybong 1c MP17b (Big Flat Creek area)	If vegetation monitoring concludes vegetation health is declining then investigate influence of groundwater level fluctuations.
	Regional standpipe monitoring bore within alluvial	Highly productive alluvial	Wybong 1a Sandy1a	Cumulative pressure head decline of not more than 40% of pressure head above base of water source

Number: MANOC-1276546935-7

Status: [Document Status (Office)] Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] Review: [Planned Review Date]

Page 32 of 120

Potential mining issue or impact	Receptor	Water source type	Applicable to	Performance measures / Required Action
Water quality changes due to mining activities, final void and emplacement waters	Water supply bore	Highly productive alluvial Less productive porous rock	Bore 1 Bore 2 # Bore 3 GW080507 GW201589 GW078502 #	No change in existing beneficial use category due to mining
	Standpipe monitoring bore within 40 m of high priority groundwater dependent system (GDE)	Highly productive alluvial (semi-confined) Less productive porous rock	Wybong 1c * MP17b (Big Flat Creek area)	No change in existing beneficial use category due to mining
	Regional standpipe monitoring bore within alluvial	Highly productive alluvial	Wybong 1a Sandy1a	No change in existing beneficial use category due to mining

Note: # predicted drawdown > 2m (AGE 2024b)

* Wybong 1c to be excluded from trigger bores due to unexpected pH values, situation to be monitored to confirm pH trends

8.2 Groundwater triggers values

8.2.1 Background

Trigger values are concentrations that, if exceeded, could indicate a potential change that “triggers” a management response. Subsequently, groundwater trigger values must be fit for purpose and conservative so that, when applied they provide an early warning of emerging potential impacts to groundwater quality. Application of trigger values set too high may be inadequate to identify emerging issues. Conversely, if trigger values are too low, natural variation may be mistaken for emerging impacts.

Groundwater quality can vary both spatially and temporally and influenced by a range of factors including rainfall, residence time in the aquifer, and groundwater-rock interactions. Because of the high variability in groundwater chemistry, in some cases, groundwater quality may inherently not meet the water quality objectives set in the ANZECC (2018) guidelines.

Control charting is a graphical and statistical tool to track changes in recorded data over time. The inclusion of appropriate thresholds on control charts is used to inform trigger management actions. Control charts and threshold triggers developed for the monitoring network are shown on the charts included in Appendix E.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 33 of 120

8.2.2 Groundwater Levels

Groundwater modelling was undertaken to support the Environmental Assessment (EA) prepared for the various development applications. This modelling included a prediction of groundwater depressurisation and groundwater inflow to the open cut mining areas. This information is contained within the groundwater assessment reports prepared for the original development application (Umwelt, 2010) and the MOCO (AGE, 2019a). The most recent review of the groundwater model was completed in 2022 to 2024 (AGE, 2022 and AGE, 2024b).

The monitoring bore sites where trigger levels were adopted were selected to ensure the sites provided good spatial coverage in the alluvial aquifers, coal measures and overlying conglomerate, would not be removed by mining, and would yield water for the life of the mine.

Using the predicted groundwater level drawdown at each identified trigger bore is a logical basis from which to set the groundwater level trigger threshold within the development consent conditions. Figure 8-1 shows the locations of the bores selected for trigger thresholds. Table 8-2 presents the bores selected and trigger thresholds.

A two-tier approach will be used for groundwater level triggers as follows:

- Lower Available Limit (UAL) is the Tier 1 threshold and based on 25% of the depth between the 5th percentile (statistical trend) and the Tier 2 trigger level (maximum predicted drawdown). The 5th percentile was calculated for all groundwater level data (until June 2024). The main purpose of the Tier 1 trigger level is to serve as an early warning mechanism. Overall, where drawdown is predicted in monitoring bores, it is highly likely that this trigger will be exceeded at some point in the future. When the UAL is exceeded, it indicates a downward trend warrants consideration. According to the TARP (Section 8.3) an internal review is required for three consecutive measures below the UAL.
- Lower Cut-off Level (LCL) is the Tier 2 threshold and based on maximum drawdown predicted by groundwater modelling. The trigger levels have been set at 2 m below the predicted maximum drawdown at identified locations to account for uncertainty in model predictions as well as climatic variability. According to the TARP (Section 8.3) a detailed investigation is required for three consecutive exceedances of the LCL and find to be attributed by mining.

The predictions of the groundwater modelling were used to identify monitoring bores that may go dry over time due to approved drawdown and depressurisation. As explained above, Tier 1 trigger levels were developed for these bores as an early warning mechanism. As shown in Table 8-2, four of the monitoring bores (MP20-A, MP9-B, VW1-4 and Wybong1b) are predicted to go dry at some point in the future, and the Tier 2 triggers were set at the base of the bore or VWP sensor plus 1 m. All Tier 2 trigger levels for the bores that may become dry should be regarded as an early warning mechanism and will be re-assessed during future GWMP reviews (as stipulated in Section 9.5 of this GWMP).

Hydrographs showing the two tiers are included in Appendix E. Table 8-2 presents the trigger thresholds.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 34 of 120

Table 8-2 Adopted Groundwater Impact Assessment Criteria (Triggers) for Water Level

Monitoring Location ²	Rationale for site	Type	Bore depth (m)	Base of bore (mAHD)	Recent GW elevation (mAHD)	Tier 1 Trigger Limit (mAHD)	Tier 2 Trigger Limit (mAHD)	Latest WL to Tier 2 (m)	Tier 2 to bottom of bore (m)
MP20-A ¹	Big Flat Creek colluvium/alluvium	Standpipe + logger	66	101	111.83	109.3	102.0	9.8	1.0
BFC5a	Big Flat Creek colluvium/alluvium	Single VWP	50	101	135.0	129.4	112.7	22.3	11.7
MP4-C	Big Flat Creek colluvium/alluvium	Standpipe	18	59	164.7	162.8	160.9	3.8	10.3
MP9-B ¹	Big Flat Creek colluvium/alluvium	Single VWP	64	101	113.5	110.7	102.0	11.5	1.0
GW01D	Shallow strata/ weathered conglomerate	Standpipe	6	173.7	178.5	176.4	174.8	3.7	1.2
GW26	Remote from mining background area	Standpipe	103	107	143.4	141.1	134.3	9.1	27.3
NGW01B	Unweathered conglomerates	Standpipe + logger	31	115	131.8	128.9	123.9	7.9	8.9
NGW02B	Unweathered conglomerates	Standpipe + logger	42	174	209.6	204.7	193.4	16.2	19.4
VW1-4 (45m) ¹	Wybong Creek alluvial area coverage	Multi VWP	45	101	131.6	107.5	102.0	29.6	1.0
VW2-4 (38m)	Wybong Creek alluvial area coverage	Multi VWP	38	80	121.6	117.2	103.1	18.5	23.1
VW2-2 (75.5m)	Wybong Creek alluvial area coverage	Multi VWP	76	70	126.0	119.6	102.2	23.9	32.2
VW3-2 (100m)	Southern boundary coverage	Multi VWP	100	100	138.9	130.9	115.0	23.9	15.0
Wybong 1a	Wybong Creek alluvium	Standpipe	47	93	127.8	127.1	125.6	2.3	0.4

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 35 of 120

Monitoring Location ²	Rationale for site	Type	Bore depth (m)	Base of bore (mAHD)	Recent GW elevation (mAHD)	Tier 1 Trigger Limit (mAHD)	Tier 2 Trigger Limit (mAHD)	Latest WL to Tier 2 (m)	Tier 2 to bottom of bore (m)
Wybong 1b ¹	Unweathered conglomerate	Standpipe	35	105	122.4	118.2	105.7	16.7	1.0
Wybong 1c ¹	Great northern seam	Standpipe	65	75	120.9	113.9	94.9	26.0	1.0
Sandy1a	Permian non-coal interburden	Standpipe	35	92	112.8	111.9	110.4	2.4	15.9
Sandy1b	Permian non-coal interburden	Standpipe	71	56	112.7	111.8	110.3	2.4	53.9
Bore 3 (R130) [#]	Landholder bore	Private production bore	30	116	133.9	133.3	131.8 ²	2.1	15.8
GW080507 (R144)	Landholder bore	Private production bore	4	209	212.9	210.9	209.4 ²	3.5	0.6
GW201589 (R144)	Landholder bore	Private production bore	65	135	171.9	189.9	188.4 ²	-16.5	53.8
GW078502 (R83)	Landholder bore	Private production bore		tbd	tbd	tbd	2m drawdown		
Bore 1 (R261)	Landholder bore	Private production bore		tbd	tbd	tbd	2m drawdown		
Bore 2 (R157)	Landholder bore	Private production bore		tbd	tbd	tbd	2m drawdown		

Notes: 1 Trigger 2 = 1m above base of bore.

2 Tier 2 trigger set at 2m drawdown consistent with performance criteria.

Tbd = to be determined if monitoring occur.

Private agreement in place with landowner – trigger limit does not apply

GW = groundwater; WL = Water level

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 36 of 120

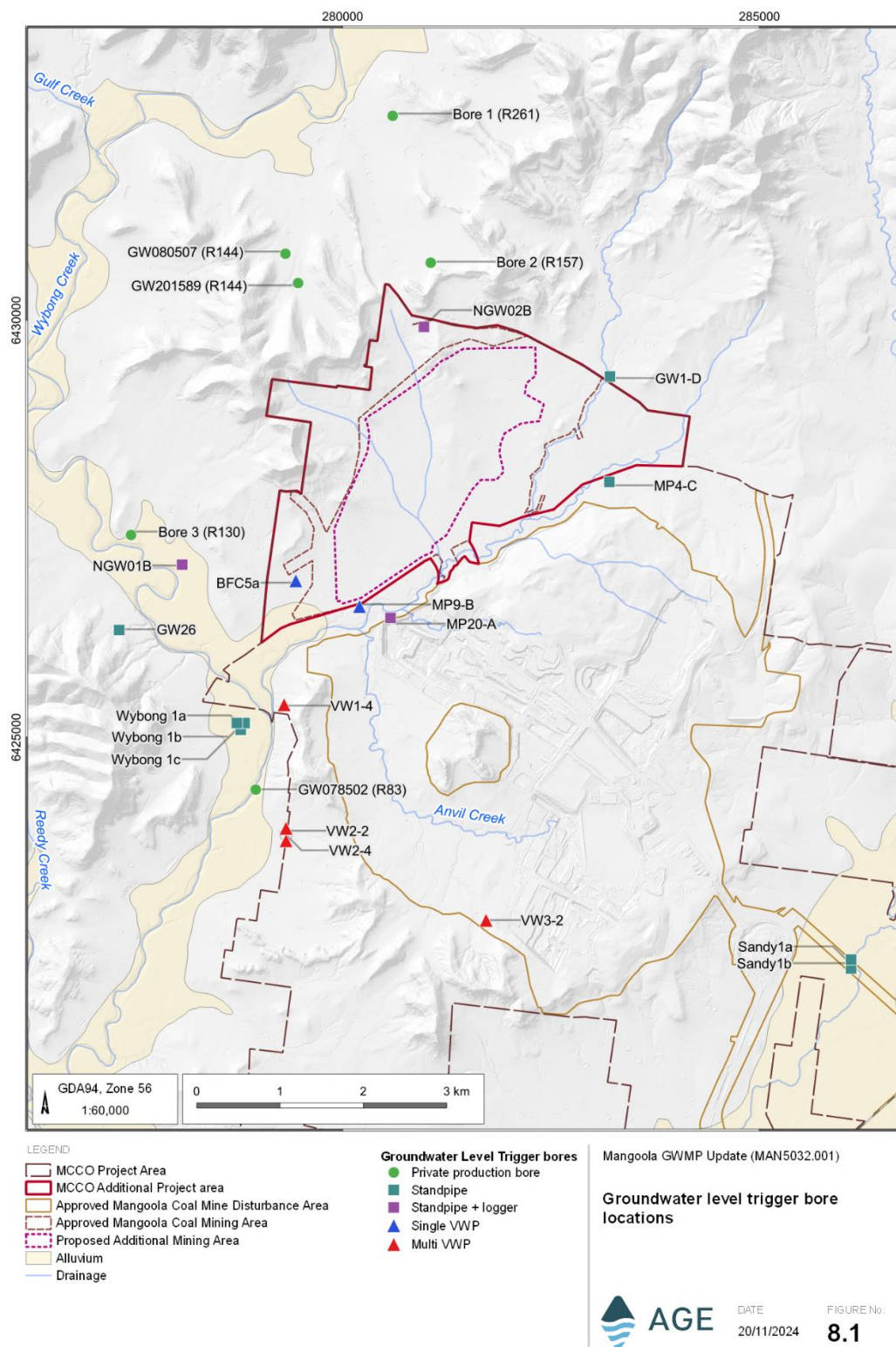


Figure 8-1 Groundwater level trigger bore locations

Number: MANOC-1276546935-7

Status: [Document Status (Office)] Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] Review: [Planned Review Date]

Page 37 of 120

8.2.3 Groundwater Quality

As discussed in Section 5.2 water quality within the majority of monitoring bores sampled is naturally saline with no identified beneficial use. Water quality assessment criteria are applied to those monitoring bores within or near the zone of predicted drawdown which, regardless of strata monitored, record a water quality that could potentially have a beneficial use if it were to be utilised. The ANZECC (2000) Stock Water Guidelines of 5,000 mg/L (TDS) for beef cattle or EC of 7500 uS/cm were used to indicate which bores yielded groundwater with a potential beneficial use.

A two-tier approach will be used for pH and EC trigger values as follows:

- Upper Allowable Limit (UAL) as Tier 1, based on the 95th percentile for EC (as the main salinity indicator) of all groundwater quality data (until June 2024). The UAL indicate trending is towards an unacceptable level but is still within reasonable expected limits. According to the TARP (Section 8.3) an internal review is required for three consecutive exceedances.
 - To overcome unnecessary duplication of analysis and graphing, pH was omitted from the Tier 1 percentile based trigger value since pH levels are generally within and very close to the Tier 2 pH limit of pH 6 to pH 9.
- Upper Cut-off Limit (UCL) as the beef cattle guideline limit of 7500 uS/cm for EC and pH is pH 6 to pH 9. According to the TARP (Section 8.3) a detailed investigation is required for three consecutive exceedances of Tier 2.

Four of the trigger bores have EC values above the beef cattle guideline value and in this case only the Tier 1 trigger value will be used.

As the EC often rises for one sampling round before reducing; an eight sample rolling median will be calculated for trigger bores with a skewed baseline data distribution for comparison with the trigger thresholds for EC. The triggers thresholds for pH and EC are presented on the control charts included in Appendix E. The trigger thresholds for each monitoring site and water quality indicator are summarised in Table 8-3.

Three of the 2022 groundwater quality trigger sites (Mangoola, 2022) were mined out and removed from the list in Table 8-3, namely GW10A2, GW47877 and GW202249.

To ensure that appropriate geographical coverage for trigger locations is maintained, the newly installed monitoring bores (Wybong 1a to 1c and Sandy 1a and 1b) as well as monitoring bore MN1006 were added to the list in Table 8-3.

As shown in Table 8-3, the pH levels in monitoring bores Wybong1b and Wybong1c is alkaline and above the proposed maximum threshold of 9 (Tier 2). It is uncertain, at this stage, why the pH levels are so high, however this is potentially due to the grout used in the bores as such these locations will continue to be monitored, but will not have a pH trigger. This will be revised in the next review of the GWMP (once more data is gathered). It is proposed to continue monitoring but to exclude pH triggers for these two locations until more data is gathered.

Table 8-3 Adopted Groundwater Impact Assessment Criteria (Triggers) for Groundwater Quality

Monitoring Bore	Potential Beneficial use	Geology	Bore depth (m)	Current pH	Tier 2 pH Trigger Limit	Current EC (µS/cm) ¹	Tier 1 (EC 95 th percent (µS/cm)	Tier 2 EC Trigger Limit (µS/cm)
GW06*	Stock water	Shallow Strata/ weathered conglomerate	<5	6.7	6.0 - 9.0	141	333	7500
GW14	Stock water	Fassifern and Pilot seams	85	7.1	6.0 - 9.0	5,390	6,712	7500
GW26	Stock water	Unweathered conglomerates	103	7.0	6.0 - 9.0	1,958	2,742	7500
MP1-A	Stock water	Fassifern and Pilot seams	70	8.1	6.0 - 9.0	6,050	6,716	7500
MP2-A	None (monitoring only)	Fassifern and Pilot seams	70	7.6	6.0 - 9.0	14,400	17,596	-
MP3-A	None (monitoring only)	Fassifern and Pilot seams	68	7.7	6.0 - 9.0	8,570	10,540	-
MP17-B	None (monitoring only)	Big Flat Creek area coverage	-	7.2	6.0 - 9.0	1,424	22,797	-
NGW01B	Stock water	Unweathered conglomerates	31	7.7	6.0 - 9.0	4,160	5,356	7500
NGW02B	Stock water	Unweathered conglomerates	42	7.7	6.0 - 9.0	4,360	5,584	7500
MN1006	Stock water	Fassifern and Pilot seams	35	7.5	6.0 - 9.0	3,980	5,873	7500
Wybong 1a	Stock water	Wybong Creek alluvium	~20	7.2	6.0 - 9.0	2,439	2,660	7500
Wybong 1b	Stock water	Unweathered conglomerate	~40	11.8 **	tbc	4,120	4,103	7500
Wybong 1c	Stock water	Great northern seam	~50	12.0 **	tbc	4,430	5,650	7500
Sandy1a	Stock water	Permian non-coal interburden	35	6.9	6.0 - 9.0	3,050	3,464	7500
Sandy1b	Stock water	Permian non-coal interburden	70	7.5	6.0 - 9.0	1,580	1,790	7500

Notes: * sites to be used as triggers until mined out, located in proposed northern mining area.

** pH triggers excluded, and more baseline data is required to confirm. (tbc = to be confirmed)

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 39 of 120

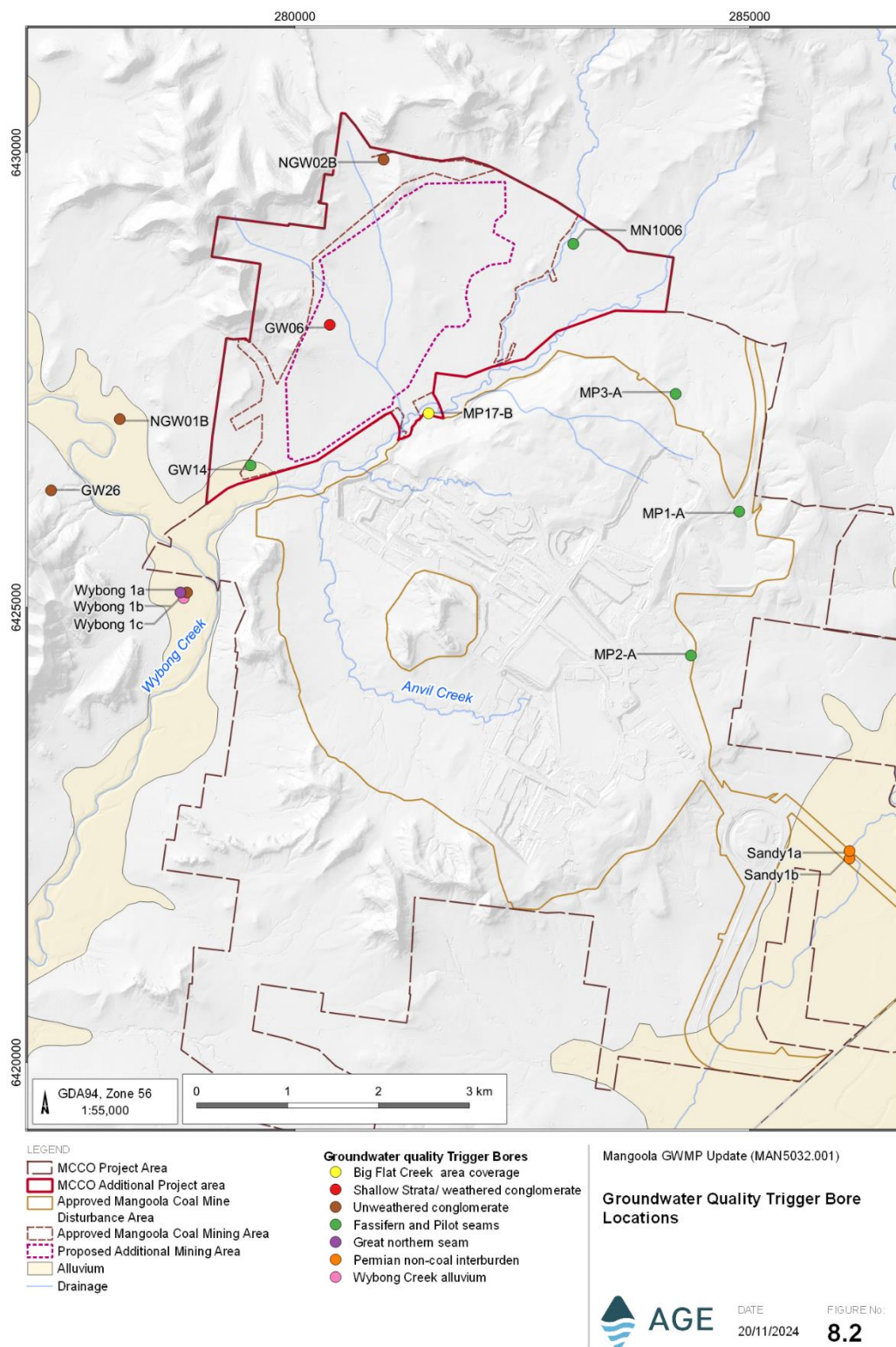


Figure 8-2 Groundwater Quality Trigger Bore Locations

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 40 of 120

8.3 Trigger Action Response Plans

The performance measures and control thresholds described in the previous two sections are part of the trigger action response plans (TARPs) that outline actions and responses in the event trigger thresholds are exceeded.

Tier 1 triggers are introduced to act as an early warning mechanism and based on the statistical trend of the dataset. Tier 2 triggers are based on predicted maximum drawdown for groundwater levels and the adopted beneficial use for groundwater quality.

The exceedance of a Tier 2 trigger threshold on their own occurrence does not indicate an incident and/or environmental harm has occurred or that management actions are required. The confirmed exceedances will prompt an investigation, carried by suitably qualified personnel, to determine the reasons for trigger events, which could include but not be limited to mining activities, climatic conditions or other abstraction including agriculture.

In the case exceedances are attributed to mining activities, the changes in groundwater conditions, such as a decrease in water level or increase in salinity, will be compared to performance measures (discussed in Section 8.1) to evaluate the significance of the trigger event.

The procedures to be undertaken for a trigger event and/or non-compliance with performance measure is summarised in the TARPs in Table 8-4, Table 8-5 and Table 8-6.

As indicated in the TARPS, exceedances of the Tier 1 triggers prompt internal investigation to ensure data is correct and exceedances of Tier 2 triggers prompted a detail investigation by a qualified hydrogeologist.

The results of the trigger investigations will be reported in each annual review. Each year if it is clear the baseline dataset is changing in response to factors not related to mining such as climate or land management then the trigger thresholds will be recalculated, and the control thresholds adjusted to improve the baseline statistics. When this occurs the GWMP will be updated as indicated in Section 9.5.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 41 of 120

Table 8-4 Trigger Action Response Plan for groundwater quality and groundwater level exceedances

Normal State	Groundwater monitoring data indicates performance measures achieved (Table 8-1). Groundwater monitoring data for trigger bores falls within Tier 2 trigger levels (Table 8-2 for water levels and Table 8-3 for water quality). Groundwater drawdown predictions from the numerical groundwater model generally in accordance with observed groundwater level trends.	
Trigger Action Response Plan <u>Trigger threshold exceeded for water quality and water level</u>	Level 1 Trigger – Alert / Investigate internally	Level 2 Trigger – High Alert / Rectify
	Three consecutive monitoring result values outside of the <u>Tier 1</u> adopted impact assessment criteria for quality and/or standing water level presented in the GWMP. Provide an early warning mechanism. Not of a serious nature, but a change that may need to be monitored. An incident has not deemed to have occurred.	The change from Level 1: Three consecutive monitoring result values outside of the <u>Tier 2</u> adopted impact assessment criteria for quality and/or standing water level presented in the GWMP. There is a definite negative trend or situation developing and appropriate actions need to be determined based on risk. A situation has occurred that potentially possess an immediate risk and remedial action is to be taken.
	Action / Response	Action / Response Plan
	1) Notify the Mangoola Coal ECM. 2) Undertake additional monitoring of the bore if required. 3) Review results against baseline monitoring for the bore (<u>internal review only</u>). a) Review operations and investigate for links to operational activities. b) Investigate any external influence which may be affecting the results including climatic data.	Follow steps 1 to 4 of the Level 1 TARP and continue below: 1) Seek advice from qualified hydrogeologist. 2) Determine if an incident has occurred as defined under EPL 12894, SSD 8642 and/ or EPBC 2018/8280. a. IF NO – fall back to Level 1. b. IF YES – follow steps below:

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 42 of 120

Action / Response	Action / Response Plan
4) Determine if an incident has occurred as defined under EPL 12894 and / or SSD 8642. 5) Examine procedures and update if necessary. 6) Report in annual review.	3) Compare against water quality trends and relationships with adjacent bores. 4) Review groundwater model predictions, confirm model assumptions are correct/ reflect what is occurring in the mine. 5) Climate influenced: recalculate baseline where appropriate and report in annual review. 6) Assess risk of environmental harm, take all preventative measures to prevent or minimise environmental harm and enact PIRMP if required. 7) Notify as per D9 of SSD 8642, EPL 12894 Condition R2 and Condition 19 of EPBC 2018/8280 if an incident has occurred. Note: Any exceedances of water levels or quality that have application to private users will be documented in the Annual Review and shared with the relevant (as and when identified) landholder(s). 8) Submit a detailed report to relevant Department agencies regarding the incident as per EPBC Approval 2018/2820, EPL 12894, and SSD8642 9) Prioritise actions including any groundwater isolation contingency plans or modification of mining operations based on the risk to the environment and likelihood of a repeat incident. 10) Provide affected landholders with suitable water supply from the mine water management system.

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 43 of 120

Action / Response	Action / Response Plan
	11) Monitor the completion of actions to ensure they have been effective. 12) Report in annual review. 13) Review and if necessary revise GWMP as per D7 of SSD 8642.

Notes: ¹ Pollution Incident Response Management Plan (PIRMP).

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 44 of 120

Table 8-5 Trigger Action Response Plan for groundwater extraction exceeding licence limits

Normal State	Groundwater extraction is within licence limits. Groundwater inflow predictions from the numerical groundwater model is generally in accordance with estimated groundwater inflow rates.	
Trigger Action Response Plan <u>Groundwater extraction exceeding license limits</u>	Level 1 Trigger – Alert / Investigate	Level 2 Trigger – High Alert / Rectify
	Annual Review Reporting of groundwater intercepted/extracted by mining exceeds approved predicted groundwater make at corresponding stage of mining as outlined in Section 6.6.1 or advice from independent hydrologist says there is an unexplained increase in groundwater inflows during the quarterly groundwater inflow assessment Not of a serious nature, but a change that needs to be monitored. An incident has not occurred and trigger is not a result of mining.	The change from Level 1: There is a definite negative trend or situation developing and remedial action needs to be planned and executed.
	Action / Response	Action / Response
	1) Notify the Mangoola Coal ECM. 2) Confirm model predictions versus monitored volumes. 3) Review surface water quality to determine if water quality in pit compared with water quality in Big Flat Creek shows a surface water loss. 4) Review operations and investigate for links to operational activities. 5) Review Groundwater monitoring network data.	Follow steps 1 to 8 of the Level 1 TARP and continue below: 1) Conduct an investigation into non-compliance with performance measure. 2) Review groundwater model predictions, confirm model assumptions are correct and reflect what is occurring in the mine. 3) Determine if an incident has occurred (exceedance of license allocation) as defined under EPL 12894, SSD 8642 and/ or EPBC 2018/8280.

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 45 of 120

Action / Response	Action / Response
6) Investigate any external influence which may be affecting the results including climatic data. 7) Seek advice from qualified hydrogeologist if required. 8) Report in annual review.	- IF NO – fall back to Level 1. - IF YES – follow steps below: 4) Assess risk of environmental harm, take all preventative measures to prevent or minimise environmental harm and enact PIRMP if required. 5) Notify as per D9 of SSD 8642,EPL 12894 Condition R2 and Condition 19 of EPBC 2018/8280 if an incident has occurred. Seek additional license allocation and make appropriate transfer in consultation with DPHI Water. 6) Monitor the completion of actions to ensure they have been effective. 7) Review and if necessary revise GWMP as per SSD 8642. 8) Submit a detailed report to relevant Department agencies regarding the incident as per EPBC Approval 2018/2820, EPL 12894, and SSD8642 9) Prioritise actions including any groundwater isolation contingency plans, modification of operations, temporary license transfers or purchase of more license allocation based on the risk to the environment and likelihood of a repeat incident.

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version
(Office)]

Review: [Planned Review Date]

Page 46 of 120

Table 8-6 Trigger Action Response Plan for a Groundwater Complaint

Normal State	Mangoola continue monitoring private bores as per SSD 8642 conditions B41 to B45.	
Trigger Action Response Plan Groundwater related complaint	Level 1 Trigger – Alert / Investigate	Level 2 Trigger – High Alert / Rectify
	Abnormal: Complaint received regarding groundwater. Not of a serious nature, but a change that needs to be monitored. An incident has not occurred and trigger is not a result of mining.	The change from Level 1: There is a definite negative trend or situation developing and remedial action needs to be planned and executed.
	Action / Response	Action / Response
	1) Notify the Mangoola Coal ECM. 2) Undertake additional monitoring of the private bore If required. 3) Review results against baseline monitoring for the bore (if available). 4) Compare against water quality trends and relationships with adjacent bores. 5) Review groundwater model predictions, confirm model assumptions are correct/reflect what is occurring in the mine. 6) Review operations and investigate for links to operational activities.	Follow steps 1 to 8 of the Level 1 TARP and continue below: 1) Determine if an incident has occurred as defined under EPL 12894, SSD 8642 and/ or EPBC 2018/8280. a. IF NO – fall back to Level 1. b. IF YES – follow steps below: 2) Conduct an investigation into the incident and prioritise actions based on the risk to the environment and likelihood of a repeat incident. 3) Assess risk of environmental harm, take all preventative measures to prevent or minimise environmental harm and enact PIRMP if required.

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version
(Office)]

Review: [Planned Review Date]

Action / Response	Action / Response
7) Investigate any external influence which may be affecting the results including climatic data. 8) Consult and gain advice from qualified hydrogeologist if required. 9) Continue Monitoring and Reporting as per the requirements of the GWMP. 10) Respond to complainant as per site Complaints Management Procedure. 11) Report in annual review.	4) Prioritise actions based on the risk to the environment and likelihood of a repeat incident. 5) Provide landholder with suitable water supply from the mine water management system if requirement is confirmed. 6) Follow Section 8.4 for any community complaints and disputes. 7) Monitor the completion of actions to ensure they have been effective. 8) Respond to complainant as per site Complaints Management Procedure. 9) Notify as per D9 of SSD 8642,EPL 12894 Condition R2 and Condition 19 of EPBC 2018/8280 if an incident has occurred.. 10) Submit a detailed report to relevant Department agencies regarding the incident as per EPBC Approval 2018/2820, EPL 12894, and SSD8642

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version
(Office)]

Review: [Planned Review Date]

Page 48 of 120

Table 8-7 Trigger Action Response Plan for the Sandy Creek Farm Dams

Normal State	Sandy Creek Farm Dams (SCFDs) and Water Dam Seepage Collection Sump (SCS) operates at desired levels	
Trigger Action Response Plan Groundwater related complaint	Trigger – Alert / Investigate	
	Discharges occur from the SCFDs and / or the SCS, during any rainfall event, where initial storage volumes are greater than 50% capacity, or Discharges occur from the SCFDs and / or the SCS during a rainfall event less than 50 mm in 24 hours. Not of a serious nature, but a change that needs to be monitored.	
	An incident has not occurred, and trigger is not a result of mining.	
Action / Response		Action / Response
1) Notify the Mangoola Coal ECM. 2) Review operational pumping was / is in place to limit the volume of discharge. 3) Conduct surface water quality monitoring as per Section 3.7.1 of the SWMP. 4) Review Teledata to check dam levels and rainfall depths for the 24 hours preceding the discharge. 5) Review operations and investigate for links to operational activities. An incident has not occurred and trigger is not a result of mining If dams were 50% or less full continue monitoring equipment and pumping infrastructure; or		Follow steps 1 to 8 of the Level 1 TARP and continue below: 1) Determine if an incident has occurred as defined under EPL 12894, SSD 8642 and EPBC 2018/8280. a. IF NO – fall back to Level 1. b. IF YES – follow steps below: 2) An incident is deemed to have occurred: If either / both dams were greater than 50% full; or There was less than 50mm of rain in the preceding 24 hours then: 3) Conduct an investigation into the incident and prioritise actions based on the risk to the environment and likelihood of a repeat incident.

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 49 of 120

Action / Response	Action / Response
If there was more than 50mm of rain in the preceding 24 hours continue monitoring equipment and pumping infrastructure. 6) Report in annual review	4) Assess risk of environmental harm, take all preventative measures to prevent or minimise environmental harm and enact PIRMP if required. 5) Prioritise actions based on the risk to the environment and likelihood of a repeat incident. 6) Monitor the completion of actions to ensure they have been effective. 7) If complaints are received, respond accordingly. 8) Notify as per D9 of SSD 8642, EPL 12894 Condition R2 and Condition 19 of EPBC 2018/8280 if an incident has occurred. 9) Submit a detailed report to relevant Department agencies regarding the incident as per EPBC Approval 2018/2820, EPL 12894, and SSD8642 10) Review and if necessary revise relevant strategies, plans, programs and reports as per EPL 12894 and / SSD 8642.

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version
(Office)]

Review: [Planned Review Date]

Page 50 of 120

8.4 Compensatory Water Supply guiding principles, complaint management and reporting protocol

The WMP provides a summary of the statutory reporting requirements in Section 9 for any incident and non-compliance.

8.4.1 Compensatory water supply guiding principles

As discussed in Section 4.3, Condition B39 of SSD 8642 requires that prior to commencing construction of the MCCO Project, the owners of the private water supply bores listed in

Table 4-2 may request Mangoola Coal monitor the groundwater level within their bore to determine if there are any impacts from mining activities over time. If monitoring records drawdown of more than 2 m as a result of mining, this initiates the requirement for Mangoola Coal to investigate the need to provide compensatory water measures in accordance with SSD 8642 conditions B41 to B45.

On 17 May 2021 Mangoola Coal offered monitoring to owners of the bores listed in

Table 4-2 in accordance with the requirements of SSD 8642. Bore-specific monitoring plans are being developed according to the time frames provided in

Table 4-2.

SSD 8642 provides the following conditions (B40 to B45):

- *B40. Prior to the commencement of mining operations north of the Wybong Road under this consent, the Applicant must notify owners of licensed privately-owned groundwater bores that are predicted to have a drawdown of greater than 2 m as a result of the development that they may be eligible for compensatory water under conditions B41 to B45.*
- *B41. The applicant must provide a compensatory water supply to any landowner of privately-owned land whose rightful water supply is adversely and directly impacted (other than an impact that is minor or negligible) as a result of the development, in consultation with DPE Water, and to the satisfaction of the Planning Secretary.*
- *B42. The compensatory water supply measures must provide an alternative long term supply of water that is equivalent, in quality and volume, to the loss attributable to the development. The burden of proof that the impact on water supply is not due to mining, rests with the Applicant. Equivalent water supply should be provided (at least on an interim basis) as soon as practicable after the loss is identified, unless otherwise agreed with the landowner.*
- *B43. If the Applicant and the landowner cannot agree on whether the impact on water supply is attributed to the development of the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution.*

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 51 of 120

- *B44. If the applicant is unable to provide an alternative long term supply of water, then the Applicant must provide compensation, to the satisfaction of the Planning Secretary⁴.*
- *B45. In the event of any complaint relating to a privately-owned licenced groundwater bore which may, in the opinion of the Planning Secretary, have been adversely and directly impacted as a result of the development (other than an impact that is minor or negligible), the Applicant must, as soon as practicable, facilitate the provision of a temporary water supply, pending the outcome of any groundwater investigation and/or the provision of an alternative long term supply of water as required under conditions B41 and B42, to the satisfaction of the Planning Secretary.*

8.4.2 Community Complaints

Mangoola Open Cut maintains a centralised location to record details of relevant external stakeholder communications. A Community Response Line (1800 014 339) is in operation 24 hours per day, seven days a week and is regularly advertised in a local newspaper. Records of any complaints are kept and a monthly summary of complaints is uploaded to the website as per Condition D17(a)(x) of SSD 8642.

8.4.3 Dispute resolution

Without limitation to any other rights of a Party⁵ under a compensatory water supply proposal, either Party may give a written notice (Dispute Notice) to the other Party if a dispute arises.

The Parties will use best endeavours to meet within twenty (20) Business Days of the date that the dispute Notice is given to try to resolve the dispute in a timely manner.

- If the Parties cannot reach agreement within twenty (20) Business Days of the giving of the Dispute Notice, the Parties may make use of the dispute resolution processes under Condition B43 and B44 of SSD 8642.

⁴ The water management plan (see Condition B50 of SSD 8642) is required to include trigger levels for investigation potentially adverse impacts on water supplies. Also refer to Section 8.2 of this GWMP)

⁵ means Mangoola and the Bore Owner and Party means either of them.

9. Environmental Performance Review and Improvement Program

9.1 Annual Review

The results of groundwater monitoring data will be compiled in the Annual Review. The results of any trigger exceedance investigations will also be summarised in the Annual Review.

9.2 Monitoring Equipment

Data loss due to data logger failures or vandalism will be investigated and replaced as soon as practical, and not seen as non-compliance or incidents.

9.3 Reporting of groundwater take for exploration activities

Occasional exploration activities may include drilling and air-lifting of groundwater to the surface. The yield of groundwater during any exploration drilling activities will be recorded and reported at the end of the water use year as required under the *Water Management (General) Amendment (Groundwater Exemptions) Regulation 2019 NSW*. The water take will be recorded on a daily basis using flow meters / bulk tanker loads to comply with clause 21(6) of the Water Regulation that requires records of water take must be taken within 24 hours after water is taken and in an approved form and manner.

9.4 Groundwater Model

The validity of the groundwater model predictions will be independently reviewed every three years against water level and mine inflow data to determine if the model is providing useful predictions. If the numerical model predictions do not compare well with the observations over the previous three-year period, then the numerical model will be updated and if necessary recalibrated. Predictions of water level changes and water take will be undertaken using the updated model. The model was calibrated in 2023/2024 and the model predictions have been applied in this GWMP update.

Condition B50(v)(#8) of SSD-8642 includes:

“The groundwater inflow predictions for Mangoola Coal will be validated by a qualified groundwater consultant regularly (at least every 3 years), or if significant changes to mining operation occur or monitoring results identify a need (e.g. where groundwater extraction from the pit shows a significant change that is inconsistent with predictions). The predictions will be validated against historical monitoring data collected as part of the groundwater monitoring program.”

9.5 GWMP review and revision

The GWMP will be reviewed every three years and also after the independent environmental audit detailed in SSD 8642 D13. The GWMP will also be reviewed when there is a significant variation between groundwater model results and monitoring results and if the groundwater model requires recalibration following an annual review or three-year independent review.

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 53 of 120

This GWMP will be updated if necessary, with findings any independent model review, annual review, independent environmental audit and groundwater monitoring, to promote continuous improvement.

If changes are required to the GWMP related to changes in control charting process or where principles of no environmental harm are not met, it will be resubmitted to the Planning Secretary for approval within six weeks of the review. The most recent version of this GWMP, as approved by the Planning Secretary, will be implemented.

9.6 Privately owned groundwater bores

Monitoring plans are developed for each of the identified private bores (Sections 4.3 and 8.1) and the monitoring results will be regularly shared with the landholders (minimum annually).

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 54 of 120

10. Contingency Plan

10.1 Contingency measures

The identification process and response protocol to adverse outcomes are provided in the trigger action response plan (TARP). The responses proposed incorporate a staged assessment and development of management measures deemed appropriate for each individual event should it occur.

Specific trigger levels have been designed to alert Mangoola Coal to observed parameter responses which are outside of normal variation and predicted responses, or where observed parameter values do not follow anticipated trends.

The triggers for instigation of response actions would occur when observed changes to monitored parameters exceed specified levels. Such changes in observed parameters or conditions include:

- sudden inrush of groundwater into the mine in exceedance of predicted inflows;
- trigger value exceedances in observed water quality or groundwater levels between sampling rounds; and
- significant variation from model predictions.

10.1.1 Big Flat Creek

The development consent requires “*A contingency plan for isolating the Big Flat Creek alluvium from Anvil Creek alluvium and mining areas in the event that it is required*” (B50(e)(v)). Groundwater monitoring has shown that implementation of this condition is not required as an alluvial aquifer does not occur along Big Flat Creek, and volumes of seepage from the underlying strata into the mining area have not been problematic and have not exceeded the volume of water licence units held to account for the water take by mining (AGE, 2024b).

As a contingency measure, Mangoola Coal undertake quarterly visual inspections of the pit wall area as indicated on the map below (Figure 10-1). This inspection will determine whether problematic inflows are occurring and identify any maintenance/ repair measures required to existing controls.

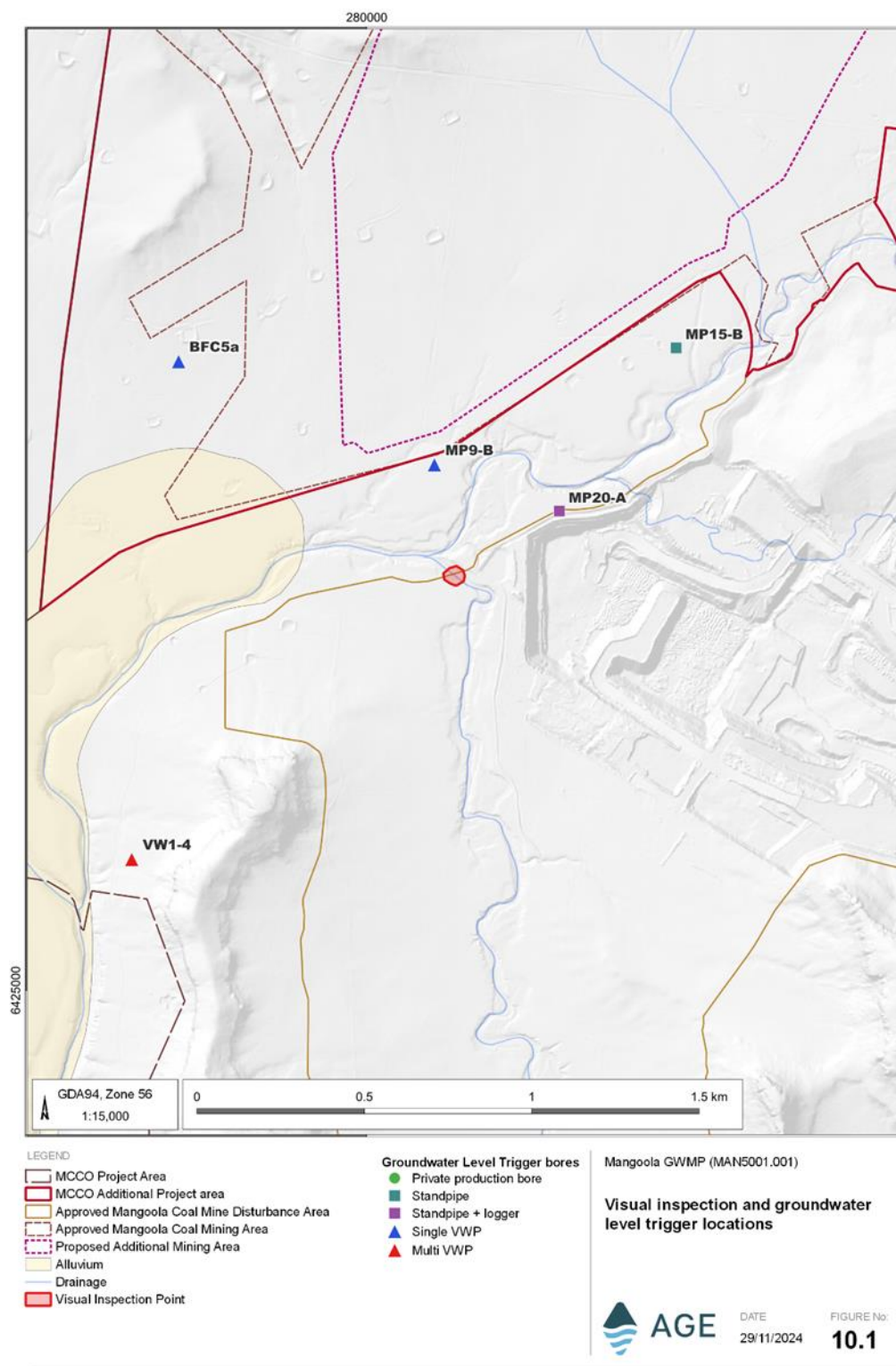


Figure 10-1 Visual inspection area of the Big Flat Creek and pit wall area and groundwater level trigger locations

Number: MANOC-1276546935-7

Status: [Document Status (Office)] Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] Review: [Planned Review Date]

Page 56 of 120

10.2 Unforeseen impacts protocol

Table 10-1 outlines the procedure to be followed (in general accordance with the criteria exceedance protocols detailed in Section 8) in the event that any unforeseen groundwater impacts are detected.

Table 10-1 Unforeseen impact procedure

Stage	Procedure
1	Review the unforeseen impact including consideration of: - Any relevant monitoring data; and - Current mine activities and land management practices in the relevant catchment
2	Commission an investigation by an appropriate specialist into the unforeseen impact, if considered appropriate by the Environmental Specialist.
3	Develop appropriate improvement measures based on the results of the above investigations, in consultation with the relevant authorities.
4	Implement additional monitoring where relevant to measure the effectiveness of the improvement measures.

11. References

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Number: MANOC-1276546935-7

Status: [Document Status (Office)] **Effective:** [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] **Review:** [Planned Review Date]

Page 58 of 120

- All other references are included in Section 10 of the WMP.

Appendix A - Regulatory requirements

Table A1 Development Consent SSD 8642 GWMP requirements

Condition No.	Condition requirement	Section reference
A1	<i>In addition to meeting the specific performance measures and criteria established under this consent, the Applicant must implement all reasonable and feasible measures to prevent, and if prevention is not reasonable and feasible, minimise, any material harm to the environment that may result from construction and operation of the development, and any rehabilitation required under this consent.</i>	
B39	<i>Prior to commencing construction, the Applicant must notify the owners of the bores listed in Table 5 that they may request monitoring of the listed bore to determine the level of drawdown from the development. In the event that the monitoring records drawdown of more than 2 metres as a result of the development, the Applicant must provide compensatory water in accordance with condition B41 to B45</i>	Sections 4.3 and 8
B40	Prior to the commencement of mining operations north of Wybong Road under this consent, the Applicant must notify owners of licensed privately-owned groundwater bores that are predicted to have a drawdown of greater than 2 meters as a result of the development that they may be eligible for compensatory water under conditions B41 to B45.	Sections 4.3 and 8
B41	The Applicant must provide a compensatory water supply to any landowner of privately-owned land whose rightful water supply is adversely and directly impacted (other than an impact that is minor or negligible) as a result of the development, in consultation with DPIE Water, and to the satisfaction of the Planning Secretary.	Refer to the TARPs in Section 8
B42	The compensatory water supply measures must provide an alternative long term supply of water that is equivalent, in quality and volume, to the loss attributable to the development. The burden of proof that the impact on water supply is not due to mining, rests with the Applicant. Equivalent water supply should be provided (at least on an interim basis) as soon as practicable after the loss is identified, unless otherwise agreed with the landowner.	
B43	If the Applicant and the landowner cannot agree on whether the impact on water supply is attributed to the development or the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution.	
B44	If the Applicant is unable to provide an alternative long term supply of water, then the Applicant must provide compensation, to the satisfaction of the Planning Secretary. Notes: The Water Management Plan (see condition B50) is required to include trigger levels for investigating potentially adverse impacts on water supplies.	
B45	In the event of any complaint relating to a privately-owned licenced groundwater bore which may, in the opinion of the Planning Secretary, have been adversely and directly impacted as a result of the development (other than an impact that is minor or negligible), the Applicant must, as soon as practicable, facilitate the provision of a temporary water supply, pending the outcome of any groundwater investigation and/or the provision of an alternative long term supply of water as required under conditions B41 and B42, to the satisfaction of the Planning Secretary.	Section 4.3 and 8

Number: MANOC-1276546935-7

Status: [Document Status (Office)] Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] Review: [Planned Review Date]

Page 60 of 120

Condition No.		Condition requirement	Section reference
B48	Table 6	<i>Water Management Performance Measures</i> <i>The Applicant must ensure that the development complies with the performance measures in Table 6 (Table 6 Water management performance measures, Conditions of Consent, page 19).</i>	Sections 8.1
B49		<i>The performance measures in Table 6 apply to the entire site, including all landforms constructed under previous development consents.</i>	Sections 8.1
B50	(e)(v)	<i>Groundwater Management Plan that includes:</i> <i>detailed baseline data of groundwater levels, yield and quality for groundwater resources and groundwater dependent ecosystems potentially impacted by the development, including groundwater supply for other water users.</i>	Sections 3 and 5
		<i>a detailed description of the groundwater management system.</i>	Section 5 and 8
		<i>groundwater performance criteria, including trigger levels for identifying and investigating any potentially adverse groundwater impacts (or trends) associated with the development, on:</i> <i>regional and local aquifers (alluvial and hardrock); and</i> <i>groundwater supply for other water users such as licensed privately-owned groundwater bores;</i>	Sections 7 to 8
		<i>a program to monitor and evaluate:</i> <i>compliance with the relevant performance measures listed in Table 6 and the performance criteria in this plan;</i> <i>water loss/seepage from water storages into the groundwater system, including from any final voids;</i> <i>groundwater inflows, outflows and storage volumes, to inform the Site Water Balance;</i> <i>the hydrogeological setting of any nearby alluvial aquifers and the likelihood of any indirect impacts from the development;</i> <i>impacts on groundwater dependent ecosystems;</i> <i>impacts on groundwater supply for other water users; and</i> <i>the effectiveness of the groundwater management system;</i>	Sections 5 and 7
		<i>A contingency plan for isolating the Big Flat Creek alluvium from Anvil Creek alluvium and mining areas in the event that it is required;</i>	Section 10.1.1
		<i>reporting procedures for the results of the monitoring program, including notifying other water users of any elevated results;</i>	Sections 9
		<i>a trigger action response plan to respond to any exceedances of the relevant performance measures and groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the development;</i>	Section 8
		<i>a program to periodically validate the groundwater model for the development, including an independent review of the model every 3 years (unless otherwise agreed by the Planning Secretary), and comparison of monitoring results with modelled predictions; and</i>	Section 9.4
	(e)(vi)	<i>a protocol to report on the measures, monitoring results and performance criteria identified above, in the Annual Review referred to in condition D11.</i>	Sections 9
D5		<i>Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:</i>	
	(a)	<i>Summary of relevant background or baseline data;</i>	Sections 3 and 5
	(b)	<i>Details of</i>	

Number: MANOC-1276546935-7

Status: [Document
Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document
Version (Office)]

Review: [Planned
Review Date]

Page 61 of 120

Condition No.	Condition requirement	Section reference
(b)(i)	<i>The relevant statutory requirements (including any relevant approval, license or lease conditions);</i>	Section 2
(b)(ii)	<i>Any relevant limits or performance measures and criteria; and</i>	Section 8
(b)(iii)	<i>The specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;</i>	Section 8
(c)	<i>Any relevant commitments or recommendations identified in the document/s listed in condition A2(c);</i>	Sections 4.2, 5 and 6
(d)	<i>A description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;</i>	Sections 7 and 8
(e)	<i>A program to monitor and report on the:</i>	
(e)(i)	<i>Impacts and environmental performance of the development; and</i>	Sections 6
(e)(ii)	<i>Effectiveness of the management measures set out pursuant to condition D4(c);</i>	Section 8
(f)	<i>A contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;</i>	Section 10
(g)	<i>A program to investigate and implement ways to improve the environmental performance of the development over time;</i>	Section 9
(h)	<i>A protocol for managing and reporting any:</i>	
h (i)	<i>incident, non-compliance or exceedance of any impact assessment criterion or performance criterion);</i>	Sections 8 and 9
(h)(ii)	<i>complaint; or</i>	Section 8
(h)(iii)	<i>failure to comply with other statutory requirements;</i>	Section 8
(i)	<i>Public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and</i>	Section 9
(j)	<i>A protocol for periodic review of the plan.</i>	Section 9

Table A2 Development Consent SSD 8642 GWMP Performance Measures (Condition B48 Table 6)

Feature	Performance Measure	Relevant WMP Section
Alluvial aquifers	- Negligible impacts to alluvial aquifers as a result of the development, beyond those predicted in the document/s listed in condition A2(c), including: - negligible change in groundwater levels; - negligible change in groundwater quality; and - negligible impact to other groundwater users, - Maintain appropriate setbacks in accordance with the <i>Aquifer Interference Policy</i> (DPI 2012)	Section 8.1

Number: MANOC-1276546935-7

Status: [Document Status (Office)] Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] Review: [Planned Review Date]

Page 62 of 120

Statement of commitments

As a requirement of the Statement of Commitment the following conditions are included in the GWMP.

Table A3 MCCO Project Statement of Commitments Related to Water Management

Commitment	Relevant WMP Section
Mangoola will review and update the existing WMP for the MCCO Project in consultation with DPI Water and DPE and then implement this plan. Subject to the requirements of the conditions of consent, the GWMP will include:	
- A Groundwater Management Plan, including - Relevant baseline data on groundwater levels, yield and quality - Groundwater assessment criteria, including trigger levels for investigating any potentially adverse impacts - A groundwater monitoring program	Section 5 Section 8 Sections 4
The WMP prepared for the MCCO Project will include TARPs for both surface water and groundwater. The TARPs will identify when additional management measures, monitoring or rehabilitation measures may be required	Section 8
Mangoola will undertake groundwater monitoring in accordance with a groundwater monitoring program. The program will be reviewed annually and revised as necessary. Upon implementation as part of the MCCO Project the following groundwater monitoring will be undertaken: - Bi-monthly water levels - Bi-monthly field water quality - Annual comprehensive water quality analysis at selected bores including pH, electrical conductivity, total dissolved solids, major ions, alkalinity and dissolved and total metals	Section 4
The results of the groundwater monitoring will be reviewed annually to determine if any additional monitoring sites are required, or if optimisation of the existing monitoring sites, frequency of sampling and analytical suite should be undertaken	Section 9
The existing groundwater monitoring network detailed in the existing Groundwater Management Plan will be updated with the additional sites installed since the Groundwater Management Plan was developed. Mangoola will also install new monitoring bores to confirm the VWP pressure changes, and also to monitor water levels in the Wybong Creek alluvium and GDEs prior to the commencement of mining in the MCCO Additional Project Area ⁶	Section 4.2

⁶ The proposed additional monitoring bores to confirm the VWP pressure changes are: GWMP1a, GWMP1b, GWMP2, GWMP3, GW26A, NGW01_D and NGW01_E (refer to Section 4.2).

The drilling program was initiated prior to the commencement of mining (6 December 2021) with the groundwater bores identified as the priority to be drilled. The drilling of these bores was planned and scheduled to be completed to meet the requirements of this commitment. During 2021 and 2022 the region around Mangoola received greater than average rainfall (~1000mm per annum). This rainfall has made access to the proposed drilling locations, with a drill rig, practically impossible. Mangoola has engaged Australasian Groundwater and Environmental Consultants (the groundwater consultants) to review the drilling locations and proposed alternative drilling locations that will meet the intent to confirm the VWP pressures. The alternatives were proposed, and further rainfall was received, due to this the alternate locations became unsafe or impractical to access with the drill rig. Mangoola has made attempts in the field to access these areas and has completed multiple field inspections with the drilling contractors. Based on the advice of the drilling contractors, the groundwater consultants and the Mangoola Health and Safety department, these areas cannot currently be accessed by the drill rig to complete these holes.

In consultation with the groundwater consultant Mangoola have updated the Groundwater Management Plan (required under condition B50 of SSD8642) to include the commitment to install the proposed bores prior to the extraction of coal in the MCCO area. Prior to this there is no predicted changes to VWP pressure caused by Mangoola Operations. The management plan also commits to utilise the data from the new bore sites to confirm the VWP pressure changes as required by the commitments in the EIS.

Number: MANOC-1276546935-7

Status: [Document Status (Office)] **Effective:** [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] **Review:** [Planned Review Date]

Page 63 of 120

Commitment	Relevant WMP Section
Mangoola will monitor any private bores where impacts are predicted to identify if any impacts occur from the MCCO Project. Should these bores be affected by the MCCO Project, Mangoola will repair the bore, provide an alternative water supply or implement other measures agreed with the landowner	Sections 4.3 and 6.2
Mangoola will assess the validity of groundwater model predictions by comparing the extraction volumes and groundwater level data against model predictions every three years. If the data indicates significant divergence from the model predictions, an updated groundwater model will be constructed for the simulation of mining.	Section 9.4
Mangoola commit to complete additional baseline monitoring along Big Flat Creek in the area adjacent the eastern flank of the out-of-pit emplacement area for a minimum of 12 months prior to the commencement of mining as requested. This monitoring is proposed to be conducted at a selection of the existing bores that have been installed along Big Flat Creek in this area and may include GW01, MN 1006, GW047877, REG001 and GW07 as deemed appropriate (see Figure 8.1 in the GWIA Appendix 12 of the EIS). Mangoola commit to include this proposed monitoring within the revised water monitoring program for the MCCO Project. The monthly monitoring frequency is only proposed prior to the commencement of mining with the monitoring frequency and commitments made in the MCCO Project EIS and GWIA to be followed once the baseline program has been completed and mining commences.	Section 5.4
Mangoola commits to include details in the revised Water Management Plan relating to the monitoring, management and mitigation of potential impact risk associated with drawdown of water level to registered water users and potential leachate generation from out-of-pit spoil emplacement area adjacent to Big Flat Creek.	Sections 5.4 and 4.3
Mangoola commit to revise the GWMP for the MCCO Project to include new groundwater monitoring sites to monitor the potential impacts of the MCCO Project. The locations of the proposed bores are shown using purple dots on Figure 2.10 and are identified as Wybong 1, Sandy 1, GWMP1, GWMP2 and GWMP3.	Section 4.2

Number: MANOC-1276546935-7

Status: [Document Status (Office)] Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)] Review: [Planned Review Date]

Page 64 of 120

Appendix B - Groundwater Monitoring Network

Table B1: Groundwater Monitoring Summary

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
BFC01a	280759	6427279	Decommissioned due to mine progression *					
BFC1b	280755	6427279	Vibrating wire	Conglomerate	Bimonthly	Level	No	No
BFC02a	280773	6427175	Decommissioned due to mine progression *					
BFC2b	280770	6427178	Single VWP	Unweathered conglomerates	Daily	Pressure	No	No
BFC3a	280846	6427053.5	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
BFC3b	280850	6427055	Single VWP	Unweathered conglomerates	Daily	Pressure	No	No
BFC5a	279438	6426876	Single VWP	Conglomerate	Monthly	Level	No	Yes
BFC7a	279581	6426351	Standpipe	Conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
					Annually	+ Comprehensive chemical analysis		
BFC7b	279583	6426354	Vibrating wire	Conglomerate	Bimonthly	Level	No	No
BFC8a	279610	6426223	Standpipe	Conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
BFC8b	279613	6426223	Vibrating wire	Conglomerate	Bimonthly	Pressure	No	No
GW01-D	283207	6429325	Standpipe	Shallow strata/ weathered conglomerate	Bimonthly	Level, EC, pH	No	Yes

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 66 of 120

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
GW01-S	283207	6429327	Standpipe	Shallow strata/ weathered conglomerate	Bimonthly	Level, EC, pH	No	No
GW02	284064.0	6428454.0	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly Annually	Level, EC, pH and nutrients + Comprehensive chemical analysis	No	No
GW04 (EPL Monitoring Point 10)	284755	6427782	Standpipe	Permian interburden	Bimonthly Half-yearly Annually	Level, EC, pH and nutrients + Ion speciation + Comprehensive chemical analysis	No	No
GW06	280383	6428105	Standpipe	Triassic conglomerate	Bimonthly	Level and EC	Yes	No
					Half-yearly	+ Ion speciation		
GW07-D	281796	6427520	Standpipe	Regolith	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
					Annually	+ Comprehensive chemical analysis		
GW07-S	281796	6427520	Standpipe	Regolith	Bimonthly Half-yearly Annually	Level, EC, pH and nutrients + Ion speciation + Comprehensive chemical analysis	No	No
GW10-A2	280808	6427233	Decommissioned due to mine progression *					
GW10-P1	280808	6427233	Decommissioned due to mine progression *					

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
GW10-P2	280808	6427233	Decommissioned due to mine progression *					
GW13	280015.0	6426794.0	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
GW14	279512	6426559	Standpipe	Permian coal seams	Bimonthly	Level, EC, pH and nutrients	Yes	No
					Half-yearly	+ Ion speciation		
					Annually	+ Comprehensive chemical analysis		
GW15	280214.0	6426384.0	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	No	No
GW26 (EPL Monitoring Point 11)	277319	6426285	Standpipe	Conglomerate	Bimonthly	Level, EC, pH and nutrients	Yes	Yes
					Half-yearly	+ Ion speciation		
					Annually	+ Comprehensive chemical analysis		
GW35	281698.0	6425279.0	Standpipe	Fassifern and Pilot seams	Bimonthly	Level, EC, pH and nutrients	No	No
GW047877	282447	6428562	Decommissioned due to mine progression *					
GW202249	281196	6428217	Decommissioned due to mine progression *					
Jennar Well	286571.3	6429835.7	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
MB1	284816.0	6425033.0	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
MB2	284836.0	6424974.0	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 68 of 120

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
MP1a	284886.2	6426052.2	Standpipe + logger	Fassifern and Pilot seams	Bimonthly	Level, EC, pH and nutrients	Yes	No
MP1b	284886.2	6426052.2	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	No	No
MP2a ¹	284355	6424470	Standpipe+ logger	Permian coal seams	Daily	Pressure	Yes	No
					Bimonthly	Level, EC, pH and nutrients		
					Half-yearly	+ Ion speciation		
MP2b ¹	284355	6424470	Standpipe + logger	Conglomerate	Daily	Pressure	No	No
					Bimonthly	Level, EC, pH and nutrients		
					Half-yearly	+ Ion speciation		
MP3a	284186	6427346	Standpipe	Permian coal seams	Bimonthly	Level, EC, pH and nutrients	Yes	No
					Half-yearly	+ Ion speciation		
MP3b	284186.8	6427346.1	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	No	No
MP4a	283204.6	6428063.9	Standpipe	Fassifern and Pilot seams	Bimonthly	Level, EC, pH and nutrients	No	No
MP4b	283200.0	6428064.6	Standpipe	Deeper coal measures	Bimonthly	Level, EC, pH and nutrients	No	No
MP4c	283200	6428061	Standpipe	Permian coal seams	Monthly	Level, EC and pH	No	Yes
					Half-yearly	+ Ion speciation		
MP9a	280204	6426566	Standpipe	Regolith	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
					Annually	+ Comprehensive chemical analysis		

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 69 of 120

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
MP9b	280202	6426568	Vibrating wire	Conglomerate	Bimonthly	Pressure	No	Yes
MP10b	284946	6425122	Standpipe	Conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
MP10a	284946	6425122	Standpipe	Permian coal seams	Bimonthly	Level, EC and pH	No	No
					Half-yearly	+ Ion speciation		
MP15-B	280924	6426917	Standpipe with logger	Permian strata	Daily	Pressure	No	No
MP17-B	281469.7	6427132.6	Standpipe	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	Yes	No
MP17-C	281469.7	6427132.6	Single VWP	Fassifern and Pilot Seams	Bimonthly	Pressure	No	No
MP18a	280063	6426227	Standpipe	Permian coal seams	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
MP18b ¹	280059	6426227	Standpipe	Conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
					Half-yearly	+ Ion speciation		
MP19b	280379.7	6426327.9	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	No	No
MP20a	280575	6426430	Standpipe+ logger	Permian strata	Monthly	Level	No	Yes
MP20b	280570.2	6426427.5	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	No	No
VW1	279265	6425572	Vibrating wire	Permian strata	Daily	Pressure	No	Yes ³
GWMP3 (next to VW1)	279265	6425572	Standpipe	Permian strata	Monthly	Level	No	No

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 70 of 120

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
VW2	279342	6423746	Vibrating wire	Permian strata	Daily	Pressure	No	Yes ⁴
VW3	281721	6422805	Vibrating wire	Permian strata	Daily	Pressure	No	Yes ⁵
MN1006 (MN008)	283061.0	6428994.0	Standpipe + logger	Fassifern and Pilot seams	Bimonthly	Level, EC, pH and nutrients	Yes	No
MN1007 ⁶	278509	6428191	Vibrating Wire	Permian strata	Daily	Pressure	No	No
MN1014	282862.0	6428265.0	Standpipe + logger	Deeper coal measures	Bimonthly	Level, EC, pH and nutrients	No	No
NGW01B	278073.8	6427068.6	Standpipe + logger	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	Yes	Yes
NGW01C	278071.3	6427062.0	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	No	No
NGW02B	280975.3	6429919.9	Standpipe + logger	Unweathered conglomerates	Bimonthly	Level, EC, pH and nutrients	Yes	Yes
NGW03A	285374.2	6428679.1	Standpipe + logger	Shallow Strata/ weathered conglomerate	Bimonthly	Level, EC, pH and nutrients	No	No
REG01 (MN0011)	282095	6427980	Standpipe	Deeper Coal measures	Inactive, mined out			
GWMP2 (next to MN1007)	278509	6428191	Standpipe	Permian strata	Monthly	Level	No	No
Wybong1a	278764	6425142	Standpipe	Alluvium	Monthly Bimonthly	Level Level, EC, pH and nutrients	Yes	Yes
Wybong1b	278764	6425142	Standpipe	Unweathered conglomerate	Monthly Bimonthly	Level Level, EC, pH and nutrients	No	Yes
Wybong1c	278764	6425142	Standpipe	Great Northern Seam	Monthly Bimonthly	Level Level, EC, pH and nutrients	No	Yes
Sandy 1a	284433	6422221	Standpipe	Permian non-coal inter-burden	Monthly Bimonthly	Level Level, EC, pH and nutrients	Yes	Yes

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 71 of 120

Monitoring Bore	Easting ²	Northing ²	Type of Monitoring	Monitored Formation	Monitoring Frequency	Groundwater Monitoring Parameters	Compliance Trigger Bore	
							Groundwater Quality	Groundwater Level
Sandy 1b	284433	6422221	Standpipe	Permian non-coal inter-burden	Monthly Bimonthly	Level Level, EC, pH and nutrients	Yes	Yes
Bore 1 (R261)	280599	6432450	No monitoring in progress					
Bore 2 (R157)	281056	6430688	No monitoring in progress					
GW080507 (R144)	279313	6430796	Production with level logger		Download quarterly	Level	No	Yes
GW201589 (R144)	279464	6430445	Production with level logger		Download quarterly	Level	No	Yes
Bore 3 (R130)~	277461	6427424	Production with level logger		Download quarterly	Level	No	Yes
GW078502 (R83)	278957	6424371	No monitoring in progress					
GW26A	277367	6426593	Standpipe	Weathered rock or alluvium	Monthly	Level, EC, pH	No	No
GWMP1a	277913	6422707	Standpipe	Alluvium	Monthly	Level, EC, pH	No	No
GWMP1b	277913	6422707	Standpipe	Great Northern Seam	Monthly	Level, EC, pH	No	No
NGW01_D	278062	6427044	Standpipe	Conglomerate	Monthly	Level, EC, pH	No	No
NGW01_E	278060	6427042	Standpipe	Conglomerate	Monthly	Level, EC, pH	No	No

Notes: ¹ Equipped with automatic data logging capacity.

⁴ Bores VW2-2 and VW2-4.

² GDA 1994 MGA Zone 56.

⁵ Bore VW3-2.

³ VW1-4.

⁶ MN1007 is has vibrating wire piezometer pressure sensors installed in single borehole at 35m,114m,140m, and 182m

* Data obtained from Mangoola Mine – Annual Groundwater Review Report for 2023

~ Private agreement in place with landowner R130

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

All loggers installed in standpipes and vWP are downloaded monthly. For any trigger exceedance assessments this means three exceedances of three consecutive months

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

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Version: [Document Version
(Office)]

Review: [Planned Review Date]

Table B: Annual Comprehensive Water Quality Analysis

Annual Speciation Monitoring Parameters (mg/L unless stated otherwise)		
pH (pH Unit)	Dissolved Iron (Fe)	Mercury (Hg)
Electrical conductivity (EC) (µS/cm)	Silver (Ag)	Fluoride (F)
Total Dissolved Solids (TDS)	Arsenic (As)	Nitrite (NO ₂ as N)
Total Suspended Solids (TSS)	Boron (B)	Nitrate (NO ₃ as N)
Calcium (Ca)	Barium (Ba)	Total Kjeldahl Nitrogen (TKN as N)
Magnesium (Mg)	Cadmium (Cd)	Total nitrogen (Total N as N)
Sodium (Na)	Copper (Cu)	Total phosphorous (P)
Potassium (K)	Dissolved Manganese (Mn)	Total cations (meq/L)
Alkalinity – hydroxide, carbonate, bicarbonate, total (as CaCO ₃)	Lead (Pb)	Total anions (meq/L) (half-yearly)
Sulphate (SO ₄)	Selenium (Se)	Anion – Cation balance (%)
Chloride (Cl)	Zinc (Zn)	---

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Appendix C - Summary of Baseline Data

Table D1: Groundwater Quality data

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
BFC01A	51	2650	16270	13410	12457.6	3345	15840	47	6.7	8	7	7.2	6.8	7.9
BFC02A	51	456	17040	13860	10197.7	532.5	16500	47	6.8	8.3	7.1	7.3	6.8	7.9
BFC03A	50	2790	22980	18060	15910.8	3132	22310	46	6	8.3	6.6	6.7	6.2	7.8
BFC07A	24	3810	13590	12440	11276.2	6525	13233.5	22	6.9	7.8	7.2	7.2	6.9	7.5
BFC08A	23	15240	20630	18930	18735.2	15641	20617	21	6.3	7.1	6.9	6.9	6.5	7
GW01-D	85	1426	18380	13610	11523	2660	16500	81	5.9	8.2	7.1	7.1	6.7	7.7
GW01-S	85	7880	18100	14620	14317.3	9718	17160	85	5.8	8.1	7	7.1	6.4	7.5
GW02	118	10740	26940	20840	19374.9	11988	25662.5	114	5.5	9.6	8.4	8.2	6.9	9.1
GW03-D	47	18860	30100	26400	26331.5	23193	29610	49	6.1	7.7	7	7	6.5	7.6
GW03-D	49	6.1	7.7	7	7	6.5	7.6	49	6.1	7.7	7	7	6.5	7.6
GW04	114	6430	9550	7735	7830.6	6946	9223	112	6.2	8.7	7.2	7.2	6.9	8
GW047877	28	3120	6720	4955	4793.2	3314	6564	28	6.5	8	7.1	7.1	6.7	7.8
GW06	51	141.2	381	239	248.2	162.6	353.4	33	6.4	9	7.6	7.5	6.6	8.5
GW07-D	63	1100	10870	8340	8164.3	4390	10780	65	6.3	8.5	7.8	7.8	7.2	8.4

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Page 76 of 120

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
GW07-S	37	4810	21800	14490	13820.5	5696	20244	41	6.4	8.4	7.4	7.4	6.9	8.1
GW07-S	41	6.4	8.4	7.4	7.4	6.9	8.1	26	6.7	8	7.5	7.5	6.9	7.8
GW09	26	6.7	8	7.5	7.5	6.9	7.8	26	6.7	8	7.5	7.5	6.9	7.8
GW10-A2	110	207	13730	759	2581.2	265.9	11657	108	6.4	8.5	7.2	7.3	6.5	8
GW10-P1	114	576	15840	9150	7983	706.8	14910	110	6.2	8.3	7.1	7.2	6.7	7.9
GW10-P2	114	4060	12710	8310	8422.3	4346.5	12293.5	109	6.4	8.4	7.4	7.4	6.9	8
GW13	100	119.3	644	266	311.2	129.9	607	106	6.5	9.5	8.2	8.3	7	9.3
GW14	111	1672	7050	5190	4808.5	1827.5	6885	107	6.3	8.2	7.5	7.5	7	8
GW15	82	4020	16900	11235	11438.8	5330	15944.5	76	6.2	8	7	7	6.7	7.4
GW15	32	11180	16900	13580	14131.9	12462	16682	32	6.7	7.6	7	7	6.8	7.2
GW16	48	13250	22890	20225	19767.5	16138	22153.5	50	6	7.6	7	7	6.5	7.3
GW17	53	2780	18700	13930	13028.3	5224	17684	54	6.5	7.6	7.1	7.1	6.7	7.6
GW18	37	40	9720	7320	4207.8	58.8	7954	43	5.8	8.5	7.2	7.2	6.1	8.3
GW19	45	3010	7770	6198	6317.6	5254	7686	45	5.5	7.5	6.7	6.6	5.9	7.1
GW20	44	2260	7040	5855	5504.8	3042.5	6684	44	5.8	7.1	6.5	6.5	6.1	6.8

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

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Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
GW202249	26	2058	3860	2685	2832	2202.5	3612.5	26	7.5	9.1	8	8.1	7.6	8.7
GW26	90	1828	2813	2256	2292.3	1915.6	2776	91	6.4	7.7	7.2	7.2	6.8	7.6
GW27	67	4080	19520	13750	13783.1	9442	17806	68	6	8	7	7	6.6	7.5
GW28	43	6780	11880	10710	10205.1	8083	11485	43	6.1	7.1	6.6	6.6	6.2	7
GW29	37	9400	36300	29500	28265.1	20786	33780	42	4.5	7.4	7	6.9	6.7	7.3
GW30	54	7870	21980	11695	12486.7	8550	20508.5	54	6	7.7	6.9	6.9	6.6	7.5
GW31	59	9550	24950	20430	19918.5	14226	23810	61	4.4	8.9	6.7	6.7	6	7.1
GW32	52	1943	26000	21715	19231.1	4843	25445.5	57	4.4	8	6.9	6.9	6.6	7.5
GW33	77	9210	17040	14870	14482.5	11380	16424	73	5.4	7.7	6.9	6.9	6.5	7.3
GW34	41	1467	2722	2160	2128.5	1534	2640	41	6.5	7.6	6.9	7	6.7	7.2
GW35	42	1350	2960	2183.5	2240.9	1379.2	2919.5	45	6.3	7.6	6.9	6.9	6.4	7.4
GW40	47	2870	4970	4070	4027.4	3379	4376	51	5.8	8.4	6.9	6.9	6.4	7.3
GW41	37	3960	24400	18240	17347.3	4288	23280	37	6.2	7.5	7.1	7	6.3	7.4
GW43	23	214	1630	398	492.3	232.8	1338.5	27	6.1	8	7.1	7.1	6.5	7.9
GW44	26	6080	8040	7340	7341.5	6347.5	7877.5	30	5.1	12.2	6.8	7.1	6.6	9.7

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

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Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
GW46	93	5990	9210	7540	7544	6384	8280	88	6.1	7.5	7	7	6.4	7.3
GW47	33	853	21120	14240	13162.2	5166	20222	33	6.3	7.5	6.8	6.8	6.4	7.2
GW48	27	2630	13310	3520	4468.5	2924	11620	27	6.1	7.3	6.5	6.6	6.3	7.1
GW50	15	1573	11580	1888	3752.1	1647.9	9592	14	6.8	7.2	7	7	6.8	7.1
Jennar Well	26	1343	2572	1941.5	2001.8	1588	2542.5	26	5.9	8.8	7.2	7.2	6.6	7.9
MB1	48	1315	39300	28550	24321.5	3995.5	35165	48	6.5	7.8	7.1	7.1	6.8	7.7
MB2	49	11620	16800	14210	14269.2	12252	16254	49	7	8.1	7.2	7.3	7	7.7
MN0011	35	5000	11880	6440	6490.7	5201	8424	35	6	12.7	11.8	11.2	7	12.3
MN1006 (MN0008)	43	2950	4760	3520	3628.1	3224	4240	43	6.4	8	7.3	7.3	6.7	7.7
MN1014	37	6790	10240	8220	8416.2	7176	10032	37	8.8	12.4	9.6	10.2	8.9	12.1
MP1-A	58	2520	6930	5830	5529.5	2935.5	6910	54	7.3	8.5	8	8	7.6	8.3
MP1-B	59	2360	7800	6390	5968.3	2757	7630	55	7.4	11.2	8.6	8.9	7.9	11
MP10-A	59	2300	17130	8970	8807.6	2899	16093	54	6.3	8.6	7.4	7.3	6.6	7.7
MP10-B	56	10450	18900	15160	15179.3	12635	18155	54	6.1	8	6.5	6.6	6.2	7.5
MP11-A	23	8910	18660	16210	15183.5	10402	18180	23	4.5	7.6	7	7	6.8	7.6

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

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Version: [Document Version
(Office)]

Review: [Planned Review Date]

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
MP11-B	21	10400	18070	13890	14179.5	10410	17260	22	6.9	8.3	7.4	7.4	6.9	8
MP12-A	22	2920	7570	5470	5597.3	3163.5	7429.5	23	6.9	7.6	7.1	7.2	7	7.6
MP12-B	24	2530	10220	8380	7517.9	2622	10137.5	24	6.9	11	7.6	7.9	7	9.8
MP12-C	22	2164	3560	2945	2893.6	2391	3394.5	24	6.6	8.1	7.7	7.5	6.7	8
MP13-A	26	2690	18210	11405	10261.1	2754.2	17717.5	26	6.5	7.9	6.9	7	6.5	7.5
MP13-B	54	2480	10550	8620	7654.6	2767.8	10500	53	6.4	7.8	7	7	6.5	7.7
MP13-C	25	2480	10830	8740	7048.4	2582	10778	27	6.2	12	9.8	9.6	7.1	11.7
MP14-A	32	105	3730	960	1283.4	523.6	3250	36	6.6	8.3	7.5	7.5	6.8	7.9
MP14-B	29	2410	3800	3460	3318.6	2566	3754	31	6.4	7.8	7	7.1	6.5	7.6
MP14-C	26	2070	4260	3225	3314.7	2460	4215	28	6.7	7.9	7.2	7.3	6.9	7.7
MP15-B	54	3340	17040	14775	14397.6	10489	16887	64	6.7	8.7	7.2	7.3	6.9	7.8
MP16-B	102	8490	17290	14330	14234.2	11205	16684	97	6.7	8.4	7	7.1	6.8	7.7
MP17-B	24	1277	23230	11240	11176.8	1424	22780.5	24	7	8.2	7.2	7.4	7	8.2
MP18-A	43	4160	12470	9460	9354.3	4740	12164	43	5.9	7.3	6.8	6.9	6.6	7.3
MP18-A	43	5.9	7.3	6.8	6.9	6.6	7.3	43	5.9	7.3	6.8	6.9	6.6	7.3

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
MP19-A	20	9610	15700	14410	13779	10057	15700	20	6.3	7.1	6.9	6.8	6.6	7
MP19-A	20	6.3	7.1	6.9	6.8	6.6	7	20	6.3	7.1	6.9	6.8	6.6	7
MP2-A	51	2520	20230	11090	10292.2	2925	18320	51	6.9	8.8	7.6	7.6	7	8.4
MP2-B	55	11070	23660	18750	18979.8	12860	23630	59	6.5	7.9	7	7.1	6.6	7.8
MP20-A	36	11440	17200	15160	14863.1	12055	16795	41	6.4	7.3	6.9	6.9	6.5	7.1
MP20-A	41	6.4	7.3	6.9	6.9	6.5	7.1	41	6.4	7.3	6.9	6.9	6.5	7.1
MP3-A	58	2180	10840	8505	6846.3	2431.2	10540	56	7.1	11.6	7.6	7.8	7.1	9.4
MP3-B	56	2490	13970	11170	10756.8	4610	13690	53	6.8	7.9	7.3	7.3	6.9	7.6
MP4-A	149	6610	11530	9450	9722.6	8474	11260	151	6.2	9.5	7.6	7.7	7.3	8.3
MP4-B	146	5770	12770	6845	7113.4	6120	8190	142	6.5	9.4	7.9	7.9	7.5	8.3
MP4-C	149	10330	30280	24200	24460.9	19946	29634	146	4.7	8.8	6.9	6.9	6.6	7.6
MP6-A	15	2640	11940	9720	7163.3	2675	11933	15	6.7	8.3	7.4	7.5	6.8	8.2
MP6-B	15	2700	10370	7220	6870	3316	9789	15	8.2	11.4	10.1	10	8.8	11.3
MP8-B	14	2540	16820	14095	10536.4	2546.5	16761.5	14	6.9	8	7.3	7.3	7	7.9
MP9-A	146	6970	24100	14265	14381.2	11308	16840	143	5.8	8.3	6.7	6.8	6.4	7.3

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Site	EC (uS/cm)							pH						
	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile	No of measurements	Min	Max	Median	Average	5th %ile	95th %ile
NGW01B	32	3280	5610	4415	4423.9	3375	5358	31	7.1	7.8	7.6	7.5	7.3	7.7
NGW01C	33	5720	9720	7390	7557.6	6196	8884	32	6.6	7.5	7.1	7.1	6.7	7.3
NGW02B	34	4080	5790	4965	4930	4227.5	5583.5	34	6.3	7.7	7.4	7.3	6.7	7.6
NGW03A	33	5300	7570	6210	6342.1	5568	7256	32	6	6.8	6.6	6.5	6.1	6.7

Note: The table summarises the data collected from the start of the record at each site until the end of 2021.

Table D2: Groundwater level data

Site	No of measurements	min	ave	max	Site	No of measurements	min	ave	max
GW01-D	56	0.68	1.8748214	2.71	MP1-B	40	2.07	13.1595	16.38
GW01-S	56	0.58	1.8338929	2.74	MP2-A	39	4.04	36.046154	39.98
GW02	81	1.96	3.3177407	5.35	MP2-B	40	6.2	22.94775	28.73
GW03-D	61	3.09	3.9692623	4.84	MP3-A	39	6.82	27.766667	28.94
GW04	81	11.28	11.823889	13.07	MP3-B	39	1.9	24.784872	26.87
GW06	11	0.63	0.7063636	1.11	MP4-A	94	1.48	2.5285106	4.31
GW07-D	65	0.71	3.2110769	5.88	MP4-B	94	1.85	2.5970213	4.36
GW09	25	1.41	2.0132	2.78	MP4-C	94	2.63	4.2480851	5.43

Number: MANOC-1276546935-7

Status: [Document Status (Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version (Office)]

Review: [Planned Review Date]

Site	No of measurements	min	ave	max	Site	No of measurements	min	ave	max
GW10-A1	1	1.39	1.39	1.39	MP9-A	95	3.93	9.1126316	14.22
GW10-A2	79	2.35	7.7914557	13.52	MP10-A	43	6.38	16.825349	18.93
GW10-P1	79	5.62	9.6712658	17.33	MP10-B	43	8.16	10.671628	17.12
GW10-P2	79	3.24	10.133797	16.36	MP11-B	22	1.94	4.0140909	9.32
GW13	79	2.04	8.2723418	11.45	MP12-A	24	2.94	9.65875	33.89
GW14	78	3.2	12.507821	34.77	MP12-B	23	9.46	10.782174	15.1
GW15	82	3.17	11.287012	23.38	MP12-C	24	3.98	9.9258333	34.06
GW16	57	6.74	9.7537719	22.13	MP13-A	32	11	14.059688	18.32
GW17	57	7.68	11.503509	24.45	MP13-B	40	14.06	28.52675	45.85
GW18	44	6.47	8.8268182	17.86	MP13-C	30	14.28	24.637333	41.57
GW19	46	12.52	14.608696	23.55	MP14-A	30	3.6	11.792667	20.85
GW20	46	20.9	22.785	28.11	MP14-B	28	9.91	23.483214	48.67
GW26	67	15.15	15.858358	17.45	MP14-C	27	14.25	20.905926	36
GW27	63	6.03	8.5231746	17.6	MP15-B	70	4.1	8.593	14.9
GW28	43	7.62	8.1887209	8.62	MP16-B	92	3.53	8.7875	12.9
GW29	50	5.97	7.0032	7.75	MP17-B	28	2.52	5.3728571	16.28
GW30	54	6.98	8.2185185	14.52	MP18-A	10	41.06	45.193	48.65

Number: MANOC-1276546935-7

Status: [Document Status
(Office)]

Effective: [Effective Date]

Owner: [Owner (Office)]

Version: [Document Version
(Office)]

Review: [Planned Review Date]

Site	No of measurements	min	ave	max	Site	No of measurements	min	ave	max
GW31	60	6.8	8.2	13.47	MP18-B	8	15.08	15.10125	15.13
GW32	59	7	8.3468644	12.81	MP19-A	9	45.13	46.016667	47.14
GW33	61	6.85	7.8261475	11.2	MP19-B	5	18.09	18.098	18.1
GW34	45	34.26	36.643333	39.49	MP20-A	11	21.15	32.726364	34.03
GW35	53	9.3	60.178774	66.13	MP20-B	4	21.12	25.5575	38.85
GW40	59	33.99	38.806441	49.5	MP6-A	15	52.13	52.313333	52.48
GW41	37	8.52	9.8572973	10.51	MP6-B	15	36.21	37.946667	39.22
GW43	23	0.45	1.4804348	2.83	MP8-B	23	3.01	9.5617391	17.64
GW44	27	11.41	11.706296	12.12	BFC01A	35	0.47	8.9997143	12.15
GW46	74	17.43	19.438311	22.96	BFC02A	34	0.58	9.0897059	12.26
GW47	49	16.04	22.046531	27.22	BFC03A	35	0.54	8.9374286	12.85
GW48	36	16.67	19.771944	28.3	BFC07A	29	0.44	9.5948276	12.91
GW50	29	23.075	26.681897	27.67	BFC08A	28	0.48	8.7203571	11.58
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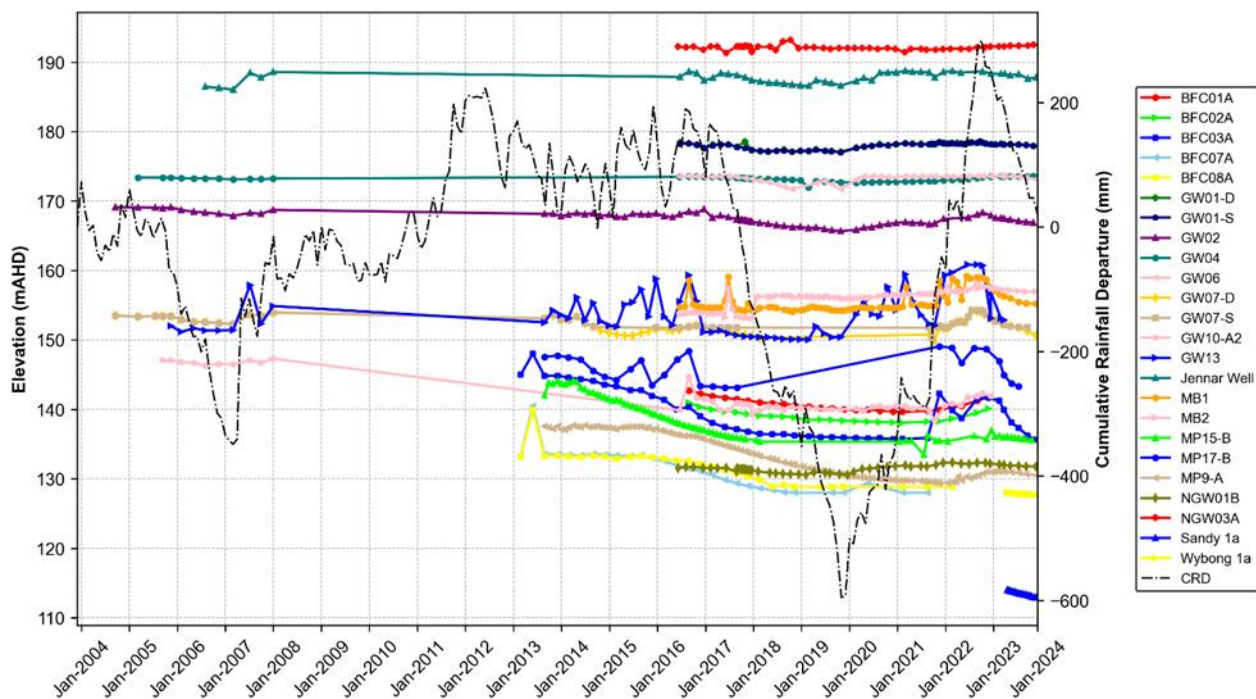
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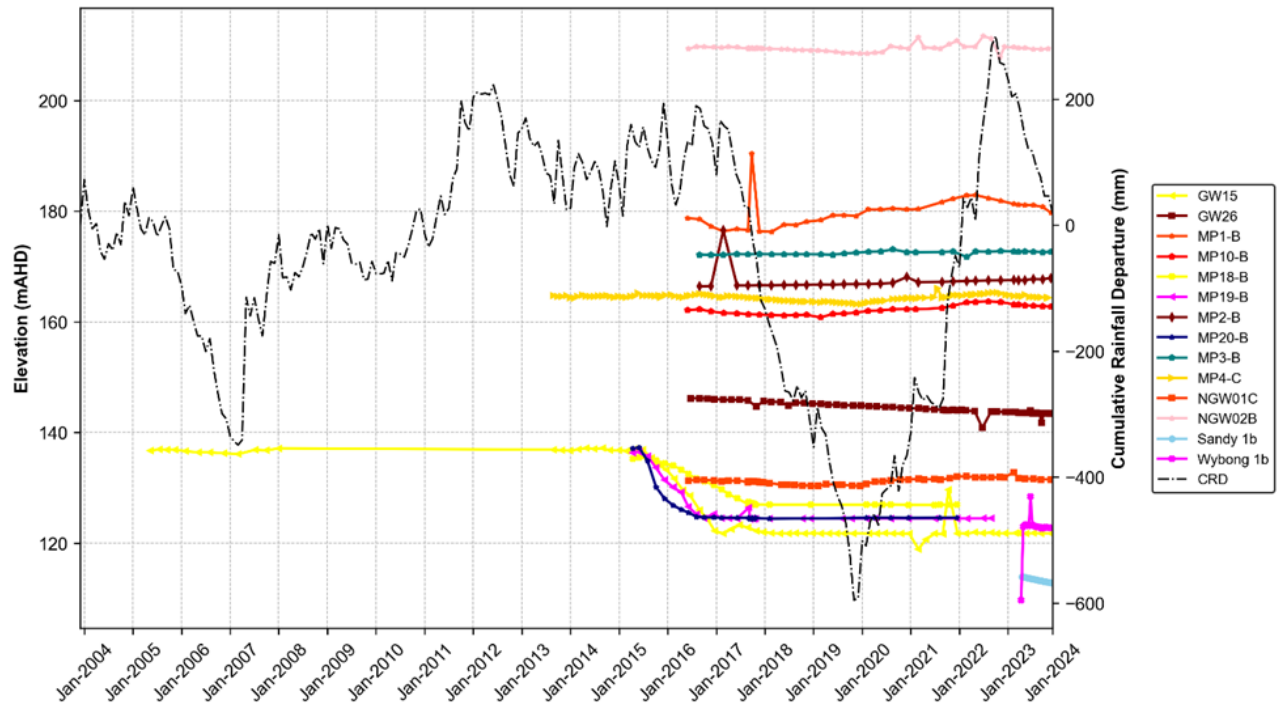
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Appendix D - Graphical Summary

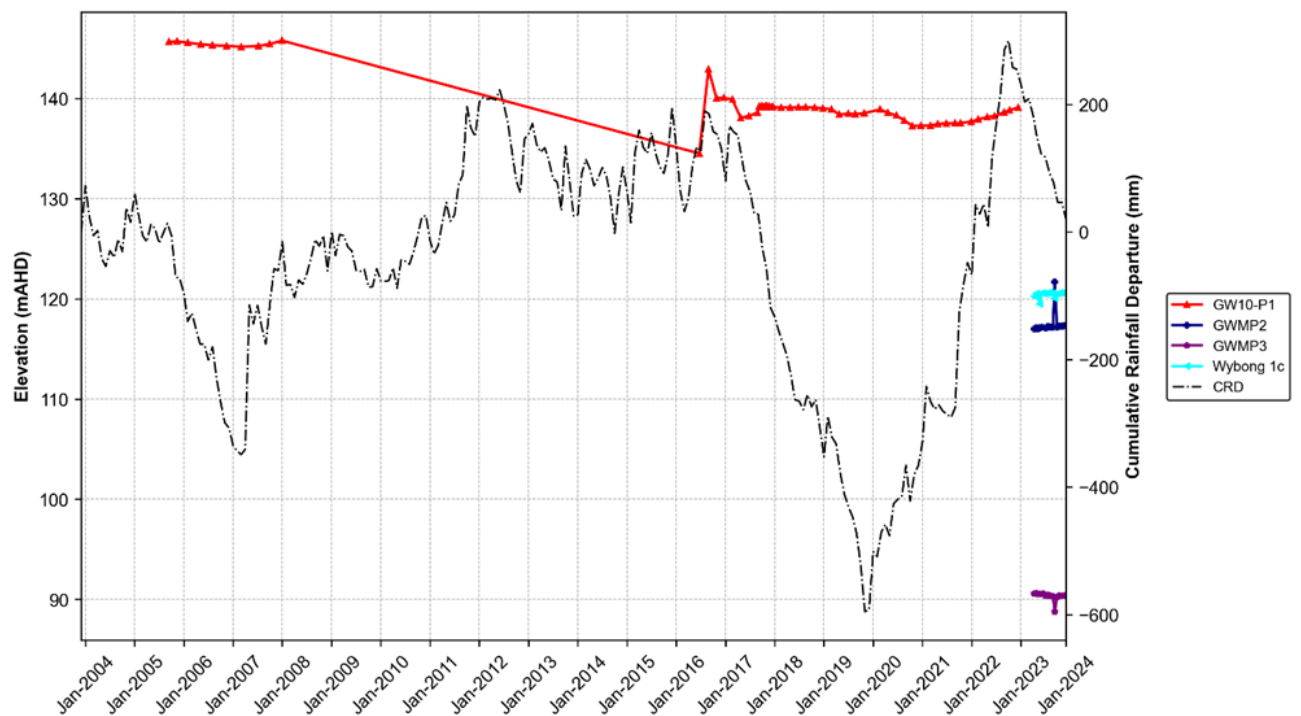
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Hydrographs of Shallow Strata / Weathered Conglomerate bores



Hydrographs of Unweathered Conglomerate bores



Hydrographs of Great Northern Seam and Awaba Tuff bores

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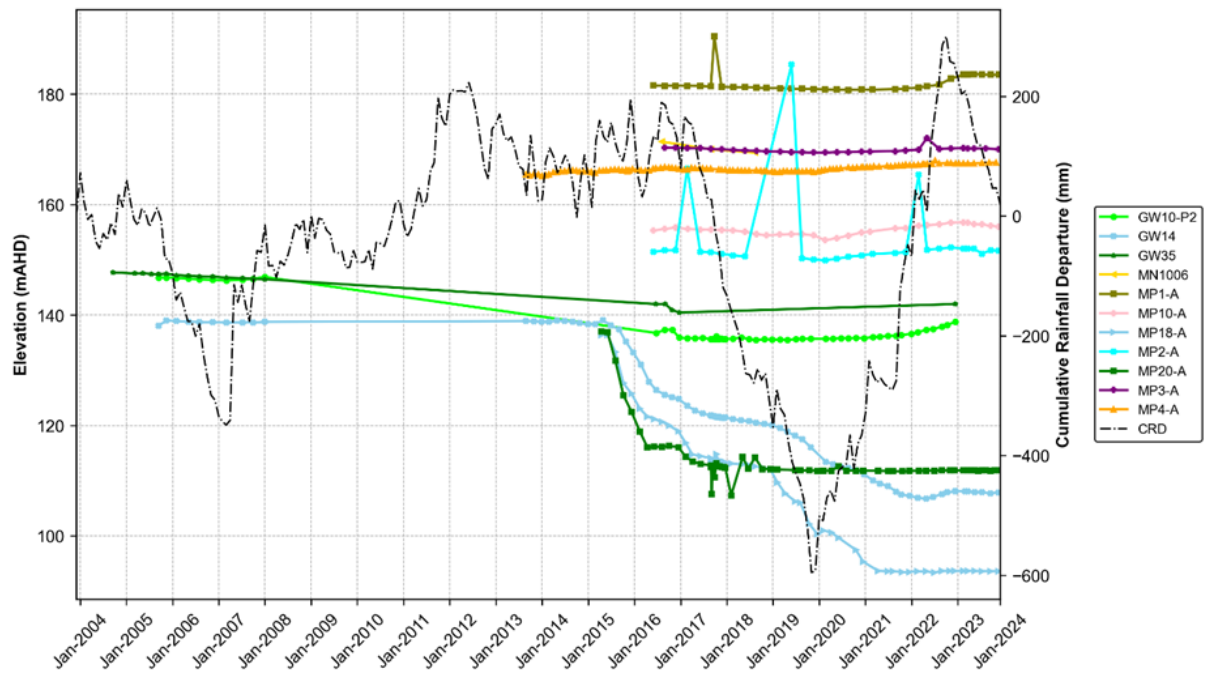
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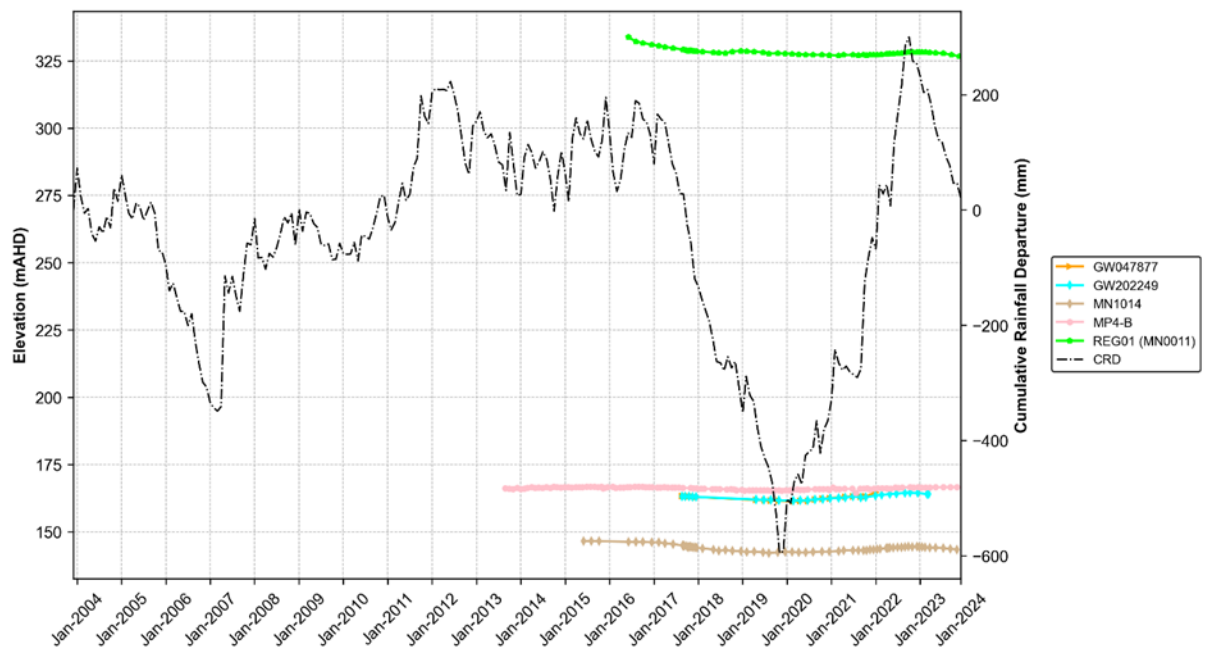
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Page 86 of 120



Hydrographs of Fassifern and Pilot Seams bores



Hydrographs of Deeper Coal Measures bores

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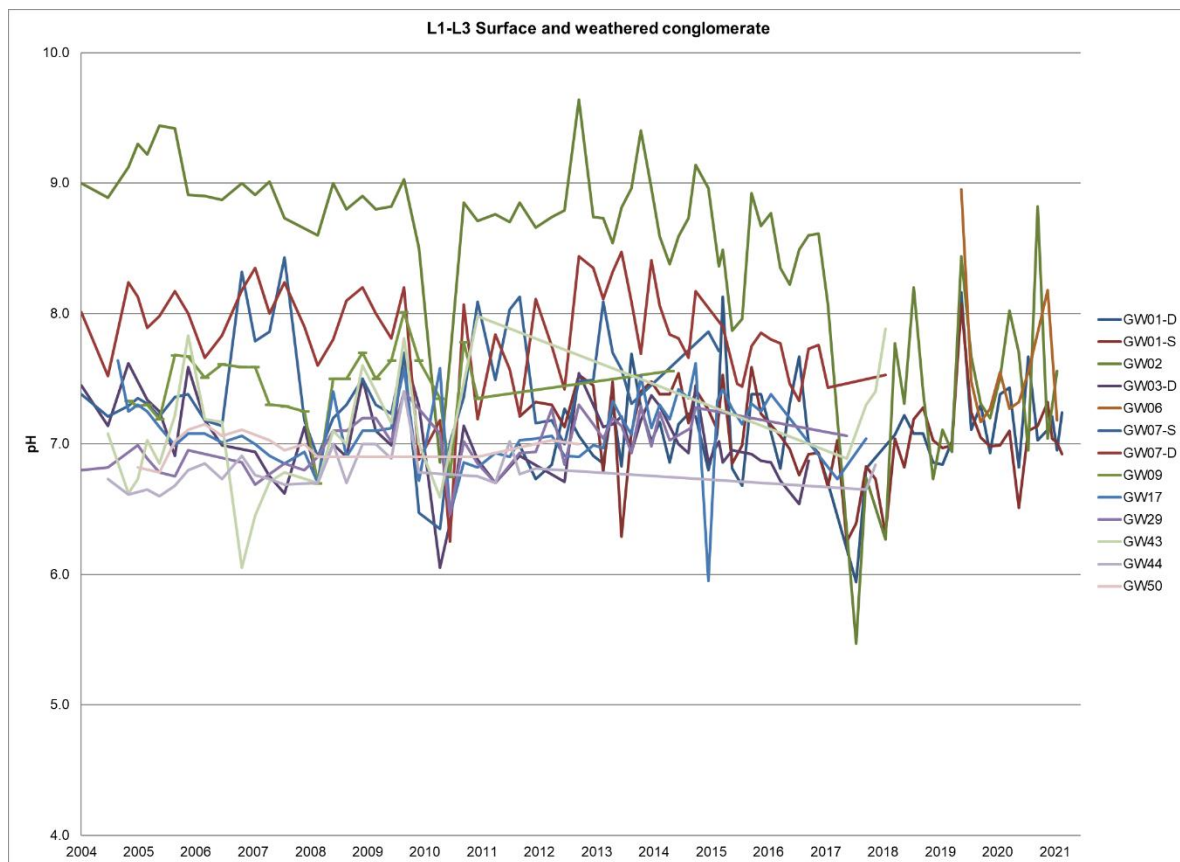
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Page 87 of 120

D.3 pH



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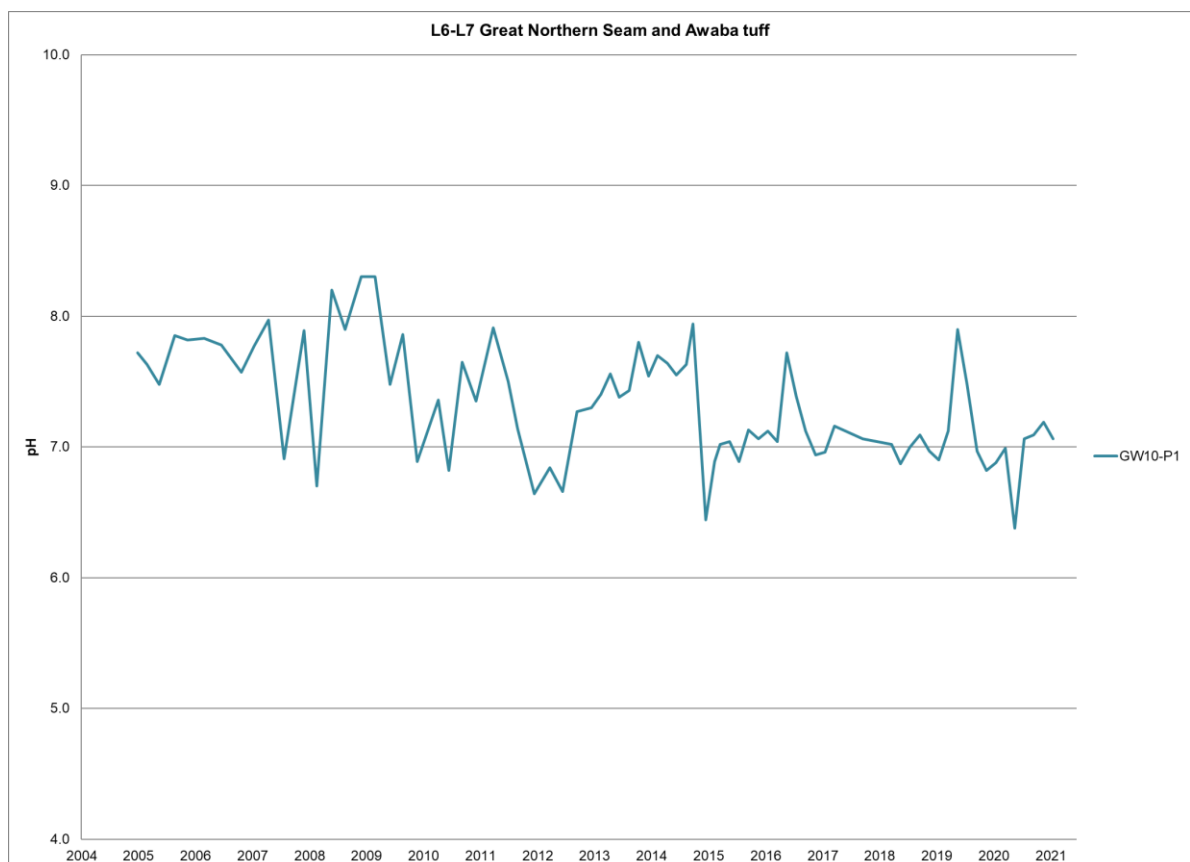
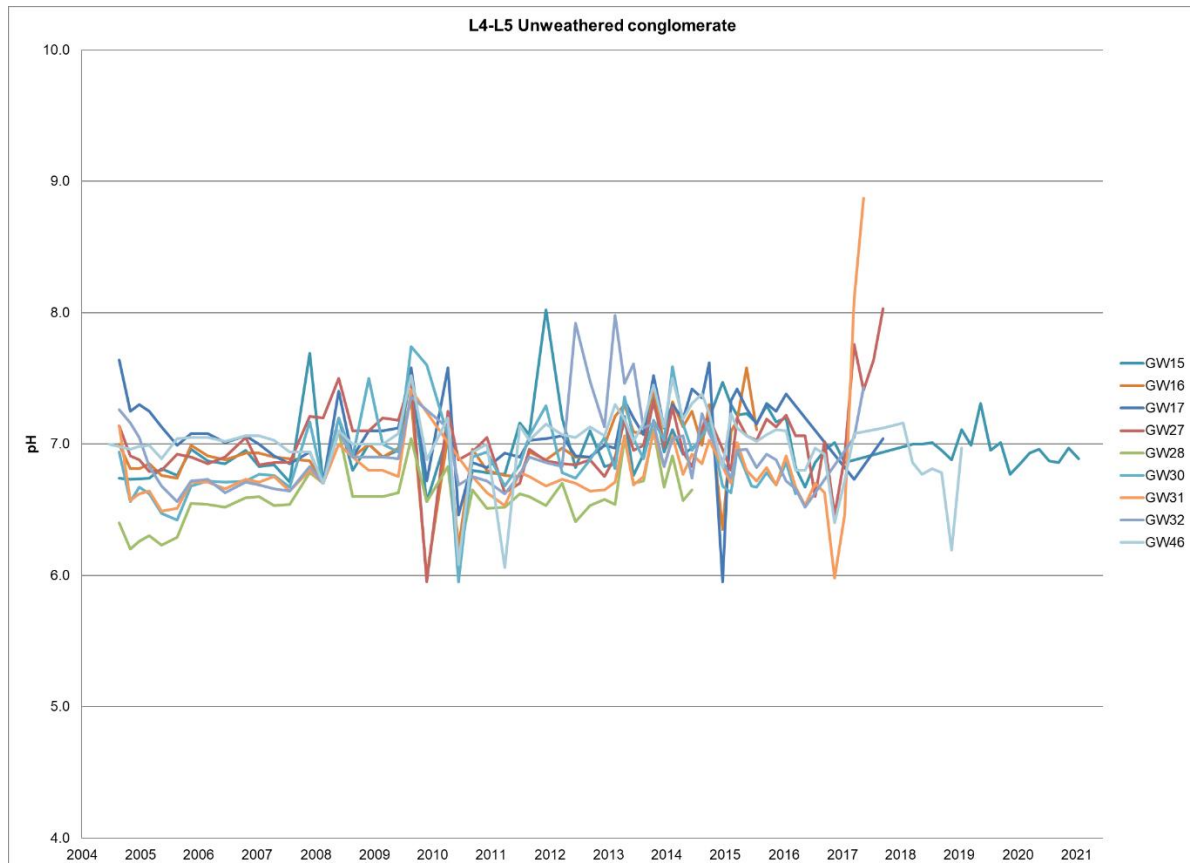
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Page 88 of 120



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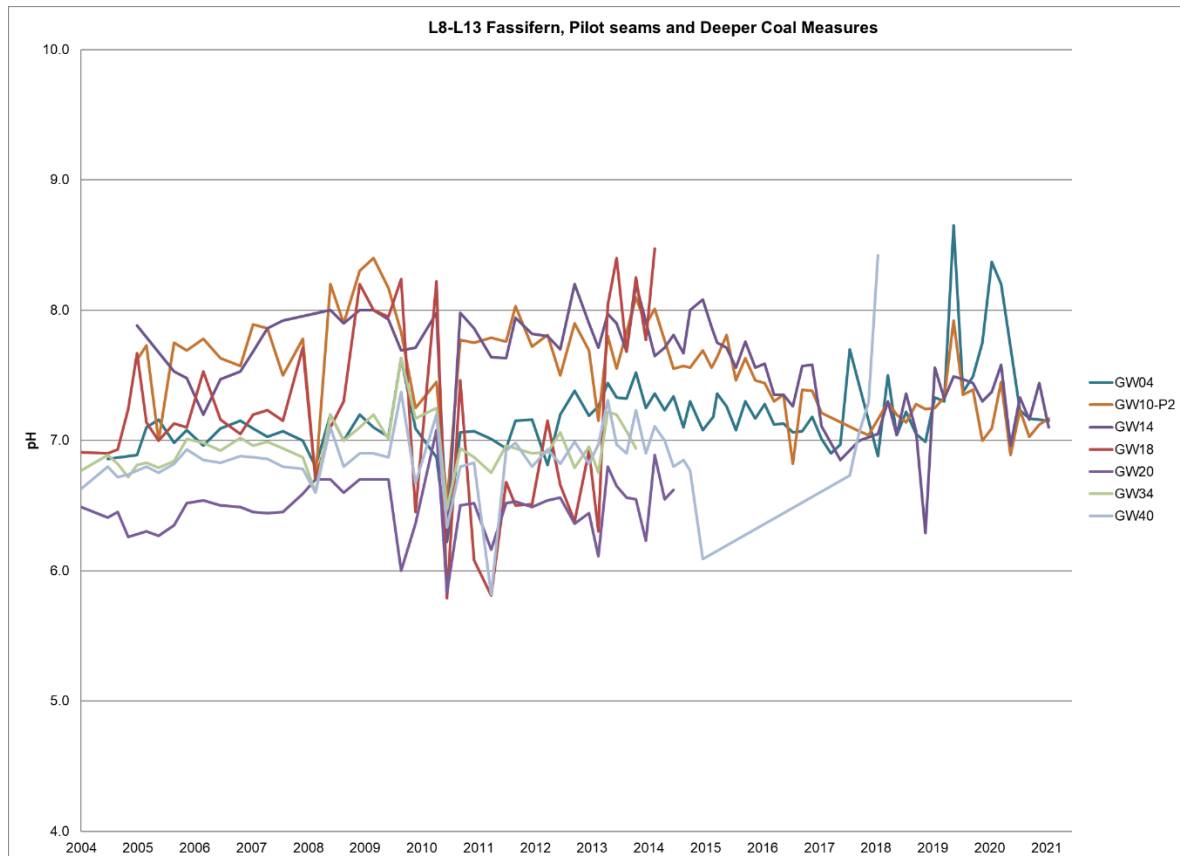
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Page 89 of 120



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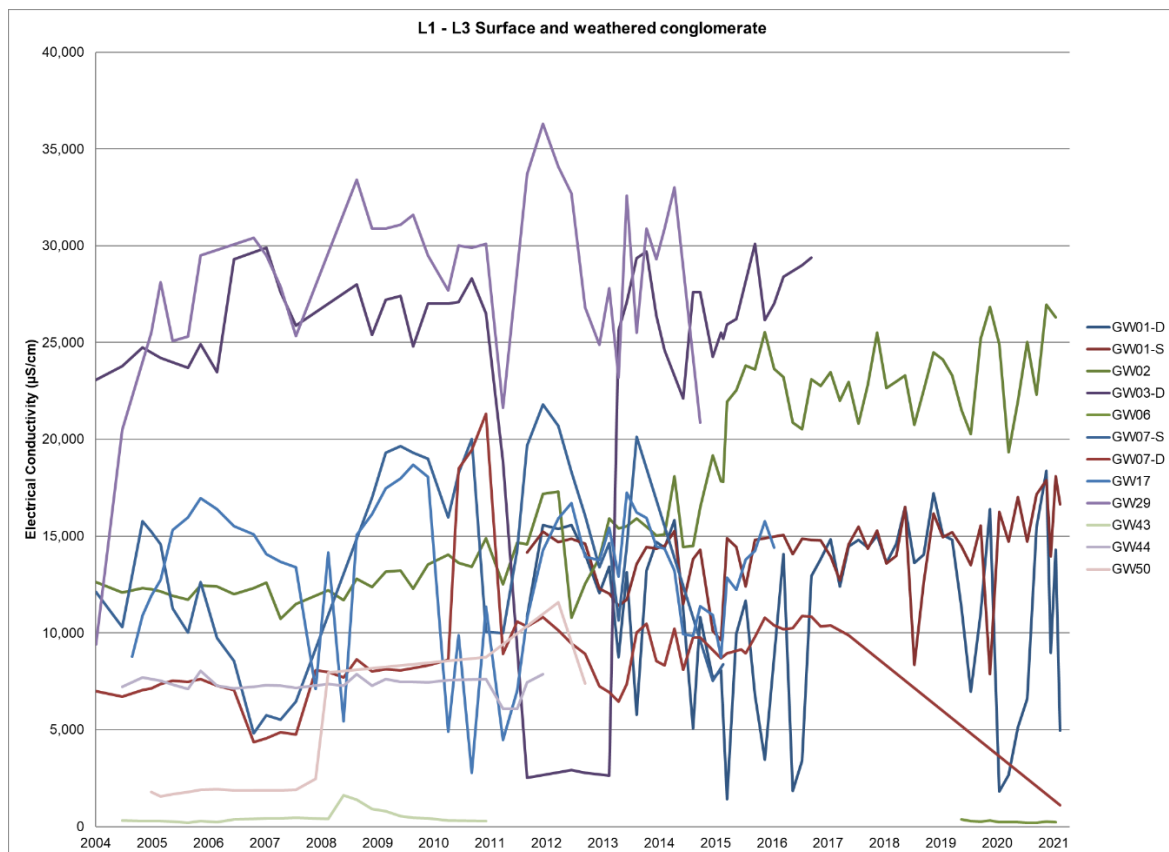
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Page 90 of 120

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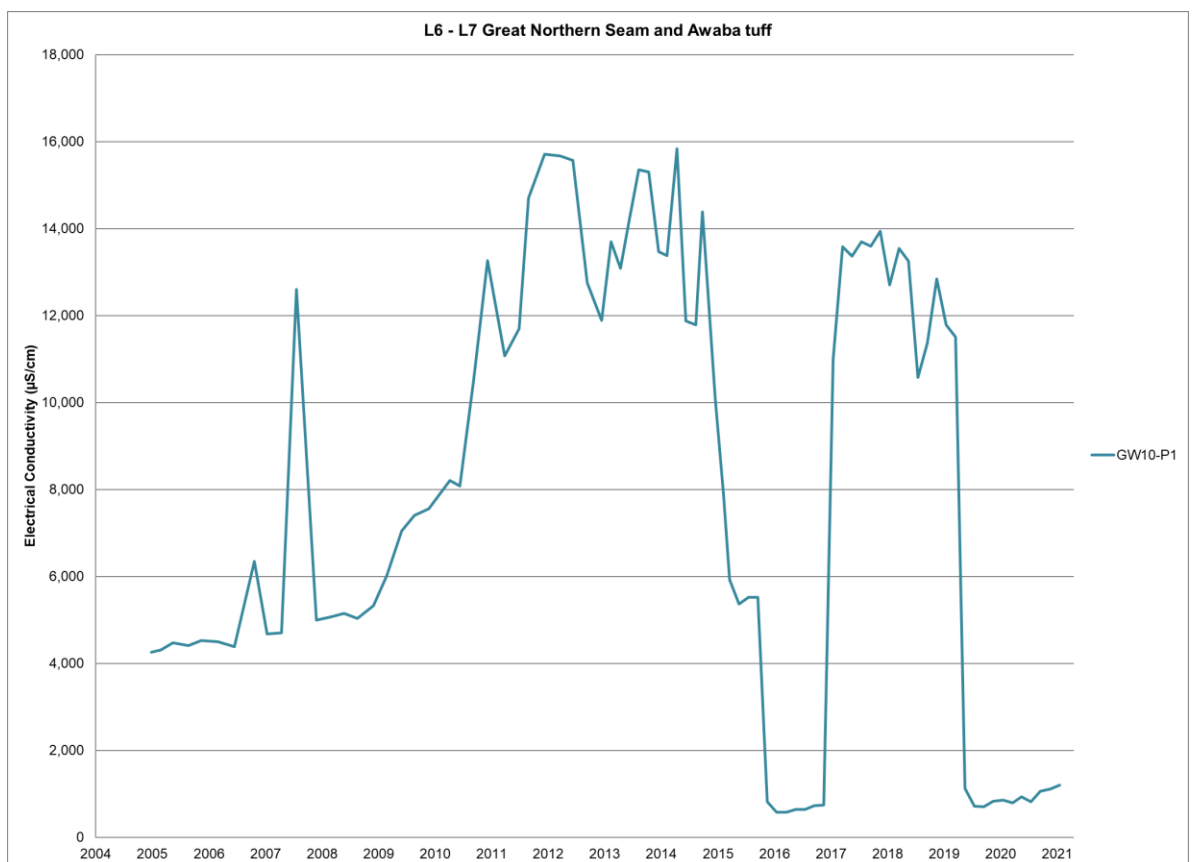
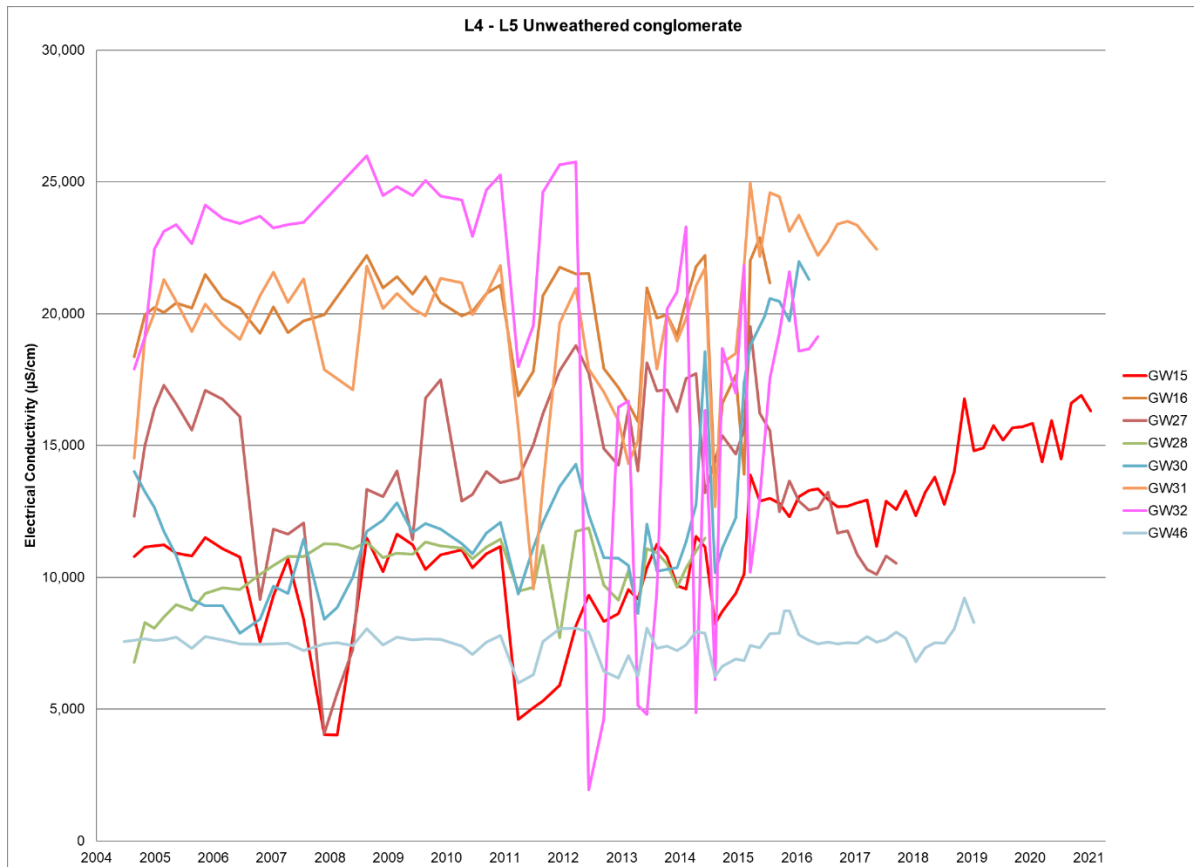
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Page 91 of 120



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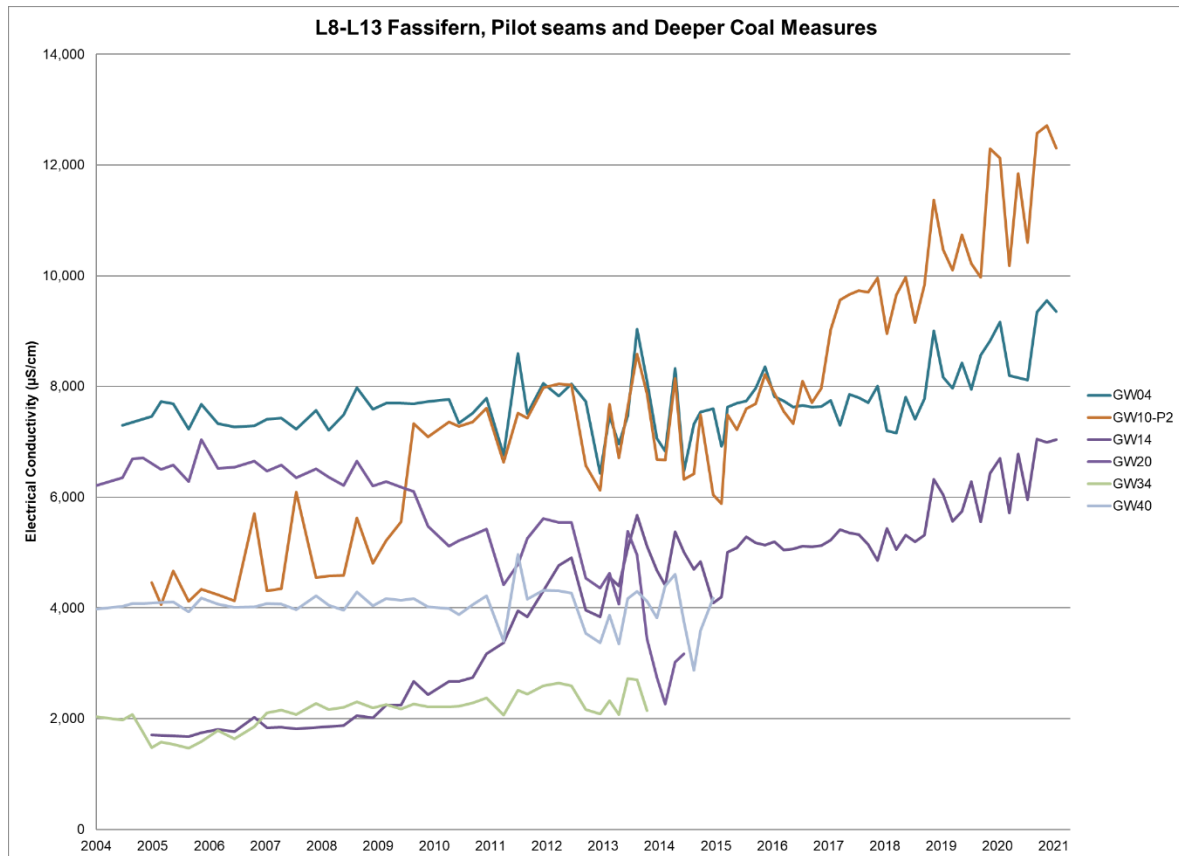
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Page 92 of 120



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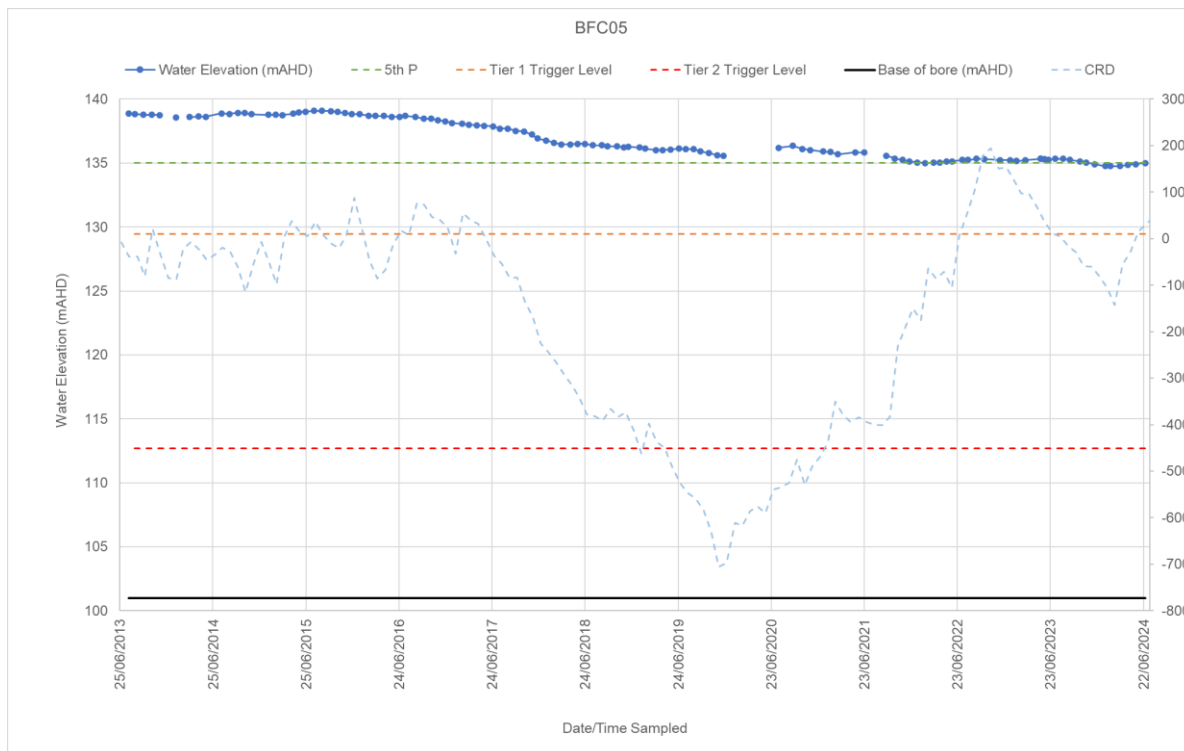
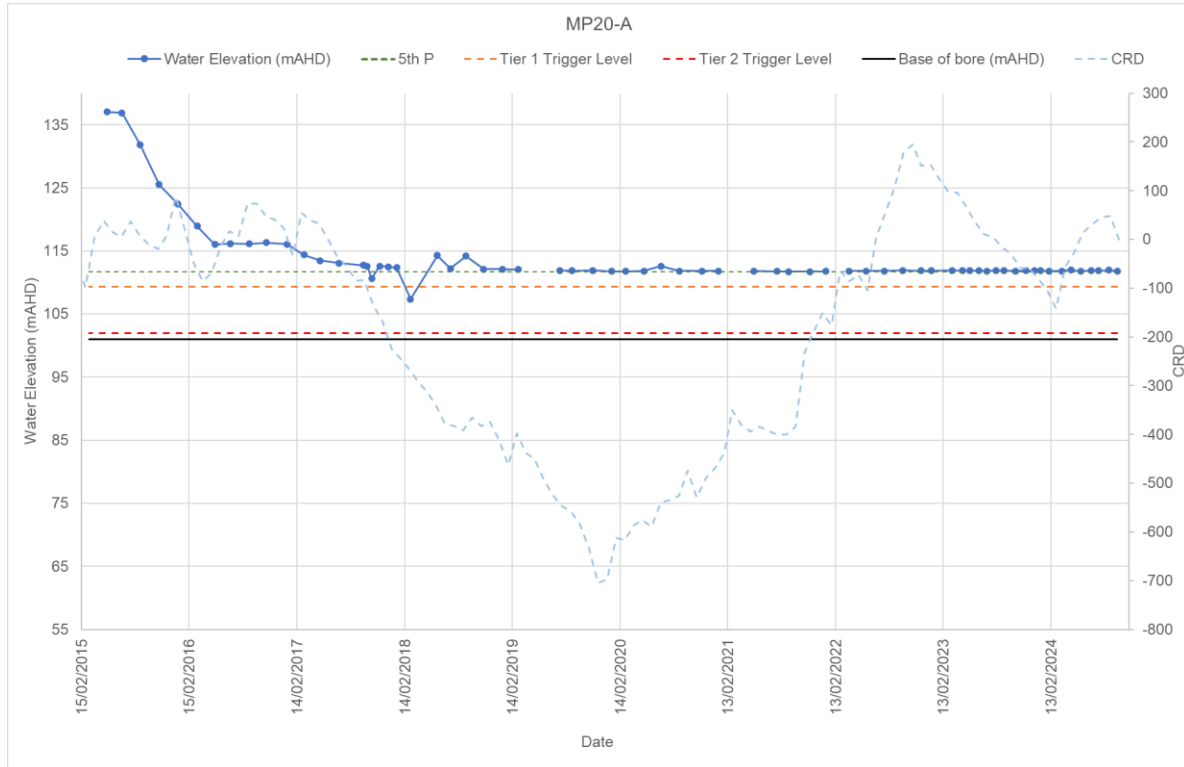
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Page 93 of 120

Appendix E - Trigger Charts

E.1. Groundwater Level



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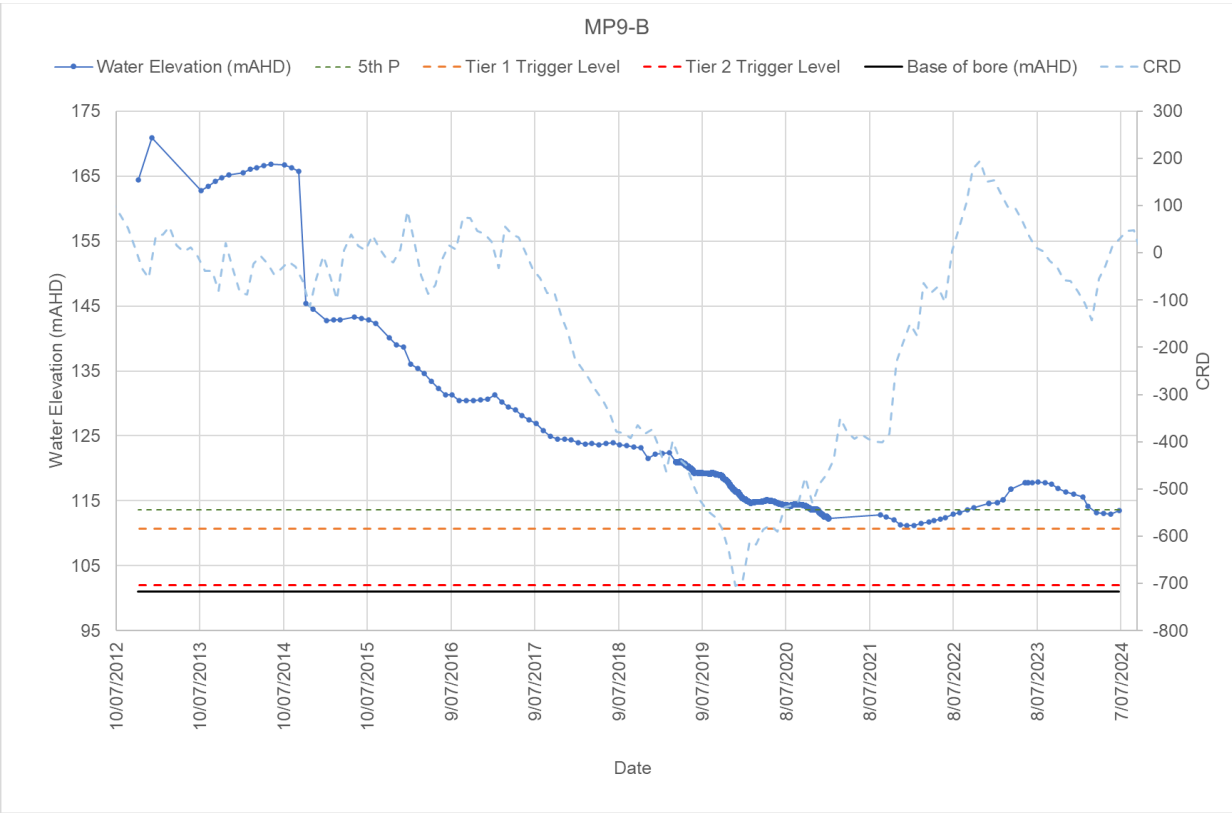
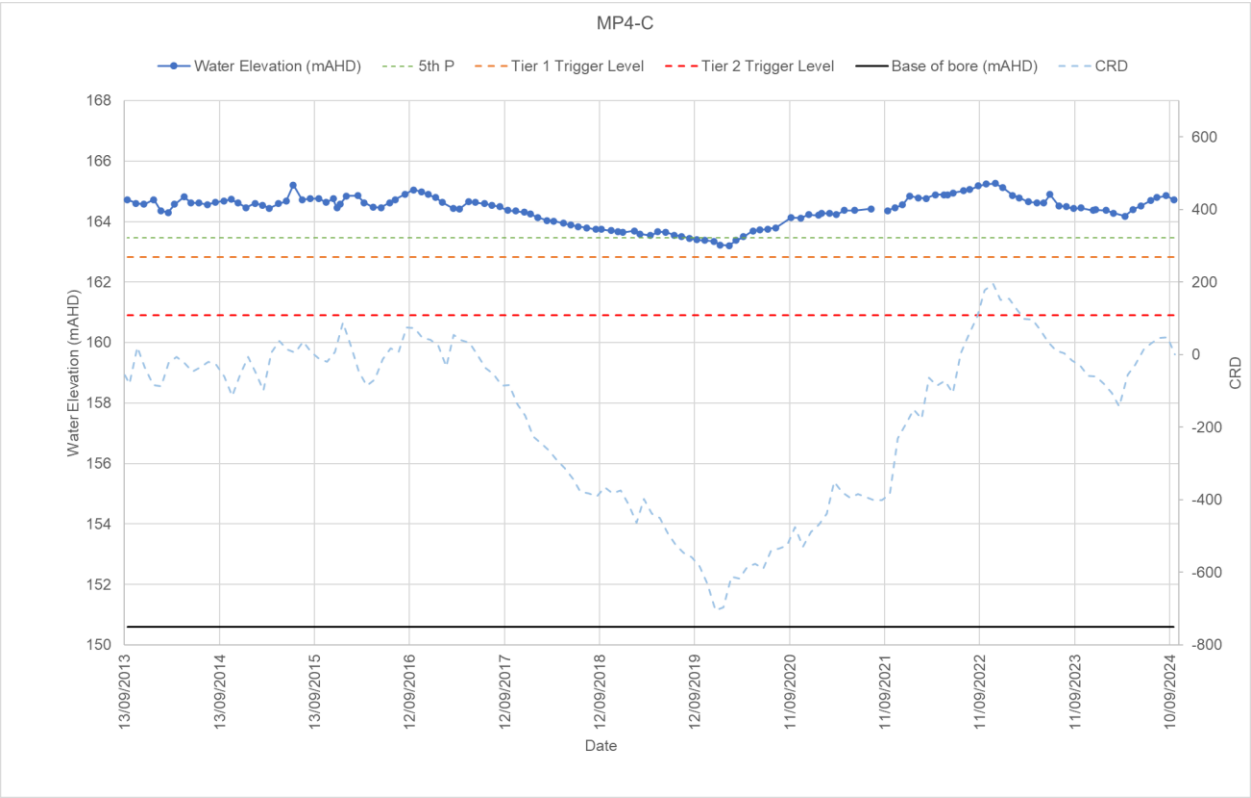
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Page 94 of 120



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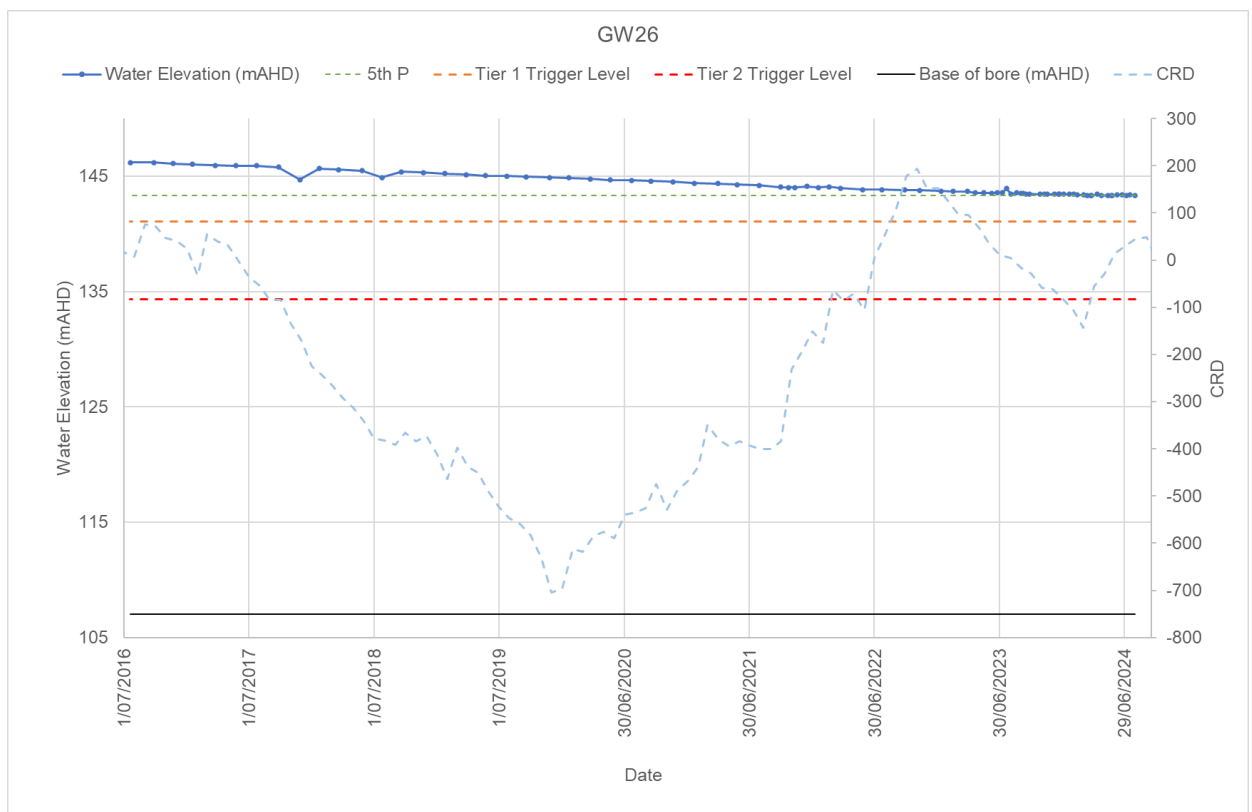
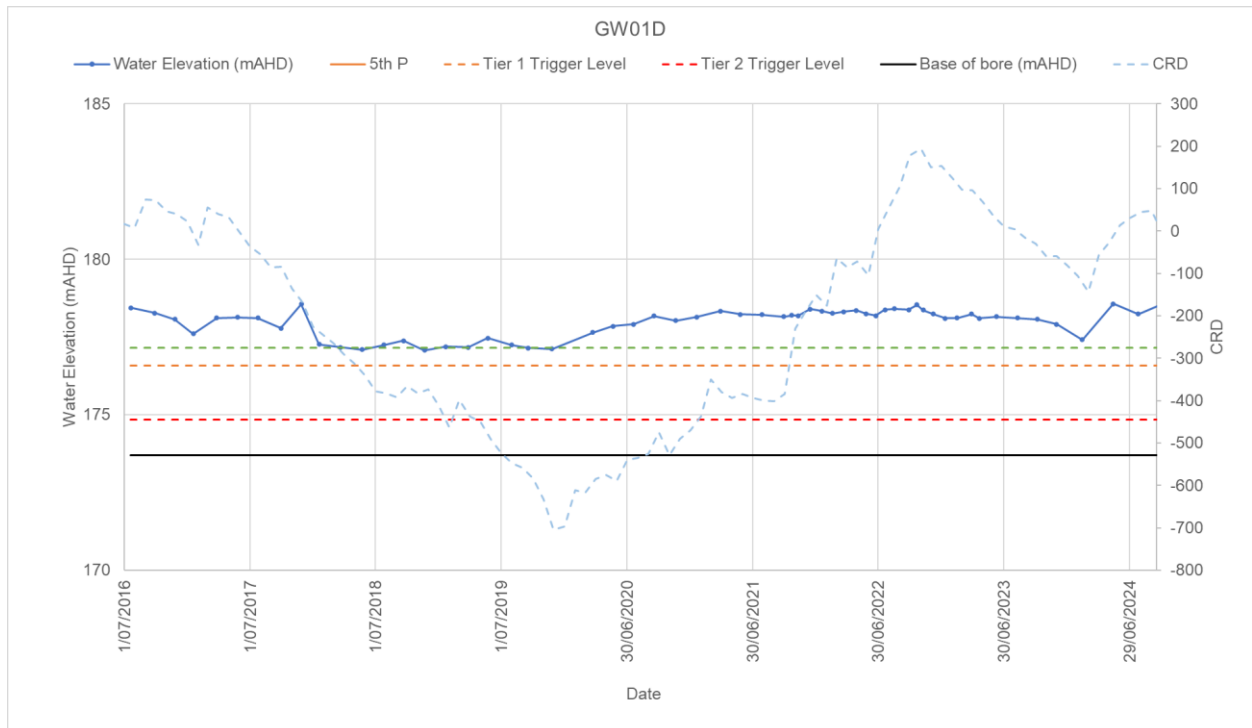
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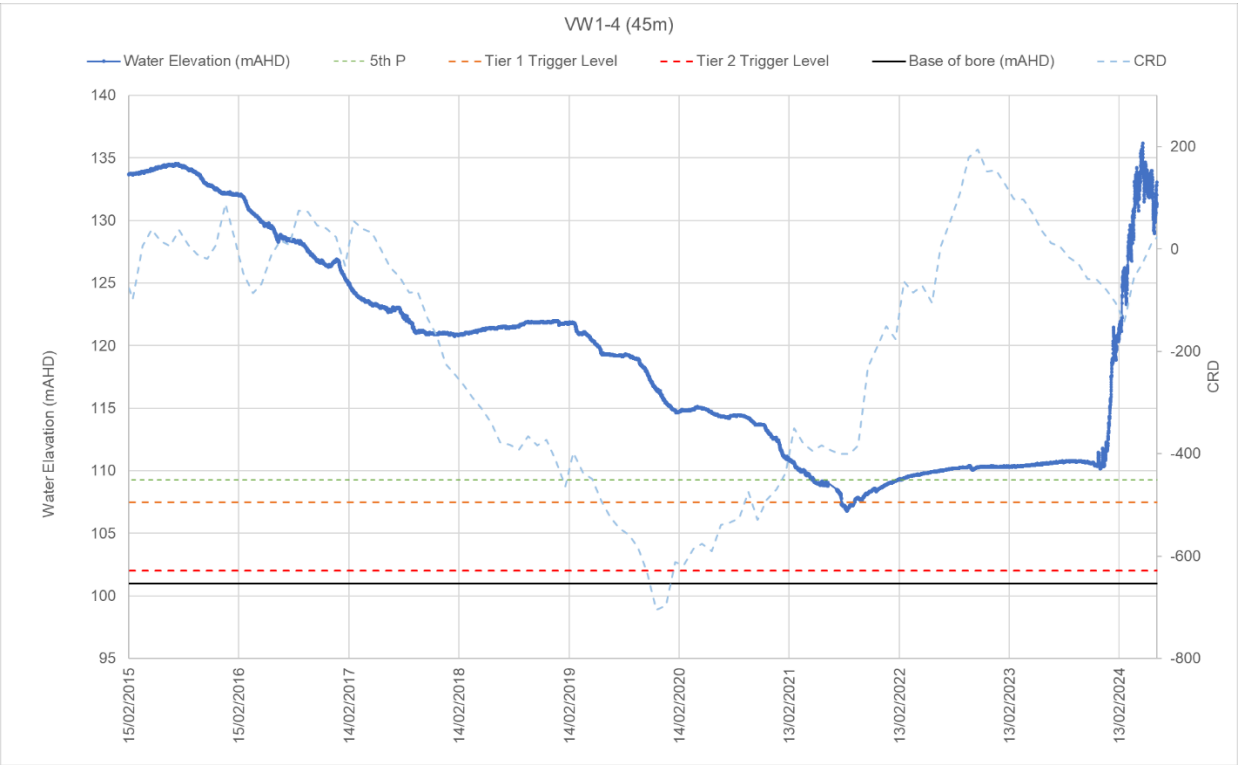
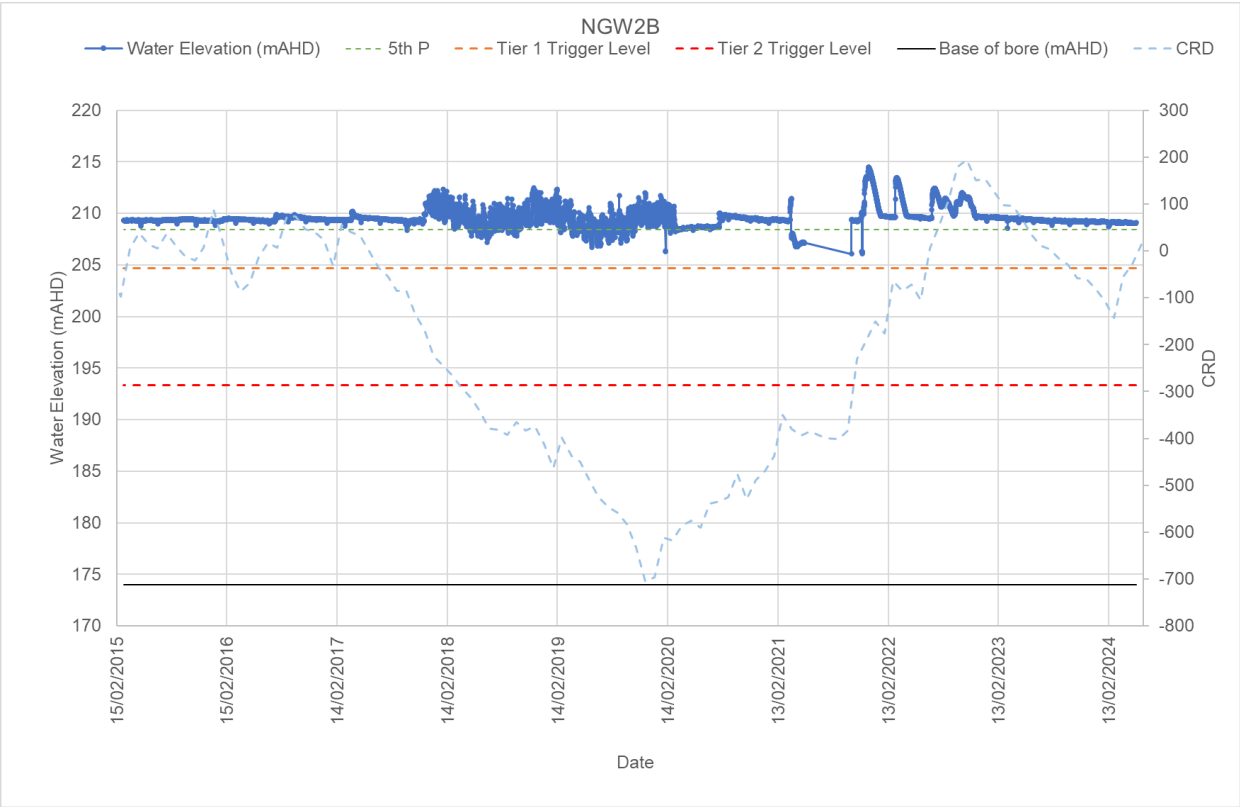
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Page 96 of 120



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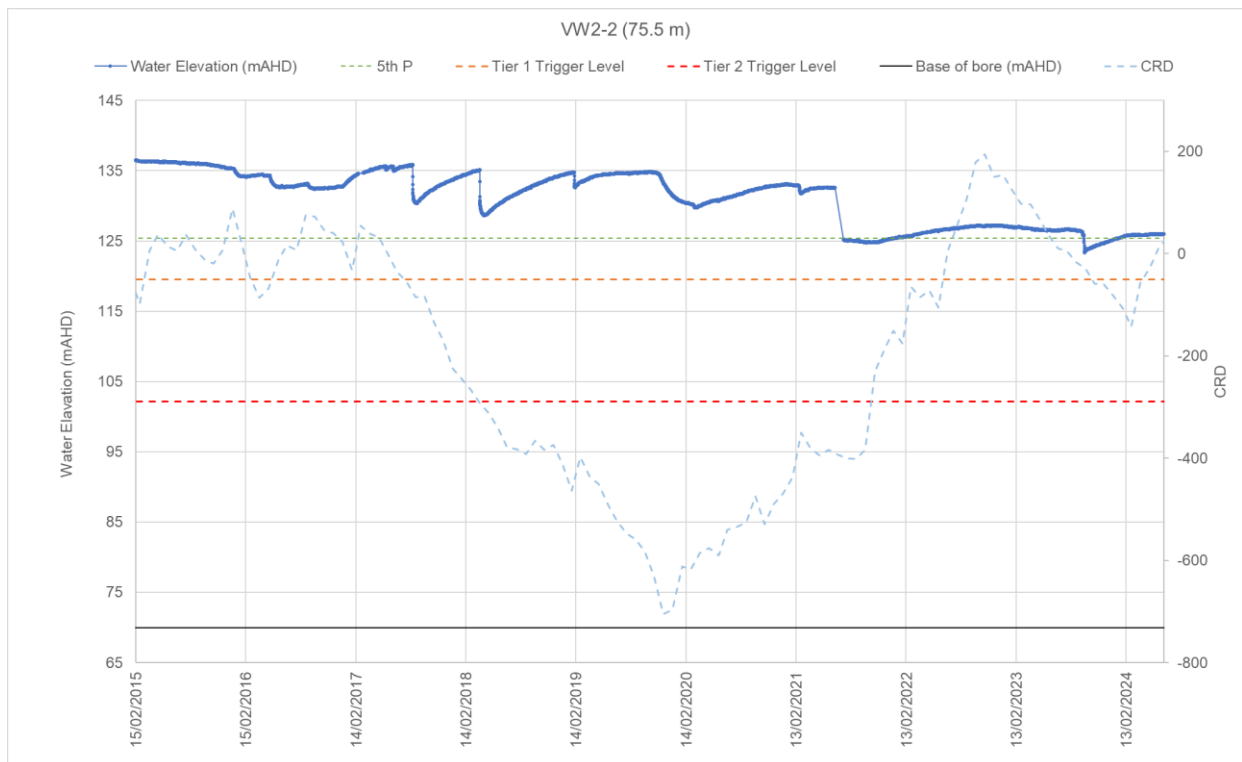
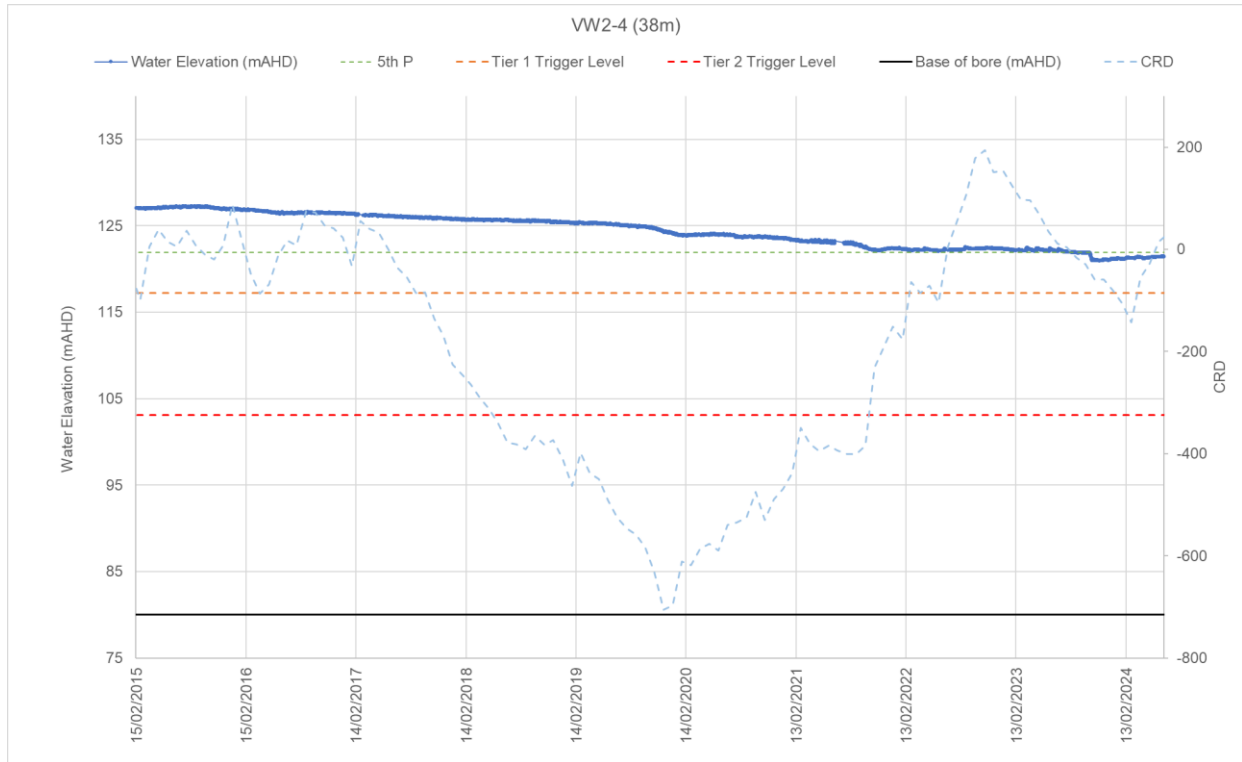
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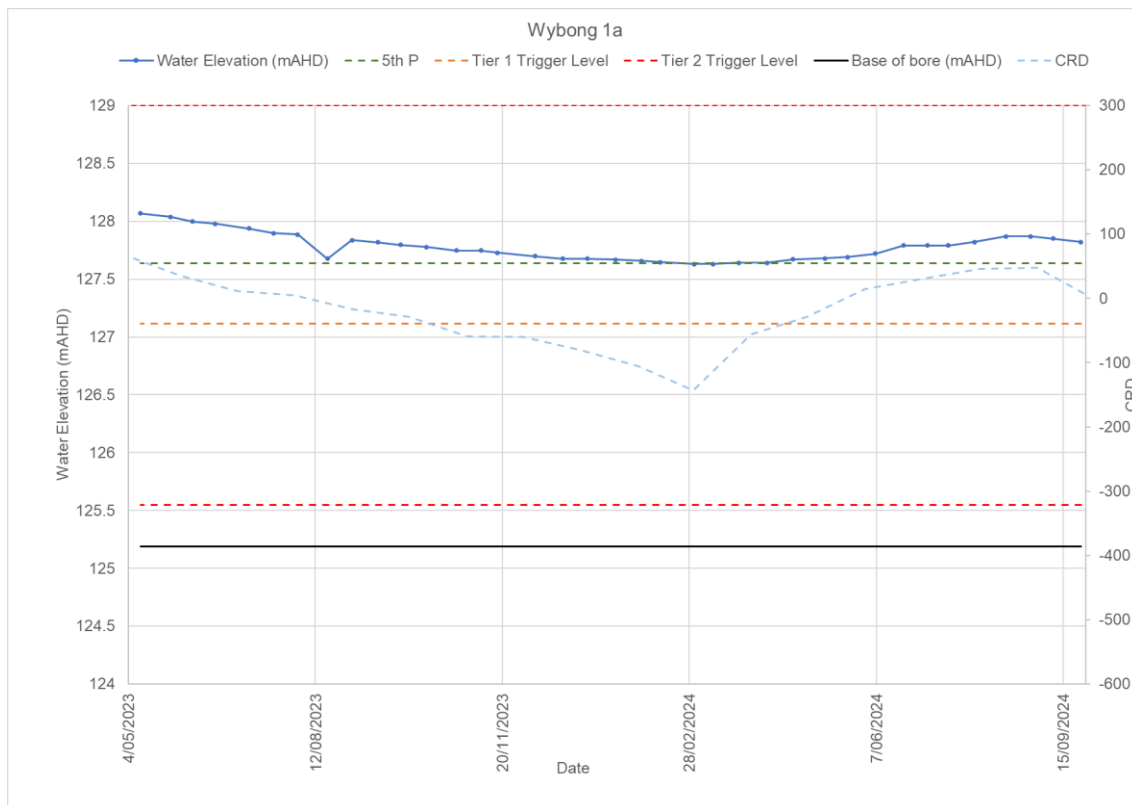
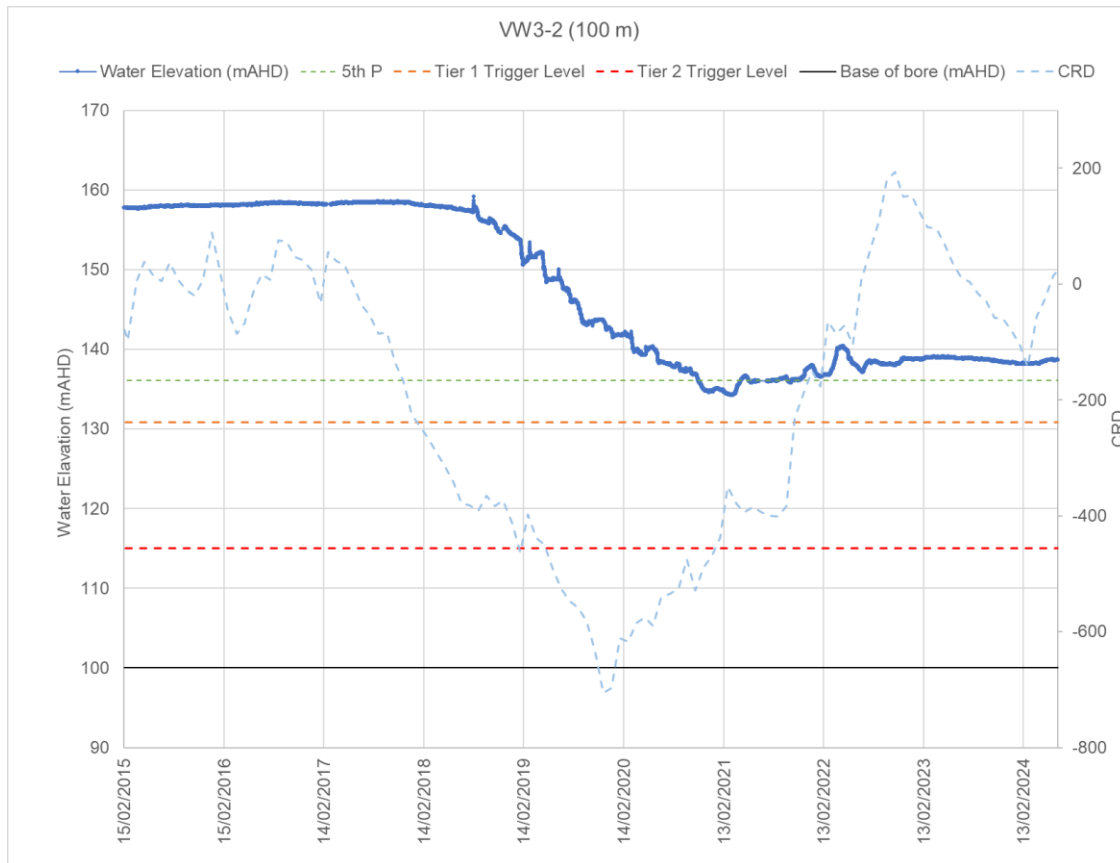
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Page 98 of 120



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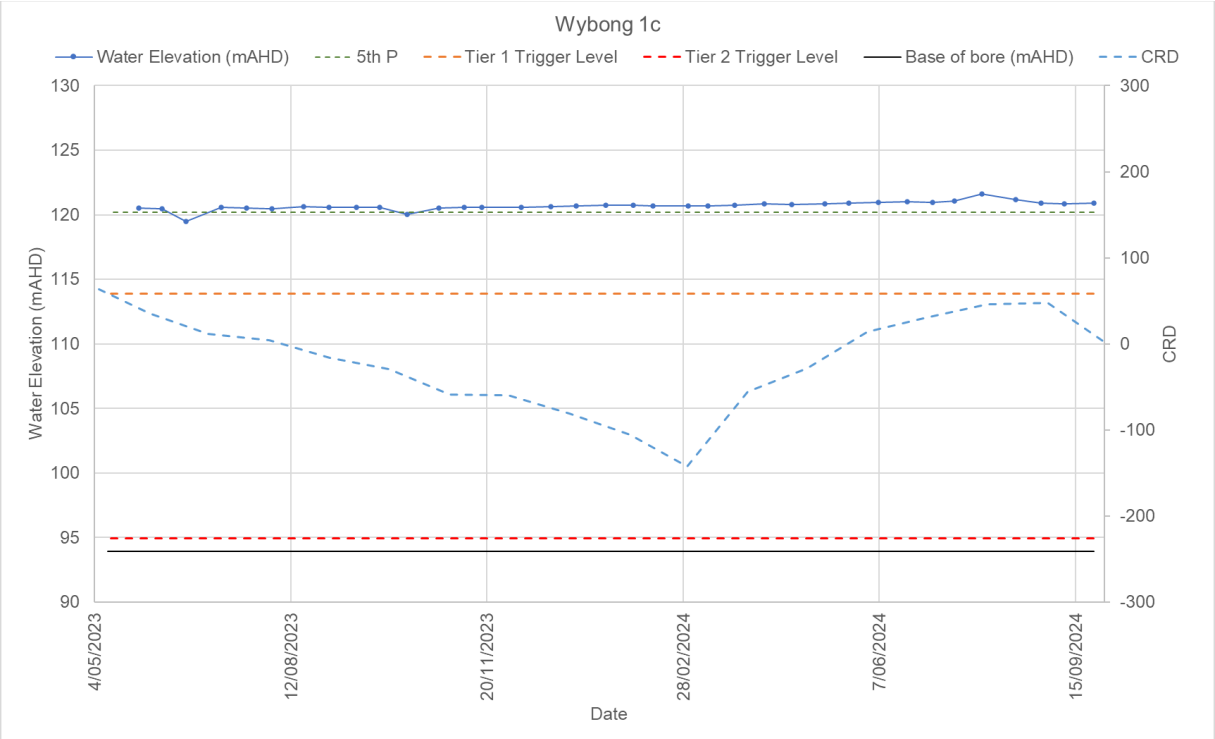
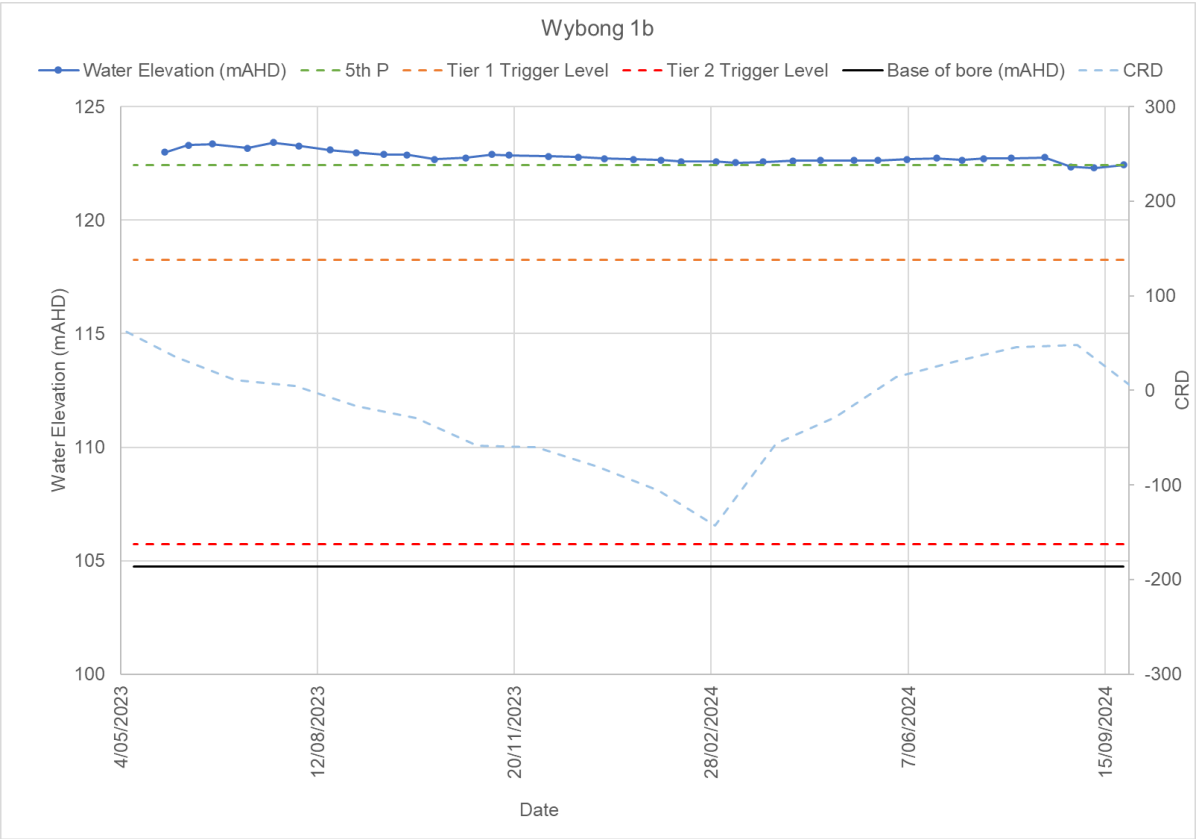
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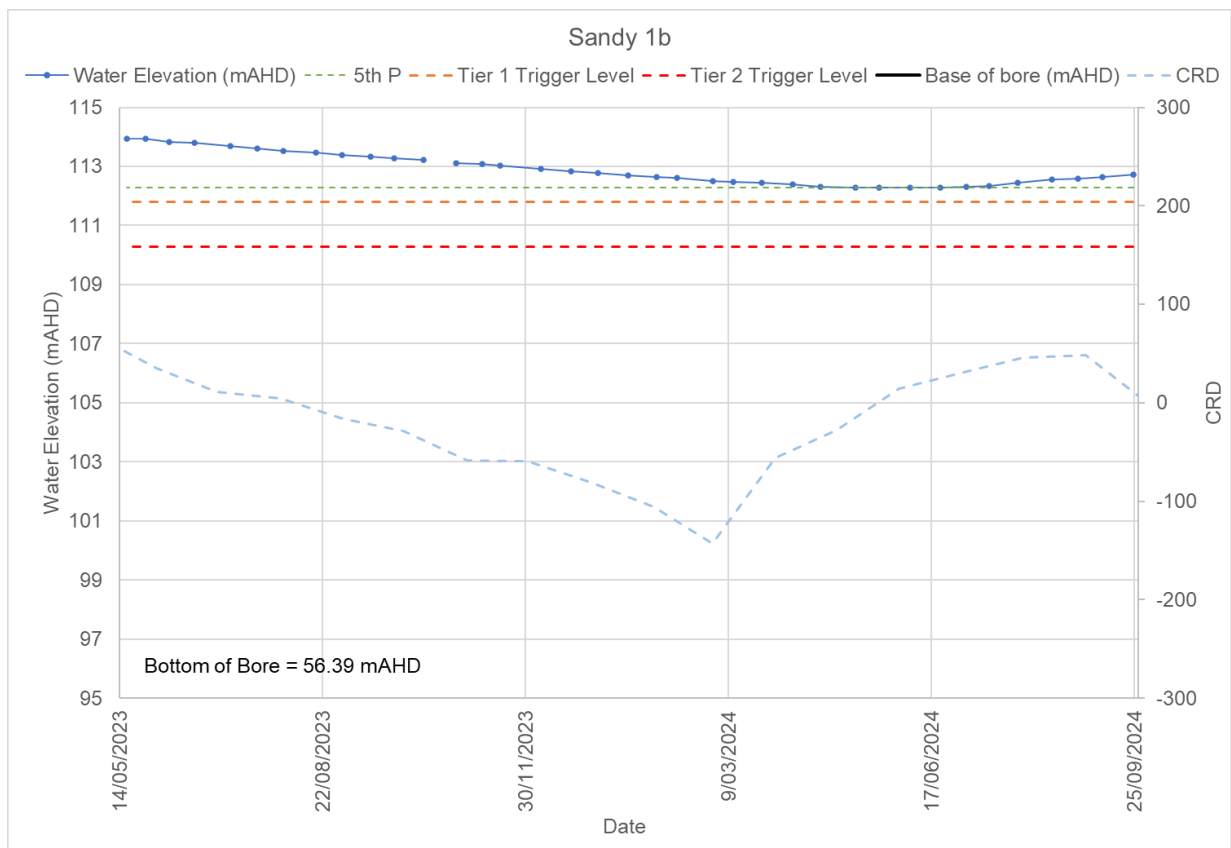
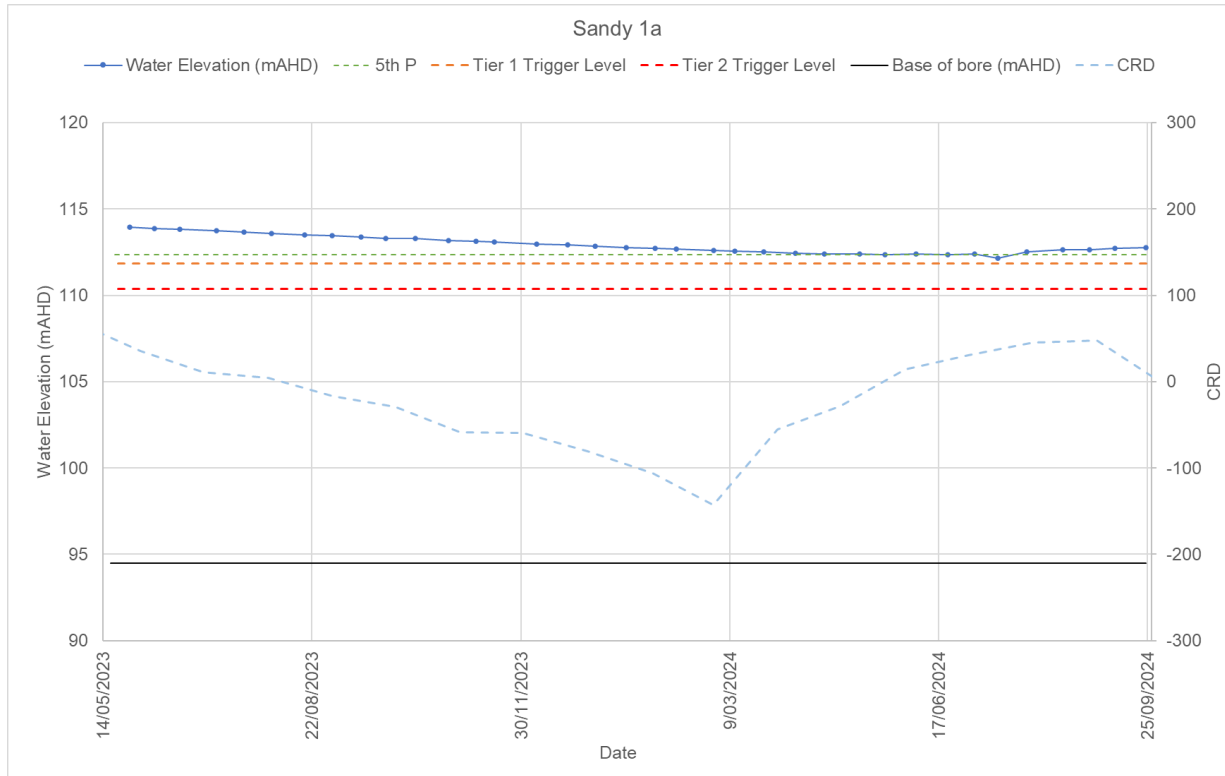
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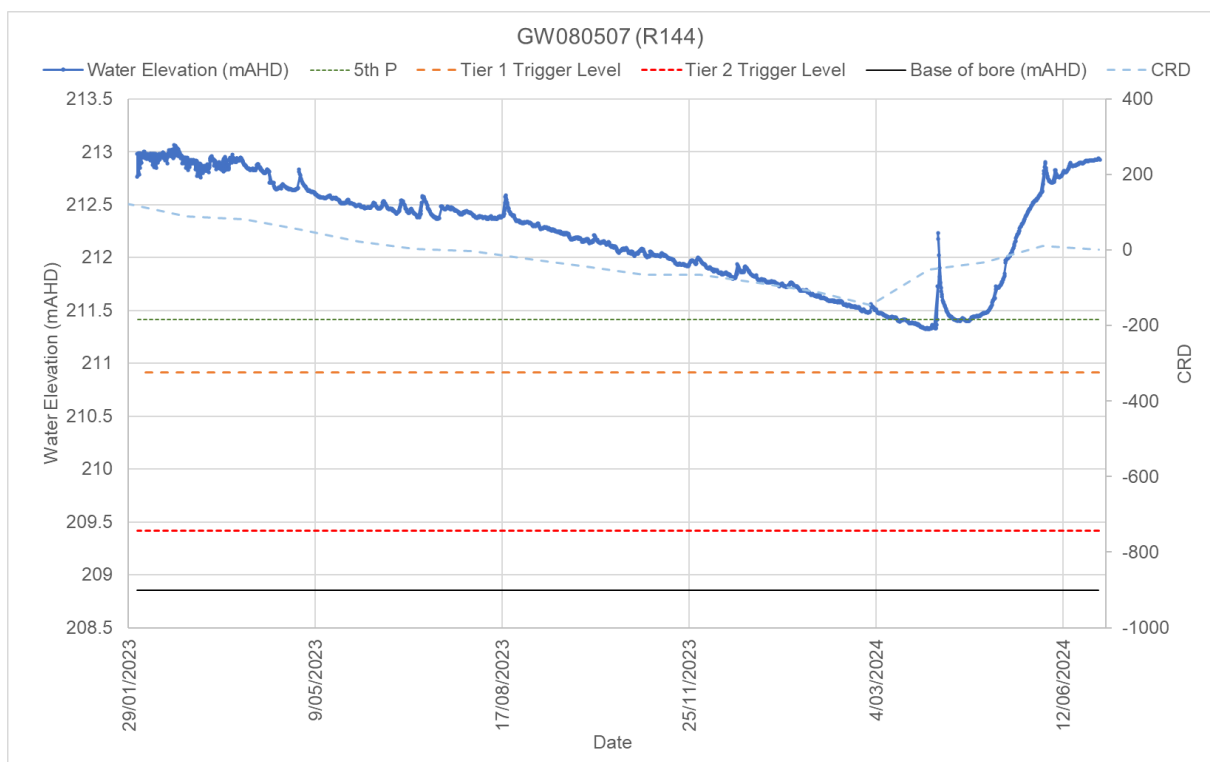
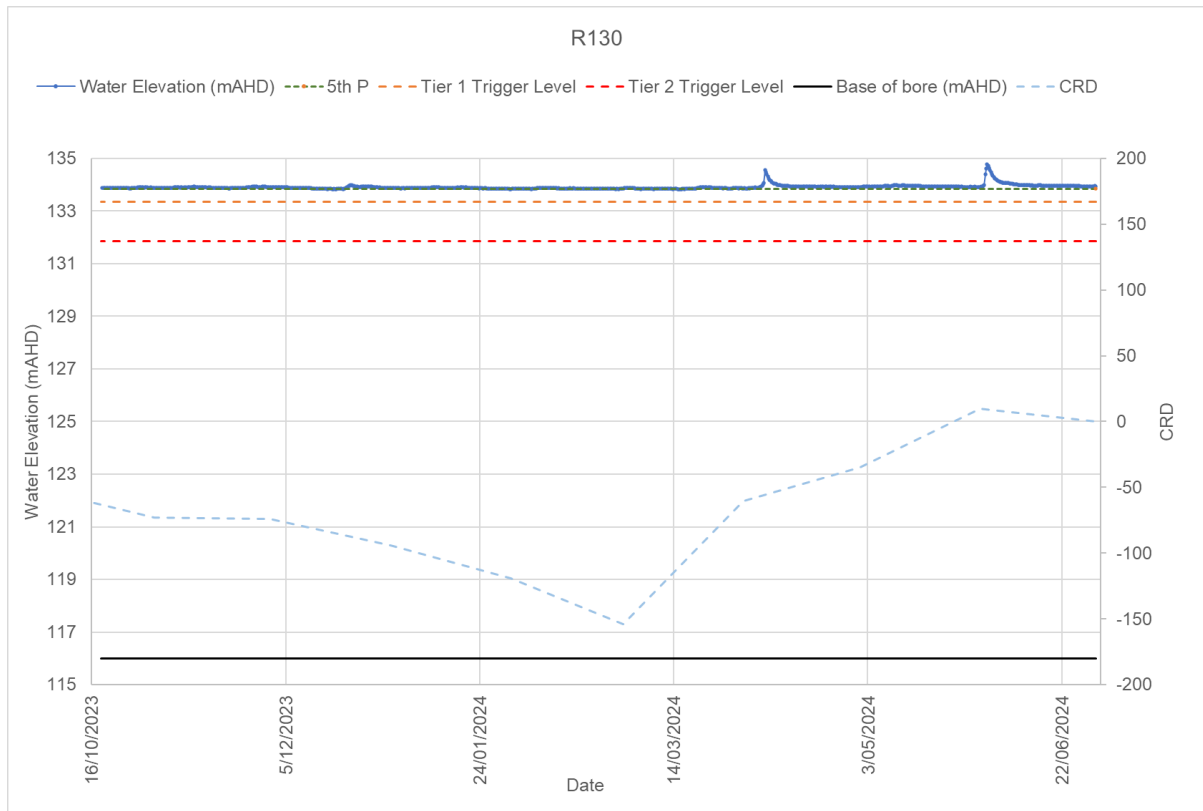
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Page 99 of 120







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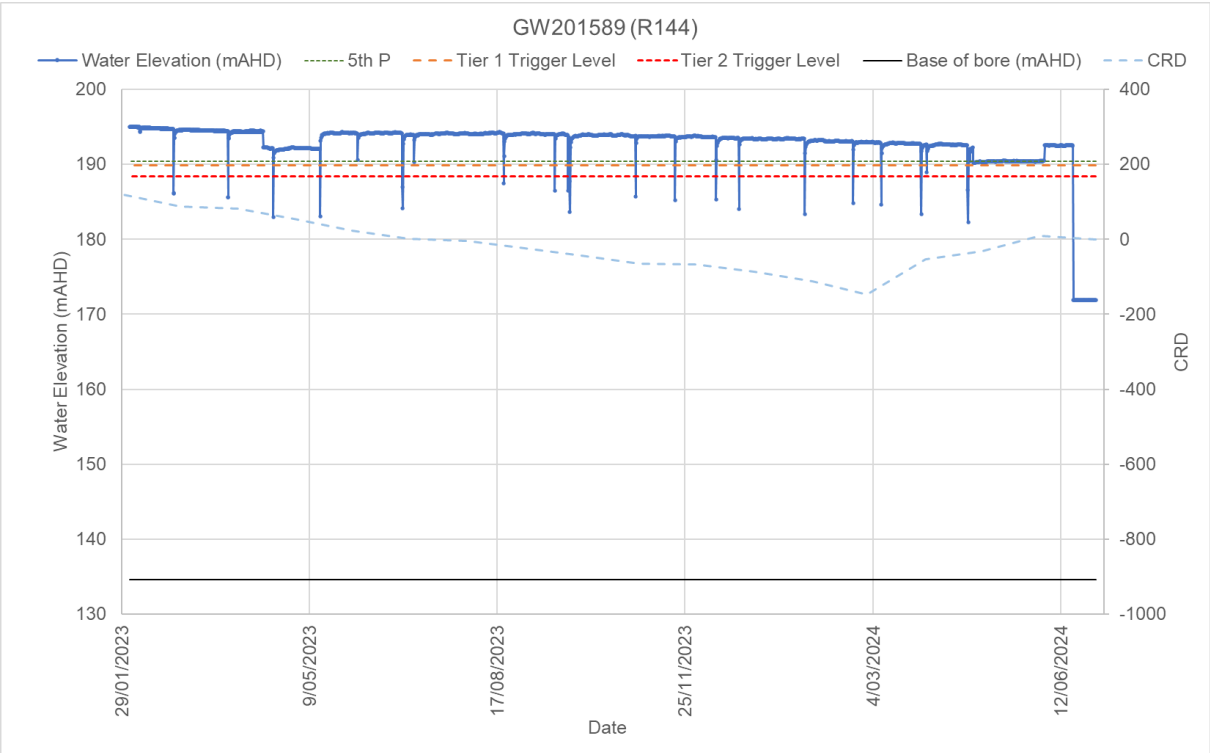
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Page 103 of

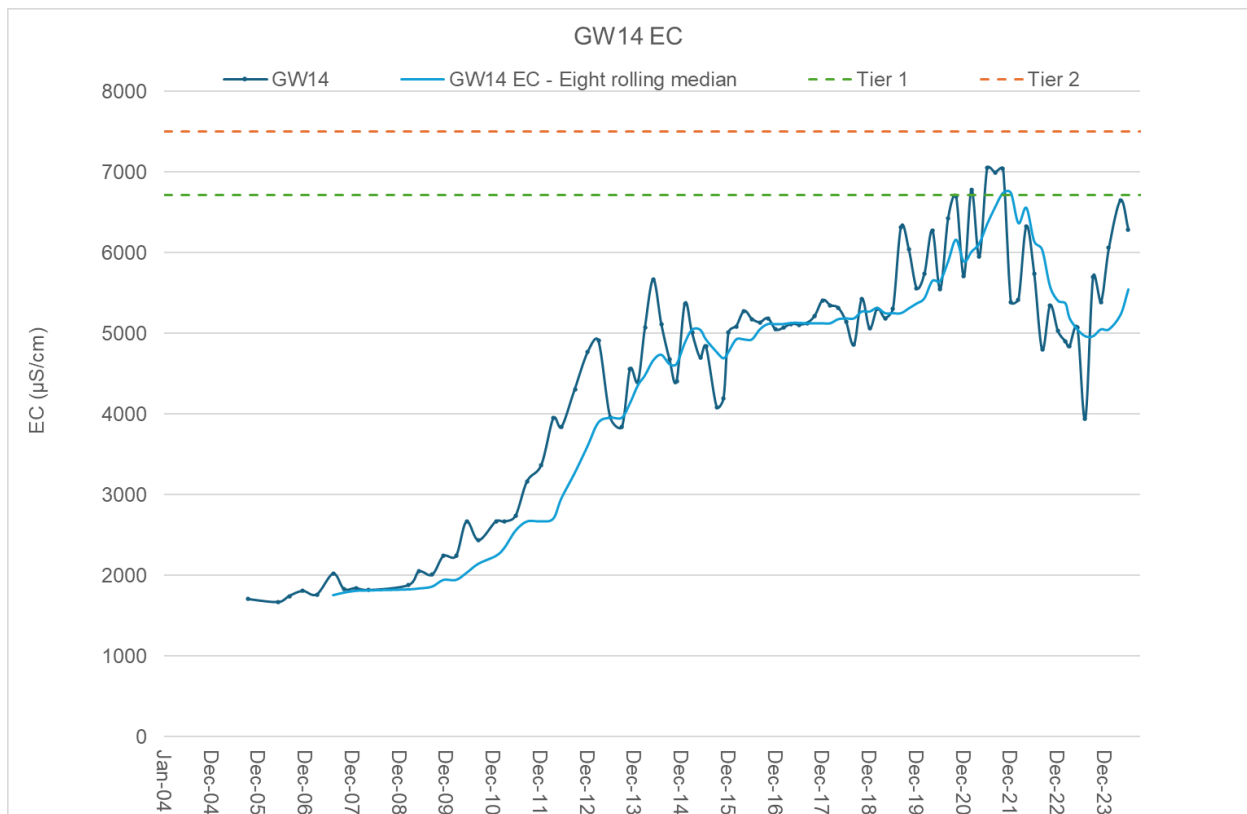
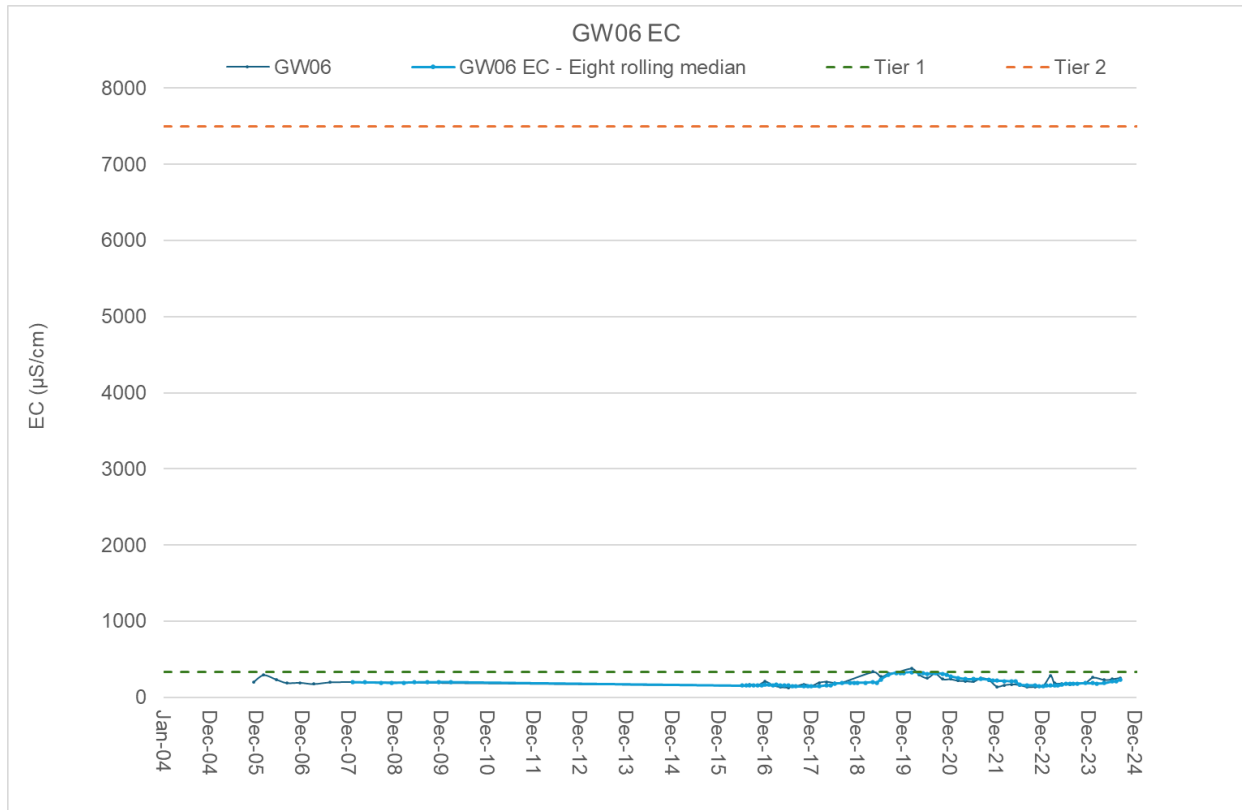
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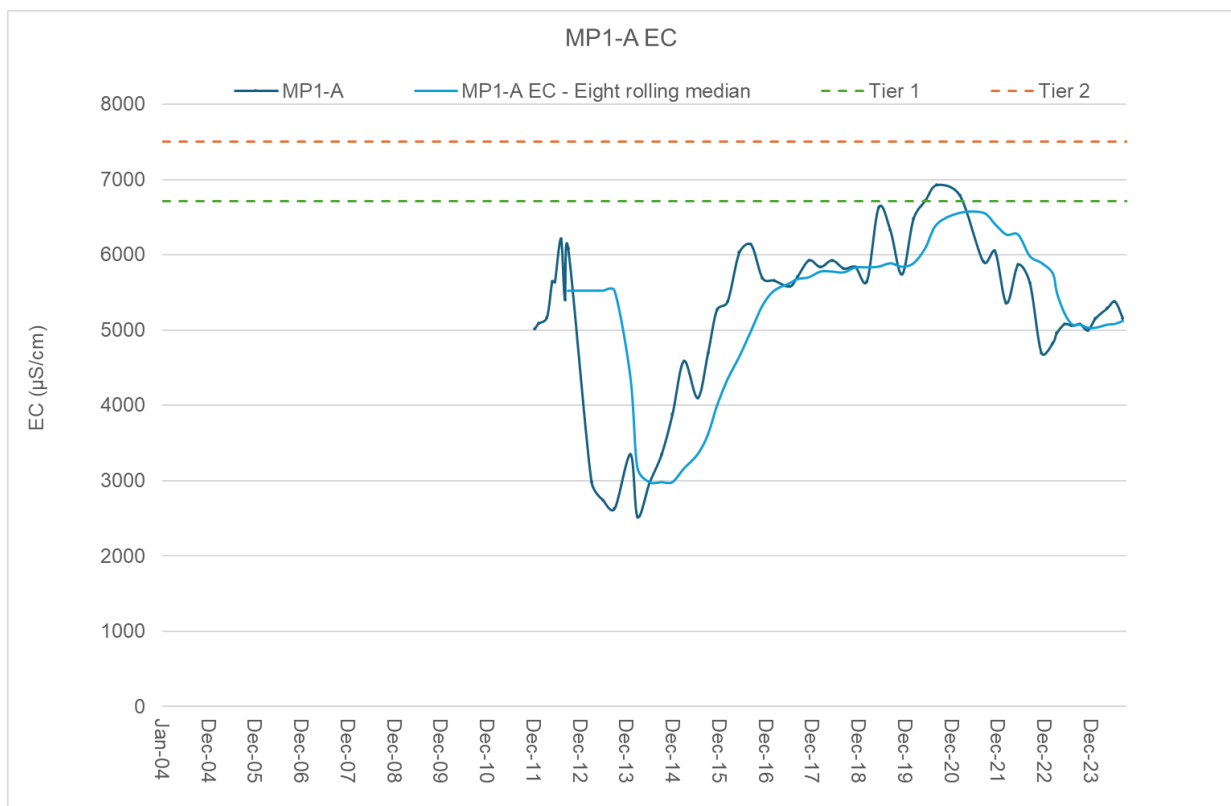
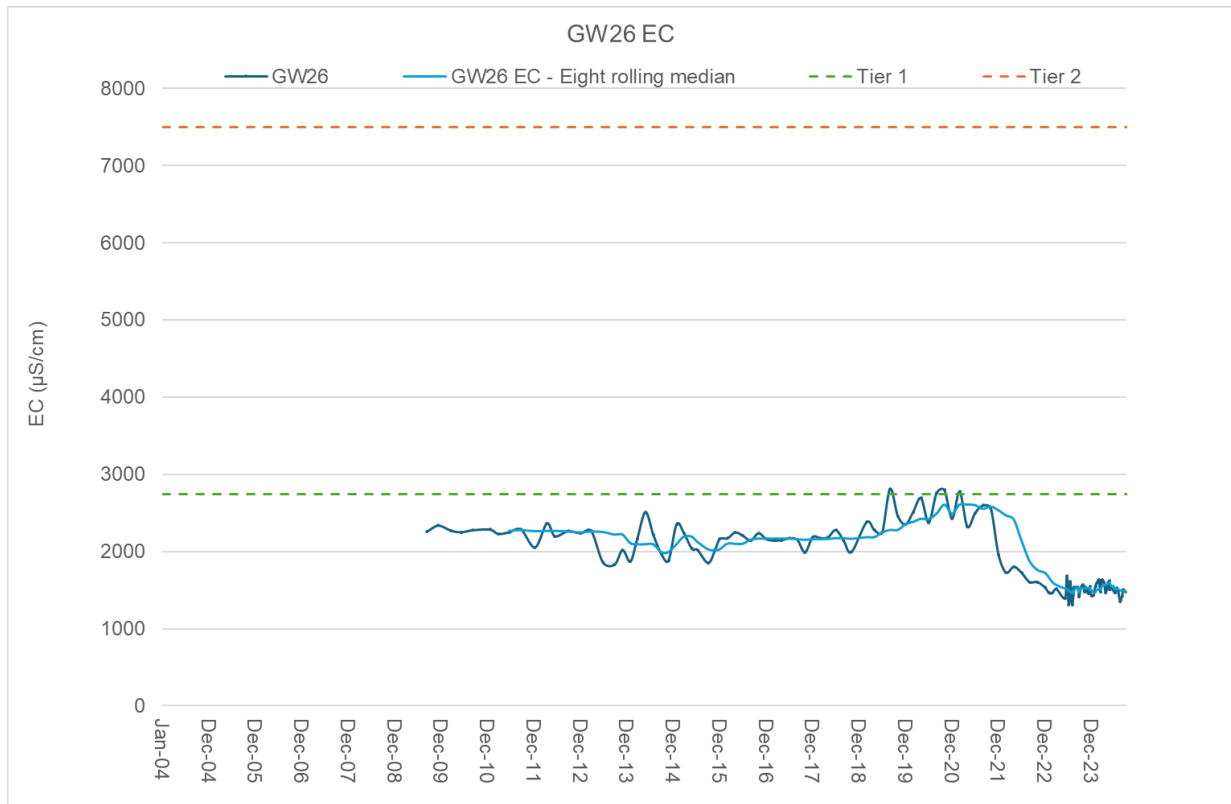
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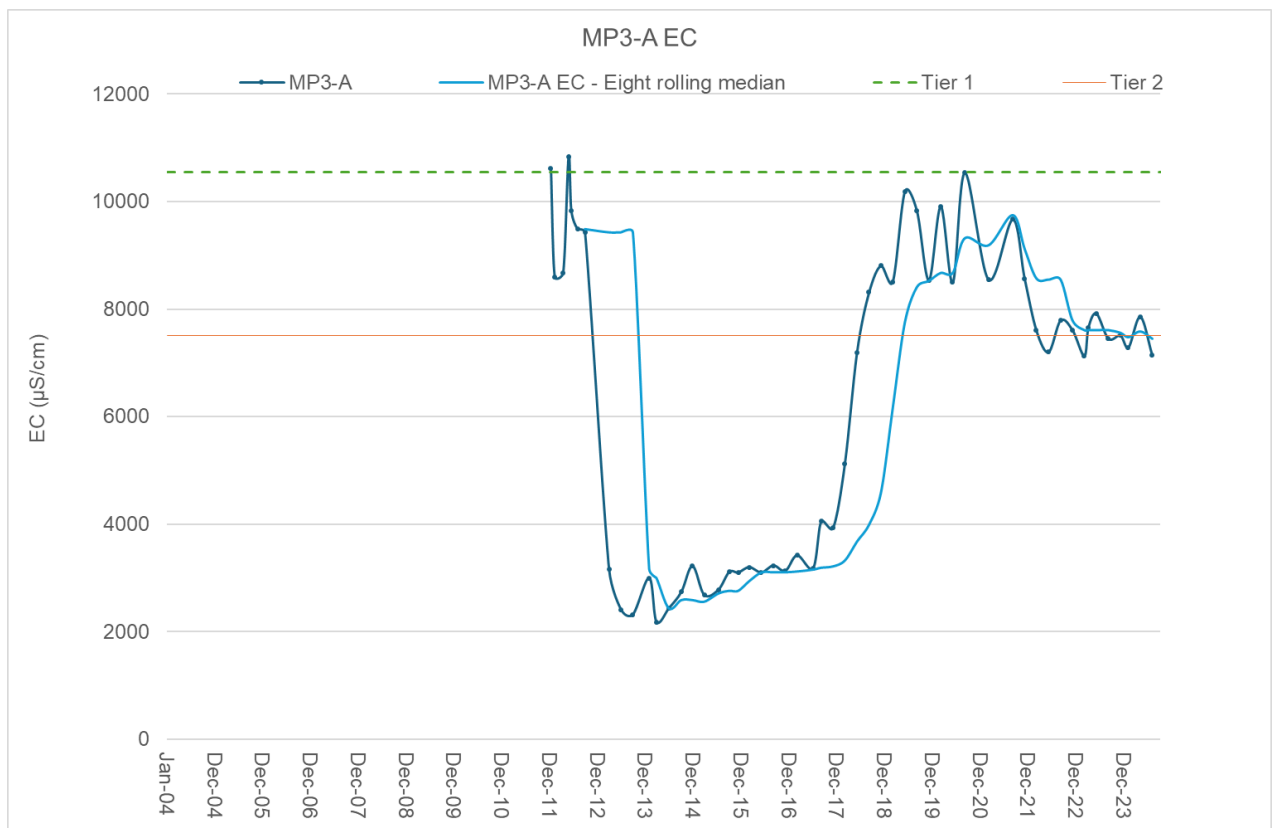
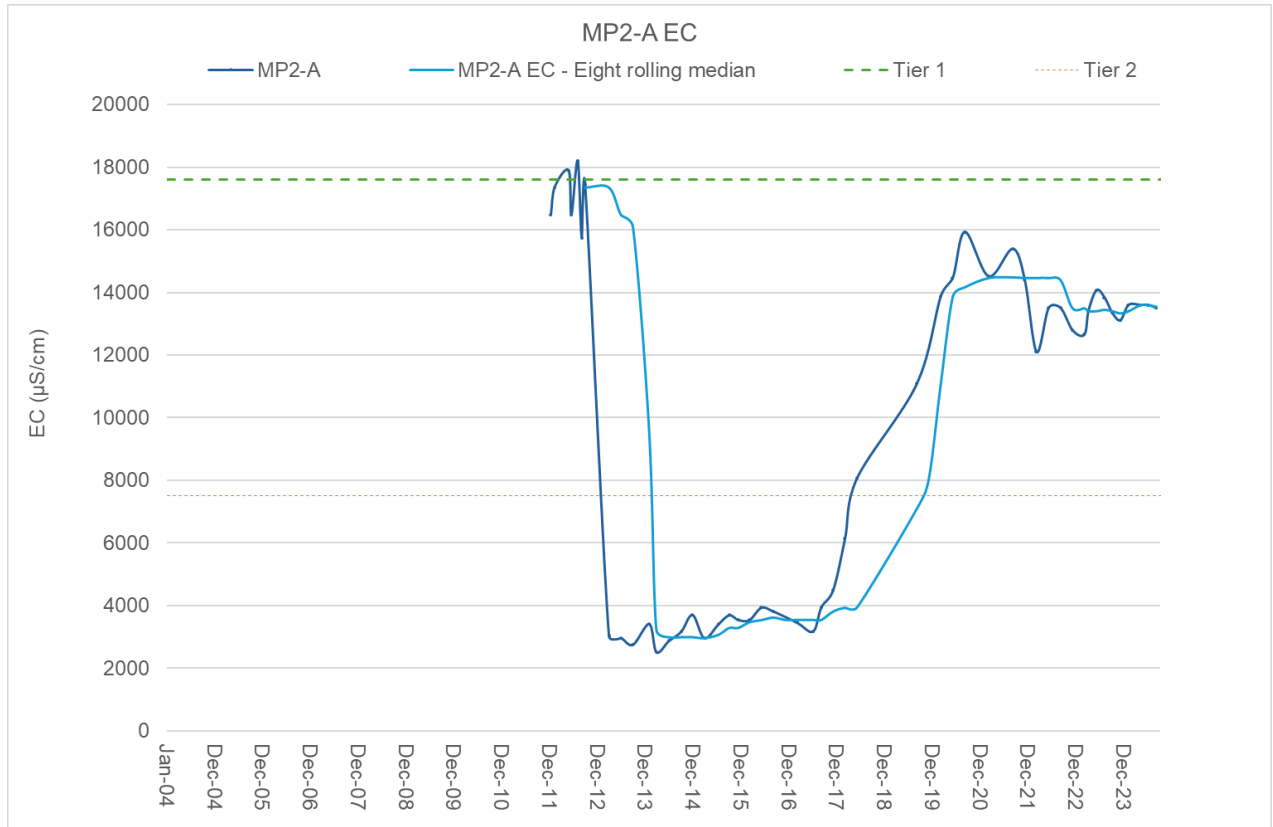
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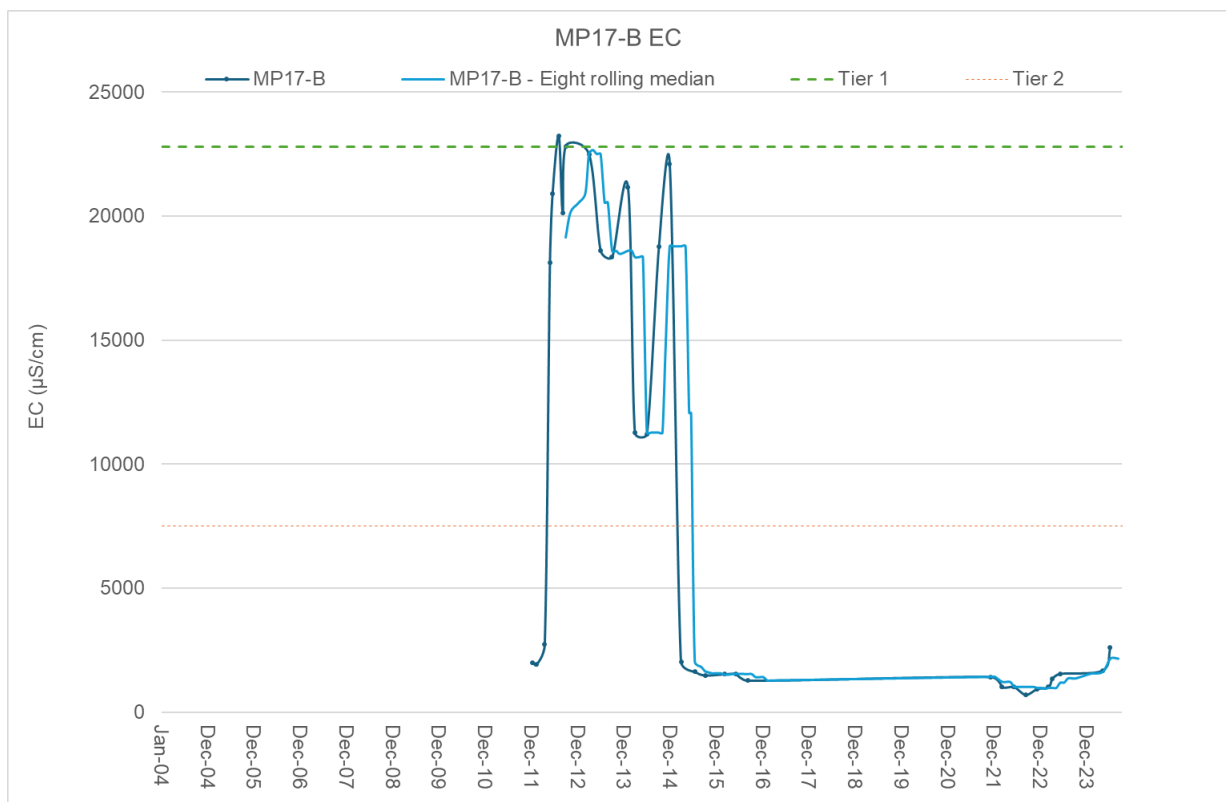
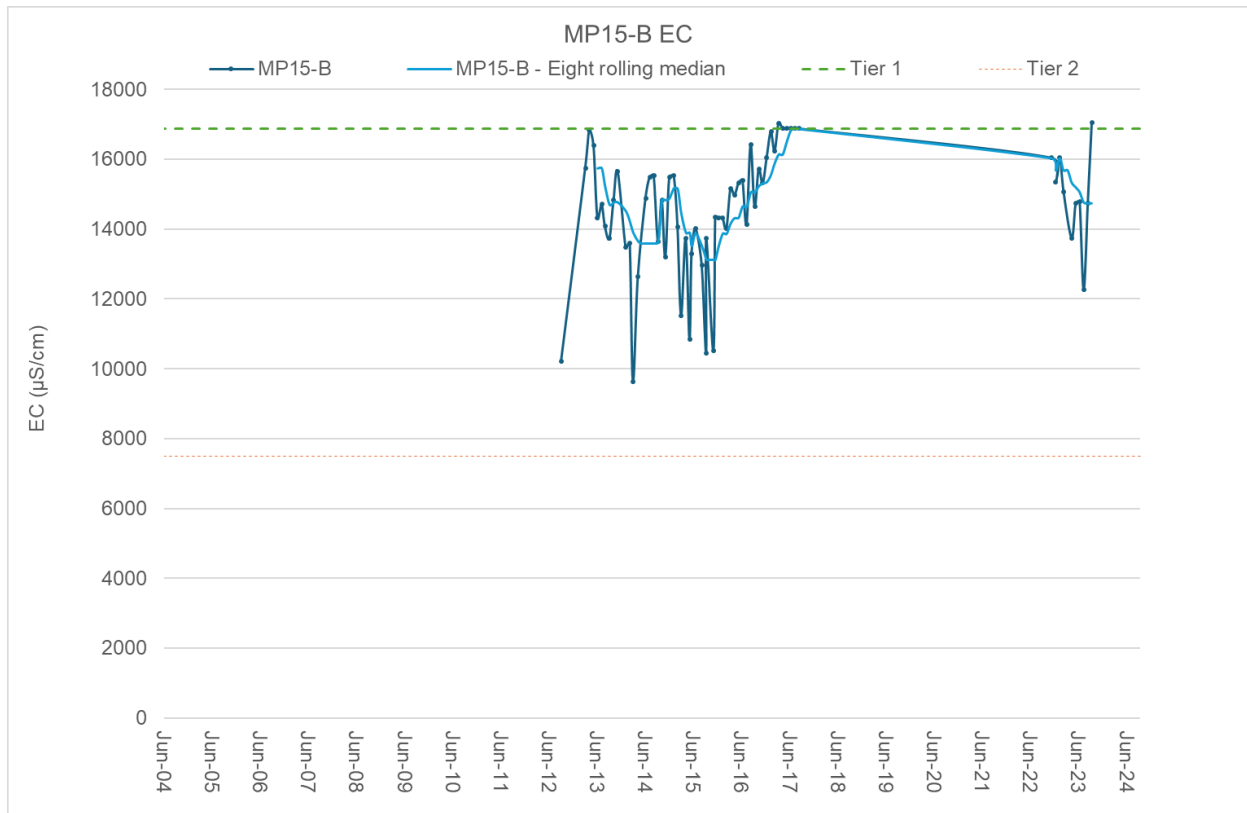
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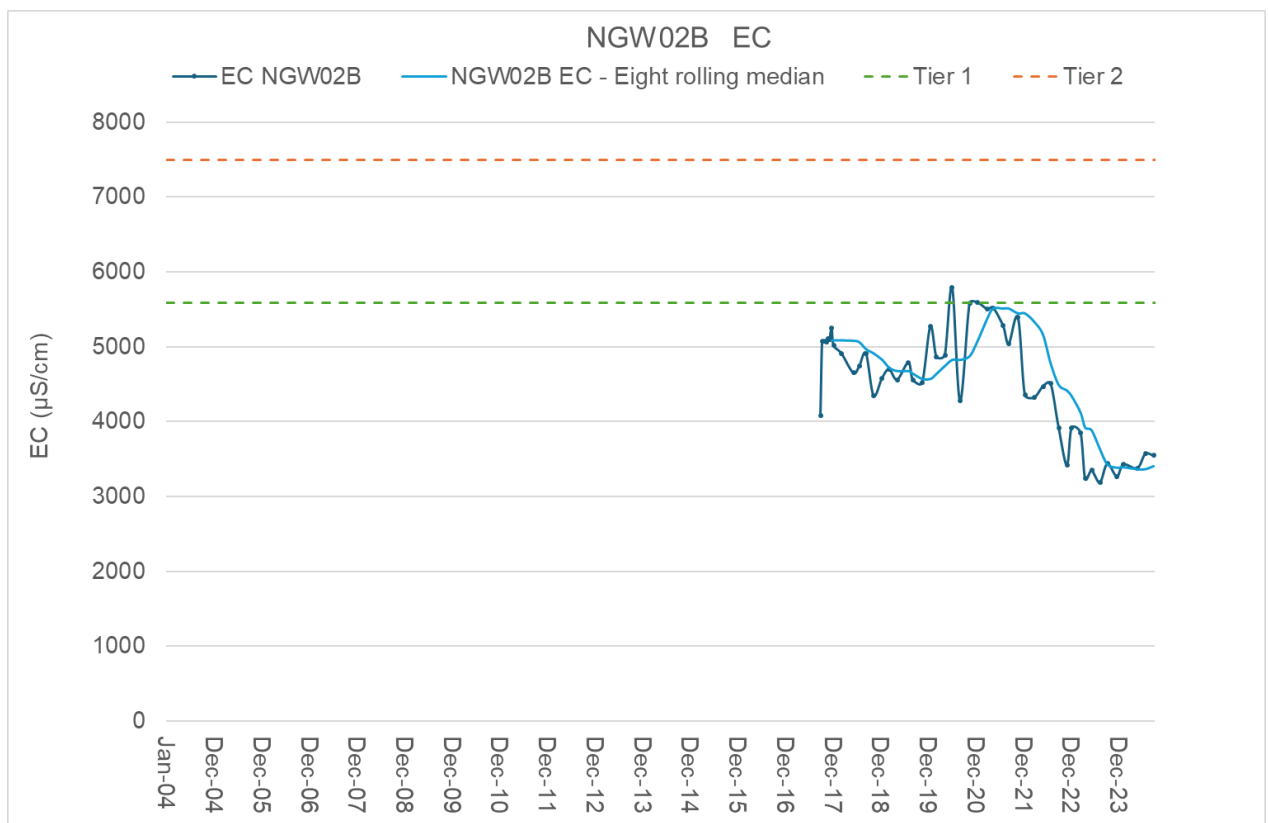
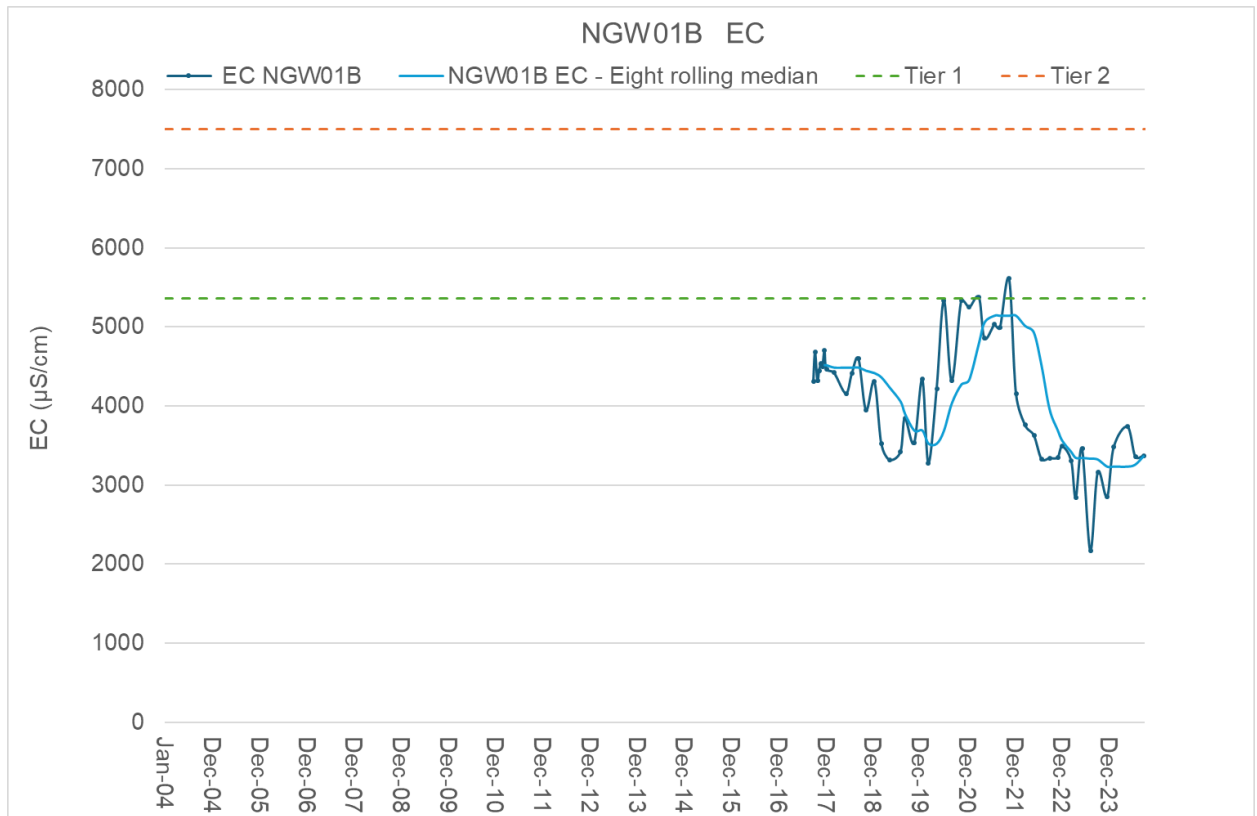
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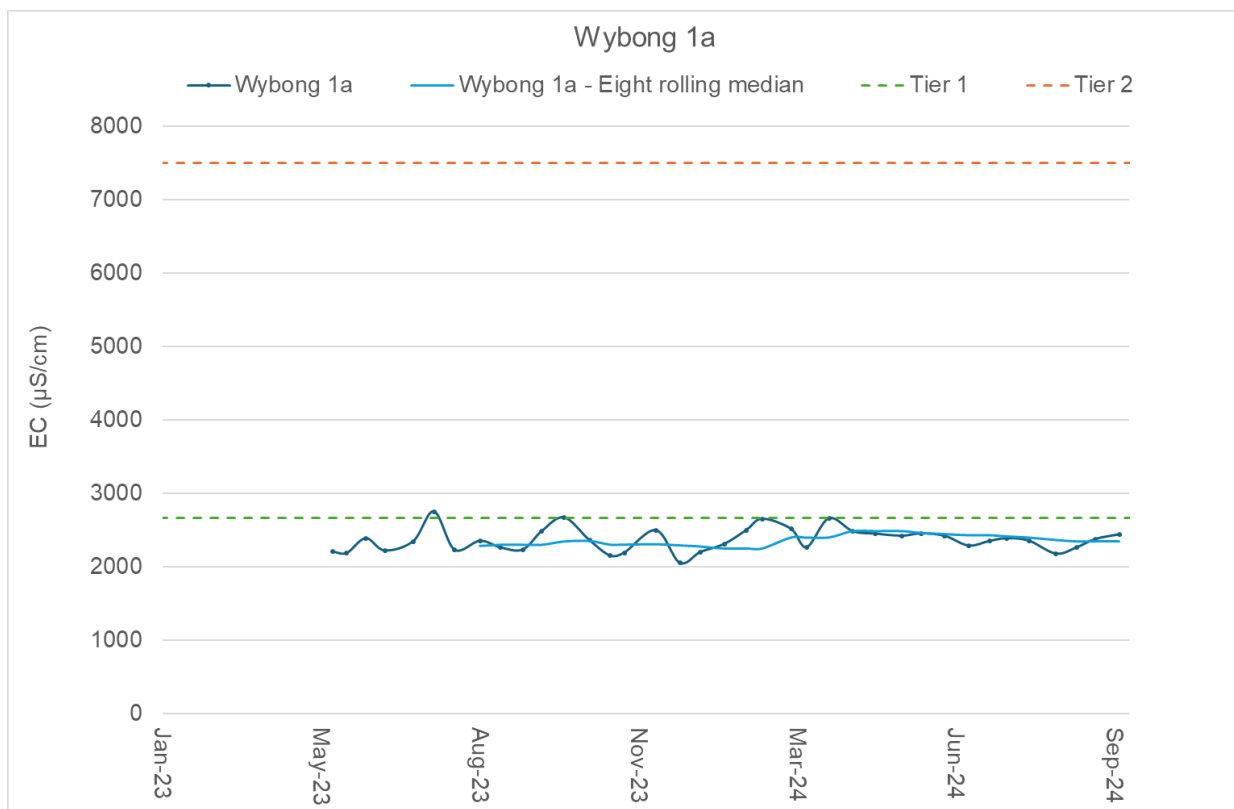
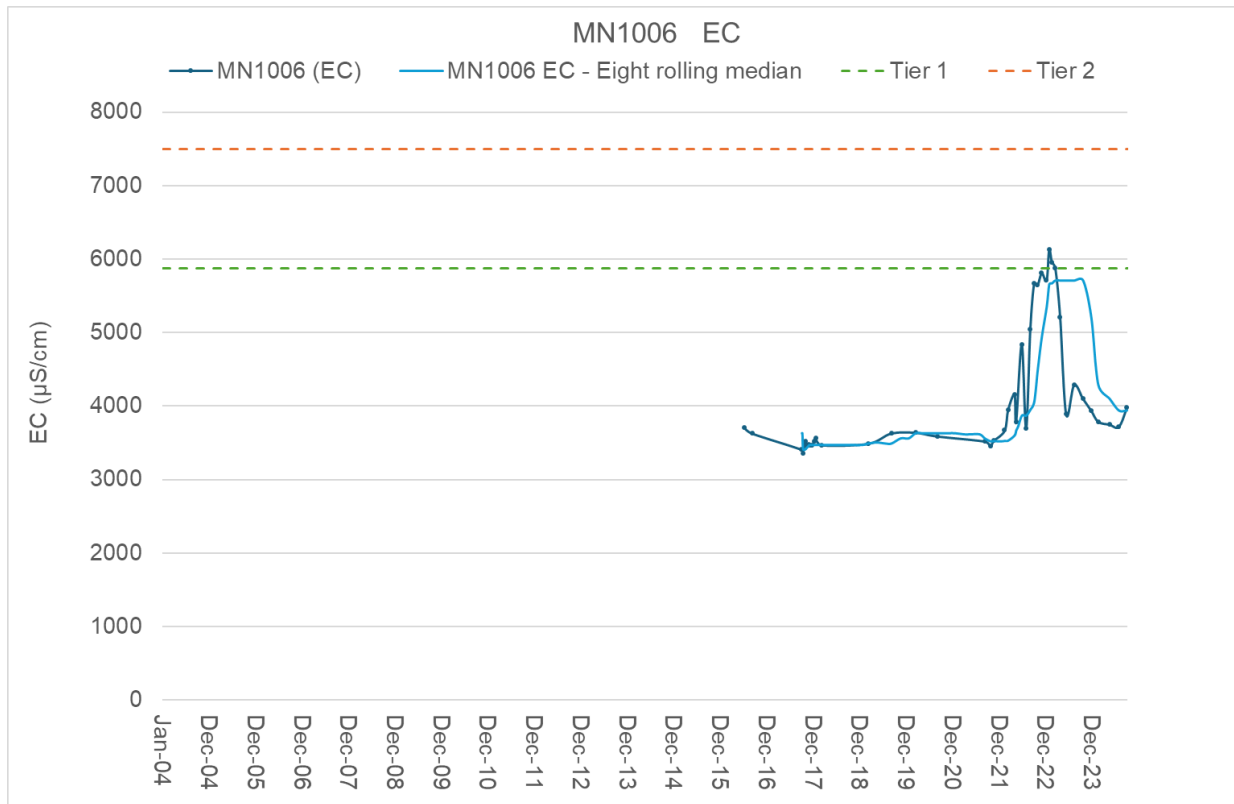
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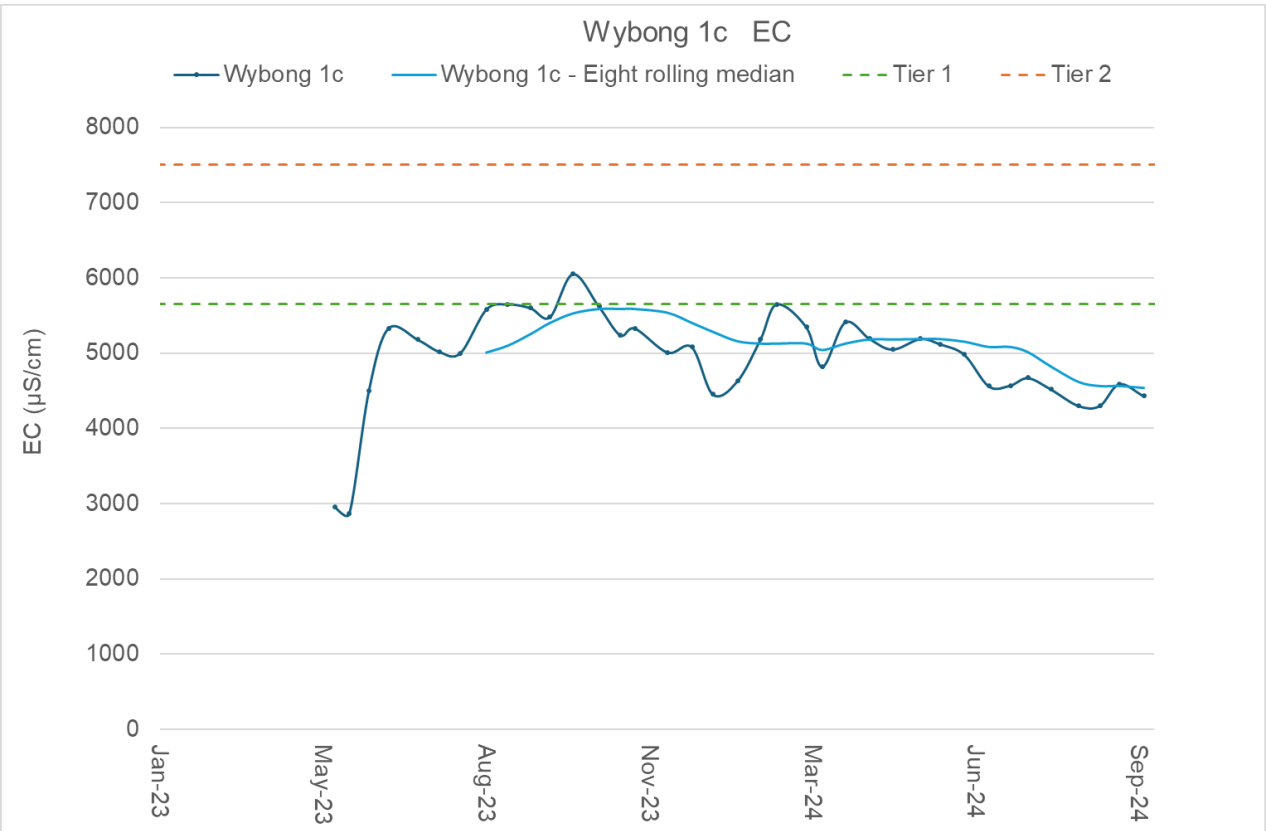
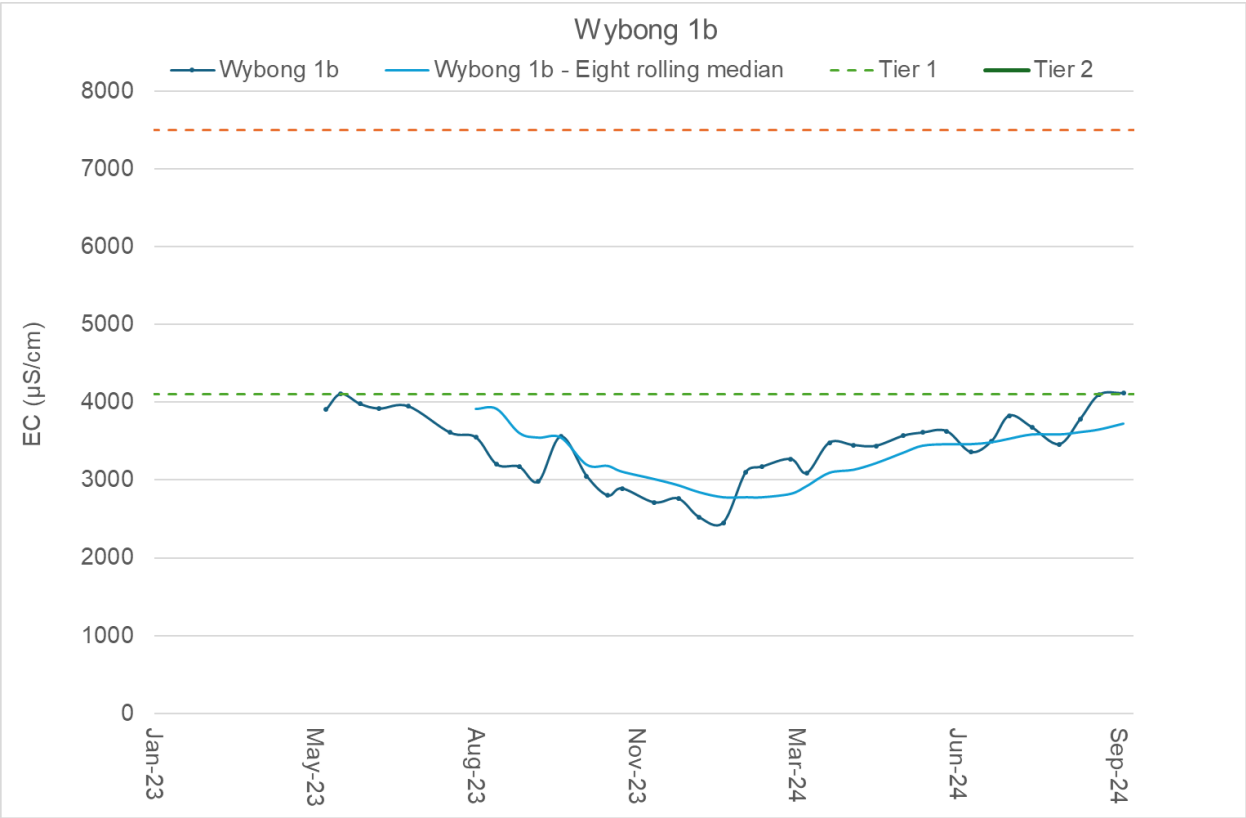
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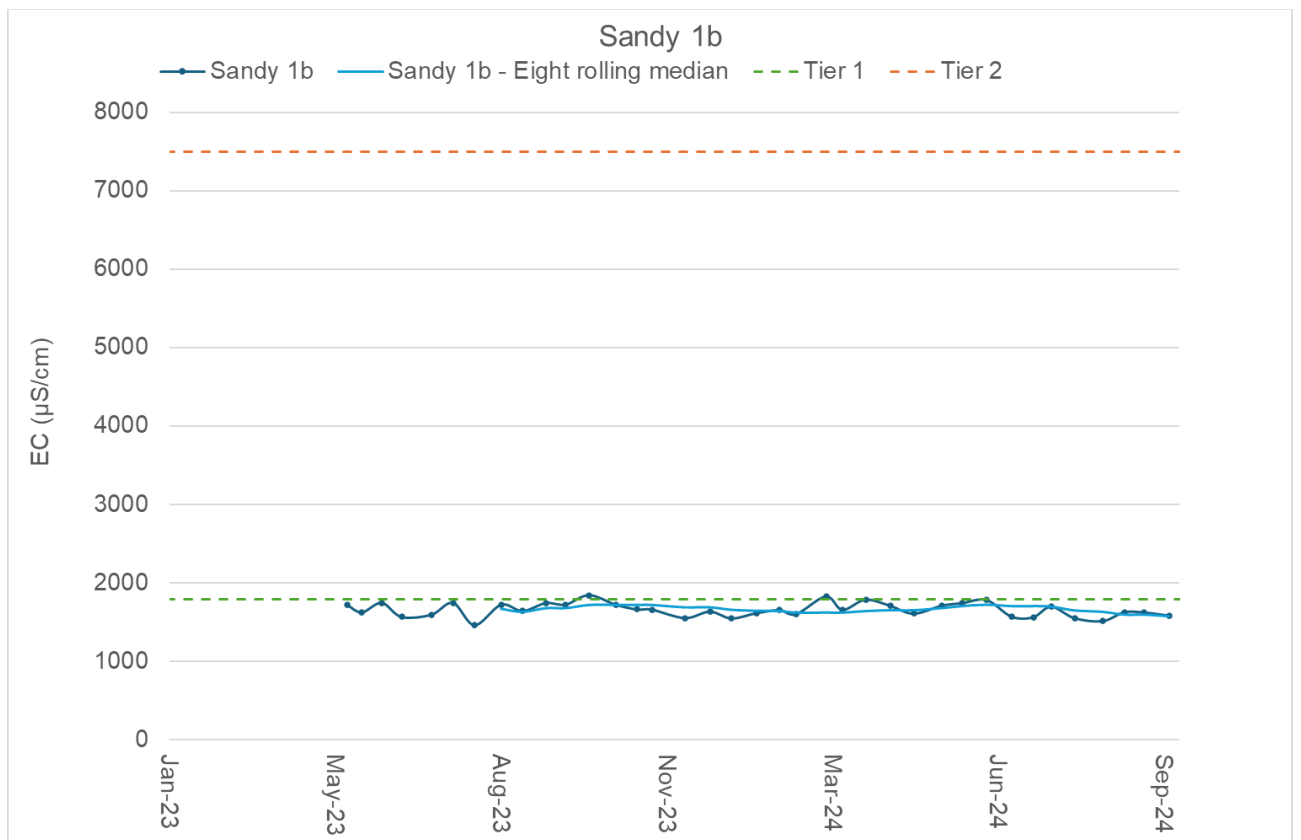
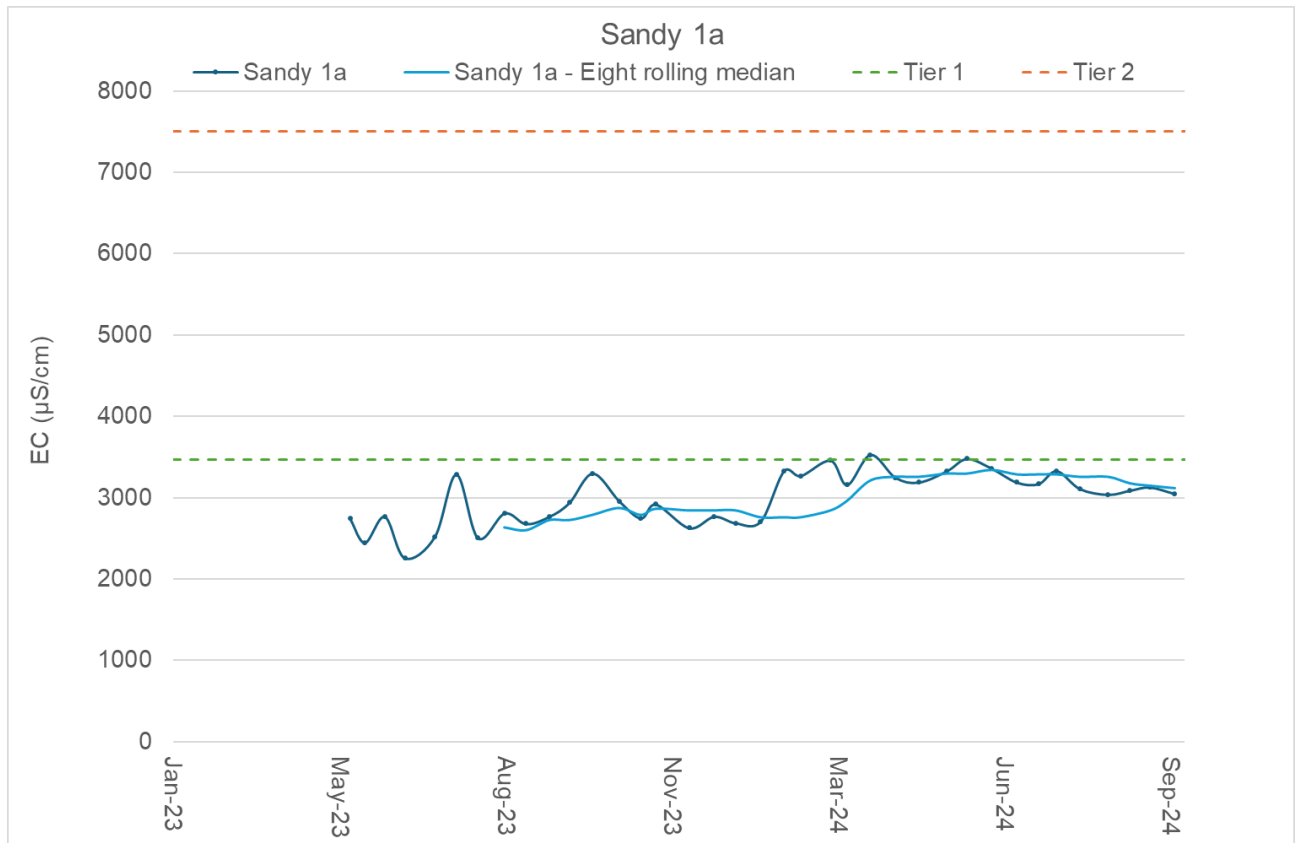
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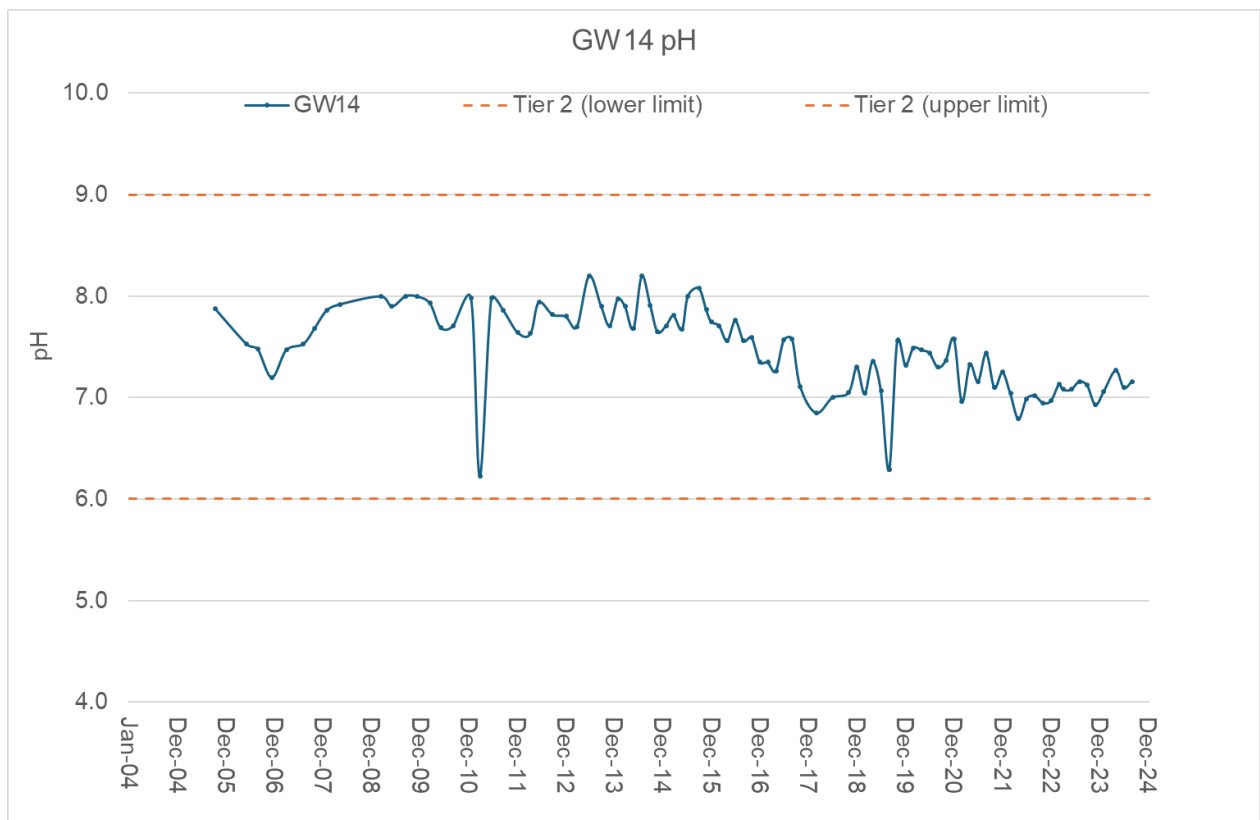
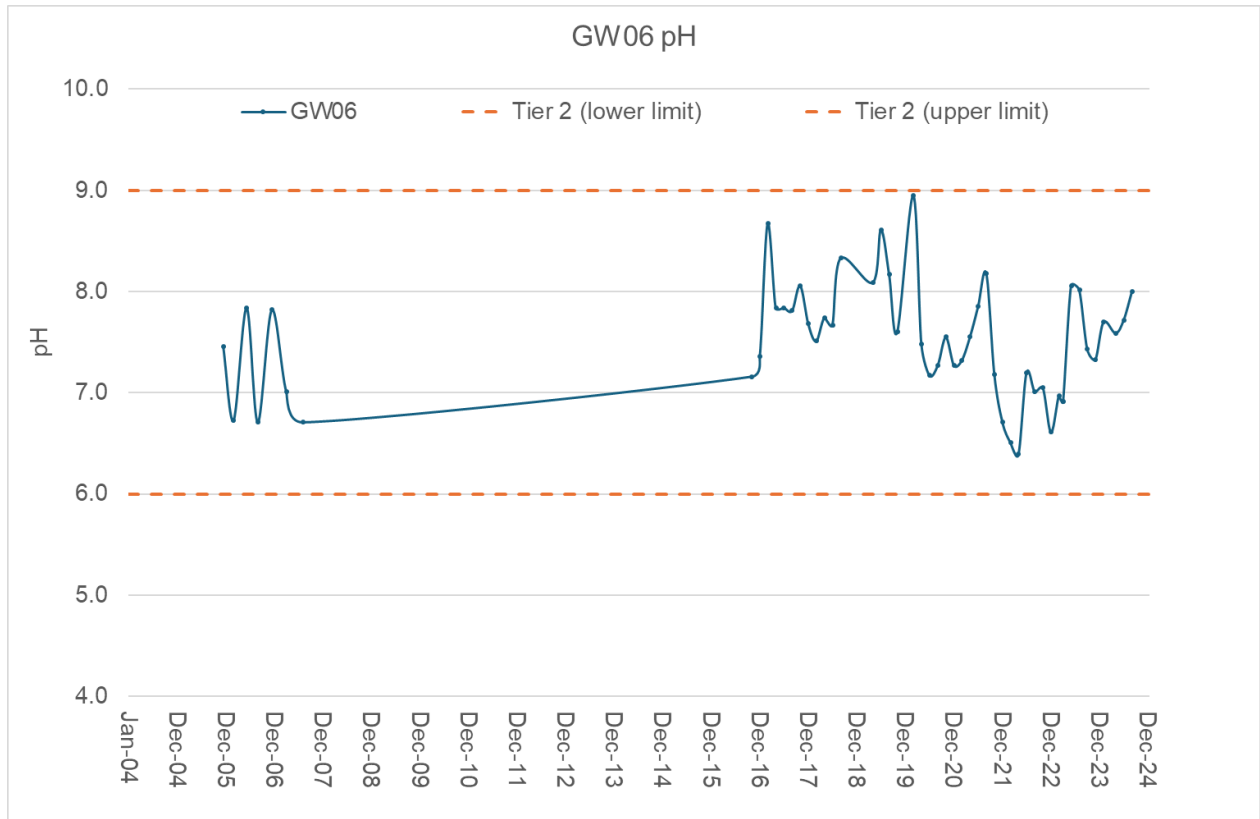
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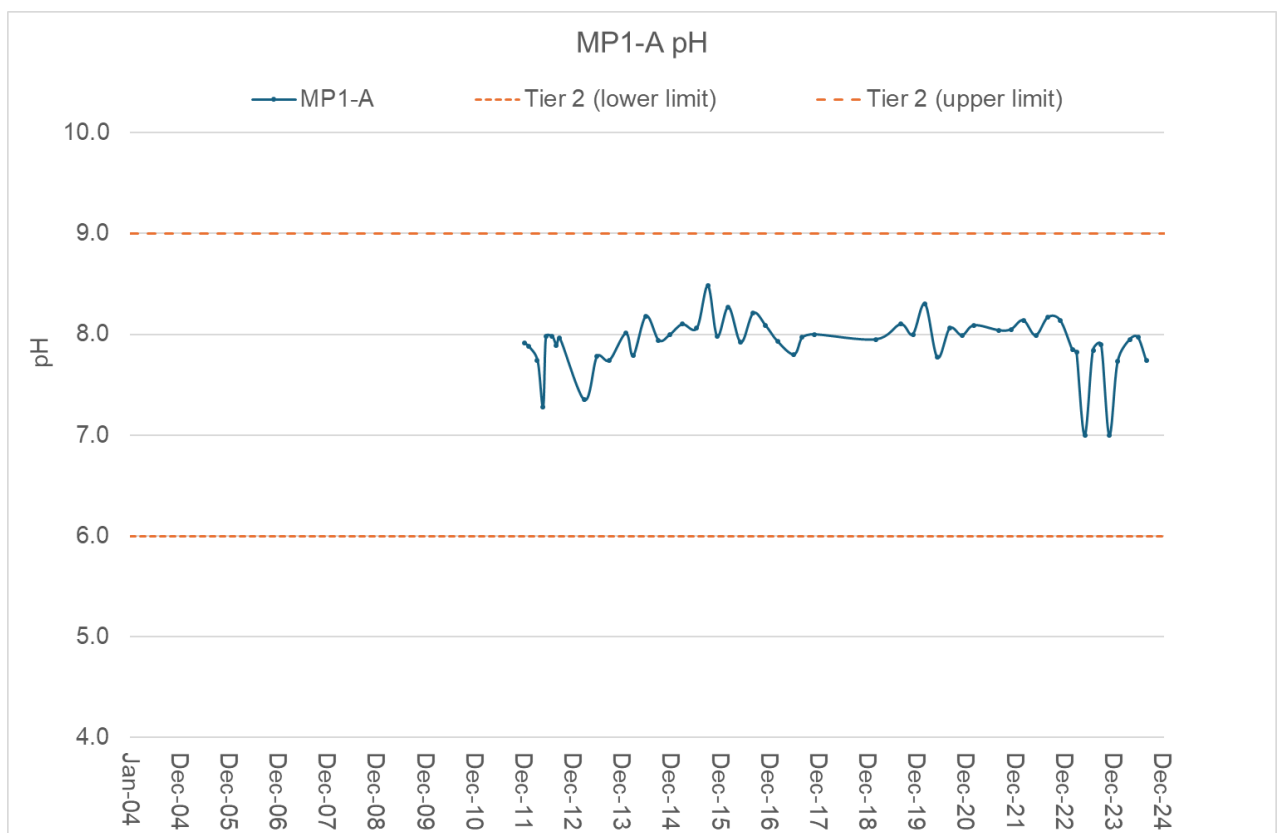
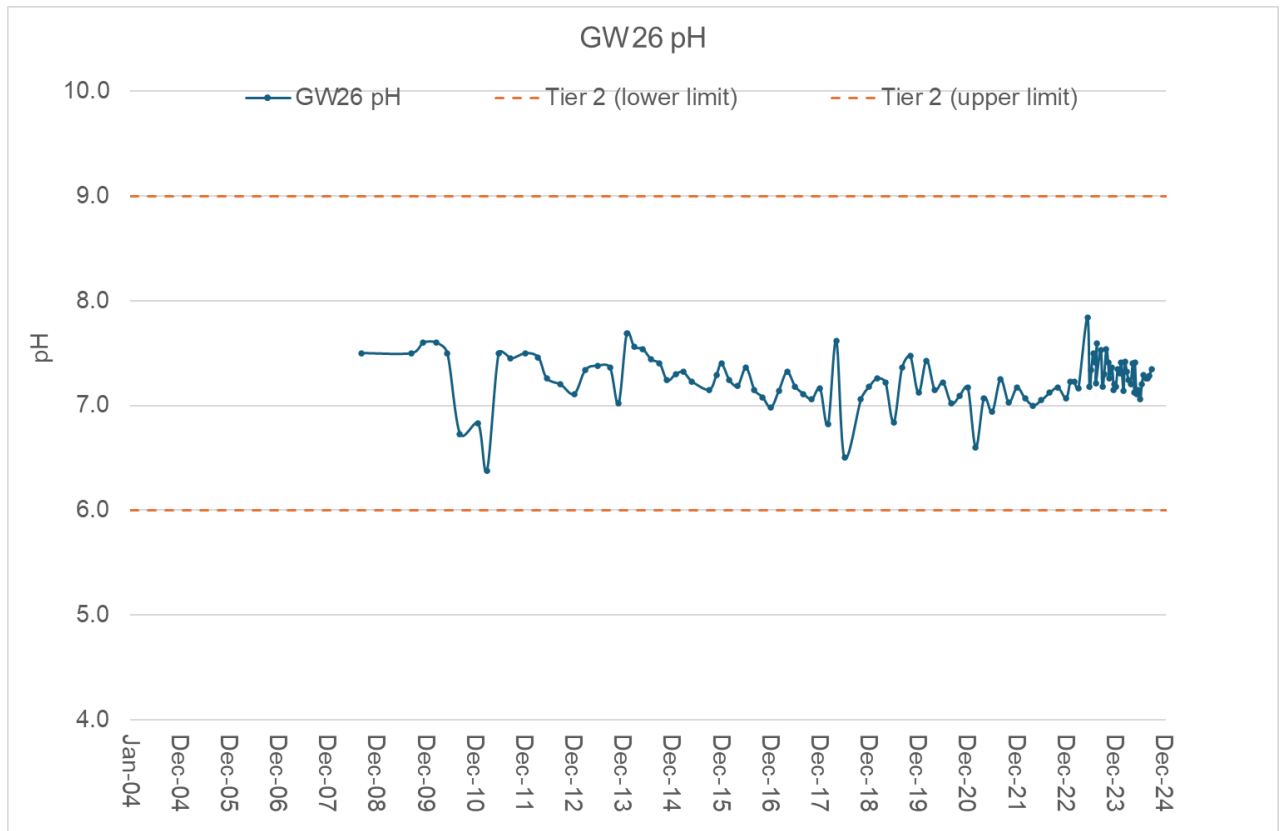
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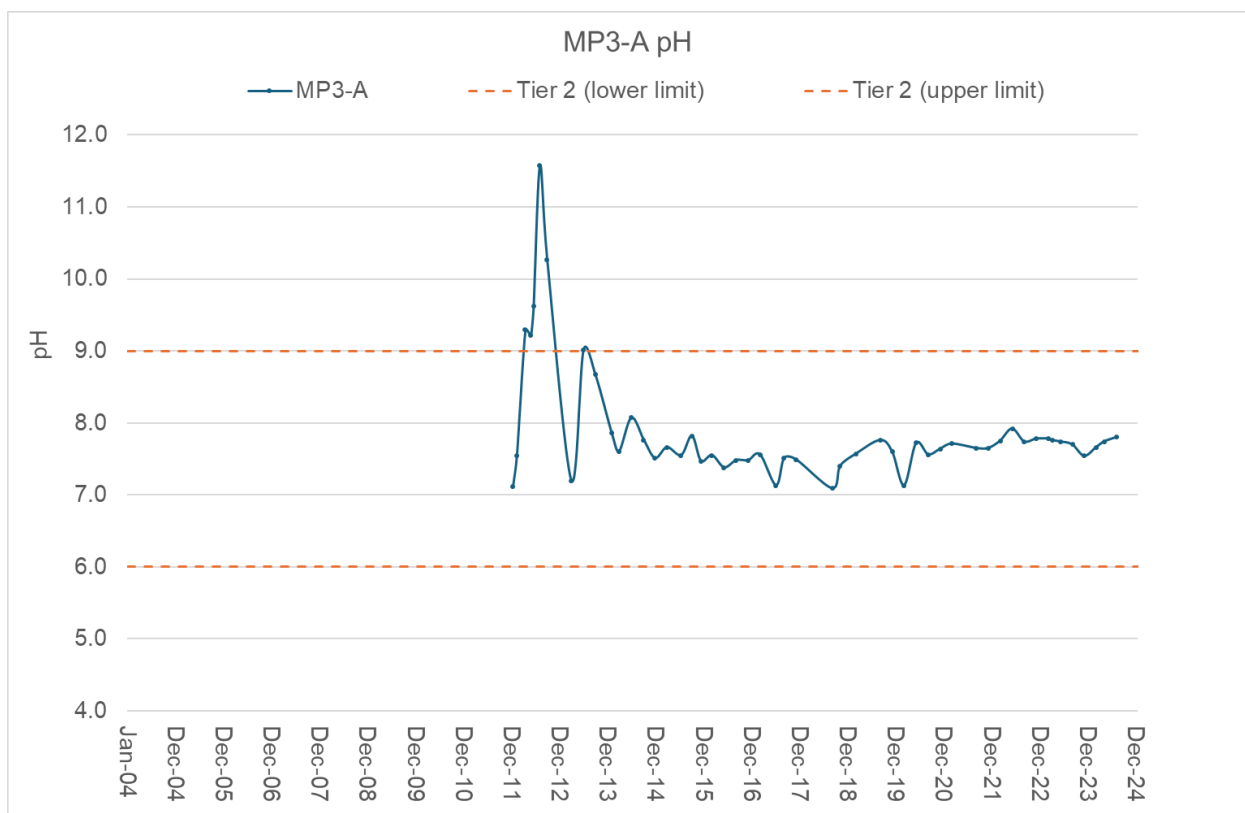
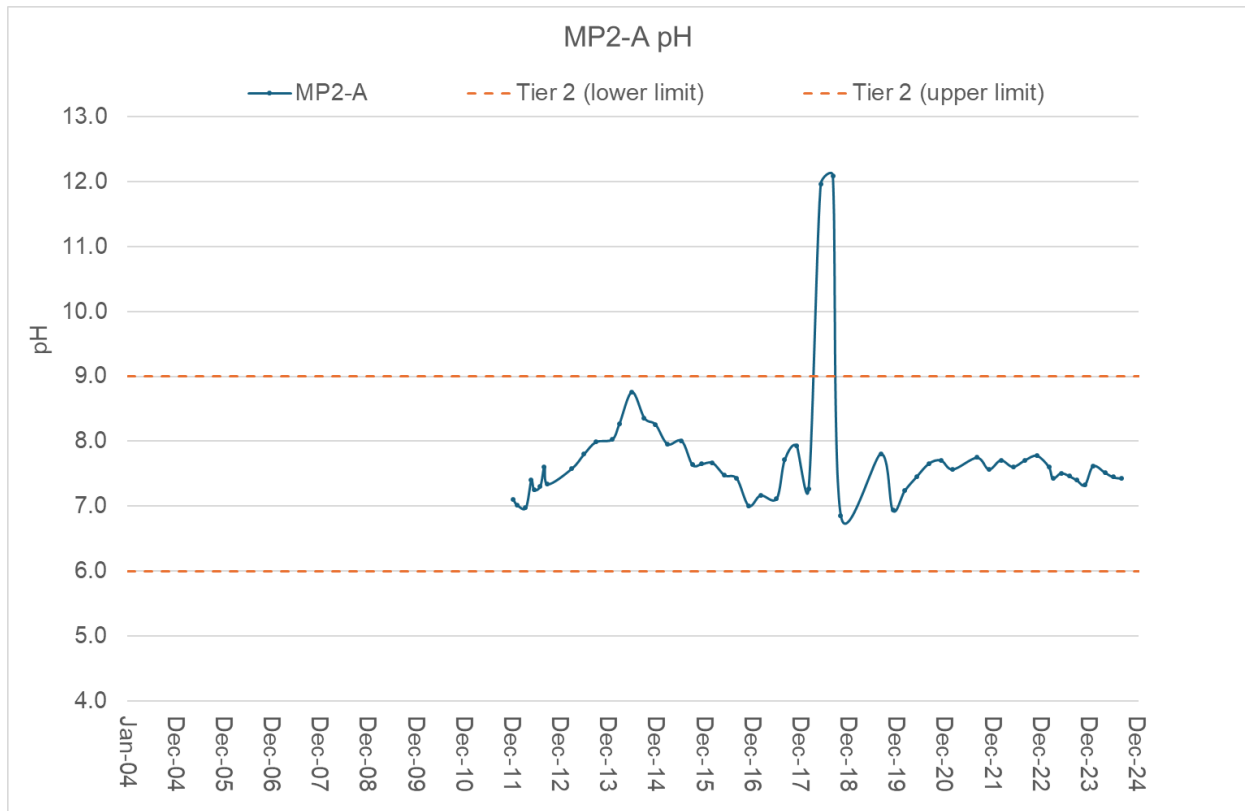
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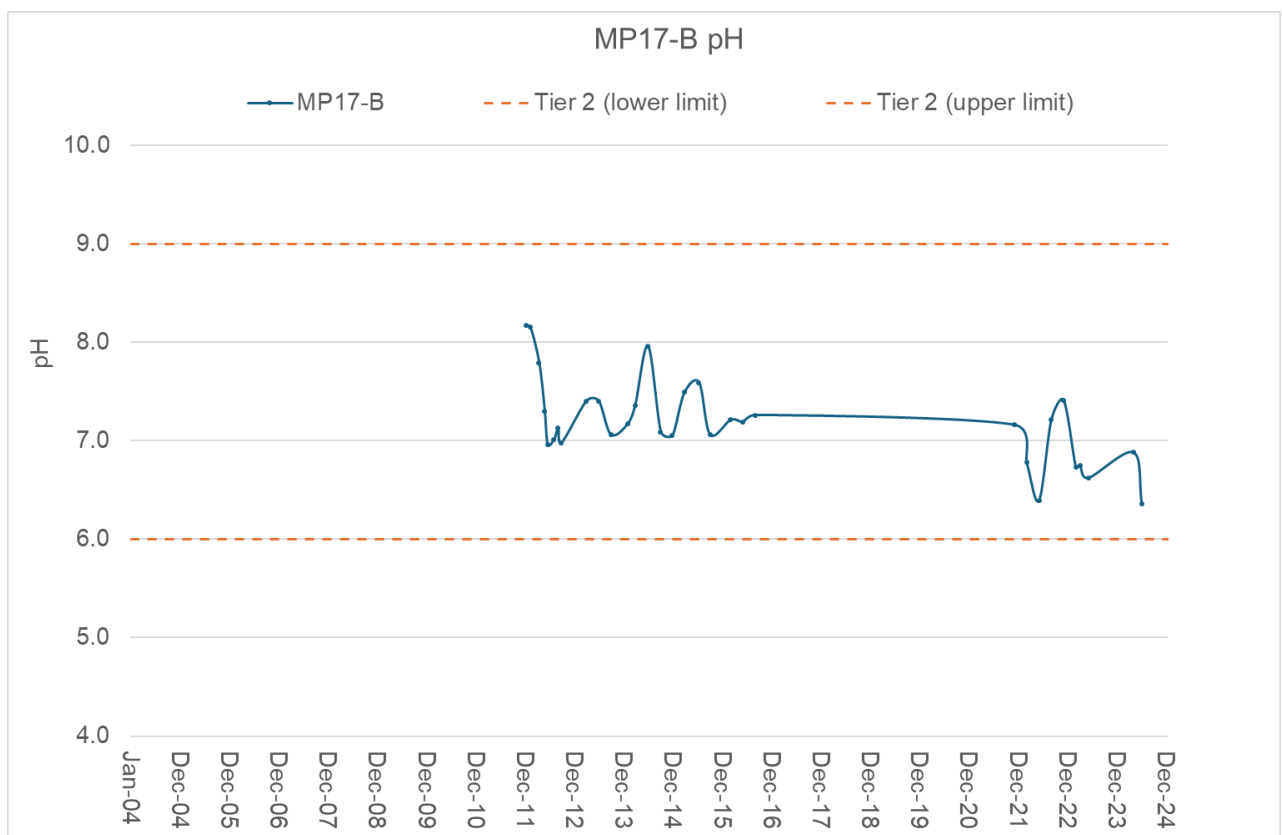
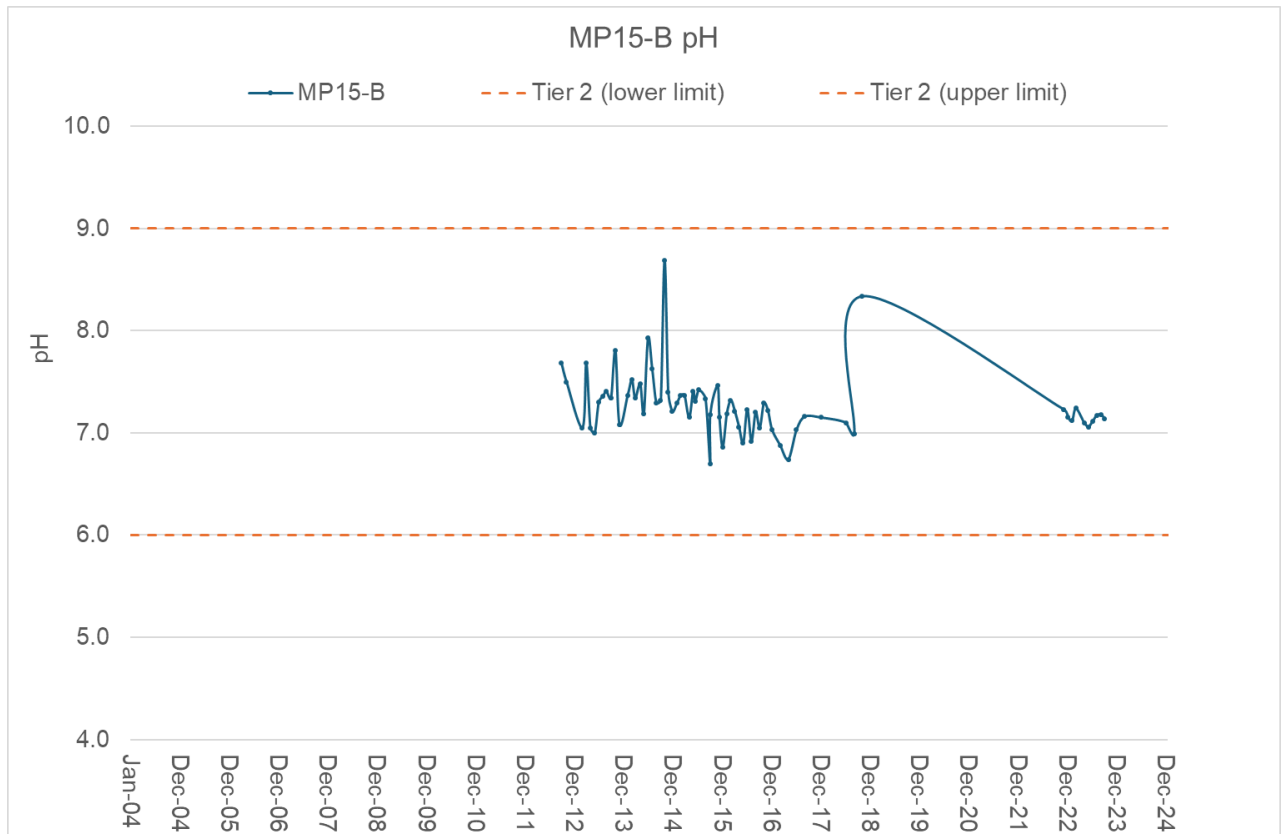
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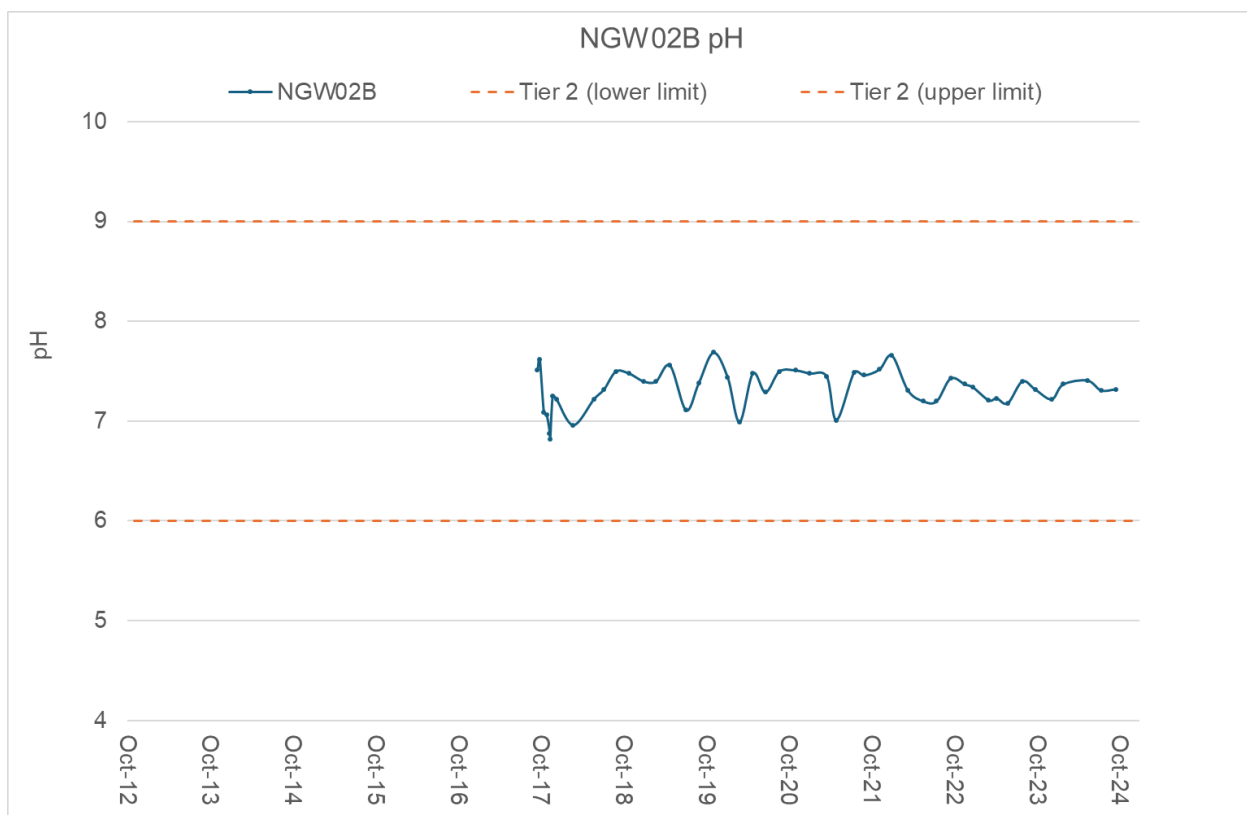
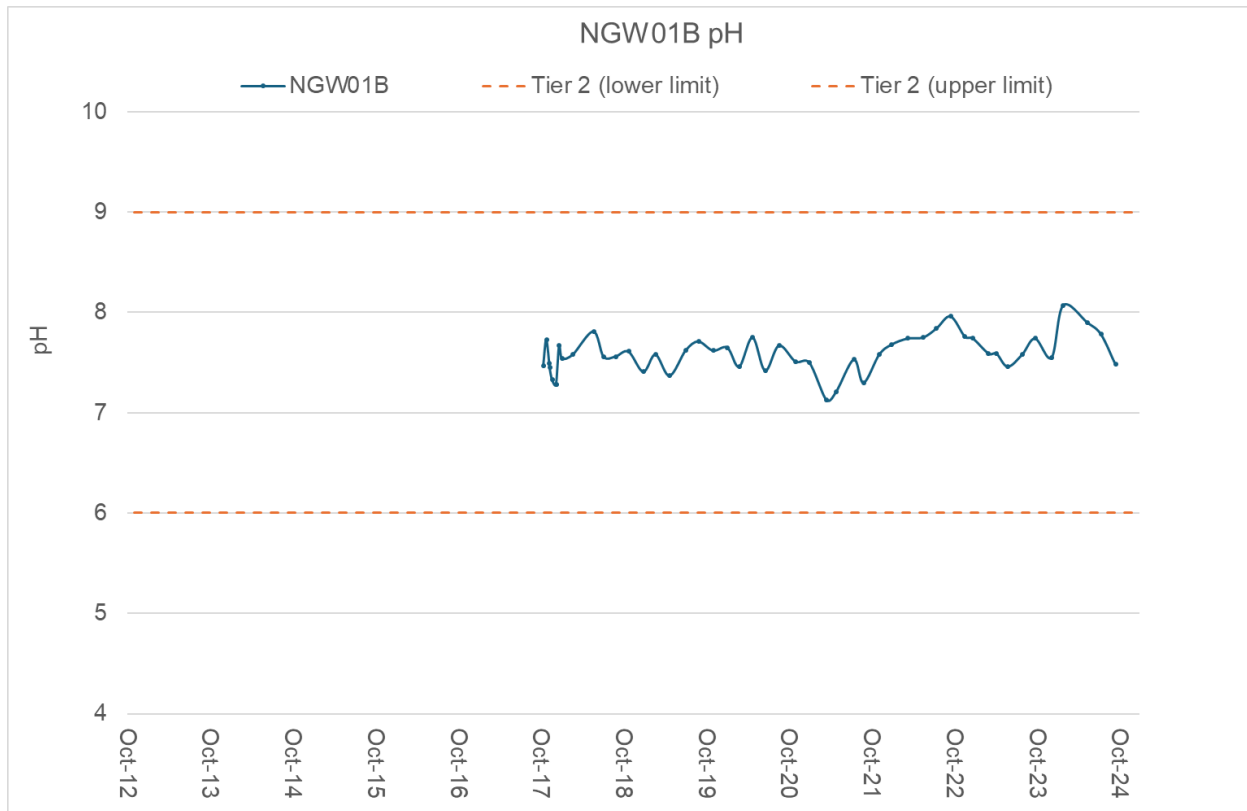
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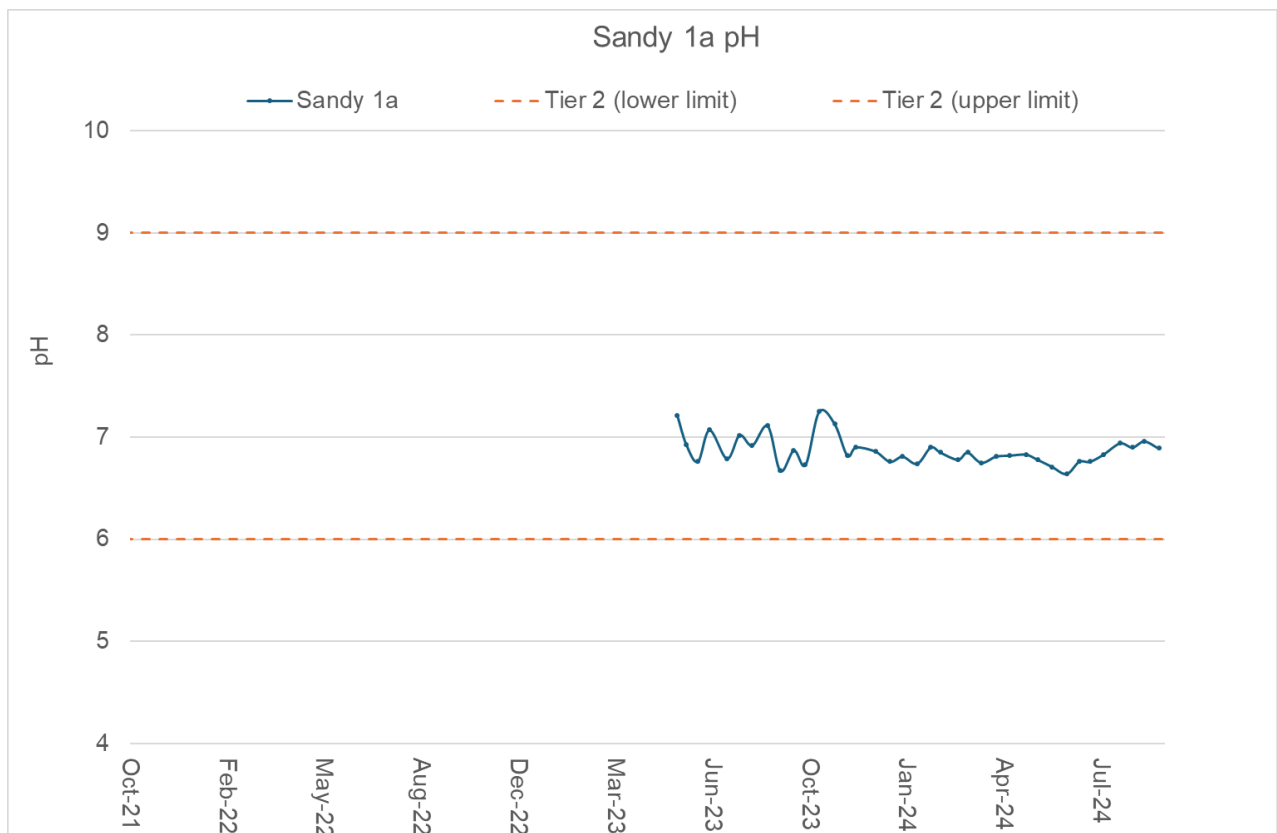
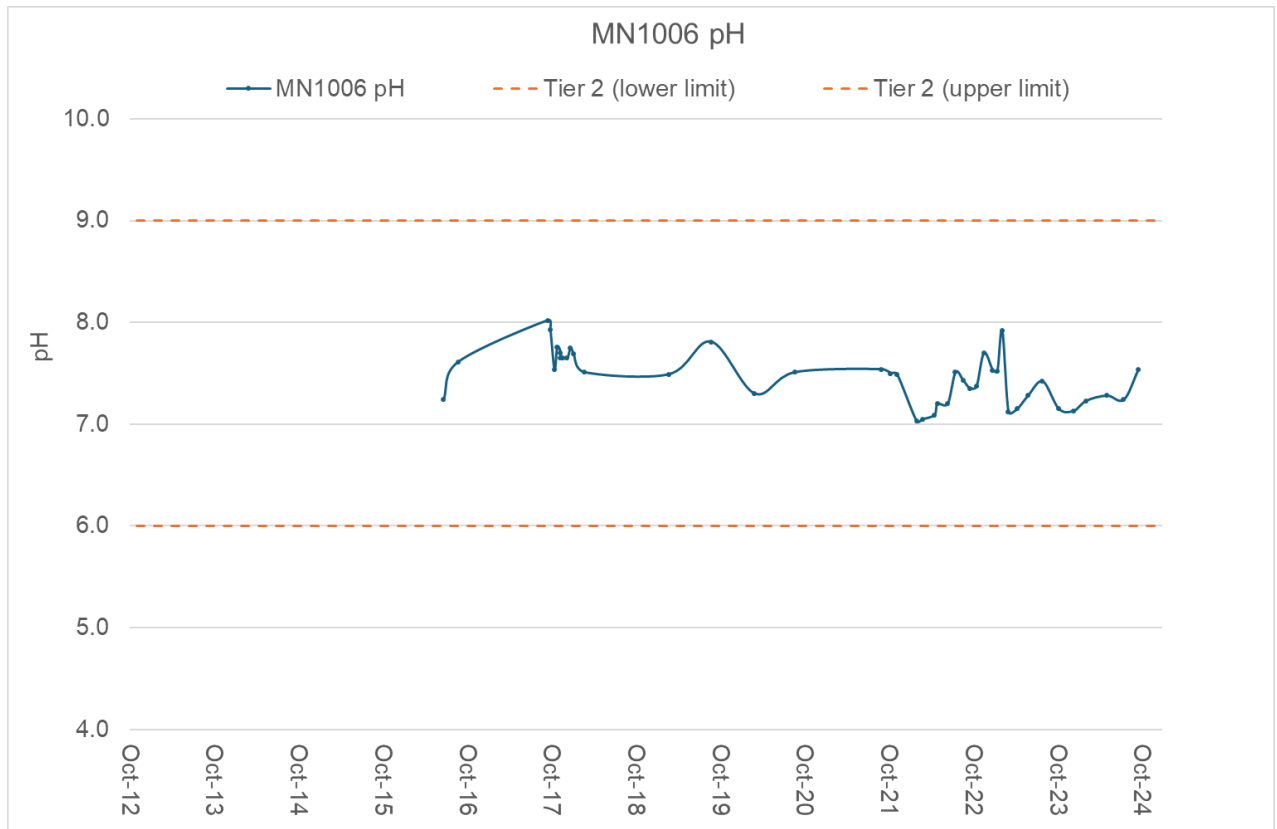
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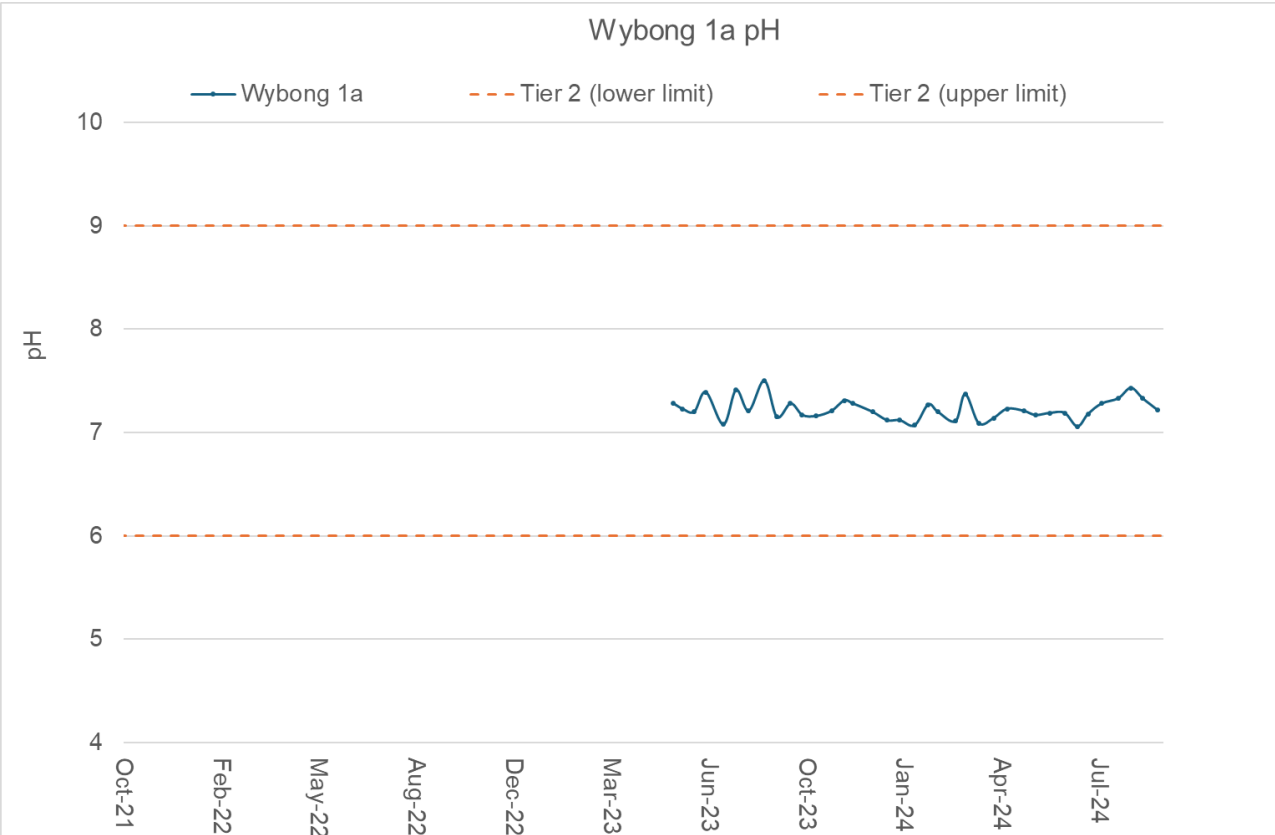
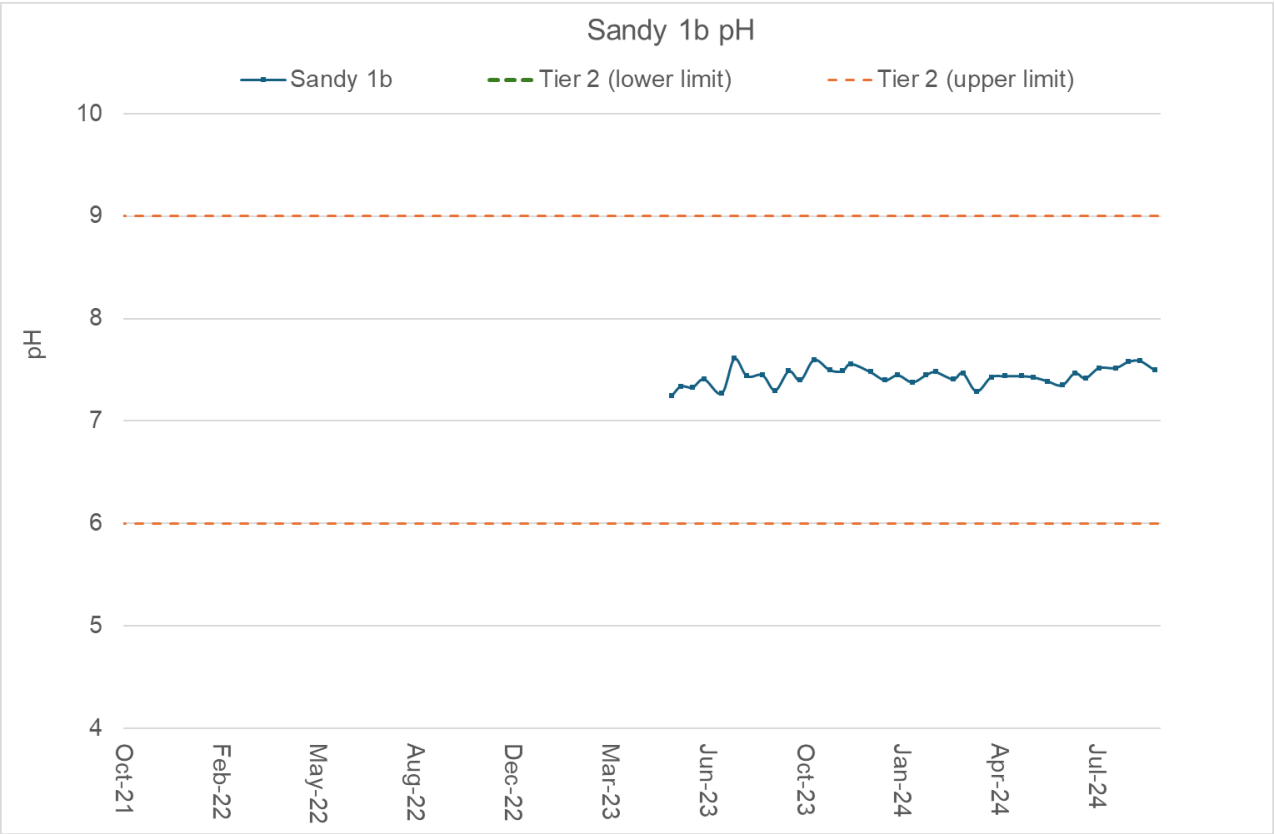
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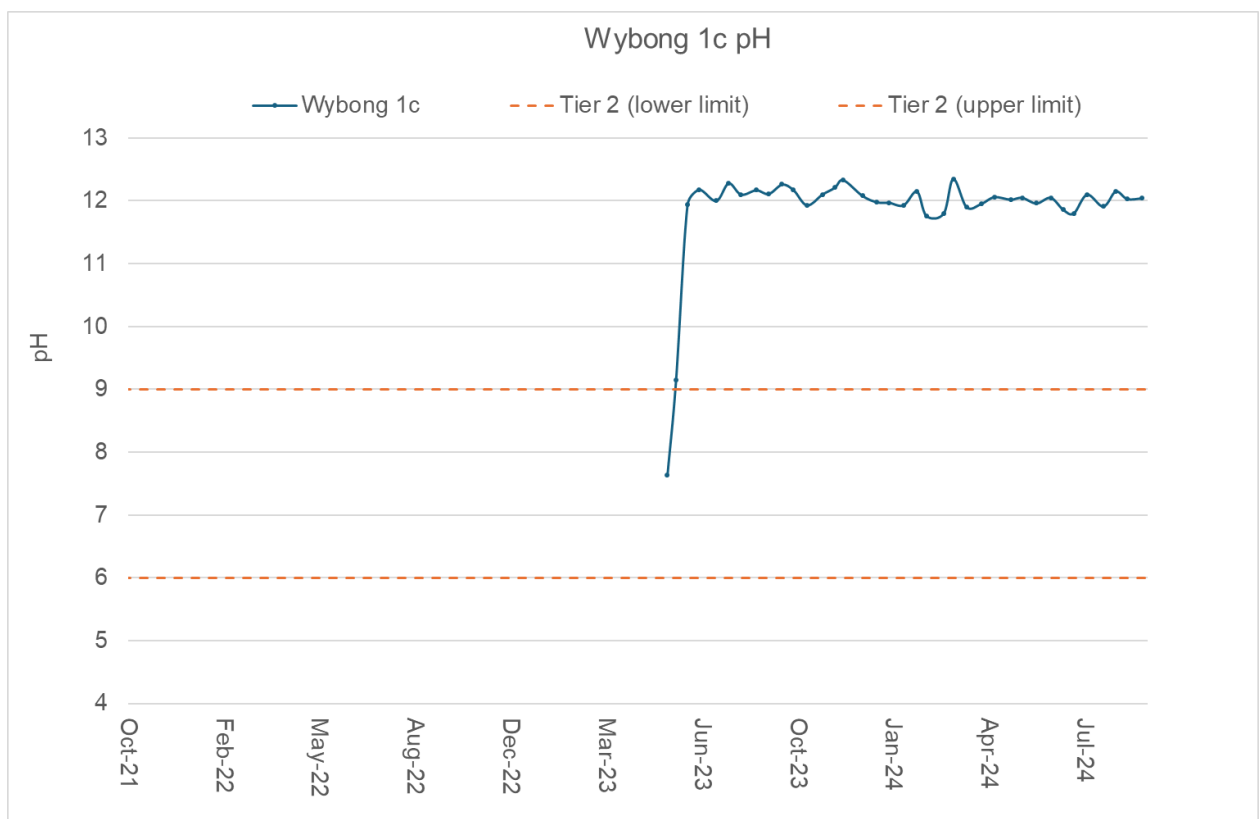
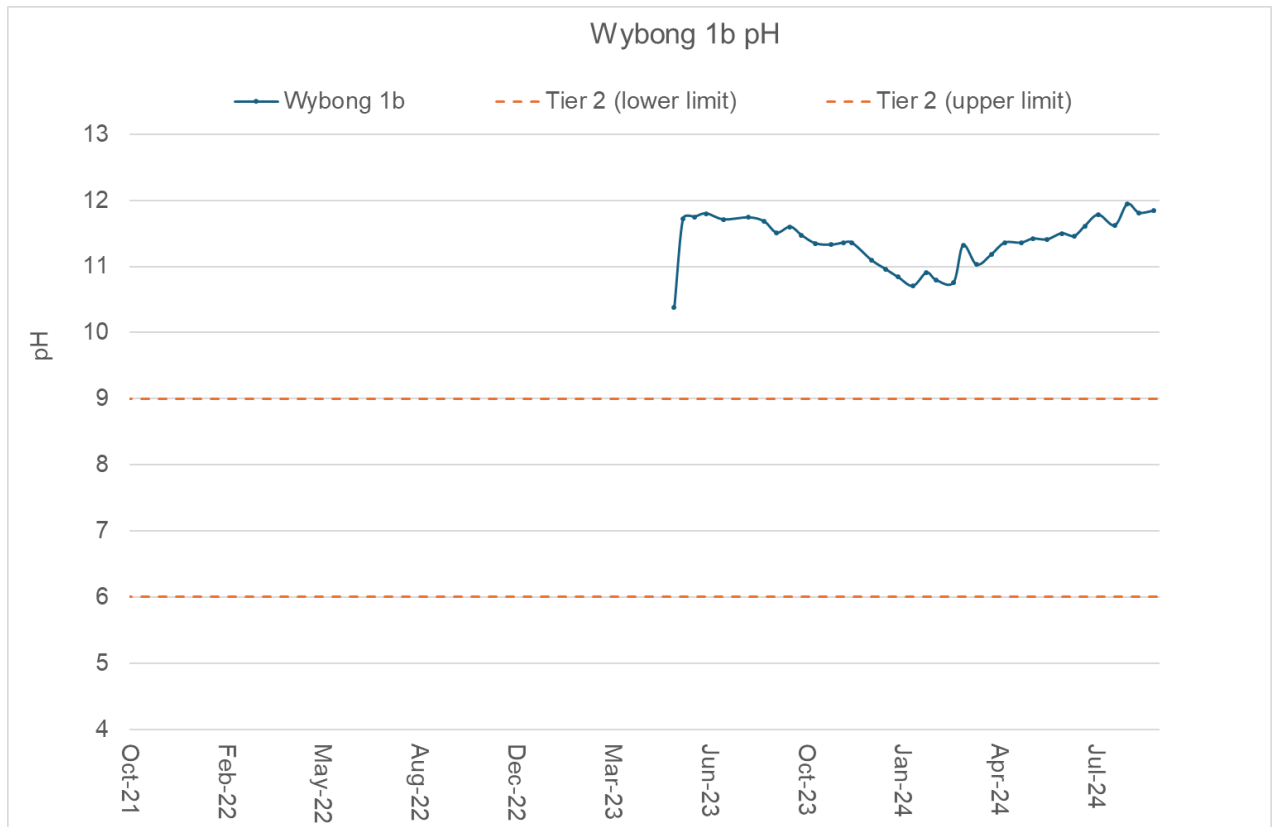
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Appendix F – Authority Correspondence
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