

Airly Mine

Water Management Plan

March 2024

DOCUMENT CONTROL

DOCUMENT CONTROL				
DOCUMENT DETAILS	Name		Airly Mine: Water Management Plan	
	Author		Ian Gilmore and Tyler Tinkler (GHD Pty Ltd)	
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DETAILS OF CHANGE				
Revision	Trigger	Date	Brief details of change	
0	SSD-5581	21/04/2017	Original water management plan.	
1		27/04/2017	Updated to include revised water balance results.	
2		24/07/2017	Updated to include recalibrated hydrogeological model results.	
3		18/07/2018	Revised to address comments from a review by NSW Department of Planning and Environment and an independent expert review of the groundwater management plan and to include conditions for EPBC approval 2013/7076.	
4	SSD-5581 Mod 2	30/10/2019	Revised following approval for Modification 2 to development consent SSD-5581 allowing for receipt of up to 170 ML/year of water from Charbon Colliery by rail.	
5		29/03/2021	Revised to update monitoring data and requirements	
6		20/11/2021	Revised to address comments from the Independent Review of Airly Mine Groundwater Management Plan (SLR, 2021) WMP is being reviewed in light of the Point Hatteras Extraction Plan	
7		10/01/2023	Inclusion of correspondence from DPE. WMP updated to consider MW17-19 Extraction Plan and the CLZ Extraction Plan in ML1814 (for first workings only).	
8		2/06/2023	Update in accordance with the clarifications sought by the NSW DPE dated 31 March 2023 (ref OUT23/4966)	

	9		22/03/2024	Update in accordance with DPIE request to update TARPs F2 and F4 (DPIE reference SSD-5581-PA-65)
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Glossary

Alluvial	Deposition from running waters.
Aquifer	Underground water storage within either disturbed or undisturbed strata.
Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Baseflow	The component of streamflow that originates from groundwater.
Bord and pillar	Method of underground coal mining where the coal seam is divided into a regular block array (pillars) by driving roadways. In some cases, the pillars are partly or completely removed in a concurrent or later operation.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Brackish water	Water that has more salinity than fresh water, but not as much as sea water. Typically containing between 0.5 and 30 grams of dissolved salt per litre of water.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Clean water	Waters within a site that have not come into physical contact with coal or mined carbonaceous material.
Coal handling plant	A facility where coal is crushed and screened.
Cross-section	A plot of ground elevation across a stream valley or a portion of it, usually along a line perpendicular to the flow direction.
Datum	A level surface used as a reference in measuring elevations.
Dewatering	Transfer of water from underground workings to the surface.
Dirty water	Waters within a site that have come into contact with coal or mined carbonaceous material or otherwise contain an elevated sediment load.
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Drawdown	A reduction in piezometric or hydraulic head within an aquifer.
Electrical conductivity	A measure of the concentration of dissolved salts in water.
Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Fractures	Cracks within the strata that develop naturally or as a result of underground works.

Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report, geomorphology relates to the form and structure of waterways.
Groundwater	Subsurface water that occurs in soils and geological formations.
Guideline	Numerical value or narrative statement that provides appropriate guidance for a designated water use or impact.
Hardness	The concentration of multivalent cations present in water. Generally, hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate (CaCO ₃) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Headcut	Erosional feature where an abrupt vertical drop in the stream bed occurs, resembling a small waterfall when the stream is flowing or a short bluff when the stream is dry.
Headward erosion	The upstream lengthening and/or cutting of a valley or gully at its head, as the stream erodes away the rock and soil at its headwaters in the opposite direction that it flows.
Hydrograph	A graph which shows how a water level (either surface or underground) at any particular location changes with time.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Hydrology	The study of rainfall and surface water runoff processes.
Infiltration	The downward movement of water into soil and rock, which is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Licensed discharge point	A location where a licensed operation discharges water to the environment in accordance with conditions stipulated within the site environment protection licence.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Outcrop	Where the bedrock is exposed at the ground surface.
Overburden	The strata between the coal seam being extracted and the surface.
Partial extraction	A continuous miner system of mining whereby some of the coal pillars in a panel, or parts thereof, are systematically extracted.
Percentile	The value of a variable below which a certain per cent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
Perennial	A watercourse or part of a watercourse that has continuous flow throughout the year.

Permian	The youngest geological period of the Palaeozoic era, covering a span between approximately 290 and 250 million years ago.
pH	Value measure used to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution. A value of 7 is applied to a water that is neither acidic or alkaline. A value less than 7 represents an acidic condition.
Quaternary	The most recent geological period spanning from approximately 2.5 million years ago to present.
Rainfall excess	Amount of rainfall that ends up as streamflow, also termed runoff.
Recharge	Inflow of water from surrounding strata into underground mine workings via infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Run of mine	Raw coal production (unprocessed).
Sediment	Soil or other particles that settle to the bed of lakes, rivers, oceans and other waters.
Slope	A landform element inclined from the horizontal at an angle, measured as degrees or as a percentage.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.
Strata	Plural of stratum.
Stratum	Layer of rock or soil with internally consistent characteristics that distinguish it from other layers.
Subsidence	The vertical difference between the pre-mining surface level and the post-mining surface level at a point.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Guideline value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. A trigger value indicates a risk of impact if exceeded and should 'trigger' action to conduct further investigations or to implement management or remedial processes.
Triassic	The geological period that spans between approximately 250 and 200 million years ago.

Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Underground water	Water stored in underground aquifers. During the mining process a proportion of this water is released and managed by the underground settling and pumping system.
Wastewater	Liquid waste discharged by a community or industry.

Abbreviations

AEP	Annual exceedance probability
AHD	Australian height datum
AUSRIVAS	Australian Rivers Assessment System
BCD	Biodiversity and Conservation Division (of the NSW Department of Planning, Industry and Environment)
bgl	Below ground level
BOD	Biochemical oxygen demand
BOM	Bureau of Meteorology
Centennial	Centennial Coal Company Limited
Centennial Airly	Centennial Airly Pty Limited
CHP	Coal handling plant
CPP	Coal preparation plant
DO	Dissolved oxygen
DoEE	Department of Environment and Energy
DPI Water	Department of Primary Industries – Water
DPIE	Department of Planning, Industry and Environment
DPE	Department of Planning and Environment
EC	Electrical conductivity
EIS	Environmental impact statement
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment protection licence
GDE	Groundwater dependent ecosystem
GMMP	Groundwater Monitoring and Management Plan
ha	Hectare
kL	Kilolitre
km	Kilometre
L/day	Litre per day
L/s	Litre per second
LDP	Licensed discharge point
LOR	Limit of reporting

m	Metre
m/day	Metre per day
m/s	Metre per second
mg/L	Milligram per litre
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
Mtpa	Million tonnes per annum
NRAR	Natural Resource Access Regulator
NTU	Nephelometric turbidity unit
PIRMP	Pollution incident response management plan
RCE	Riparian, channel and environmental
REA	Reject emplacement area
ROM	Run of mine
SILO	Scientific Information for Landowners
SSGV	Site-specific guideline value
TARP	Trigger action response plan
TDS	Total dissolved solids
TSS	Total suspended solids
VWP	Vibrating wire piezometer
WAL	Water access licence
WMP	Water management plan
$\mu\text{S/cm}$	Microsiemens per centimetre

1. Introduction

Airly Mine is an underground coal mine owned and operated by Centennial Airly Pty Limited (Centennial Airly), a wholly owned subsidiary of Centennial Coal Company Limited (Centennial). Centennial is a wholly owned subsidiary of Banpu Public Company Limited. Airly Mine is located near the village of Capertee, approximately 40 km north-west of Lithgow in the Western Coalfield, as shown in Figure 1.1.

This Water Management Plan (WMP) has been prepared for Airly Mine. The WMP applies to all operations at Airly Mine and include the existing and approved operations and associated infrastructure within the site boundary. The WMP will be progressively developed as water management requirements at the site change over time.

In accordance with development consent SSD-5581 for Airly Mine, this WMP has been prepared by Ian Gilmore and Tyler Tinkler and reviewed by Stuart Gray and Alyssa Barron of GHD Pty Ltd in consultation with Airly Mine.

The WMP was provided to the Commonwealth Department of the Environment and Energy (DoEE), NSW Environment Protection Authority (EPA) and the former NSW Department of Primary Industries – Water (DPI Water) for consultation in March 2017 in accordance with the requirements of Schedule 4, Condition 13 of development consent SSD-5581.

Revision 1 of the WMP was submitted to the DoEE, EPA, DPI Water and the former Office of Environment and Heritage for consultation in June 2017 as part of the extraction plan for the Cliff Line Zone and Zone of First Workings, in accordance with the requirements of Schedule 3, Condition 7 (i) (iii) of development consent SSD-5581. Revision 6 of the WMP was submitted to the Department of Planning, Industry and Environment (now the Department of Planning and Environment (DPE)) in August 2021.

Responses were received from DPI Water in a letter dated 25 May 2017 and from the former NSW Department of Planning and Environment in an email dated 1 June 2018. Correspondence was also received from DPE in a letter dated 3 November 2021. All correspondence with government regulators with regard to the WMP is provided in Appendix A. Consultation comments are provided in Appendix B, along with how these comments have been addressed in the WMP.

Version 7 of the WMP presents the following amendments:

- Inclusion of 2019, 2020 and 2021 data
- Updated figures for the current mining progress and watercourse stability following the field study completed in Spring 2020
- Reduced analytical suites and monitoring frequency for surface and groundwater locations based on review of historical data
- Addresses the comments from the Independent Review of Airly Mine Groundwater Management Plan
- The WMP is continually reviewed to account for updates to the mine plan, trends in monitoring data and changes to the water management system at Airly Mine.

Version 7 of the WMP was prepared to consider MW17-19 Extraction Plan and the CLZ Extraction Plan in ML1814 (for first workings only). Version 8 has been prepared to address clarifications sought by the NSW DPE (dated 31 March 2023, ref OUT23/4966) and the amended MW17-18 Extraction Plan. Version 9 has been prepared to address a DPIE request to update TARPs F2 and F4 (DPIE reference SSD-5581-PA-65). In addition to the request, GHD have included newly developed Site-Specific Guideline Values (SSGVs) for monitoring locations ARP12, Kingdom and Nioka as a sufficient dataset has been reached.

1.1 Overview of site operations

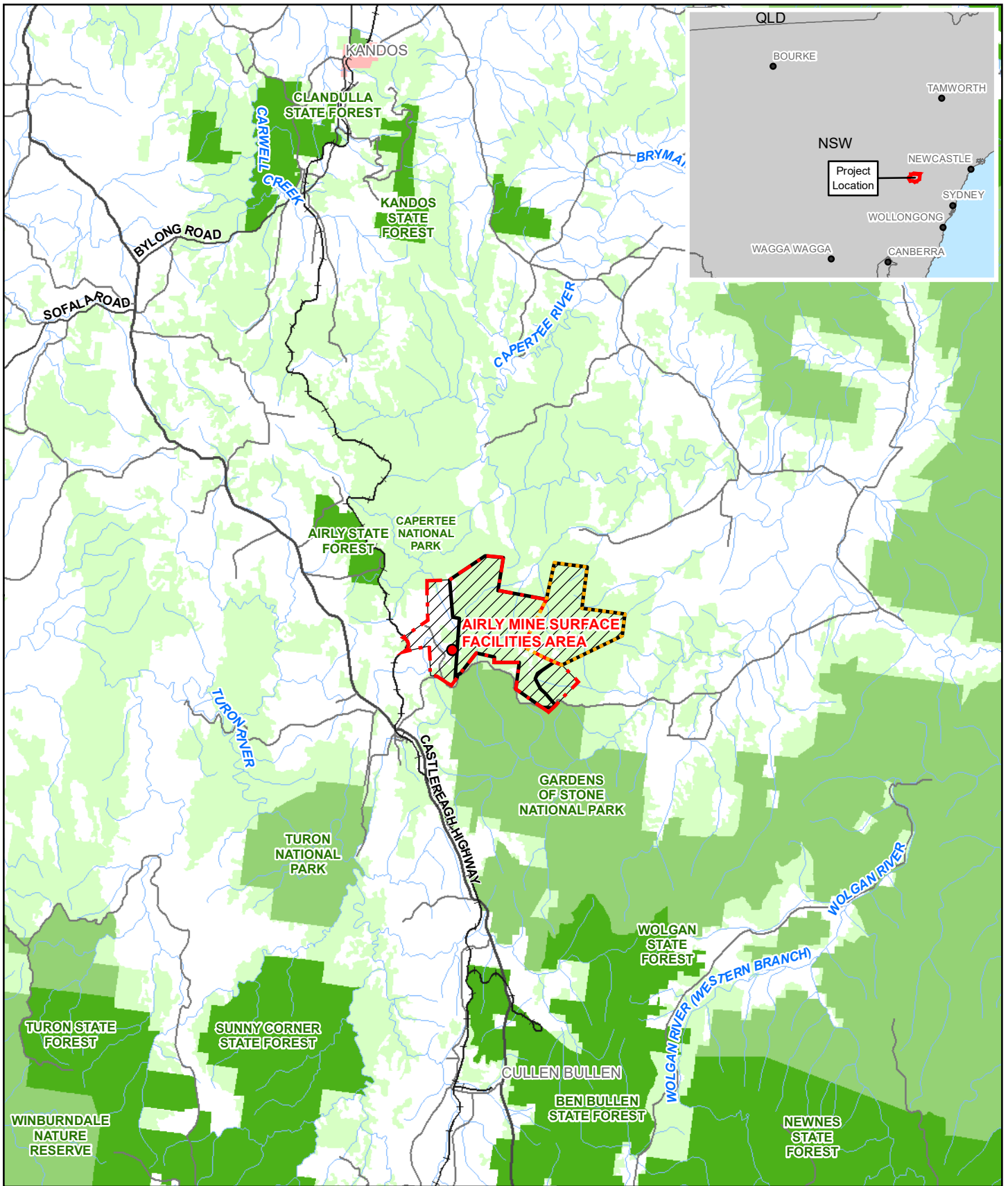
1.1.1 Site features

The site surface features associated with operations at Airly Mine are provided in Figure 1.2 and include water management and pollution control infrastructure, underground mining access, a coal handling plant (CHP) used to crush coal, rail loop and train loader used to load coal for export from the site and workshop and administration infrastructure.

Airly Mine is also approved to construct and operate a coal preparation plant (CPP) to beneficiate run of mine (ROM) coal and a reject emplacement area (REA) to dispose of reject material, however neither have been constructed to date.

1.1.2 Coal production

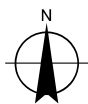
Airly Mine currently has approval to extract up to 1.8 million tonnes per annum (Mtpa) of ROM coal from the Lithgow Seam using mining methods that incorporate extraction by first workings, partial pillar extraction or panel and pillar mining. ROM and product coal is transported off site by rail for the export and domestic markets.



LEGEND

- Airly Surface Facilities Area
- Mining Lease ML 1331
- Mining Lease ML 1814
- Authorisation A232
- Approved development consent boundary
- Principal road
- Secondary road
- Minor road
- Existing rail
- Waterway
- Built up area
- Recreation area
- Nature conservation
- State forest
- Forest or shrub

Paper Size A4
 0 1.5 3 4.5 6
 Kilometres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56

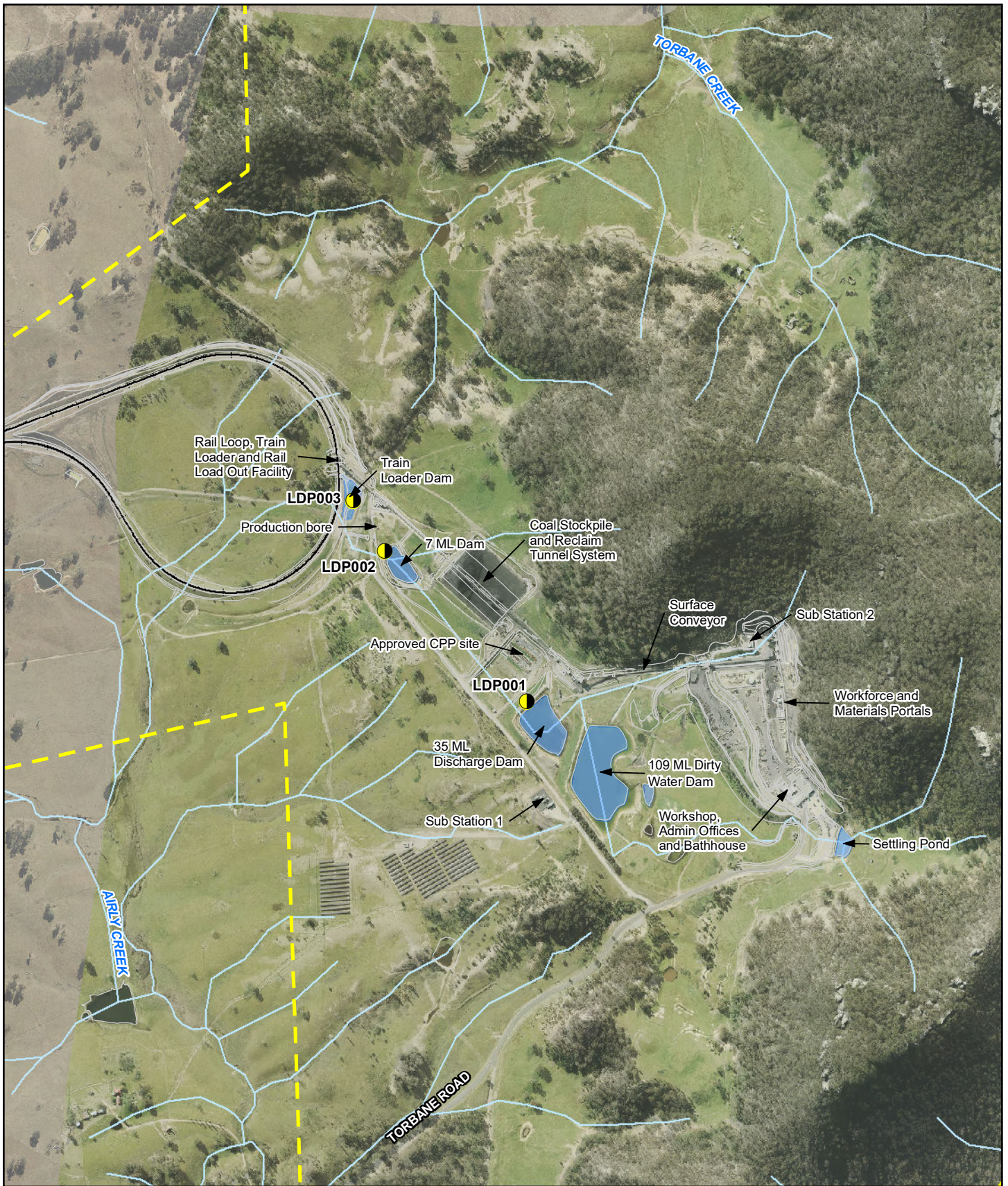


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 Water Management Plan






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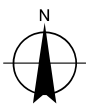
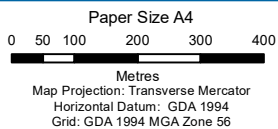
Locality plan

Figure 1-1



LEGEND

-  Licensed discharge point
-  Pollution control structure
-  Infrastructure
-  Rail loop
-  Approved development consent boundary
-  Waterway



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Site features

Figure 1-2

1.1.3 History

A summary of the history of Airly Mine operations is provided in Table 1.1.

Table 1.1 History of Airly Mine

Date	History
April 1993	Airly Mine granted development consent DA162/91 for a period of 20 years until October 2014.
December 1997	Centennial Airly purchased the undeveloped Airly Mine from Novacoal.
December 1998	Trial mine phase commenced, with regular transport of ROM coal to Mount Piper Power Station.
1999	Development consent DA162/91 was modified to allow up to 500,000 tonnes of coal per annum to be transported by road for two years.
2002	Airly Mine was placed into care and maintenance.
2009	Centennial Airly recommenced construction of Airly Mine with production commencing in December 2009.
October 2014	Development consent DA162/91 was modified to allow for the continuation of mining until October 2015.
August 2015	Development consent DA162/91 was modified to allow for the continuation of mining until April 2016.
March 2016	Development consent DA162/91 was modified to allow for the continuation of mining until October 2016.
September 2016	Development consent DA162/91 was modified to allow for the continuation of mining until January 2017.
December 2016	State significant development SSD-5581 was approved for the Airly Mine Extension Project.
January 2017	Airly Mine commenced operations under SSD-5581 on 31 January 2017.
August 2018	Modification 1 to development consent SSD-5581 was approved to amend the wording of the development consent to remove restrictions on mining.
July 2019	Modification 2 to development consent SSD-5581 was approved to allow receipt of up to 170 ML/year of water from Charbon Colliery by rail.

1.2 Approvals and licensing requirements

1.2.1 Development consent

The WMP addresses specific water components of the conditions of development consent SSD-5581, which was granted by the Planning Assessment Commission of NSW on 15 December 2016 for the Airly Mine Extension Project. Development consent SSD-5581 has been modified twice to amend the wording of the development consent to remove restrictions on mining (Modification 1) and to allow the receipt of up to 170 ML/year of water from Charbon Colliery by rail.

The relevant requirements of the consent are outlined in Table 1.2, along with the sections of the WMP where these have been addressed.

Table 1.2 Development consent SSD-5581 conditions

Condition		Where addressed
Extraction plan		
Schedule 3 7. (i) (iii)	<i>Water Management Plan</i> which has been prepared in consultation with BCD [Biodiversity and Conservation Division, within the Department of Planning, Industry and Environment] and the Water Division [Water Division within the Department of Planning, Industry and Environment], which provides for the management of potential impacts and/or environmental consequences of the proposed underground workings on watercourses and aquifers, including:	Appendix A Appendix B
	Detailed baseline data on: <ul style="list-style-type: none"> • Surface water flows and quality in Gap and Genowlan Creeks; • Surface water flows in Airly village spring and the Grotto; • Groundwater levels, yield and quality in the region; 	Section 5.1 Section 5.3 Appendix C Appendix D Appendix E
	Surface and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality;	Section 6.2
	A surface water monitoring program to monitor and report on: <ul style="list-style-type: none"> • Stream flows and quality. • Stream and riparian vegetation health. • Channel and bank stability. 	Section 4.2 Section 4.5
	A groundwater monitoring program to monitor and report on: <ul style="list-style-type: none"> • Springs, their discharge quantity and quality, as well as any associated groundwater dependent ecosystems. • Groundwater inflows to the underground mining operations. • The height of groundwater depressurization. • Background changes in groundwater yield/quality against mine-induced changes, in particular, on groundwater bore users. • Permeability, hydraulic gradient, flow direction and connectivity of the deep and shallow groundwater aquifers. 	Section 4.4
	A description of any adaptive management practices implemented to guide future mining activities in the event of greater than predicted impacts on aquatic habitat.	Appendix H

Condition		Where addressed
	A program to validate the surface water and groundwater models for the development, and compare monitoring results with modelled predictions.	Section 7.4 Section 7.6
	A plan to respond to any exceedances of the surface water and groundwater assessment criteria.	Section 6.3 Appendix F
Water Supply		
Schedule 4 9	The Applicant must ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of operations on site to match its available water supply. Note: Under the Water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain the necessary water licences for the development.	Section 1.2.5 Section 3.2.3 Section 3.5.1
Water Pollution		
Schedule 4 10	Unless an EPL [environment protection licence] authorises otherwise, the Applicant must comply with Section 120 of the POEO Act [<i>Protection of the Environment Operations Act 1997</i>].	Section 1.2.4
Compensatory Water Supply		
Schedule 4 11	The Applicant must provide a compensatory water supply to the owner of any privately-owned land whose water supply is adversely and directly impacted (other than a negligible impact) as a result of the development, in consultation with the Water Division, and to the satisfaction of the Secretary. The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent, in quality and volume, to the loss attributed to the development. Equivalent water supply should be provided (at least on an interim basis) within 24 hours of the loss being identified. If the Applicant and the landowner cannot agree on 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 Secretary for resolution. If the Applicant is unable to provide an alternative long-term supply of water, then the Applicant must provide alternative compensation to the satisfaction of the Secretary.	Appendix F
Water Management Performance Measures		
Schedule 4 12	The Applicant must comply with the performance measures in Table 6 [Water Management Performance Measures] to the satisfaction of the Secretary.	Table 1.3
Water Management Plan		
Schedule 4 13	Prior to carrying out any development under this consent, unless the Secretary agrees otherwise, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:	
Schedule 4 13 (a)	Be prepared in consultation with the DoEE, EPA and the Water Division, by suitably qualified and experienced person/s whose appointment has been approved by the Secretary.	Appendix A Appendix B

Condition		Where addressed
Schedule 4 13 (b)	Include detailed performance criteria and describe measures to ensure that the Applicant complies with the Water Management Performance Measures (see Table 6).	Table 1.3
Schedule 4 13 (c)	In addition to the standard requirements for management plans (see condition 3 of Schedule 6), this plan must include a:	
Schedule 4 13 (c) (i)	Site Water Balance, that includes details of:	
	Sources and security of water supply, including contingency supply for future reporting periods;	Section 3.2 Section 3.3 Section 3.4 Section 3.5
	Water use and management on site;	Section 3.2 Section 3.3 Section 3.4
	Any off-site discharges; and	Section 1.2.4 Section 3.2.2 Section 3.5.2
	Reporting procedures, including the preparation of a site water balance for each calendar year; and	Section 7.4
	Investigates and implements all reasonable and feasible measures to minimise water use on site.	Section 3.5.1
Schedule 4 13 (c) (ii)	Surface Water Management Plan, that includes:	
	Detailed baseline data on water flows and quality in the watercourses that could potentially be affected by the development, including, but not limited to Gap, Genowlan and Airly Creeks.	Section 5.1
	Continuous flow monitoring at Airly village spring and the Grotto.	Section 4.2.2 Section 4.4.1
	Provisions for the recalculation of site-specific trigger values in relation to water discharges to Airly Creek once a minimum of two years data is obtained from the Airly Creek 'U/S' monitoring location in accordance with ANZECC guidelines.	Section 6.1.1
	The provision and implementation of adaptive management measures to ensure that subsequent water discharges to Airly Creek comply with the recalculated site-specific trigger values derived from the Airly Creek 'U/S' monitoring location.	Appendix F
	A detailed description of the water management system, including the: <ul style="list-style-type: none"> • Clean water diversion systems. • Erosion and sediment controls (mine water system). • Mine water management systems. 	Section 3.2 Section 3.3

Condition		Where addressed
	<p>Detailed objectives and performance criteria, including trigger levels for investigating any potentially adverse impacts associated with the development for:</p> <ul style="list-style-type: none"> • Downstream surface water quality. • Downstream water users, including with respect to any subsidence-related flow reductions in Gap and Genowlan Creeks. • Stream and riparian vegetation health in Gap, Genowlan and Airly Creeks within and immediately outside of the site. • Design and management for the emplacement of coal reject materials. • Reinstatement of drainage lines on the rehabilitated areas of the site. • Control of any potential water pollution from the rehabilitated areas of the site. 	<p>Section 6.1 Section 6.2</p>
	<p>A program to monitor and report on:</p> <ul style="list-style-type: none"> • Effectiveness of the mine water management system. • Surface water flows, quality and geomorphology of the watercourses potentially affected by the development within and immediately outside of the site. • The performance measures listed in Table 6 including, but not limited to event-based monitoring of the hydrology, quality, ecotoxicology and chemical composition of water in Airly Creek under discharge conditions at points 5 and 6, or as otherwise determined in consultation with the EPA, to ensure that protection is provided to 99% of all species in the Gardens of Stone National Park and Greater Blue Mountains World Heritage Area in accordance with ANZECC guidelines. 	<p>Section 4 Section 7 Western Operations: Regional Water Management Plan</p>
	<p>Reporting procedures for the results of the monitoring program.</p>	<p>Section 7.1 Western Operations: Regional Water Management Plan</p>
	<p>A plan to respond to any exceedances of performance measures, and repair, mitigate and/or offset any adverse surface water impacts of the development, including measures to provide compensatory water supply to any affected downstream water user under condition 11 of this Schedule [Schedule 4].</p>	<p>Section 6.3 Appendix F</p>

Condition		Where addressed
Schedule 4 13 (c) (iii)	Groundwater Management Plan, which is consistent with the NSW Government guideline entitled <i>Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities</i> , and includes:	
	Detailed baseline data of groundwater levels, yield and quality in the region that could be affected by the development, including licensed privately-owned groundwater bores and a detailed survey/schedule of groundwater dependent ecosystems (including springs and their discharge quantity and quality).	Section 5.3
	Consultation with the Water Division on the installation of all new monitoring bores, the scheduled sampling and quality determination of parameters for monitoring bores.	Section 4.4
	Groundwater assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts.	Section 6.1.4 Section 6.2.4
	A program to monitor and report on: <ul style="list-style-type: none"> • Springs and their discharge quantity and quality. • Groundwater inflows transferred to the surface water management system. • The seepage/leachate from water storages and emplacements. • Impacts of the development on: <ul style="list-style-type: none"> • Regional and local (including alluvial) aquifers. • Groundwater supply of potentially affected landowners. • Groundwater dependent ecosystems (including rules for the management of groundwater level impacts to protect groundwater dependent ecosystems), and riparian vegetation. 	Section 4.4 Section 4.5
	A program to monitor and report on stygofauna and hyporheic fauna.	Section 4.4.3 Western Region Stygofauna Monitoring and Assessment Plan
	A program to review and validate the groundwater model for the development, including independent expert review.	Section 7.6 Appendix G
	A plan to respond to any exceedances of the performance measures.	Section 6.3 Appendix F
Management Plan Requirements		
Schedule 6 2.	The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include:	
Schedule 6 2. (a)	Detailed baseline data;	Section 5

Condition		Where addressed
Schedule 6 2. (b)	A description of: <ul style="list-style-type: none"> • The relevant statutory requirements (including any relevant approval, licence or lease conditions); • Any relevant limits or performance measures/criteria; and • The specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development of any management measures; 	Section 1.2 Section 6.1 Section 6.2 Western Operations: Regional Water Management Plan
Schedule 6 2. (c)	A description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 3.2 Section 3.3
Schedule 6 2. (d)	A program to monitor and report on the: <ul style="list-style-type: none"> • Impacts and environmental performance of the development; and • Effectiveness of any management measures. 	Section 4 Section 7 Western Operations: Regional Water Management Plan
Schedule 6 2. (e)	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;	Section 6.3 Appendix F
Schedule 6 2. (f)	A program to investigate and implement ways to improve the environmental performance of the development over time;	Section 4 Section 7 Western Operations: Regional Water Management Plan
Schedule 6 2. (g)	A protocol for managing and reporting any: <ul style="list-style-type: none"> • Incidents • Complaints • Non-compliances with statutory requirements • Exceedances of the impact assessment criteria and/or performance criteria 	Western Operations: Regional Water Management Plan
Schedule 6 2. (h)	A protocol for periodic review of the plan.	Western Operations: Regional Water Management Plan

Performance measures specified by development consent SSD-5581 are presented in Table 1.3, along with the sections of the WMP where these have been addressed.

Table 1.3 Performance measures specified by SSD-5581

Feature	Performance measure	Where addressed
Subsidence Impact Performance Measures – Natural and Heritage Features, etc.		
Gap and Genowlan Creeks	Negligible environmental consequences to water quality and to bed and bank stability	Table 6.7 Table 6.11
	No greater environmental consequences than predicted in the EIS [environmental impact statement] to water flows (including baseflow)	Table 6.7
All other watercourses	No greater subsidence impacts or environmental consequences than predicted in the EIS	Table 6.7 Table 6.11
Water Management Performance Measures		
Water Management – General	Minimise the use of clean water on site	Table 6.6
	Minimise the use of the supplementary water supply from the production bore	Table 6.6
Construction and operation of linear infrastructure	Design, install and maintain erosion and sediment controls generally in accordance with the series Managing Urban Stormwater: Soils and Construction including Volume 1, Volume 2A – Installation of Services and Volume 2C – Unsealed Roads	Table 6.6
	Design, install and maintain any infrastructure within 40 m of watercourses generally in accordance with the <i>Guidelines for Controlled Activities on Waterfront Land</i> (July 2007), or its latest version	Table 6.7
	Design, install and maintain creek crossings generally in accordance with the Policy and Guidelines for Fish Friendly Waterway Crossings (NSW Fisheries 2003a) and Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings (NSW Fisheries 2003b), or their latest versions	Table 6.7
Sediment dams	Design, install and maintain the dams generally in accordance with the series Managing Urban Stormwater: Soils and Construction – Volume 1 and Volume 2E – Mines and Quarries	Table 6.6
Mine water storages	Design, install and maintain mine water storage infrastructure to ensure no unlicensed or uncontrolled discharge of mine water off-site	Table 6.6
	Minimise discharges to surface waters as far as reasonable and practicable	Table 6.6
	New on-site storages (including mine infrastructure dams, groundwater storage and treatment dams) are suitably treated to comply with a permeability standard of $< 1 \times 10^{-9}$ m/s	Table 6.6
	Achieve an improvement in the quality of water held in the Production Dam generally in accordance with Figure 6-7 in Appendix F of the EIS (surface water impact assessment) over the life of the mine	Table 6.6

Feature	Performance measure	Where addressed
Water discharge to Airly Creek	No greater impacts than predicted in the EIS for water flow and quality in Airly Creek between LDP001 and Point 4 (refer Appendix 9)	Table 6.8
	Negligible environmental consequences for water quality (i.e. protection to 99% of all species in accordance with ANZECC guidelines) and flow in Airly Creek where it enters the Gardens of Stone National Park and Greater Blue Mountains World Heritage Area	Table 6.8
Gap and Genowlan Creeks	No greater impact than predicted in the EIS for water flow and quality	Table 6.7
Emplacement of CHPP rejects	Emplacement, and/or encapsulation and/or capping to prevent or minimise the migration of pollutants due to seepage from the REA	The CPP and REA have not yet been constructed.
Chemical and petroleum storage	Chemical and hydrocarbon products to be stored in bunded areas in accordance with relevant Australian Standards	Table 6.6
Aquatic and riparian ecosystems	Maintain or improve baseline channel stability	Table 6.11
	Develop site-specific water quality objectives in accordance with ANZECC Guidelines and <i>Using the ANZECC Guidelines and Water Quality Objectives in NSW</i> procedures (DECC 2006) or its latest version	Table 6.7

1.2.2 Airly Mine Extension Project Statement of Commitments

In addition to the conditions of development consent SSD-5581 presented in Table 1.2, Centennial Airly also committed to the management strategies and monitoring activities for surface water, groundwater, geomorphology and aquatic ecology outlined in Table 1.4 as part of the Airly Mine Extension Project.

Table 1.4 Statement of commitments

Commitment	Where addressed
The existing WMP for Airly Mine will be revised, including the preparation of a Groundwater Monitoring and Management Plan (GMMP). The GMMP will include the continuation of the existing groundwater monitoring program, as well as the following:	The WMP was originally revised in April 2017 with the GMMP incorporated into the plan.
Additional groundwater monitoring bores will be installed during the pre-mining phase within Gap Creek and Genowlan Creek alluvium in the areas of predicted groundwater drawdown and monitored for groundwater levels and quality (where accessible). An additional four monitoring bores (including loggers) are planned to be installed in early 2015.	The groundwater monitoring bores ARP11, ARP12, ARP13, ARP13SP, ARP14, ARP15 and ARP15SP were installed in December 2016 and January 2017.
Daily groundwater volumes transferred to the surface facilities area will be monitored.	Section 4.4.2

Commitment	Where addressed
The GMMP will establish critical threshold levels for groundwater levels and groundwater quality to trigger additional assessment and management and will define the mechanism for identifying and reporting exceedances. Action will be taken if the Level 1 minimal impact considerations (or other critical threshold levels) are found to be exceeded.	Section 6.1.4
Groundwater monitoring data will be audited on an annual basis and compared to hydrogeological modelling predictions. The GMMP will define the mechanism for identifying and reporting variations from predictions.	Section 6.1.4 Section 7.6
Should more than 278 ML/year of groundwater flow into the underground workings (i.e. more than the existing water access licences) due to greater than predicted storage within the Permian strata (particularly within the old shale workings), it will be necessary for Centennial Airly to purchase an additional groundwater water access licence to cover the excess groundwater volume.	Section 1.2.5 Section 3.3.2 Section 6.1.4
<p>Monitor current surface and groundwater monitoring points. The surface water monitoring will include the proposed REA Dam and the associated licensed discharge point. Additional groundwater monitoring points to be installed during the pre-mining phase within Gap Creek and Genowlan Creek alluvium in the areas of predicted groundwater drawdown. The surface and groundwater monitoring points will monitor the following parameters:</p> <ul style="list-style-type: none"> • Piezometric height. • Groundwater quality. • Groundwater flow. • Surface water quality and flow. • Geomorphic conditions of third order streams. <p>The monitoring of the above noted parameters will be undertaken on a quarterly basis except for the monitoring of geomorphic condition of third order streams which will be undertaken approximately every two years.</p>	Section 4.4.1 Section 4.6.1
<p>Monitor groundwater bores on adjacent private properties to provide understanding of regional groundwater systems. Parameters to be monitored will be:</p> <ul style="list-style-type: none"> • Piezometric height. • Groundwater quality. 	Section 4.4.1
Monitor macroinvertebrate ecology in Airly Creek at appropriate upstream and downstream locations biannually (spring and autumn).	Section 4.6.2

1.2.3 Environment Protection and Biodiversity Conservation Act 1999 approval

Approval for referral 2013/7606 made under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* was granted on 18 May 2017 by the Commonwealth DoEE. The approval provides for Centennial Airly to carry out mining operations in accordance with development consent SSD-5581 with conditions relating to the protection of matters of national environmental significance.

Table 1.5 presents the EPBC referral approval conditions specific to this WMP and where these have been addressed.

Table 1.5 EPBC referral approval (2013/7076) conditions

Condition		Where addressed
Schedule 4 11.	Requirement to ensure sufficient water supply for all stages of development otherwise to adjust scale of operations to match supply	Section 3.5.1
Schedule 4 13.	Requirement for compensatory water supply (as required)	Appendix F
Schedule 4 14.	Performance measures for water management	Section 6.2
Schedule 4 15.	Preparation, approval and implementation of a water management plan	This WMP
Schedule 4 16.	Independent expert review of groundwater management plan	Appendix H

1.2.4 Environment protection licence

Airly Mine currently holds environment protection license (EPL) 12374, with water currently licensed to be discharge from the site through the following licensed discharge points (LDPs):

- LDP001 – Discharge to Airly Creek via the Production Dam.
- LDP002 – Discharge to Airly Creek via the Stockpile Dam.
- LDP003 – Discharge to Airly Creek via the Train Loader Dam.

Condition O4 of EPL 12374 requires the design storage capacity of the Production Dam, Stockpile Dam and Train Loader Dam to be maintained by dewatering within 15 days (for the Production Dam) or five days (for the Stockpile Dam and Train Loader Dam) following rainfall. Maintenance is required on all dams as necessary to retain the design storage capacity.

1.2.5 Water licences

Airly Mine currently holds two water access licences (WALs) under the Water Management Act 2000 for the extraction of groundwater. A total of 278 ML is licensed for extraction from the Sydney Basin North groundwater source of the Greater Metropolitan Region Groundwater Sources Water Sharing Plan. WAL 24386 licenses the take of up to 158 ML/year of water from the production bore (water supply works approval 10WA112537), which is used to supplement water for use in mining activities. WAL 36565 licenses the extraction of up to 120 ML/year of water from the underground workings to the Dirty Water Dam.

A number of licences are held by Airly Mine under the Water Act 1912 for groundwater monitoring bores. The details of these bores are provided in Section 4.4.1.

1.3 Water management plan objectives

The WMP has been developed to address the legislative, approvals and licensing requirements presented in Section 1.2. The objectives of the WMP are:

- Collate and review existing information and studies relating to the operation of the water management system at Airly Mine.
- Establish an understanding of the water management system at the site.
- Categorise the existing conditions that are specific to water management requirements.
- Develop catchment plans for the site.
- Identify and maximise the separation of the clean and dirty water management systems.
- Undertake a review of the capacity of dirty water surface storages in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008).
- Determine the suitability of waterway conditions.
- Undertake a water quality assessment and review of existing water quality assessment criteria.
- Minimise water discharges from the site by maximising, where practicable, opportunities for the reuse and recycling of water on site.
- Manage discharges to natural waterways in accordance with relevant EPL conditions or as agreed with the EPA.
- Determine the future water management requirements.
- Review and develop water monitoring requirements.

1.4 Relationship to other plans

Water is managed regionally via the implementation of the Western Operations: *Regional Water Management Plan* and at an operational level via implementation of the site-specific WMP (this document). This WMP is also included in extraction plans for Airly Mine.

1.4.1 Extraction plans

Extraction plans are developed prior to carrying out any first workings within the Cliff Line Zone and Zone of First Workings or for all secondary workings (i.e., splitting and quartering or mini-wall mining). Generally, extraction plans describe the applicable regulatory framework, mine planning and management and monitoring measures to be implemented to ensure the protection of all surface/subsurface natural and built features and the protection of public safety during extraction. This WMP has been prepared in accordance with Condition 7 (i) (iii) in Schedule 3 of SSD_5581, and as such is included within each extraction plan for Airly Mine to manage potential subsidence-related impacts to water resources. A biodiversity management plan is also included as a sub-plan to each extraction plan.

1.4.2 Western Region Stygofauna Monitoring and Assessment Plan

The Western Region Stygofauna Monitoring and Assessment Plan has been developed in order to monitor and assess existing communities of aquatic subterranean fauna (stygofauna) across a number of Centennial sites located in the Western Coalfield, including Airly Mine.

2. Environment

2.1 Climate

Airly Mine has a site-based meteorological station which was established in April 2010 and recorded rainfall data until mid-2022. A new rainfall gauge was subsequently installed on Genowlan Mountain.

Point data were obtained from the Scientific Information for Landowners (SILO) database operated by the Queensland Government's Department of Environment and Science. SILO point data consist of interpolated estimates based on historically observed data from Bureau of Meteorology (BOM) stations. For this assessment, SILO data was obtained for the grid point centred at -33.10N, 150.00E, which includes the Airly Mine surface facilities area.

Figure 2.1 presents the historical SILO point daily rainfall data between 1889 and 2020 and site-based rainfall recorded between 2010 and 2020.

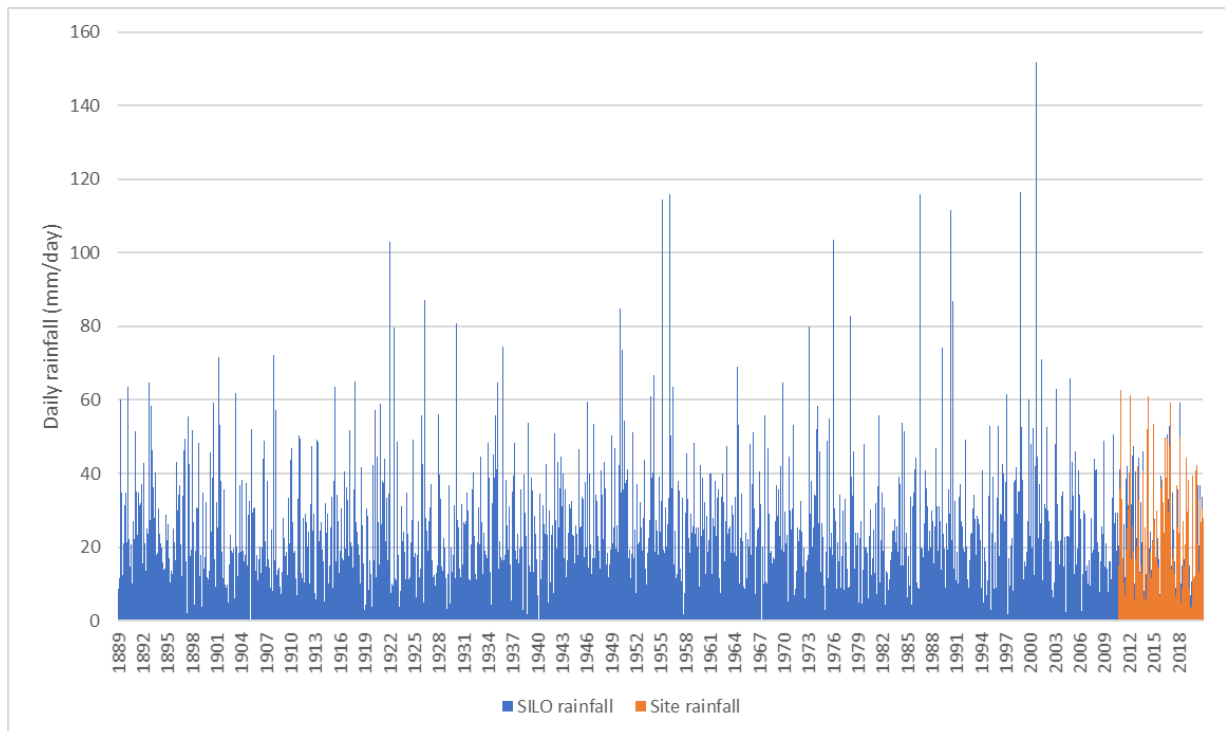


Figure 2.1 Historical daily rainfall at Airly Mine

The annual statistics associated with the SILO point daily rainfall data presented in Figure 2.1 are:

- Minimum rainfall total – 299.8 mm in 1982.
- Average rainfall total – 688 mm.
- Median rainfall total – 669 mm.
- Maximum rainfall total – 1544 mm in 1950.

The SILO rainfall dataset has been used to generate a cumulative rainfall departure (CRD) curve. CRD is the monthly accumulation of the difference between the observed monthly rainfall and the long-term average monthly rainfall. Any increase in the CRD reflects above average rainfall while a decrease in CRD reflects below average rainfall. A constant or steady CRD curve represents average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall. The CRD curve over the period from 2010 to 2021 is shown in Figure 2.2.

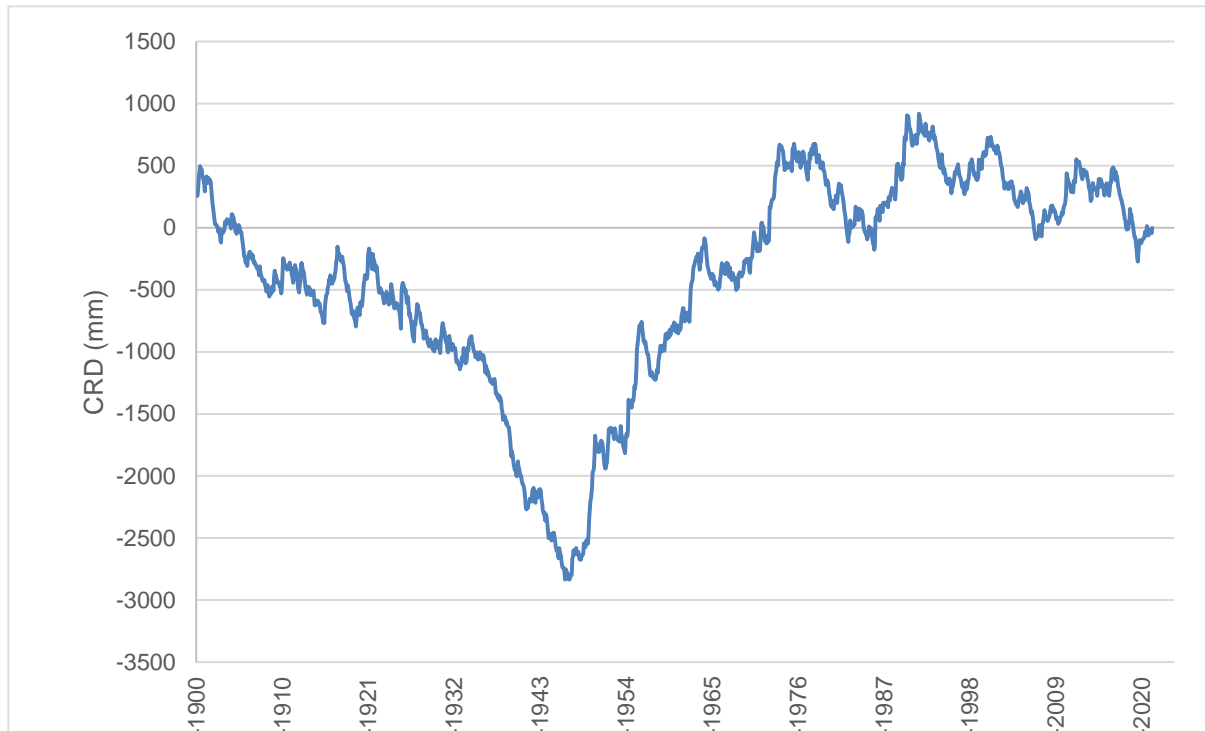


Figure 2.2 Rainfall CRD curve

The CRD curve indicates that generally below average rainfall was observed at site between early-2002 and mid-2007. The period of below average rainfall between mid-2016 and early 2020 corresponds with the period of drought conditions in NSW. Periods of above average rainfall have been observed between mid-2007 early and mid-2012 and since February 2020.

Average daily evaporation rates per month were determined from the historical SILO point data between 1889 and 2020 are presented in Figure 2.3.

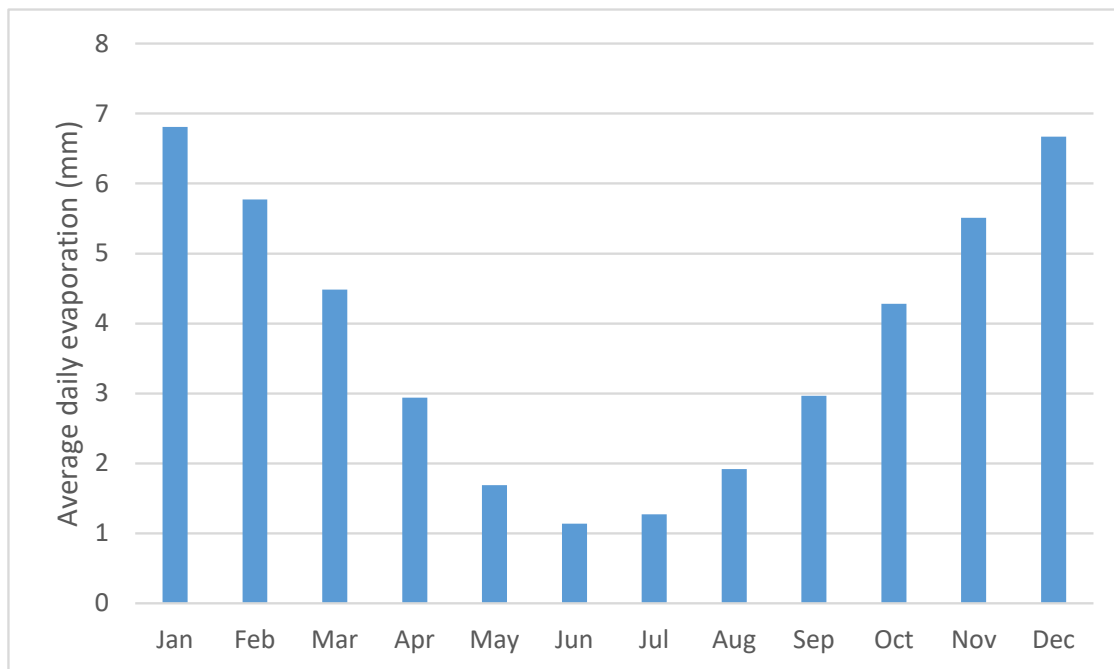


Figure 2.3 Average daily evaporation

Total average annual evaporation is approximately 1381 mm, compared to the annual average rainfall total of approximately 688 mm. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 693 mm.

2.2 Topography

Airly Mine is located in the Western Coalfield of NSW, within the Sydney Basin. The site is characterized by steep and rugged topography, as well as lower lying, undulating areas. The topography is dominated by Mount Airly to the west and Genowlan Mountain to the east. Site elevation varies from over 1000 m Australian Height Datum (AHD) to less than 400 m AHD in the south-eastern section of the site.

2.3 Geology

Airly Mine is located within the southern part of the Western Coalfield of NSW, on the western edge of the Sydney Basin. The area is underlain by Triassic sandstone of the Narrabeen Group, which is underlain by the Illawarra Coal Measures.

The stratigraphy at Airly Mine is summarized in Table 2.1. This information has been sourced from the *Western Coalfield (south) Regional 1:100,000 Geology Map* (Yoo 1992) and exploration logs for Airly Mine. The outcrop geology in the vicinity of Airly Mine is shown in Figure 2.4.

The Grose sandstone of the Triassic Narrabeen Group outcrops throughout the plateau and cliffs of Mount Airly and Genowlan Mountain, with small areas of Tertiary basalt outcrop at the higher elevations as shown in Figure 2.4. The Triassic strata are up to 200 m thick.

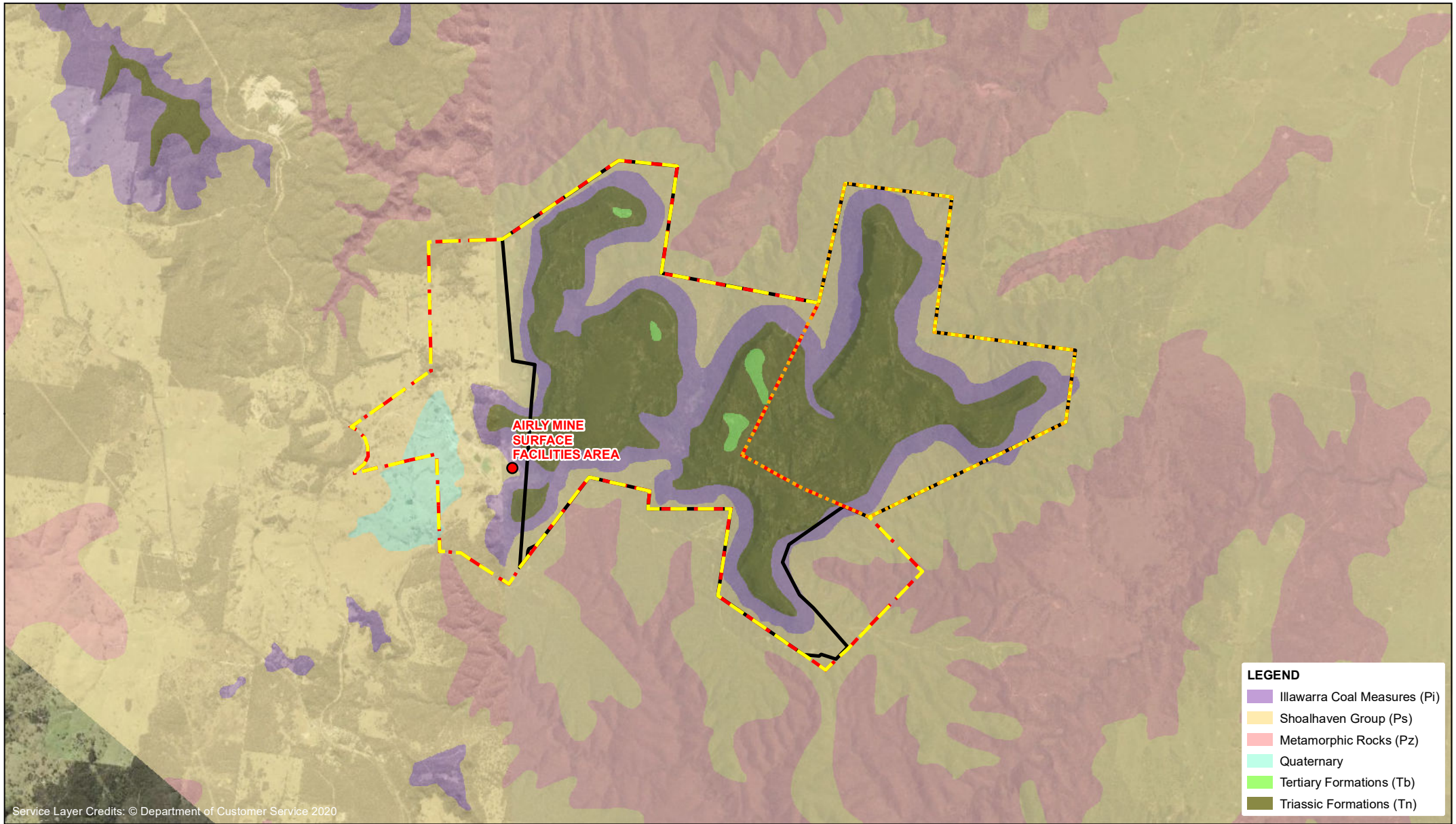
Table 2.1 Stratigraphic sequence

Period	Stratigraphy			Lithology
	Group	Subgroup	Formation	
Quaternary	Alluvium			Silt, clay, sand, gravel
Tertiary				Basalt, dolerite
Triassic	Narrabeen	Grose	Burra-Moko Head Sandstone	Quartz sandstone, red-brown claystone
			Caley Formation	Claystone, shale, quartz, sandstone
Permian	Illawarra Coal Measures	Wallerawang	Middle River Coal Gap Sandstone	Coal, lithic sandstone, claystone
		Charbon	Glen Davis Formation Irongdale Coal Long Swamp Formation	Sandstone, claystone, coal, mudstone
		Cullen Bullen	Lidsdale Seam Blackmans Flat Conglomerate Lithgow Seam Marrangaroo Formation	Coal, claystone, siltstone, mudstone, conglomerate
	Shoalhaven Group		Berry Siltstone	Siltstone, lithic sandstone conglomerate
Devonian	Metamorphic rocks			Quartzite, shale, sandstone, limestone, tuff

The Permian Illawarra Coal Measures outcrop around the Triassic formations at lower elevations, including the zone between Mount Airly and Genowlan Mountain. The Lithgow Seam within the lower Illawarra Coal Measures is the target coal seam at Airly Mine. The seam outcrops completely within the site boundary and is therefore disconnected to the areas of occurrence of this seam located several kilometres to the south and north-west. The thickness of the Lithgow Seam ranges between 3 m and 4 m with an average thickness of 3.4 m.

The depth of cover above the Lithgow Seam ranges from less than 20 m in areas of outcrop and in the Gap Creek area, up to approximately 310 m. The seam dips gradually to the east at around 1 degree. The average thickness of the Permian overburden is 105 m (Golder Associates 2013).

Interbedded siltstone and sandstone of the older Shoalhaven Group outcrop across the surface facilities area and beyond the Airly Mine boundary. Metamorphic rocks also outcrop beyond the site in areas of lower elevation.



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LEGEND

- Illawarra Coal Measures (Pi)
- Shoalhaven Group (Ps)
- Metamorphic Rocks (Pz)
- Quaternary
- Tertiary Formations (Tb)
- Triassic Formations (Tn)

Paper Size A4

0 500 1,000 1,500 2,000 2,500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Airly Surface Facilities Area
- Mining Lease ML 1331
- Mining Lease ML 1814
- Authorisation A232
- Approved development consent boundary



Airly Mine
Water Management Plan

Job Number	22-12602550
Revision	0
Date	14 Jul 2023

Geological map

Figure 2-3

2.4 Hydrogeology

The local groundwater sources within the Airly Mine site are generally low yielding and predominantly within the Quaternary alluvium, weathered and/or fractured sandstone and coal seams that occur within Mount Airly and Genowlan Mountain. They are classified as 'less productive' in accordance with the criteria specified in the NSW Aquifer Interference Policy (i.e., the yield is typically less than 5 L/s and/or the total dissolved solids (TDS) concentration is typically greater than 1500 mg/L).

The regional groundwater sources occur within the Shoalhaven Group below the target coal seam, as well as within the underlying metamorphic rocks. A schematic representation of local and regional groundwater flow is shown in Figure 2.5.

2.4.1 Local groundwater sources

2.4.1.1 Alluvium

The alluvium forms an unconfined shallow aquifer with groundwater ranging in depth from less than 1 m to over 5 m below ground level (bgl) with an aquifer thickness generally less than 12 m.

The alluvium associated with Gap Creek and Genowlan Creek is generally a silty sand material and recharged from rainfall, creek flow and inter-aquifer flow from adjacent (primarily Permian) strata. Alluvial groundwater discharges to connected streams as baseflow. Due to the highly connected nature of the alluvial groundwater and watercourses, it is considered that the beneficial use category of the alluvial groundwater is environmental protection.

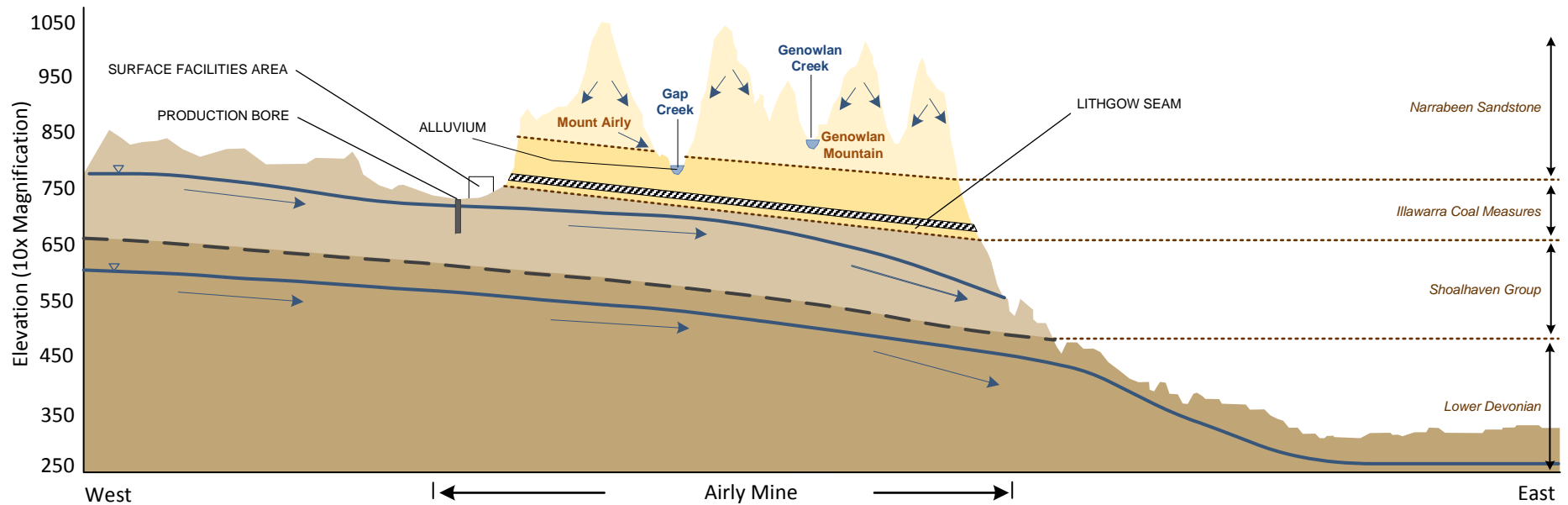
A falling head test reported by RPS (2013) indicated a hydraulic conductivity of 0.11 m/day for alluvium at Gap Creek (test conducted at borehole ARP05). Based on water sampling undertaken at the site, the alluvium is fresh and slightly acidic. A second falling head test was carried out within Genowlan Creek alluvium in 2013 and a hydraulic conductivity of 0.044 m/day was calculated (GHD 2014a).

It is understood that areas of Genowlan Creek and Gap Creek are fed relatively consistently by rainfall-based flows which emerge from the Quaternary colluvium and alluvium. Although the source for this recharge is rainfall-based, anecdotal evidence infers that these rainfall-based flows are held in the Quaternary strata and released slowly into the reaches of Genowlan Creek above the Grotto, as well as in certain reaches of Gap Creek. Flows in the Grotto and Gap Creek vary with rainfall seasonality (as indicated by existing flow gauges) whereas anecdotally the flows through the Oasis are persistent, varying from approximately 2.2 L/s in average conditions to 1 L/s during drought (RPS 2013). Flow monitoring in the Oasis at monitoring point Genowlan Creek 2 indicates flows of generally 5 L/s to 0.4 L/s depending on rainfall trends, decreasing to no flow from December 2019 to February 2020 following a sustained period of drought.

Flow monitoring data is discussed in Section 5.1.2.

2.4.1.2 Porous and fractured rock

The local porous and fractured rock groundwater sources include the Narrabeen Sandstone and coal seams of the Illawarra Coal Measures. These sources are recharged by rainfall via fractures within overlying strata and seep out of the side of the mountains or directly into watercourses. With the majority of discharge from these sources being to seepage areas, there is minimal inter-aquifer flow to underlying regional groundwater sources.



→ GROUNDWATER FLOW

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LOCATION	Airly
SEAM	NA
DRAWN	IG
CHECKED	SG
APPROVED	SG
SCALE	NTS

Airly Mine
Water Management Plan

Local and regional groundwater flow

DATE Mar 2021

Figure 2-4

Packer testing and falling head testing reported by RPS (2013) indicate the following hydraulic conductivities for these groundwater sources:

- Narrabeen Sandstone: 0.002–0.15 m/day (based on two packer tests at ARP01, one packer test at ARP02 and one falling head test at ARP03).
- Lithgow Seam: 0.02–0.08 m/day (based on packer tests at ARP01 and ARP04 and falling head tests at ARP02 and APR03).

Packer testing reported by GHD (2014a) indicates the following hydraulic conductivities:

- Narrabeen Sandstone: 0.00015 m/day (ARP06).
- Lithgow Seam: 0.07 m/day (ARP06).
- Marrangaroo Formation: 0.00016 m/day (ARP06).

2.4.2 Regional groundwater sources

Regional groundwater sources occur within strata well below the coal measures and extend beyond the Airly Mine boundary as shown in Figure 2.5.

The upper groundwater source occurs within siltstone and sandstone of the Shoalhaven Group. According to the Western Coalfield (south) Regional 1:100,000 Geology Map (Yoo 1992), this rock formation was deposited in a marine environment and therefore the groundwater is highly brackish to saline. The existing production bore at the Airly Mine surface facilities area is installed within this groundwater source. The recharge area is predominantly to the west of Airly Mine where the Shoalhaven Group outcrops as shown in Figure 2.4. Groundwater flow is generally to the east.

Packer testing reported by RPS (2013) for the Shoalhaven Group indicates a low hydraulic conductivity in the order of 0.0003 m/day at a depth of approximately 190 m bgl at APR04 (i.e., 570 m AHD). However, pumping tests undertaken at the production bore in 2009 and reported by Larry Cook & Associates (2009) indicate a much higher hydraulic conductivity in the order of 0.3 m/day (at an elevation of approximately 700 m AHD).

The lower regional groundwater source occurs within Devonian metamorphic strata containing shale, sandstone, and limestone. The groundwater is slightly brackish and therefore has a lower salt content than the Shoalhaven Group and it is less sulfate dominant. It supplies numerous registered users to the east of Airly Mine. Recharge areas occur to the north, south and east of the site and groundwater flow is generally to the east.

It is considered that there would be minimal inter-aquifer hydraulic connection between the upper and lower regional groundwater sources, based on differences in groundwater chemistry. Pre-2015 groundwater sampling data indicates the Devonian groundwater (sampled from the site Nioka) is calcium-bicarbonate/sulfate type water whereas the Shoalhaven Group (sampled from the production bore) is magnesium/calcium sulfate type water. Based upon groundwater quality data from the production bore, presented in Appendix C, the beneficial use category for the Shoalhaven Group is considered to be industrial. Based on groundwater quality data sampled from the site Nioka presented in Appendix C and the results of the registered groundwater bore search discussed in Section 2.4.3, the beneficial use category of the Devonian groundwater is considered to be for stock watering.

2.4.3 Registered groundwater bores

A search of the database of registered groundwater bores managed by WaterNSW (2018) was undertaken to identify registered bores within a 5 km radius of the Airly Mine. The search identified 40 bores, with the majority (30 bores) being registered for domestic, irrigation and/or stock use, nine bores registered as monitoring bores and one registered as a test bore. Bore details and locations are outlined in Appendix C.

The registered domestic and stock bores that were identified primarily extract groundwater from the lower regional groundwater source (sandstone and conglomerate formations) to the east of site, with yields generally less than 2.5 L/s. Some registered bores are also located within Genowlan Creek alluvium to the north-east. The closest registered bores are at least 1 km from the Airly Mine boundary.

There are ten registered bores within the site boundary. One of these bores is one of Airly Mine's former test bores (GW068640) and the remainder are Airly Mine monitoring bores.

2.4.4 Groundwater dependent ecosystems

RPS (2014) and GHD (2014b) identified no high priority groundwater dependent ecosystems (GDEs) although there is potential for facultative ecosystems existing as moist sheltered gully forests to occur along creek lines. Regional groundwater flows within the site area are likely to be too deep to have much interaction with potentially occurring GDEs, however there are areas of alluvium that contain shallow aquifers that may support phreatophytes (groundwater dependent terrestrial plants). RPS (2014) list four vegetation Map Units (MU), recently updated to Plant Community Types (PCTs; RPS 2023) as potential groundwater dependent ecosystems (GDEs). These communities are likely to be utilising shallow aquifers and are therefore considered unlikely to be entirely groundwater dependent. This assumption is supported by the fact that the flora species within these vegetation communities are not restricted to alluvial drainage lines; they can occur along moist sheltered gully areas, creek lines, as well as dry slopes. Therefore, they can be termed a facultative ecosystem, which is a GDE that may rely on groundwater on a seasonal basis or only during extended period of tress (i.e. drought). At other times, water requirements may be met by soil or surface water (Serov *et al.* 2012).

Vegetation communities within the shallow aquifer zones are as follows:

- MU 3 Hillslope Talus Mountain Gum – Brown Stringybark – Grey Gum – Broad-leaved Hickory Moist Forest (PCT 3495 and 3226).
- MU 13 Tableland Gully Ribbon Gum – Blackwood – Apple Box Forest (PCT 3303).
- MU 21 Capertee – Wolgan Slopes Red Box – Grey Gum – Stringybark Grassy Open Forest (PCT 3510).
- MU 40 Capertee Slopes Red Ironbark – Red Stringybark – Narrow-leaved Stringybark Shrubby Woodland (PCT 3731).

Finally, stygofauna have been collected in low densities and diversity from groundwater bores during stygofauna monitoring conducted between 2018 and 2020.

2.5 Hydrology

Airly Mine lies within the Capertee River catchment, which is part of the Greater Hawkesbury/Nepean catchment. The Capertee River flows in a south-east direction to its confluence with the Wolgan River to form the Colo River, which ultimately contributes to the Hawkesbury River and Broken Bay.

The following four major creek systems are located within the Airly Mine boundary, as shown in Figure 2.6:

- Airly-Coco Creek (which includes Dog Trap Creek).
- Emu Swamp Creek.
- Gap-Genowlan Creek.
- Torbane-Oaky Creek.

The Airly Creek system drains the southern sector of the site and joins the Capertee River within the Gardens of Stone National Park approximately 17 km south-east of the surface facilities area at Airly Mine. Coco Creek flows out of the Gardens of Stone National Park for approximately 20 km before joining the Capertee River.

Surface runoff from a small area of the north-east of the Airly Mine boundary drains to Emu Swamp Creek, which flows in a north-east direction and joins the Capertee River approximately 10 km downstream.

Surface runoff from the northern sections of the Airly Mine site drains into Gap Creek and Genowlan Creek. The two creeks, which are groundwater fed in parts, drain northward approximately 2 km before converging into the greater Genowlan Creek. Genowlan Creek continues to drain in a north-east direction until its confluence with the Capertee River approximately 8 km downstream. The Gap-Genowlan Creek sub-catchment occupies the largest portion of the site area, with 1558 ha draining to the creek system.

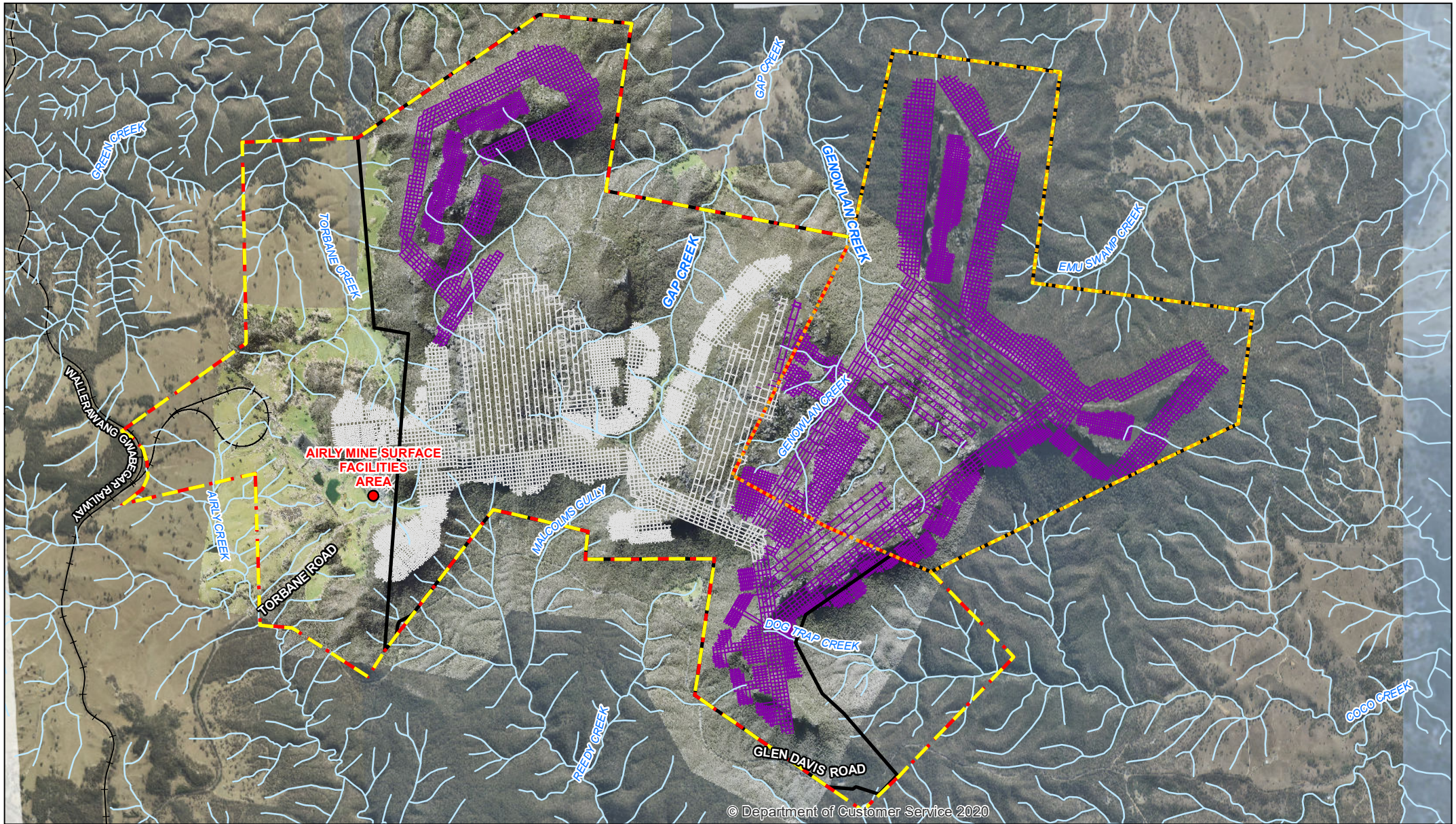
The north-west section of the site area is drained by the Torbane-Oaky Creek system. Torbane Creek joins Oaky Creek approximately 2 km downstream of the Airly Mine boundary. Approximately 518 ha of the Torbane Creek catchment and 71 ha of the upper Oaky Creek catchment lay inside the site area.

All of the watercourses draining the Airly Mine site area are ephemeral. Generally, these watercourses flow for relatively brief periods following significant rainfall events. Flows within Airly Creek, Oaky Creek, Coco Creek and Genowlan Creek become perennial outside the site boundary.

Surface water monitoring undertaken by Airly Mine includes water quality, flow and aquatic ecology, which is summarised in Table 2.2. Details of the monitoring program are provided in Section 4.2 and Section 4.6.2, with baseline monitoring results presented in Section 5.1 and Section 5.4.2.

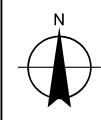
Table 2.2 Summary of surface water monitoring

Creek system	Monitoring location	Monitoring type
Airly Creek	Airly Creek Upstream	Water quality and aquatic ecology
	Airly Creek	
	Dog Trap Creek	Aquatic ecology
Gap Genowlan Creek	Gap Creek	Water quality, flow and aquatic ecology
	The Grotto	Water quality
	Genowlan Creek	Flow and aquatic ecology
	Genowlan Creek 2	Water quality, flow and aquatic ecology
	Nissan Hut Dam	Water level and water quality
Torbane-Oaky Creek	Torbane Creek	Aquatic ecology



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Paper Size A4
 0 300 600 900 1,200 1,500
 Metres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56



LEGEND

- Airly Surface Facilities Area
- Approved development consent boundary
- Authorisation A232
- Existing workings
- Mining Lease ML 1331
- Mining Lease ML 1814
- Authorisation A232
- Existing workings
- Proposed workings
- Waterway
- Railway



Airly Mine
 Water Management Plan

Job Number | 22-12602550
 Revision | 0
 Date | 14 Jul 2023

Watercourses at Airly Mine **Figure 2-5**

G:\22\010500\1\GIS\Maps\Deliverables\Western\Airly\12602550\WMP\12602550_WMP009_Watercourses_0.mxd
 Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntmail@ghd.com W www.ghd.com.au
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 Data source: LPI: DTDB 2012; Centennial: Aerial Imagery, boundaries, 2013, Mine Workings, 2012. Created by: fmackay, TMorton

3. Water management

3.1 Water management overview

The water management system at Airly Mine is comprised of surface (clean and dirty), amenities, waste and underground elements. Sources of water at the site include rainfall, runoff, external water supply and groundwater inflow to the underground mine workings. The primary water demands are for underground operations, surface dust suppression, machinery washdown, fire-fighting storage and staff amenities.

Surface water runoff from areas where there is no coal storage, transportation, handling or processing or any disturbance is considered to be clean water, as it is unlikely to be contaminated with coal fines or sediment. Runoff is diverted around dirty water and coal-contact catchments to avoid mixing with clean water runoff. Clean water runoff is typically from natural (undisturbed) and impervious catchments such as areas of vegetation, sealed roads and sealed car parks.

Dirty water is runoff from disturbed areas and areas likely to contain suspended sediment, oils, grease and hydrocarbons. This typically includes workshop and fuel storage areas. Coal-contact water is runoff from catchments where coal storage, transportation, handling or processing occurs and is managed within the dirty water management system.

A schematic of the overall water management system at Airly Mine is provided in Figure 3.1.

3.2 Surface water management

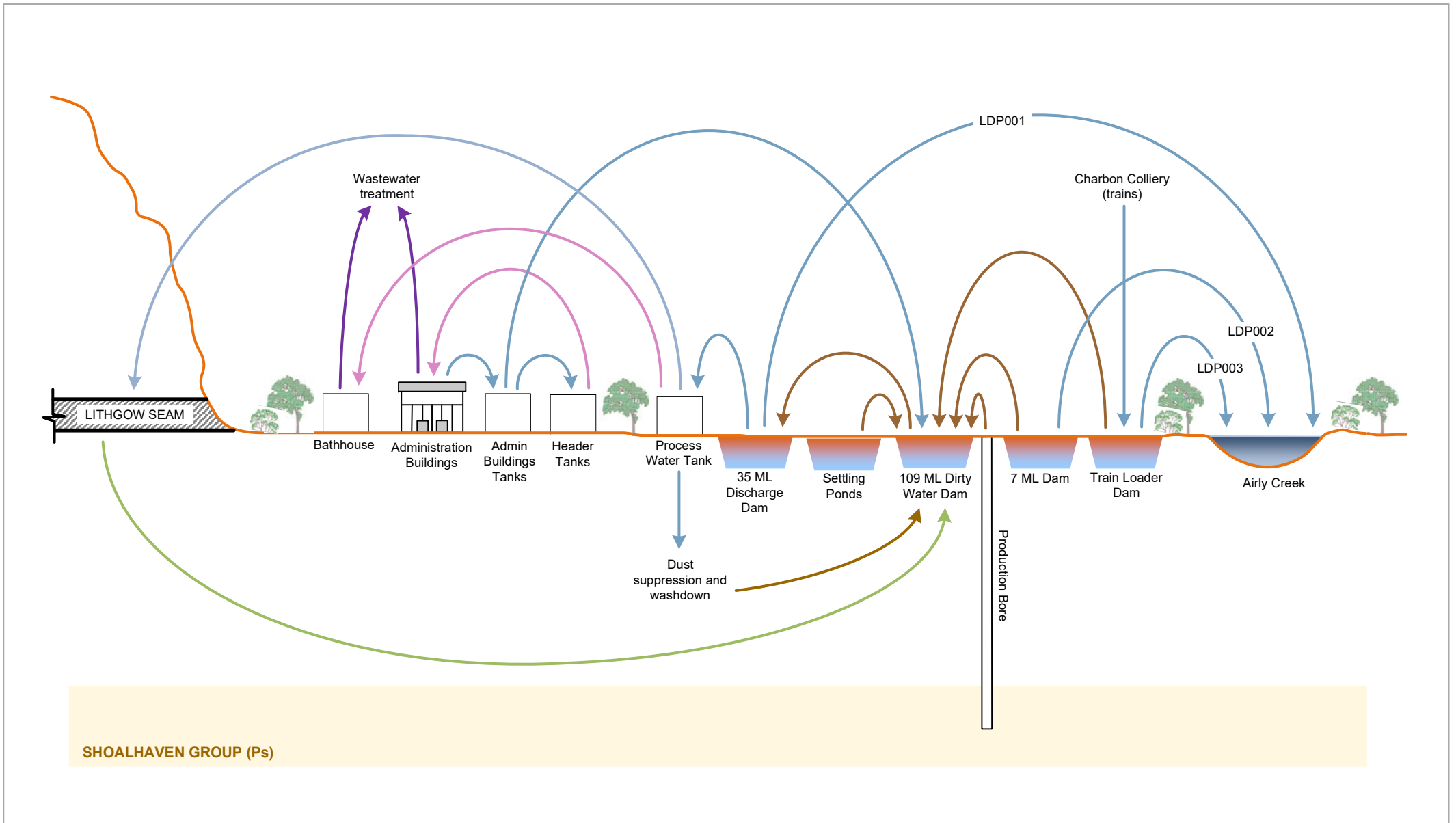
Water management at the surface facilities area of Airly Mine focuses on the capture of surface water runoff across the site by several dams and the transfer of water to a main collection dam, the Dirty Water Dam. Discharges from LDPs are minimised by the transfer and reuse of water across the site.

The surface water management features of Airly Mine are presented in Figure 3.2.

3.2.1 Clean water management

Diversion drains around the site are concrete lined on steep grades, jute mesh lined on lesser grades or grassed lined on gentle grades. Drains not concrete lined have been otherwise stabilised with rubble energy dissipaters constructed in place at the outlet points or transition areas with concrete lined sections.

The main clean water channels around the site are designed to cater for a 1% annual exceedance probability (AEP), 72-hour duration storm event.



Legend

- Clean water
- Underground water
- Dirty water
- Wastewater
- Amenities water



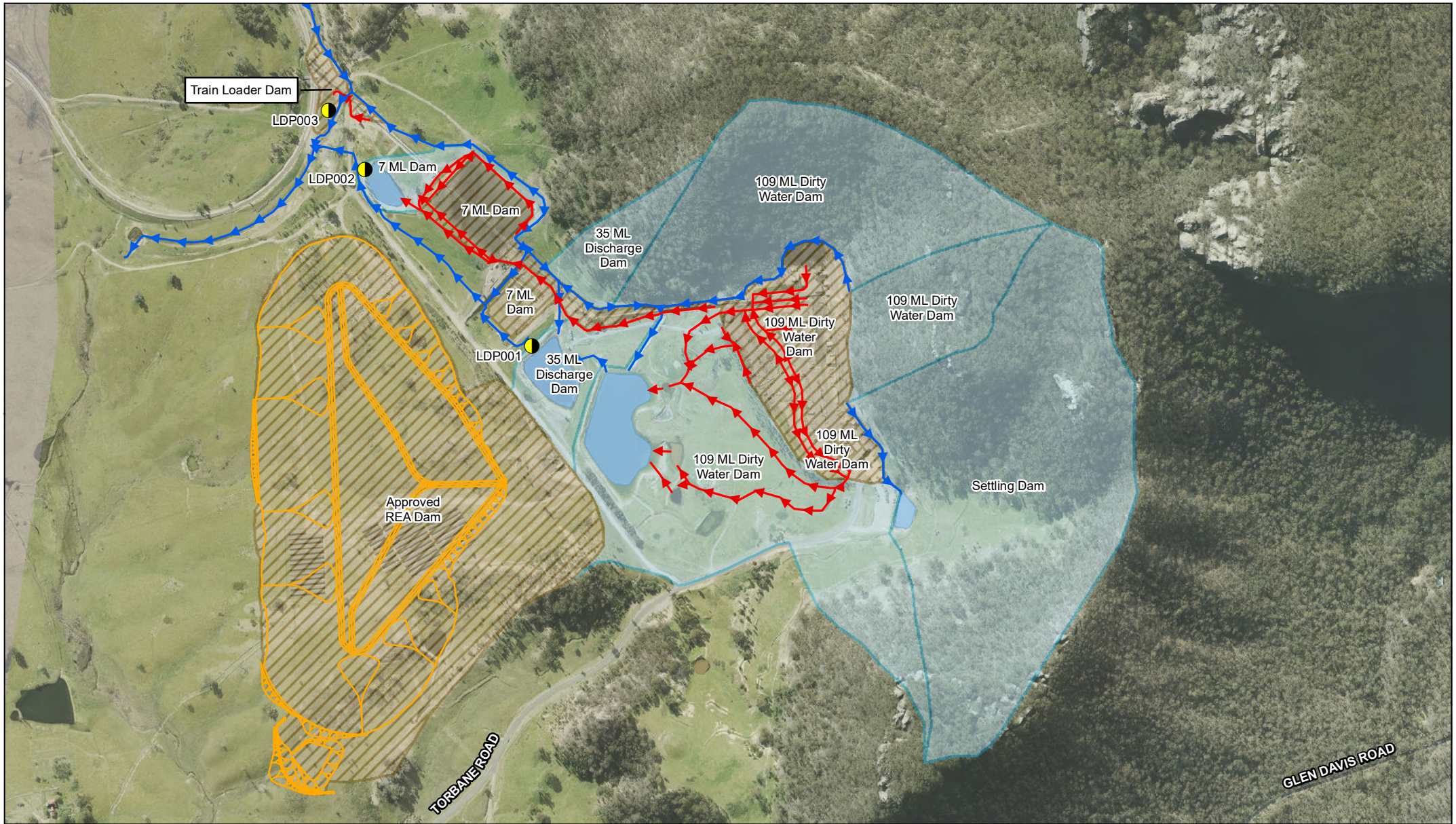
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Airly Mine
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Project No. 12510656
Revision No. A
Date 28/08/2019

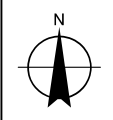
Water management schematic

FIGURE 3-1

Created by: Suzanne MacDonald



Paper Size A4
 0 50 100 150 200 250 300 350
 Metres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56



LEGEND

- Clean Water Diversion
- Dirty Water Diversion
- LDP location
- Pollution Control Structure
- Clean water catchment
- Dirty water catchment
- Approved REA concept design



Airly Mine
 Water Management Plan

Job Number | 22-12602550
 Revision | 0
 Date | 14 Jul 2023

Surface water
 management system

Figure 3-2

Table 3.1 outlines each of the clean water drain structures at Airly Mine.

Table 3.1 Clean water drains

Location	Type	Catchment area	Top width	Depth	Discharge to	Design compliance
Northern perimeter	Open channel	3.1 ha	2 m	0.5 m	Production Dam	100% AEP, 72 hour event
Eastern perimeter	Open channel	4.8 ha	9 m	0.5 m	Settling Pond	100% AEP, 72 hour event
Coal stockpile	Open channel	2.1 ha	4 m	0.5 m	Stockpile Dam	100% AEP, 72 hour event
Rail loop	Open channel	0.4 ha	7 m	0.5 m	Train Loader Dam	100% AEP, 72 hour event
Eastern hardstand area	Open channel	18.1 ha	3 m	0.5 m	Dirty Water Dam	100% AEP, 72 hour event

3.2.2 Dirty water management system

The dirty water management structures at Airly Mine form the basis of sediment control at the site. Dirty water runoff (coal-contact and sediment-laden water) is managed by a number of dirty water storages which enable suspended solids to settle out of the water column. Sediment-laden water from the eastern hardstand area is directed via diversion bunds to a series of active filter ponds which overflow to the Dirty Water Dam. The dirty water management structures are regularly de-silted to maximise available storage capacity. All farm dams and small primary dams are maintained as required.

Table 3.2 provides a summary of the dirty water storages present at Airly Mine.

Table 3.2 Dirty water storages

Storage	Maximum capacity	Function	Treatment	Design compliance	Overflow type	Discharge to
Settling Pond	3 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Spillway	Dirty Water Dam
Stockpile Dam	7 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Pump Spillway	Dirty Water Dam Airly Creek via LDP002
Train Loader Dam	6 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Pump Spillway	Dirty Water Dam Airly Creek via LDP003

Storage	Maximum capacity	Function	Treatment	Design compliance	Overflow type	Discharge to
Dirty Water Dam	98 ML	Centralised storage of dirty water	Settlement	95th percentile, 5-day rainfall depth	Pipe Spillway	Production Dam
Production Dam	23 ML	Process water supply	Sediment settling	95th percentile, 5-day rainfall depth	Spillway	Airly Creek via LDP001

3.2.2.1 Settling Pond

The Settling Pond receives surface water runoff from contributing catchments east of the surface facilities area. Overflows from the Settling Pond are directed to the Dirty Water Dam.

3.2.2.2 Stockpile Dam

The Stockpile Dam receives surface water runoff from the conveyor, stockpile and CHP storage areas as well as surface water runoff from contributing catchments. The water level in the dam is maintained low by pumping water to the Dirty Water Dam. During high rainfall events, overflows from the Stockpile Dam discharge through LDP002 into Airly Creek.

3.2.2.3 Train Loader Dam

The Train Loader Dam receives surface water runoff from the train loading area as well as transfers of supplementary process water from Charbon Colliery via rail. The water level in the dam is maintained low by pumping water to the Dirty Water Dam. During high rainfall events, overflows from the dam discharge through LDP003 into Airly Creek. It was enlarged in 2020 from a water storage capacity of 0.7 ML to 6 ML.

3.2.2.4 Dirty Water Dam

The Dirty Water Dam receives surface water runoff from the eastern hardstand area, including the mine entrance area and emergency stockpile, and from the northern perimeter clean water drainage system. Overflows from the Settling Pond and Administration Buildings Tanks, water pumped from the Stockpile Dam and Train Loader Dam and extractions from the production bore are also directed into the Dirty Water Dam.

Water is supplied from the Dirty Water Dam to the Production Dam via a pontoon mounted pipe, with water drawn from the surface of the dam. Overflows are also directed to the Production Dam.

3.2.2.5 Production Dam

The Production Dam receives surface water runoff from the northern perimeter clean water drainage system and piped transfers and overflows from the Dirty Water Dam. Water is supplied to the Process Water Tank from the Production Dam. During high rainfall events, overflows from the dam discharge through LDP001 to Airly Creek.

3.2.3 Transfers from Charbon Colliery

Up to 170 ML/year of water is approved to be imported from Charbon Colliery using rail haulage to meet any deficit in process water supply at Airly Mine. Trains are operated on an as-needs basis, with a maximum of one train per day carrying up to 780 kL of water. The importation of water from Charbon Colliery is only undertaken when surface water storages are less than 75% full at Airly Mine, such that 25% freeboard is maintained at all times at the site.

Water from the trains is discharged using flexible hoses into a drainage line which runs along the rail loop embankment to flow by gravity into the Train Loader Dam. Collected water in the Train Loader Dam is pumped to the Dirty Water Dam for settlement and storage. Following settlement, water is pumped to the Production Dam, then the Process Water Tank for use as process water.

3.3 Underground water management

3.3.1 Underground water management system

The underground water management system at Airly Mine consists of the underground mine workings and groundwater extraction through a production bore. Mining activities are supplied water by the Process Water Tank that is part of the surface water system.

Airly Mine was granted approval for groundwater extraction through the production bore (WAL 24386 and water supply works approval 10WA112537) in 2011. The volume of water extracted from this production bore is limited by the water supply works approval to 5 L/s and by the WAL to 158 ML/year (assuming an available water determination of 1.0 ML/share). Extraction of groundwater from the existing production bore is used to supplement water harvested by the surface water system for use in mining activities.

Intercepted water and operational water transferred underground from the Process Water Tank is transferred from active mining areas to inactive mining areas. The temporary storage of water in the inactive mining areas reduces the likelihood of off-site discharges.

Mine dewatering infrastructure provides metering of all mine dewatering to facilitate reporting to WAL requirements. However, to date, inflows to the mined voids have predominantly been too low to be measured (e.g., 0 ML/year reported for 2020, 2021 and 2022) and not sufficient to require mine dewatering. Monitoring results indicate that groundwater inflow volumes and process water used in underground operations is entrained in the ROM coal. As a result, all groundwater inflows and additional water is removed from the site as product coal moisture, with no water available to be reclaimed and reused as process water. 20 ML and 0.3 ML were transferred to surface in 2018 and 2019, respectively, however total volumes were reportedly surface water accumulations entering the from the facilities area. Inflows are reported to increase in response to rainfall events but remain below measurable volumes.

3.3.2 Hydrogeological predictions

A hydrogeological model was developed as part of the Airly Mine Extension Project (GHD 2014c). The hydrogeological model was re-calibrated as part of Airly Mine Extension Project Modification 2 (GHD 2019b). The mine footprint and schedule were amended in the groundwater model in 2021 in accordance with the updated Airly Mine Plan (ref: AIR_2021 BGT PO2 G01 R00 S15 -20210629.dwg).

Application of the new plan resulted in changes to the modelled drainage system footprint which represents the mined voids and, subsequently, the fracture zones represented in the model. Additionally, the operational timing of the drainage system was amended in line with the new mining schedule. No other changes to model parameters were applied. The amendments were minimal and did not constitute preparation of a stand-alone monitoring report.

Incorporation of the updated mine plan resulted in a reduction in the estimated peak inflows from the previous estimate of 76 ML (2030) to 67 ML (2029) occurring because of decreased subsidence impacts (Figure 3.3). Despite the reduction, the model continues to present overly conservative inflow estimates.

The model assumes aquifer saturation from below the water table in the upper alluvial strata. It is likely the simulated storativity is too high with actual saturation zones and permeabilities being lower than represented in the model. This may be resulting from overestimated storage coefficients, hydraulic conductivities and / or anisotropy ratios, the latter of which may currently be underestimating lateral flow and discharge at mesa faces.

While the model has been calibrated to water levels informed by the monitoring network, it is clear achieving calibration is non-unique. In this instance, given the low stored water volumes and low risk nature of dewatering impacts, further work, which could be extensive, towards a more unique model and more representative inflow estimates is considered unwarranted.

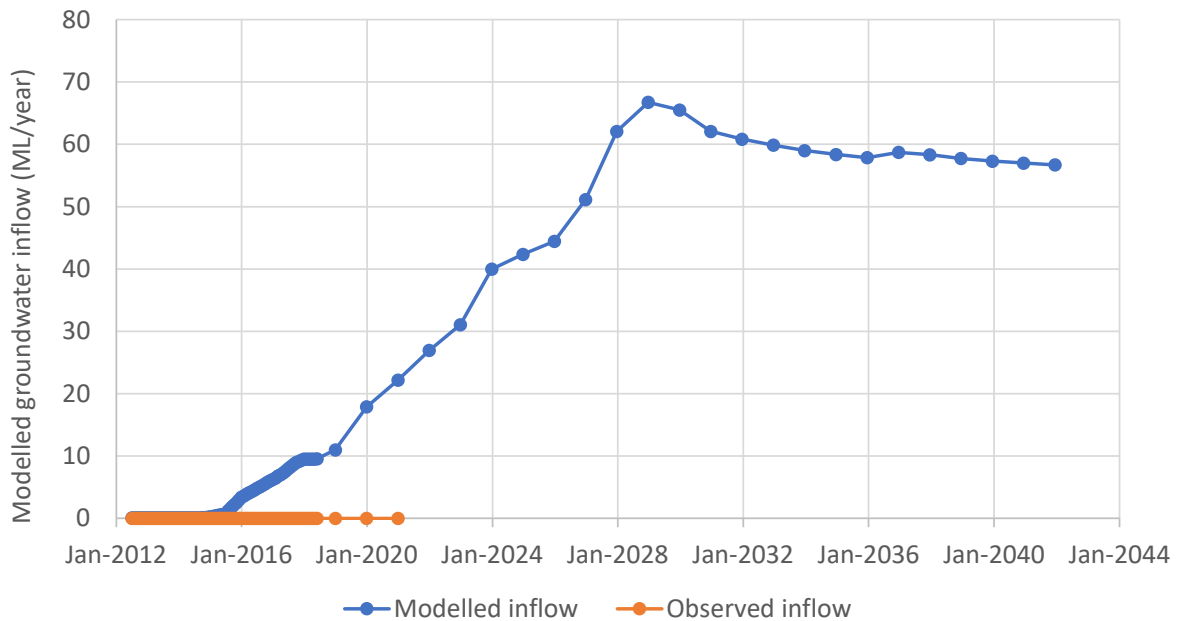


Figure 3.3 Predicted groundwater inflows into underground workings

As part of Airly Mine Mod 2 the mine plan was updated so that mine workings would not extend under the old shale workings. This will minimise the likelihood of mining impacting on the old shale workings.

3.4 Amenities and wastewater systems

As Airly Mine is not connected to a municipal water supply, drinking water is supplied by bottled water. Water for amenities is supplied by harvested water from the rooftops of the administration and facilities buildings. Trucked water is added, as required, to the Administration Buildings Tanks in order to supplement water harvested from rooftops to meet amenities requirements.

Wastewater from the administration buildings and bathhouse is directed to the Ecomax effluent treatment system for disposal via soil infiltration. The life-of-mine Ecomax effluent treatment system caters for the expected future workforce. The system consists of a dual cell EP150 anaerobic utilisation treatment plant which has a treatment capacity of 20,000 L/day with a peak load of 40,000 L/day. The unit is capable of removing 99% of nitrogen and phosphorus.

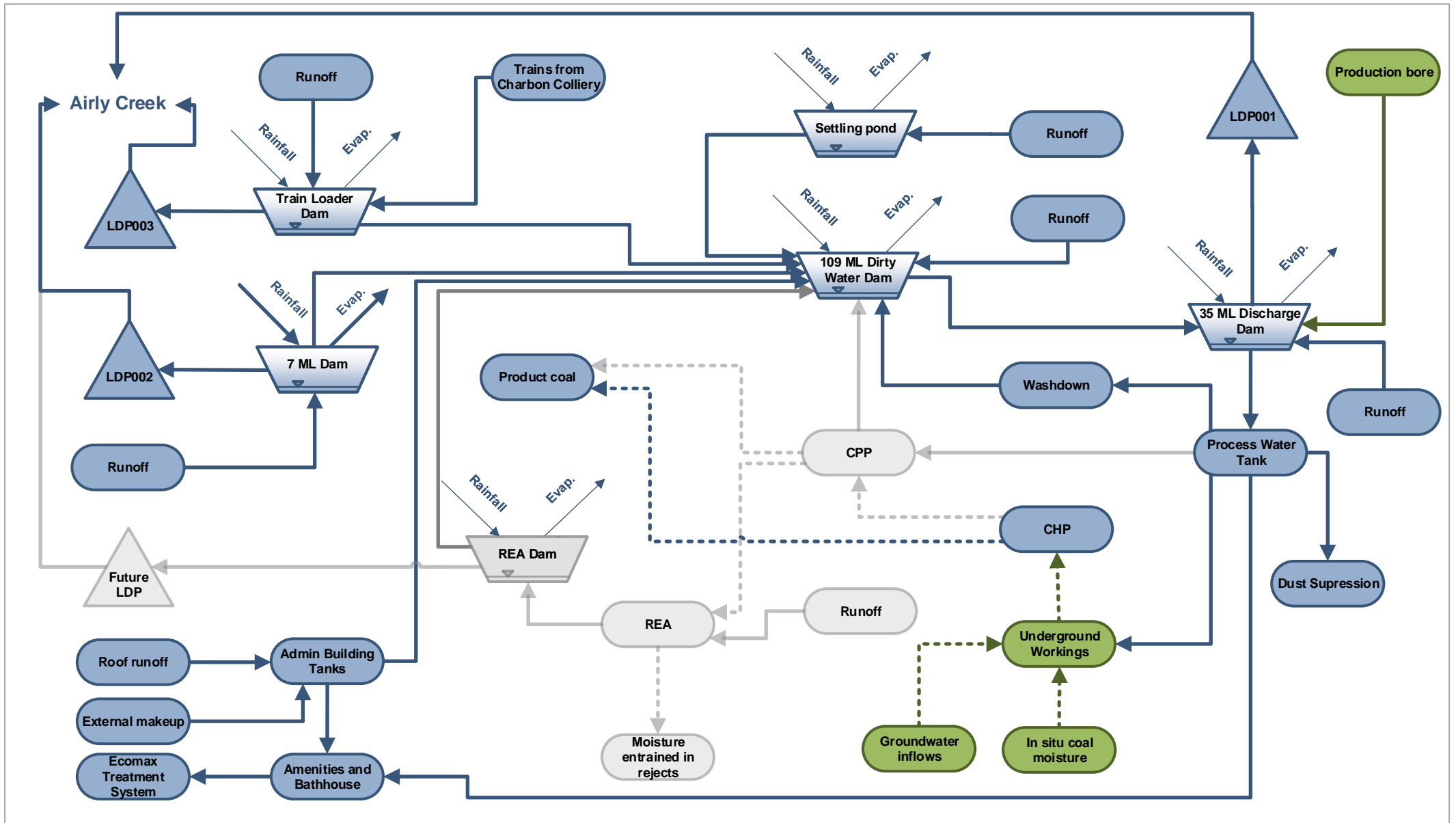
Underground sewage is contained in Alfab activated biological toilets that are discharged into the Ecomax effluent treatment system. Septic tanks have been installed to manage sewage from toilets at the train loader facility. This sewage is transported by a licensed contractor as required to the on-site Ecomax effluent treatment system or off-site to a licensed waste management facility for disposal.

3.5 Site water balance

A site water balance model was previously developed for Airly Mine as part of the Airly Mine Extension Project (GHD 2014d) to quantify transfers within the site under future operational conditions using various rainfall patterns. The site water balance was updated to reflect the current mine plan and approved operational conditions as part of this WMP (GHD, 2019e). A schematic of the overall water management system is provided in Figure 3.4. The water management system for Airly Mine was developed in GoldSim and simulated over the projected life of the mine, from 2018 until 2040. To assess the impact of rainfall on the site, modelling for the approved and proposed conditions was completed by using a historical time series of daily rainfall data extending over 130 years. A total of 130 simulations were applied, with each simulation modelling a different rainfall pattern from the record. Future predictions are based on the mean of a set of probabilistic results and approved annual site operations (GHD, 2019e). Approved annual site operations include predicted groundwater inflows, production rates, staffing, annual water transfer limits and pumping/overflow rules.

Overall, the forecast indicated sufficient water sources to meet process water requirements or a process water deficit of up to 42 ML/year in a “dry” year (GHD, 2019e). No water surplus was predicted and no increase in the frequency or magnitude, nor a deterioration of water quality, of potential discharges.

A summary of the predicted average annual inputs and outputs for the Airly Mine water management system for approved future conditions is provided in Table 3.3. The results presented for future conditions are based on the predicted site conditions in the short term (2026)



Legend	
	Underground storage
	Surface process
	Licensed discharge point
	Underground process
	Approved storage
	Entrained moisture
	Surface storage
	Approved process
	Surface water flow
	Groundwater flow
	Approved flow



Centennial Airly Pty Ltd
Airly Mine
Water Management Plan

Project No. 12548337
Revision No. 0
Date 22/07/2021

Water cycle schematic

FIGURE 3-4

Created by: Tyler Tinker

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Print date: 22/07/2021 10:25
© 2021. Whilst every care has been taken to prepare this figure, GHD make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the figure being inaccurate, incomplete or unsuitable in any way and for any reason.

Table 3.3 Summary of site water balance results

	Future conditions (2026) (ML/year)
INPUTS	
Direct rainfall onto storages and catchment runoff	166
External water supply	1
Groundwater inflows into underground workings	41
Extraction from production bore	0
In situ coal moisture	45
Transfer from Charbon Colliery	63
TOTAL INPUTS	316
OUTPUTS	
Evaporation	63
Dust suppression	5
Wastewater to Ecomax effluent treatment system	2
Discharge through LDP001	28
Discharge through LDP002	0
Discharge through LDP003	0
Discharge through REA LDP	NA
Coal product moisture	176
Moisture retained in rejects	56
TOTAL OUTPUTS	316
CHANGE IN STORAGE	
Surface water storages	0
Underground workings	0
TOTAL CHANGE IN STORAGE	0
BALANCE	
Inputs – outputs – change in storage	0

3.5.1 Water supply security

Water supply to meet site operational demand is sourced from surface water stored on site, including harvested runoff and groundwater inflows into the underground workings, and groundwater extraction from the production bore. In addition, up to 170 ML/year of water may be transferred to Airly Mine from Charbon Colliery. Water supply from the clean water sources, the production bore and Charbon Colliery is minimised by reuse and recirculation of water on site.

Water balance modelling of water supply security (GHD 2019c) indicated that the transfer of up to 170 ML/year is sufficient to supply the approved production and operational activities (including the approved CPP and REA) at Airly Mine in all rainfall conditions that could reasonably be expected based on the historical rainfall record without requiring any extraction of groundwater from the production bore or reliance on groundwater intercepted by the underground workings.

3.5.2 Discharge frequency

Figure 3.5 presents the annual exceedance probability (AEP) of discharge from LDP001 predicted by the site water balance modelling.

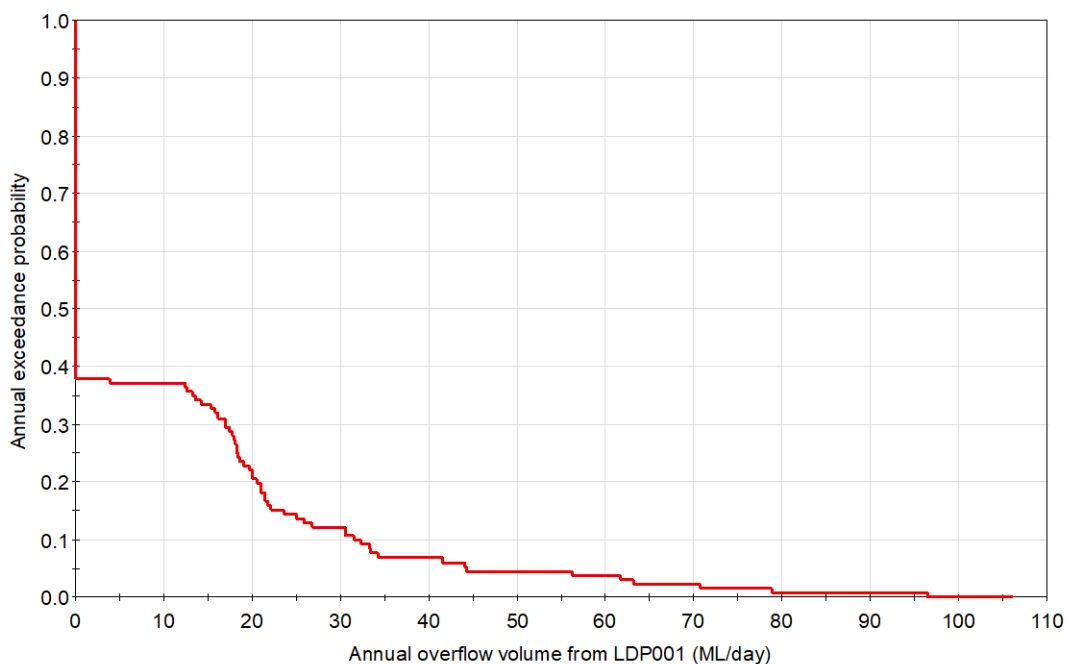


Figure 3.5 Predicted annual discharge from LDP001

Discharges off-site through LDP001 to Airly Creek were modelled to occur due to rare rainfall events. All discharges were modelled to occur as a result of rainfall events exceeding 44 mm over five days, which is the rainfall depth for a 95th percentile, five-day rainfall event design criteria for the Production Dam. Discharges were predicted to occur in less than 40% of years modelled, with the maximum annual discharge volume estimated to be approximately 100 ML/year.

Discharges through LDP002 and LDP003 were not modelled to occur under existing or future conditions.

4. Monitoring requirements

4.1 Inspections

Site inspections are completed by the Environment and Community Coordinator (or their delegate) and occur at a minimum:

- Weekly
- As soon as practicable following rainfall events that exceed 20 mm in 24 hours

An example of an inspection is undertaking the following activities:

- Inspecting water management and sediment control structures for capacity, structural integrity and effectiveness.
- Recording and reporting on the condition of each water management and sediment control structure in place.
- Recording where around the site sediment is deposited.

Maintenance of the water management and sediment control structures will be implemented when visual defects are observed.

4.2 Surface water monitoring

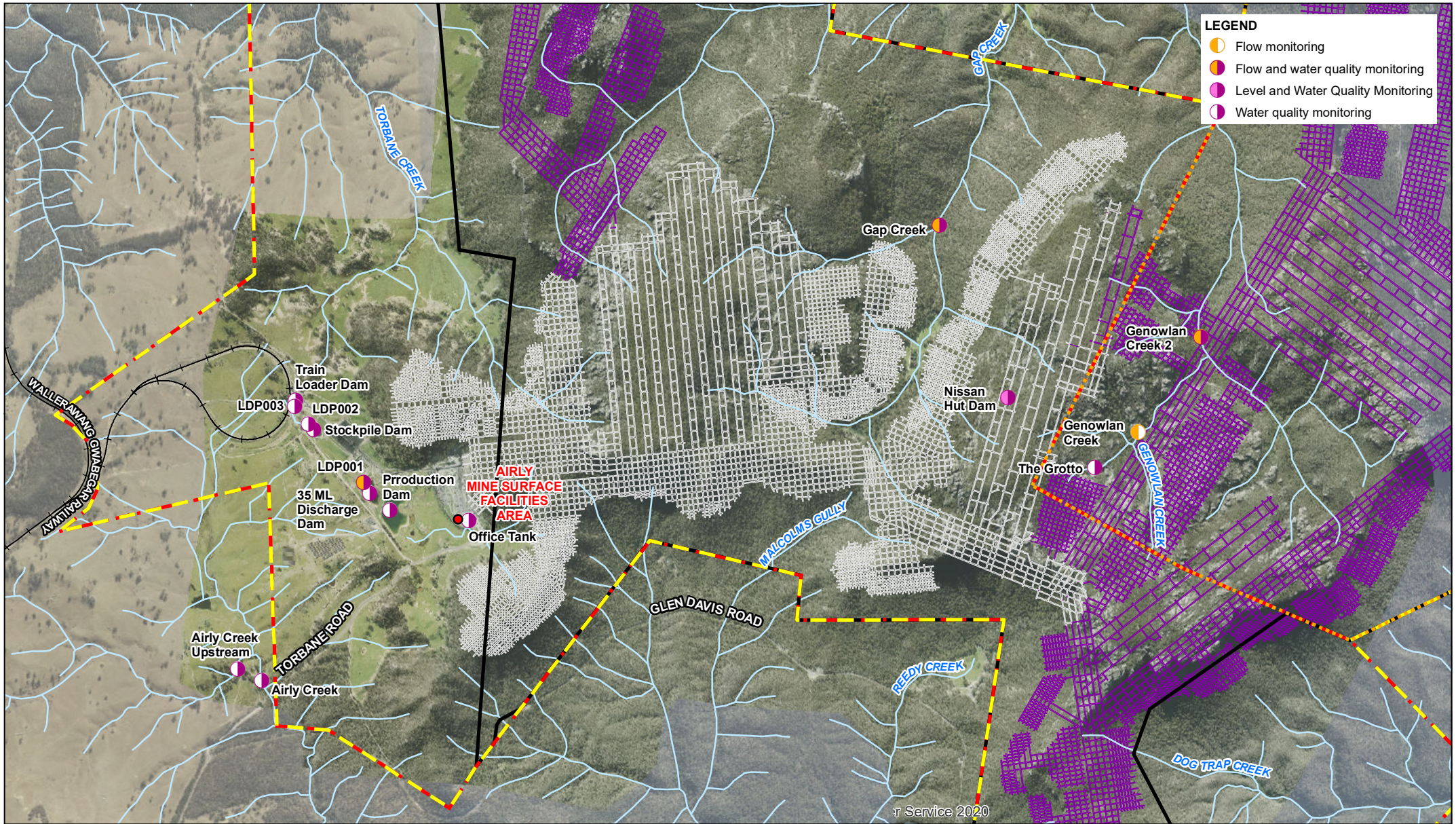
4.2.1 Surface water quality

Surface water quality at Airly Mine is currently monitored at the following locations:

- Production Dam.
- Stockpile Dam.
- Train Loader Dam.
- Dirty Water Dam.
- Office Tank (Administration Building Tank).
- Airly Creek Upstream – located on Airly Creek upstream of Airly Mine surface facilities area.
- Airly Creek – located on Airly Creek downstream of Airly Creek Upstream monitoring site and the Airly Mine surface facilities area.
- Gap Creek.
- The Grotto – located on Genowlan Creek.
- Genowlan Creek 2 – located on Genowlan Creek downstream of the Grotto.
- Nissan Hut Dam.

Figure 4.1 provides the location of the surface water monitoring points for Airly Mine. Table 4.1 summarises the location, frequency and parameters of surface water quality monitoring for Airly Mine. Previous monitoring has established baseline characteristics (see Section 5.1.1). Numerous analytes within the suite have been undetected and are no longer warranted. Ongoing monitoring monitors for changing impacts and therefore reliance on key indicators is sufficient. Further, several watercourses are remote from mining activity, regularly dry or without flow and/or difficult to access. Therefore, monitoring frequency of several creek locations has been reduced. Changes from the previous version of the WMP include the following:

- Reduced monthly analytical suite (removal of nutrients, dissolved metals and other parameters) for Production Dam, Airly Creek Upstream and Airly Creek.
- Reduced annual analytical suite (removal of dissolved metals and other parameters; inclusion of EC and pH) for Stockpile Dam, Train Loader Dam and the Dirty Water Dam.
- Reduced frequency of monitoring from monthly to quarterly for Gap Creek, The Grotto and Genowlan Creek 2.
- Reduced annual analytical suite (removal of nutrients, dissolved metals and other parameters) for Gap Creek, The Grotto and Genowlan Creek 2.
- Inclusion of monitoring at Nissan Hut Dam.



LEGEND

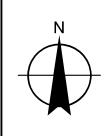
- Flow monitoring
- Flow and water quality monitoring
- Level and Water Quality Monitoring
- Water quality monitoring

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Airly Surface Facilities Area
- Mining Lease ML 1814
- Authorisation A232
- Railway
- Existing workings
- Proposed workings
- Waterway
- Approved development consent boundary
- Mining Lease ML1331



Airly Mine
Water Management Plan

Job Number | 22-12602550
Revision | 0
Date | 14 Jul 2023

Surface water
monitoring locations

Figure 4-1

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Data source: LPI: DTDB 2012; Centennial: Aerial Imagery, boundaries, 2013, Monitoring Locations, 2017. Created by: fmackay, tmorton

Table 4.1 Surface water quality monitoring frequency and parameters

Location	Frequency	Parameters
Production Dam Airly Creek Upstream Airly Creek	Monthly	Physicochemical parameters: dissolved oxygen (DO), electrical conductivity (EC), pH, TDS, total suspended solids (TSS), turbidity. Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. Metals (dissolved): aluminum, arsenic, barium, boron, cadmium, cobalt, iron, lead, manganese, mercury, nickel, silver, zinc.
Stockpile Dam Train Loader Dam Dirty Water Dam	Monthly	Physicochemical parameters: EC, pH, TSS, turbidity. Metals (dissolved and total): iron, manganese. Other parameters: oil and grease.
	Annually	Physicochemical parameters: electrical conductivity (EC), pH, DO, TDS. Nutrients: ammonia, nitrate, nitrite, nitrate + nitrite, total Kjeldahl nitrogen, total nitrogen*, total phosphorus*. Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. Metals (total): aluminium, arsenic, cadmium, cobalt, lead, mercury, nickel, silver, zinc.
Office Tank (Administration Building Tank)	Monthly	Physicochemical parameters: EC, pH, TDS. Nutrients: nitrate. Major ions: sulfate, total hardness. Metals (total): iron. Other parameters: <i>E. coli</i> detection, heterotrophic plate count, total coliforms.
Gap Creek The Grotto Genowlan Creek 2 Nissan Hut Dam	Quarterly	Physicochemical parameters: EC, pH, TDS. Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. Metals (dissolved): arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc.
	Annually	Physicochemical parameters: DO, TSS, turbidity. Metals (total): aluminium, arsenic, cadmium, cobalt, iron, lead, manganese, mercury, nickel, silver, zinc.

4.2.2 Surface water level and flow

Continuous level monitoring is currently undertaken for the following surface water storages at the surface facilities site:

- Dirty Water Dam
- Production Dam
- Stockpile Dam
- Train Loader Dam

Continuous level monitoring in Nissan Hut Dam has been undertaken since May 2022. Nissan Hut Dam is used for recreation and firefighting purposes. Gauging of Nissan Hut Dam levels is undertaken to monitor for any potential loss that could result from mining induced subsidence.

Continuous flow monitoring is currently undertaken at the following locations, as shown in Figure 4.1:

- Gap Creek
- Genowlan Creek
- Genowlan Creek 2

Flow is measured indirectly using a V notch weir, which is rated with a unique relationship between discharge and the depth of water in the upstream pool that is measured by a level sensor and recorded by a data logger (USDA 2001). Data downloads occur at the frequency of quality sampling (Table 4.1). There is no flow monitoring directly of the Grotto to avoid disturbing the site's natural aesthetics. The Grotto is often dry however flows to Genowlan Creek when wet. The Genowlan Creek flow monitoring points is <300m downstream and suffices monitoring of the Grotto. Monitoring of Genowlan Creek and Genowlan Creek 2 is intended to identify any potential impacts to flows in the creek as a result of mining operations.

Flow monitoring data at Genowlan Creek and Genowlan Creek 2 are compared to site rainfall gauge data on a quarterly basis to identify trends that may indicate mining impacts to the creeks. The assessment is undertaken to quantitatively identify changes in stream flows that would be inconsistent with periods of rainfall. Further investigation is undertaken considering the contemporaneous location of mining if inconsistency is identified.

Baseline monitoring results for surface water flow are provided in Section 5.1.2.

4.3 Discharge water monitoring

Table 4.2 outlines the discharge water quality monitoring requirements for each LDP at Airly Mine, which fulfils the specifications of EPL 12374.

Table 4.2 Discharge water quality monitoring frequency and parameters

Location	Frequency	Parameters
LDP001	Monthly during discharge	<p>Physicochemical parameters: DO, EC, pH, TDS, TSS, turbidity.</p> <p>Nutrients: ammonia, nitrate + nitrite, total nitrogen, total Kjeldahl nitrogen, total phosphorus.</p> <p>Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate.</p> <p>Metals (dissolved): aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, zinc.</p> <p>Metals (total): aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, vanadium, zinc.</p> <p>Other parameters: oil and grease.</p>
LDP002 LDP003	Monthly during discharge	<p>Physicochemical parameters: pH, TSS, turbidity.</p> <p>Other parameters: oil and grease.</p>

Continuous flow monitoring is undertaken at LDP001, in accordance with the requirements of EPL 12374. Continuous flow monitoring is also undertaken at LDP003.

Baseline monitoring results for discharge water quality and flow are provided in Section 5.2.

4.4 Groundwater monitoring

4.4.1 Groundwater levels and quality

The groundwater monitoring program at Airly Mine includes vibrating wire piezometers (VWPs), sampling of groundwater bores and flow monitoring of groundwater seepage (Figure 4.2).

Piezometric pressure is recorded automatically for each VWP every 12 hours and saved by the data logger at each bore. Groundwater levels are recorded every six hours by the water pressure transducers in the monitoring standpipes with the exception of the production bore AM2B-1 which has pumping headworks preventing access. The adjacent 'Old Production Bore' is gauged manually for the purpose of level monitoring. Seepage volume from the old shale workings is monitored continuously using a pressure transducer setup at the Village Spring. Data downloads at VWPs and standpipe monitoring bores occur at the frequency of quality sampling (Table 4.4).

Three groundwater bores located on adjacent private properties, Nioka, Kingdom and GW800787 are monitored for groundwater quality on a quarterly basis to provide an understanding of regional groundwater systems. Note that as groundwater levels cannot be monitored at Nioka, Kingdom or GW800787, piezometric pressure monitored at VWPs ARP04, ARP13 and ARP15 is used to provide an understanding of regional groundwater systems.

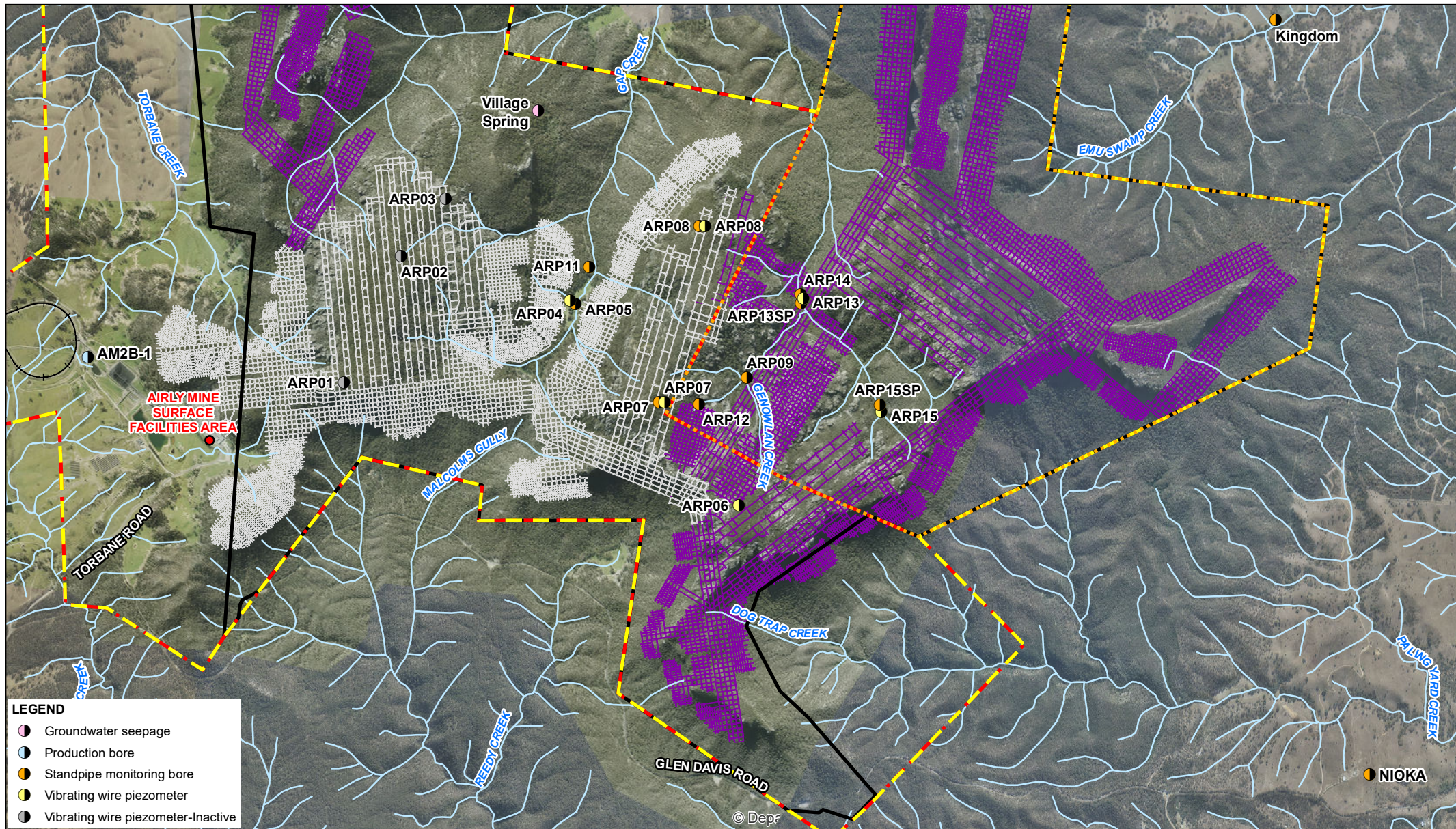
Monitoring location details are provided in Table 4.3. Table 4.4 summarises the location, functionality frequency and parameters of groundwater quality monitoring. Bores which are obsolete are listed as such, with monitoring to cease at these locations. Bore depths are detailed in Appendix C, Table C.2.1.

Baseline monitoring results for groundwater quality and levels are provided in Section 5.3.1. As per surface water monitoring, numerous analytes within the historical suite have been undetected and are no longer warranted. Ongoing monitoring monitors for changing impacts and therefore reliance on key indicators is sufficient. Further, historical trends support a reduction in sampling frequency from monthly to quarterly. Changes from Revision 4 of the WMP are consistent with recommendations presented by independent review (ZOIC, 2019) and include the following:

- Reduced frequency of monitoring from monthly to quarterly for all site groundwater bores; and
- Reduced analytical suite (select physicochemical parameters and dissolved metals, removal of nutrients, total metals, and other parameters) for all monitoring locations.

Further, monitoring of VWPs at ARP01, ARP02 and ARP03 will cease based on naturally low groundwater pressures resulting in largely dry conditions since installation. Low pressures (i.e., minimal existing groundwater) have been further evidenced by the low mine area inflows. Mining has been completed around these monitoring points and continued monitoring is not warranted.

Monitoring of standpipe ARP08SP will cease due to the commencement of mining under Point Hatteras and subsequently ARP08SP. The standpipe is blocked and no longer functional.



LEGEND

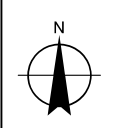
- Groundwater seepage
- Production bore
- Standpipe monitoring bore
- Vibrating wire piezometer
- Vibrating wire piezometer-inactive

Paper Size A4

0 250 500 750 1,000 1,250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Airly Surface Facilities Area
- Mining Lease ML 1814
- Authorisation A232
- Existing workings
- Proposed workings
- Waterway
- Approved development consent boundary
- Mining Lease ML 1331



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Groundwater
monitoring locations

Figure 4-2

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Data source: LPI: DTDB 2012; Centennial: Aerial Imagery, boundaries, 2013, Monitoring Locations, 2017. Created by: fmackay, tmorton

Table 4.3 Groundwater monitoring details

Monitoring type	Location	Period of data	Lithology	Status
VWP	ARP01	June 2012–2018 All loggers dysfunctional since 2018. VWP is obsolete.	Narrabeen Sandstone (74 m bgl)	VWP dry since installation Dysfunctional (2015)
			Irondale Seam (238.5 m bgl)	VWP dry since installation Dysfunctional (2018)
			Lithgow Seam (260 m bgl)	VWP dry since installation Dysfunctional (2018)
			Marrangaroo Formation (263 m bgl)	Dysfunctional (2018)
	ARP02	May 2012– 2023. VWP is obsolete	Narrabeen Sandstone (65 m bgl)	VWP dry since installation. Monitoring to cease in 2023.
			Irondale Seam (243 m bgl)	VWP dry since 2012 – Dysfunctional (2020)
			Lithgow Seam (266 m bgl)	VWP dry since installation – Dysfunctional (2020)
			Marrangaroo Formation (270 m bgl)	Dysfunctional (2020)
	ARP03	July 2012–2023. VWP is obsolete	Narrabeen Sandstone (136 m bgl)	Dysfunctional (2020)
			Middle River Seam (165 m bgl)	VWP dry since installation. Monitoring to cease in 2023.
			Lithgow Seam (252 m bgl)	VWP dry since installation – Dysfunctional (2021)
			Marrangaroo Formation (257 m bgl)	VWP dry since February 2022. Monitoring to cease in 2023.

Monitoring type	Location	Period of data	Lithology	Status
	ARP04	April 2012–present	Lithgow Seam (25 m bgl)	Working – VWP dry since June 2016
			Marrangaroo Formation (28.5 m bgl)	Working
			Shoalhaven Siltstone (210.3 m bgl)	Working
	ARP06	June 2013–present	Narrabeen Sandstone (230 m bgl)	Working
			Irondale Seam (252 m bgl)	Working – VWP dry since December 2013
			Lithgow Seam (288 m bgl)	Working – VWP dry since installation
			Marrangaroo Formation (295 m bgl)	Working – VWP dry since January 2016
	ARP07	July 2013–present (dry)	Middle River Seam (168 m bgl)	Working – VWP dry since installation
			Lithgow Seam (252 m bgl)	Working – VWP dry since installation
	ARP08	September 2013–2023 VWP is obsolete	Narrabeen Sandstone (183 m bgl)	Working – VWP dry since January 2016
			Irondale Seam (282.5 m bgl)	Dysfunctional (September 2022)
	ARP13	December 2016–present	Shoalhaven Group (120 m bgl)	Working
			Devonian strata (280 m bgl)	Working
	ARP15 ¹	January 2017–present	Lithgow Seam (125 m bgl)	Working
			Shoalhaven Group (200 m bgl)	Working – VWP dry since June 2017
Devonian strata (365 m bgl)			Working	

¹ Logger box damaged by tree fall January 2021

Monitoring type	Location	Period of data	Lithology	Status
Bore/standpipe	AM2B-1 (production bore)	2009–present (quality only)	Shoalhaven Group (38–87 m bgl)	Working
	Old Production bore	May 2017–present	Shoalhaven Group (37-69 m bgl)	Working
	ARP05	August 2012–present	Gap Creek alluvium (8–11 m bgl)	Working - generally dry between September 2017 and March 2021. Water level response since April 2021 following rainfall.
	ARP07	July 2013–present (dry)	Narrabeen Sandstone (110–119 m bgl)	Working – Dry since July 2013
	ARP08	September 2013–December 2022. Standpipe is obsolete– Mined through in late 2022.	Lithgow Seam (301–305 m bgl)	Obsolete. Monitoring to cease in 2023.
	ARP09	June 2013–present (mostly dry)	Genowlan Creek alluvium (3–4 m bgl)	Working – Mostly dry, responds after rainfall
	ARP11	January 2017–present	Permian strata (1.25–15.3 m bgl)	Working – Rainfall driven water level recovery since September 2021
	ARP12	January 2017–present (mostly dry)	Genowlan Creek alluvium (0.5–2.6 m bgl)	Working - Responds after rainfall
	ARP13SP	January 2017–present	Lithgow Seam (67.5–70.5 m bgl)	Working
	ARP14	January 2017–present	Genowlan Creek alluvium (0.5–2.3 m bgl)	Working
	ARP15SP	January 2017–present	Narrabeen sandstone (10–16 m bgl)	Working
	ARP16	December 2021 – present	Unknown	Working (dry)
	Nioka	2013, January 2018 – present (quality only)	Devonian strata	Working (quality only)

Monitoring type	Location	Period of data	Lithology	Status
	Kingdom	November 2019 – Present (quality only)	Devonian strata	Working (quality only)
	GW800787	December 2021 – Present (quality only)	Shale	Working (quality only)
Seepage	Village Spring	February 2011– present	Permian Siltstone	Regular flow - accessed when passable by foot
	Mine workings	December 2009– present	Lithgow Seam	Negligible volumes reported to date

Table 4.4 Groundwater quality monitoring frequency and parameters

Location	Frequency	Parameters
AM2B-1 (production bore) ARP05 ARP07 ARP08 ARP09 ARP11 ARP12 ARP13SP ARP14 ARP15SP Village Spring Nioka Kingdom GW800787	Quarterly	Physicochemical parameters: DO, EC, pH, TDS Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. Metals (dissolved): aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, zinc.

4.4.2 Underground water transfers

Daily monitoring of the transfer of water to and from the underground workings is undertaken using in-line flow meters.

4.4.3 Stygofauna monitoring

As per consent condition 13 (c) (iii), (refer Section 1.2.1), Airly Mine is required to maintain a program to monitor and report on stygofauna and hyporheic fauna. Originally designed as part of the *Western Region Stygofauna Monitoring and Assessment Plan*, the Airly stygofauna monitoring program is now conducted annually at the following bore locations (refer Figure 4.2):

- ARP05
- ARP09
- ARP11
- ARP13SP

- ARP14
- ARP15SP

The stygofauna monitoring methodology includes:

- Measurement of groundwater quality parameters including alkalinity, DO, EC, pH, temperature and turbidity.
- Sampling of groundwater bores and identification of stygofauna in accordance with guidelines by WA EPA (2007; 2013).

The results of post-EIS monitoring are provided in monitoring reports by GHD (GHD 2018c, 2019d, 2020, 2021). Baseline monitoring results for stygofauna monitoring are provided in Section 5.3.3.

4.5 Quality Assurance

A series of QA procedures are implemented to maintain the quality of data collected. QA procedures include compliance to the following:

- Use of standard field operating procedures (SOPs)
- Completed field records
- Documented calibration of field instruments
- Use of dedicated sampling materials and decontamination of re-used sampling equipment
- Use of laboratory supplied sampling containers and appropriate storage
- Completed chain of custody documentation
- Laboratory and testing method accreditation
- Laboratory QC analysis
- Laboratory limits of reporting below assessment criteria

Continued monitoring serves to confirm the representativeness of surface and groundwater conditions. The comparison of each event's dataset to previous records serves as a continual practice of quality assessment sufficing the collection of field QC samples.

4.6 Stream health monitoring

4.6.1 Geomorphic condition and watercourse stability

Watercourse stability monitoring is undertaken on third order streams within the site boundary (subject to access requirements), as shown in Figure 4.3, every two years. Watercourse stability monitoring will also be undertaken in areas where subsidence survey monitoring indicates greater than predicted subsidence. Visual monitoring of watercourses is carried out by suitably qualified professionals to identify any instabilities that may form as a result of mining operations. The results of the watercourse stability monitoring program will be compared to baseline data collected during the Airly Mine Extension Project.

Inspections will identify if any of the following potential subsidence impacts occur within the creek lines or immediate catchment flow paths:

- Change in stream bed or bank conditions.

- Incision or head cut development.
- Surface cracking.
- Ponding (particularly 'out of channel' ponding).
- Step changes in bed profile.

Baseline monitoring results for geomorphic condition and watercourse stability are provided in Section 5.4.1.

4.6.2 Aquatic ecology

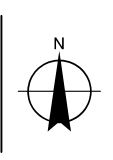
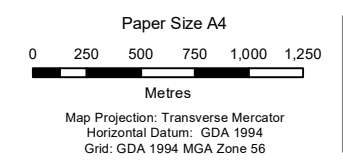
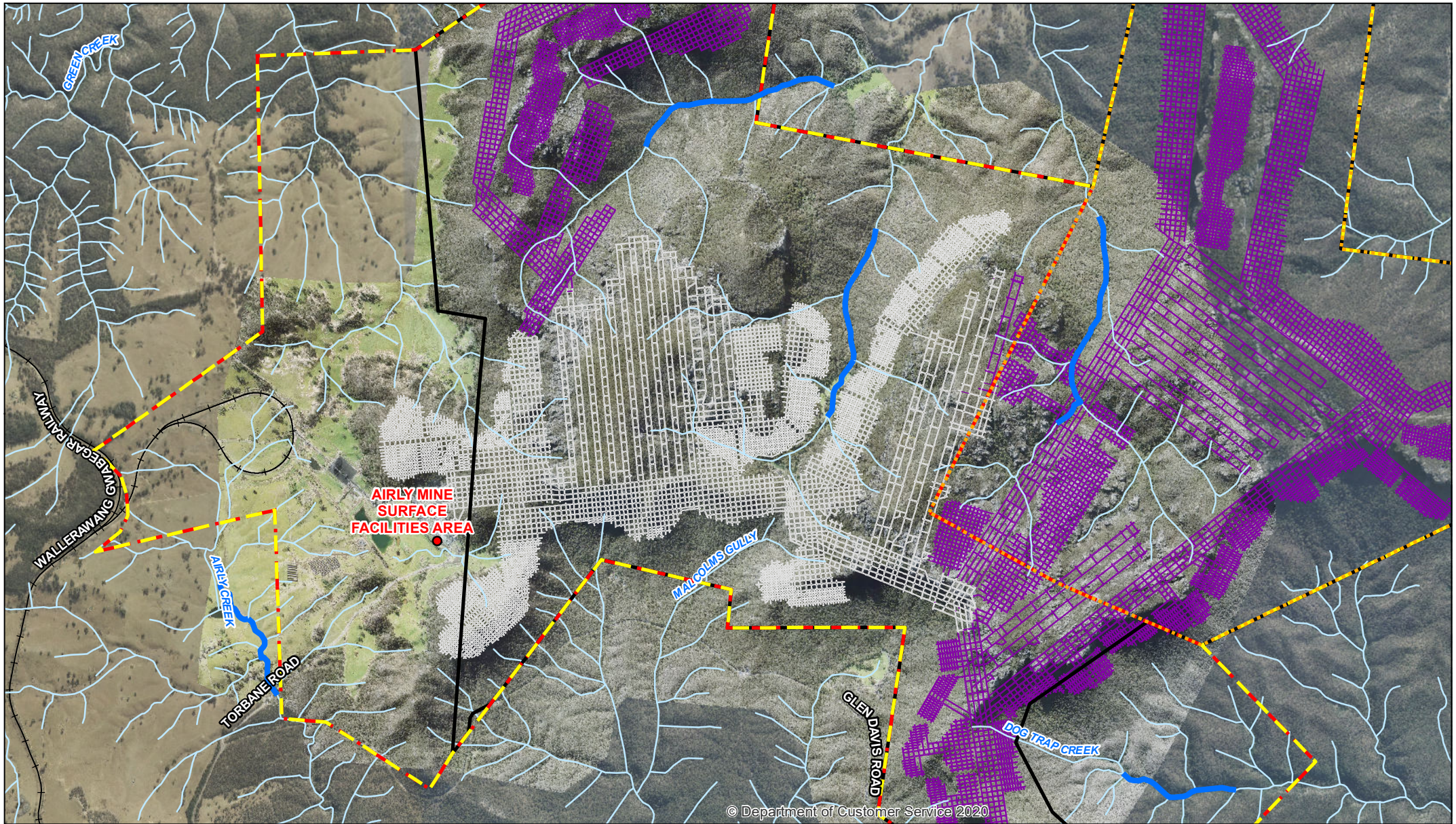
Aquatic ecology monitoring occurs biannually in autumn and spring at the following locations, as shown in Figure 4.4:

- Airly Creek (AIR) – Impact site on Airly Creek downstream of discharges from Airly Mine.
- Airly Creek Upstream (Airly Creek U/S) – Reference site on Airly Creek upstream of discharge.
- Genowlan Creek 2 (GEN) – Baseline site on Genowlan Creek.
- Genowlan Creek (GRO) – Baseline site on waterway downstream of the Grotto.
- Gap Creek (GAP) – Baseline site on Gap Creek.
- Torbane Creek (TOR) – Baseline site on Torbane Creek.
- Dogtrap Creek (DOG) – Baseline site on Dog Trap Creek.

The monitoring methodology includes:

- Sampling, sorting and identification of macroinvertebrates collected from edge habitat in accordance with the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak et al. 2004).
- Assessment of the condition of the aquatic habitat using modified NSW AUSRIVAS field sheets and riparian, channel and environmental (RCE) inventory (Peterson 1992).
- Measurement of DO, EC, pH, temperature, and turbidity just below the surface of the water column and at depth where sufficient water is available.
- Collection of surface water and sediment grab samples for water and sediment quality analysis.

Baseline monitoring results for aquatic ecology are provided in Section 5.4.2.



LEGEND

- Airly Surface Facilities Area
- Mining Lease ML1331
- Mining Lease ML1814
- Authorisation A232
- Waterway
- Monitored reaches
- Existing workings
- Proposed workings
- Railway



Airly Mine
Water Management Plan

Watercourse stability
monitoring locations

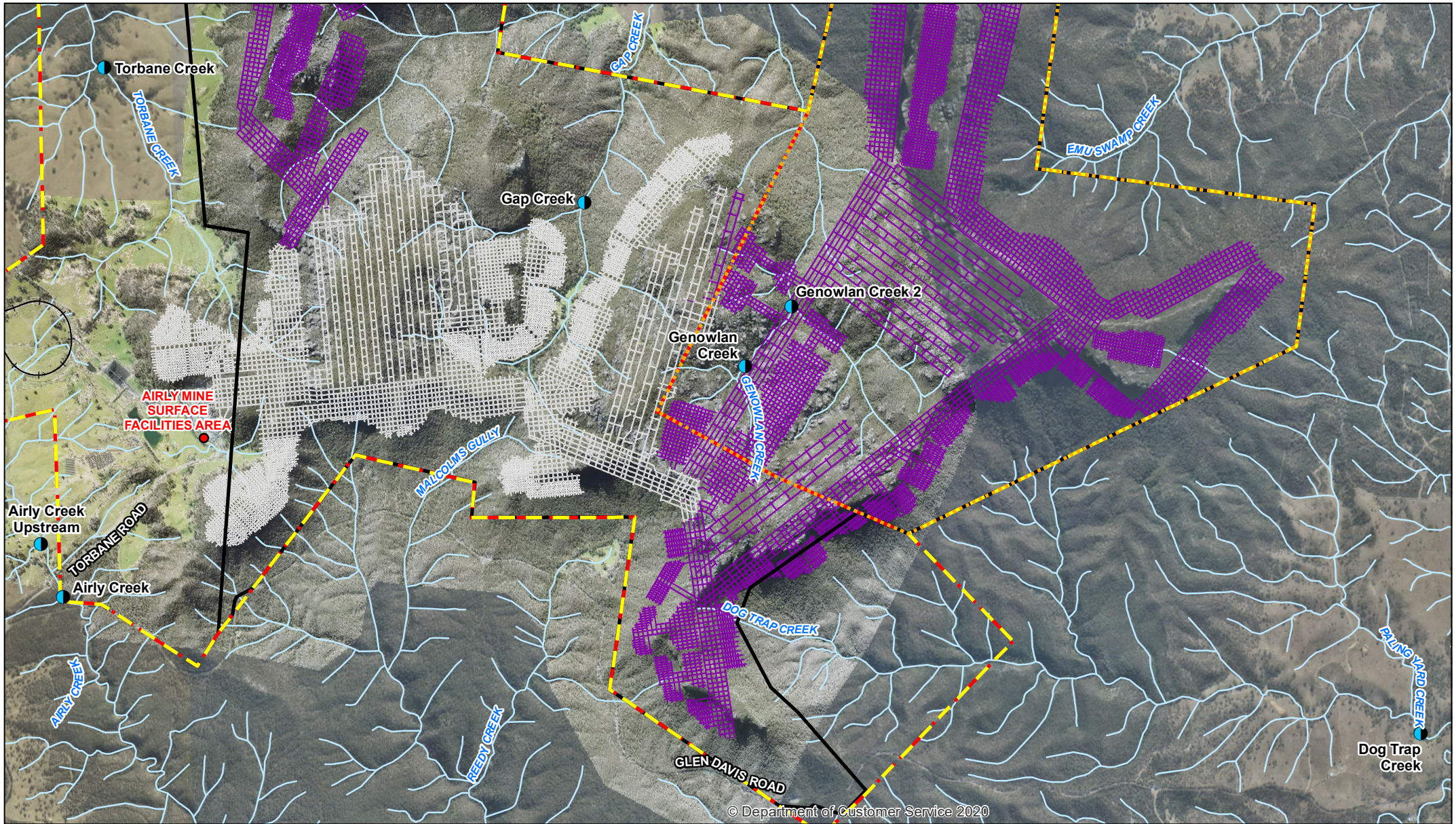
Job Number | 22-12602550
Revision | 0
Date | 14 Jul 2023

Figure 4-3

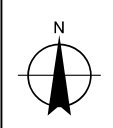
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 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56



LEGEND	
●	Airly Surface Facilities
●	Aquatic ecology monitoring
 	Mining Lease ML 1331
 	Mining Lease ML 1814
 	Authorisation
 	Existing workings
 	Proposed workings
+	Railway
—	Waterway
 	Approved development consent boundary



Airly Mine
 Water Management Plan

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Aquatic ecology
 monitoring locations

Figure 4-4

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 Data source: LPI: DTDB 2012; Centennial: Aerial Imagery, boundaries, 2013, Monitoring Locations, 2017. Created by: fmackay, TMorton

4.7 Erosion and sediment control

As part of surface water management, erosion and sediment control is critical to minimise excessive soil loss as a result of construction activities that require disturbance of existing groundcover. Erosion and sediment controls are implemented for all phases of operation including construction/maintenance activities, operational activities and during rehabilitation to mitigate the impacts of the operations on watercourses and the surrounding environment.

Erosion and sediment control measures are focused on prevention of erosion through development of erosion and sediment control plans (ESCPs) that:

- Identify activities with the potential to cause erosion and generate sediment.
- Plan activities to minimise the area of disturbance.
- Install erosion and sediment controls prior to commencement of disturbance activities.
- Maintain erosion and sediment control structures.
- Design erosion and sediment control structures with the capacity to handle the critical 20-year ARI rainfall event.

A range of erosion and sediment control measures are employed including:

- Erosion matting.
- Clean and dirty water diversion.
- Sediment filter fences.
- Rock check dams.
- Sandbag weirs.
- Temporary drains.

Inspections of all water management and sediment control structures are undertaken following heavy rainfall events (rainfall events that exceed 20 mm in 24 hours).

4.7.1 Requirements and guidelines

All erosion and sediment control measures are designed and implemented according to the requirements and guidelines provided in:

- *Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom, 2004).*
- *Managing Urban Stormwater: Soils and Construction, Volume 2A – Installation of Services (DECC, 2008a).*
- *Managing Urban Stormwater: Soils and Construction, Volume 2C – Unsealed Roads (DECC 2008b).*
- *Managing Urban Stormwater: Soils and Construction, Mines and Quarries Volume 2E (DECC 2008c)*
- *Best Practice Erosion and Sediment Control (IECA, 2008).*
- *Guidelines for Controlled Activities on Waterfront Land (July 2007)*
- *Guidelines for Fish Friendly Waterway Crossings (NSW Fisheries 2003a)*
- *Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings (NSW Fisheries 2003b)*

4.7.2 Disturbance and sediment generating activities

Disturbance and sediment generating activities that are likely to require erosion or sediment controls may include:

- Rehabilitation activities
- Site reshaping
- Temporary stockpiles
- Dewatering activities
- Temporary open channel diversions
- Instream watercourse works

4.7.3 Erosion risk

Disturbance activities are a function of the daily operations, with the resulting erosion risk varying throughout the year in response to changes in rainfall. The initial erosion risk has been estimated based on the:

- Average monthly rainfall.
- Area of disturbance (considered as the total water management system catchment).
- Soil loss classes (refer to Table 4.2; Landcom, 2004).

Typical erosion risk ratings for the western region are provided in Table 4.5. The average monthly rainfall is given by IECA (2008) based on rainfall recorded in Bathurst. The initial erosion risk is principally affected by the average rainfall, with high erosion risk identified for summer months (i.e. December to February), with the initial erosion risk reducing to low during the winter months (i.e. June to August).

When disturbance activities are undertaken within higher risk months, it is recommended that additional management measures be undertaken to ensure that the erosion and sediment controls are capable of operating effectively.

Table 4.5 Typical erosion risk

Month	Average rainfall (mm)	Erosion risk rating
January	85.1	High
February	79.1	High
March	65.0	Moderate
April	44.6	Low to moderate
May	49.4	Low to moderate
June	49.0	Low
July	50.9	Low

Month	Average rainfall (mm)	Erosion risk rating
August	64.2	Low
September	52.4	Low to moderate
October	67.1	Moderate
November	72.5	Moderate
December	73.6	High

4.7.4 Soil landscapes

The soil landscapes and associated erosion risk at Airly Mine is summarised in Table 4.6. From Table 4.6 it can be seen that the erosion hazard associated with the soil landscapes at Airly Mine varies from a moderate to extreme erosion hazard.

Table 4.6 Soil landscapes and erosion risk

Soil landscape	Typical terrain	Erosion hazard
Canobla Gap	Lower slopes in areas of poor drainage	Extreme
Capertee	Low hills	Moderate

4.7.5 Environmental constraints

Environmental constraints that should be considered when estimating the potential sediment loads associated with a proposed activity are presented in Table 4.7.

Table 4.7 Regional environmental constraints and characteristics

Component	Range of parameters
Works period and site sensitivity (DECC, 2008)	Many mining operations are likely to be greater than three years. Downstream environment defined as sensitive
Rainfall factor – R	1,360 to 1,800
Soil erodibility factor – K	0.05 to 0.075
Slope and flow length	Maximum flow length should not exceed 80 m Typical slopes are between 0.5% to 3%
Sediment basin requirement threshold	Predicted soil loss > 150 m ³ /year (based on RUSLE equation results)
Sediment basin type for construction	'Wet Basin' – Type D, 5 days 95th percentile

Component	Range of parameters
Sediment volume allowance for sediment basins	Dependent upon operations and clean out frequency – two to six months
Soil hydrologic type	Type D
Volumetric coefficient of runoff	0.39 to 0.79 (DECC, 2008 recommends 0.9 for hardstand areas)

4.7.6 Typical controls

Prior to any construction activity, temporary erosion and sediment controls shall be installed. The following are temporary erosion and sediment control that are currently being utilised at Centennial's western sites. The installation of these controls should be in accordance with the specification detailed in the Managing Urban Stormwater, Soils and Construction (Landcom, 2004) standard drawings provided in I.

4.7.6.1 Sediment fence

Sediment fences trap sediment that is mobilised by runoff across a disturbed area. Sediment fences should only be temporary and require regular maintenance to remain effective.

Sediment fences are to be installed along the contour downslope of disturbed areas. Sediment fences are not to be located within (or adjacent to) concentrated flow paths, but in positions that provide adequate vegetative filtering of sheet flows downslope of the disturbed area. Sediment fences shall be installed in accordance with the Sediment Fence Standard Drawing (SD6-8: Landcom, 2004) (refer to I).

4.7.6.2 Inlet pit protection

Where disturbance activities are to be carried out within the vicinity of an existing stormwater drainage network (i.e. a pit and pipe system), it is recommended that inlet pit protection measures are used. Pit protection measures provide a filter for sediment-laden runoff, reducing the risk of stormwater pipes being blocked with accumulated sediment. Inlet pit protection shall be installed in accordance with the Inlet Pit Protection Standard Drawing (SD6-11: Landcom, 2004) (refer to I).

4.7.6.3 Sediment traps and basins

Where disturbance activities exceed the manageable capacity of sediment fences, with respect to duration or extent, it is recommended that sediment traps and/or basins be installed. Sediment traps and basins can be constructed from available construction materials or by shaping an earth embankment. It is expected that sediment traps and basins would be installed and operated similar to a Type D Sediment Basin (SD6-4: Landcom, 2004) (refer to Appendix I).

4.7.6.4 Flow breaks (low flow channels)

The use of flow breaks decreases flow velocities within low flow channels, reducing the potential for the low flow channels to erode and scour and reduce the migration of sediment from disturbed areas. Flow breaks can be constructed from earth, natural materials (logs, mulch and so on) or from proprietary products. Breaks should be used in a similar manner to a sediment fence; however flow breaks are typically more porous than sediment fences, allowing water to flow through faster.

4.7.6.5 Rolled erosion control products

Rolled erosion control products (RECPs) reduce erosion by completely covering the disturbed area. RECPs are easily applied to disturbed areas in an emergency or where the area requires temporary stabilisation for an extended period of time. RECPs typically require little maintenance. RECPs may consist of processed natural or synthetic fibres bound together to form a continuous mat. They may also be used to facilitate vegetation establishment by temporarily or permanently reinforcing the soil surface during and after vegetation maturation.

4.7.7 Implementation

The following points provide a typical implementation strategy for managing erosion and sediment controls:

1. Sediment controls are to be implemented in the area of any ground disturbance, prior to the disturbance activity occurring. A sediment fence or appropriately designed sediment control structure must be erected downslope of the area of disturbance.
2. Dirty runoff water should be directed to the sediment controls. Small areas of ground disturbance may be managed *in situ* by using appropriate sediment source controls.
3. Dirty runoff that may be exposed to hydrocarbons must be treated with an oil/water separator, where practicable. The collected hydrocarbon wastes must be disposed off-site by a licensed waste operator. Remote site facilities should be managed on a site by site basis within the confines of the facility.
4. Areas where contamination of water by hydrocarbons must be minimised. Servicing of vehicles must be conducted within appropriate areas designed to treat potential hydrocarbon spills.
5. Equipment and materials should be cleaned in the designated washdown areas. Primary washdown of underground mining equipment should, where practicable, be conducted within the primary washdown bay underground. Remote site facilities should be managed on a site by site basis within the confines of the facility.
6. Washdown of underground mining equipment on surface may only be conducted in the approved and signposted washdown areas.
7. All emergency discharge sites are to include flow dissipaters to reduce scouring directly downstream of the discharge point.
8. All erosion and sediment controls are to remain in place until the area of disturbance can be satisfactorily rehabilitated and stabilised.

Table 4.8 summarises the acceptable water quality objectives for disturbances activities when works may occur outside the catchment of an LDP.

Table 4.8 Water quality objectives

Parameter	Units	Concentration limit
pH	pH units	6.5–8.5
Oil and grease	mg/L	10
Total suspended solids	mg/L	50

5. Baseline data

5.1 Surface water monitoring

5.1.1 Surface water quality

Appendix D and E present the baseline surface water quality data for selected parameters monitored at surface water storages on site and Airly Creek, Gap Creek and Genowlan Creek. Table 5.1 presents the extent of baseline data considered.

Where the analytical result was below the limit of reporting (LOR) for a particular parameter, then the detection limit was included in the calculation.

Table 5.1 Details of baseline surface water quality data

Location	Period from	Period to	Number of monitoring events
Production Dam	18/01/2010	02/12/2020	128
Stockpile Dam	17/02/2010	02/12/2020	129
Train Loader Dam	06/01/2011	02/12/2020	98
Dirty Water Dam	18/01/2010	03/06/2020	128
Airly Creek Upstream	04/04/2014	03/11/2020	73
Airly Creek	18/01/2010	02/12/2020	135
Gap Creek	11/07/2012	23/12/2020	88
The Grotto	11/07/2012	22/12/2020	105
Genowlan Creek 2	18/01/2018	19/06/2020	43

5.1.2 Surface water flow

Figure 5.1 presents the recorded flows at the Gap Creek monitoring site, from February 2013 to October 2021. Recorded flows at the Genowlan Creek monitoring site are presented in Figure 5.2, from February 2013 to October 2021. Flow gauging was not available between February and November 2016 at Genowlan Creek. Figure 5.3 presents the flows recorded at the Genowlan Creek 2 gauge from May 2019 to October 2021. The CRD curve derived from rainfall recorded at the Airly Mine surface facilities area is also presented in each figure.

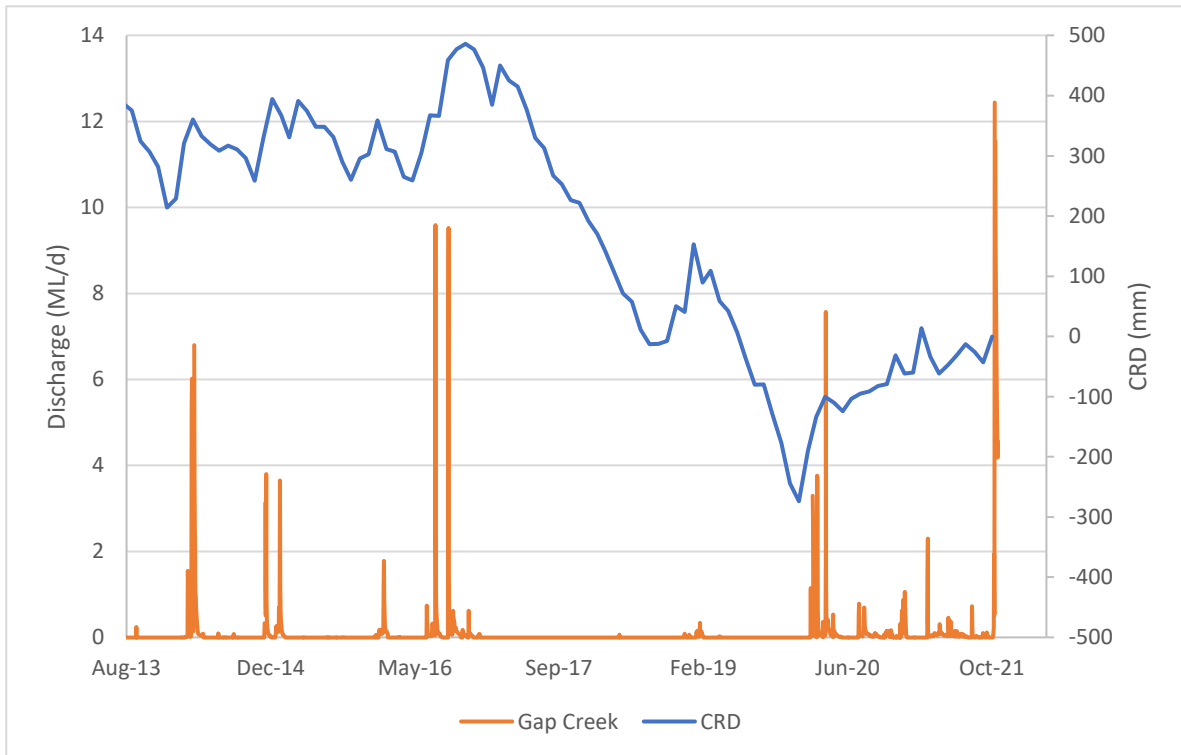


Figure 5.1 Recorded flows at Gap Creek

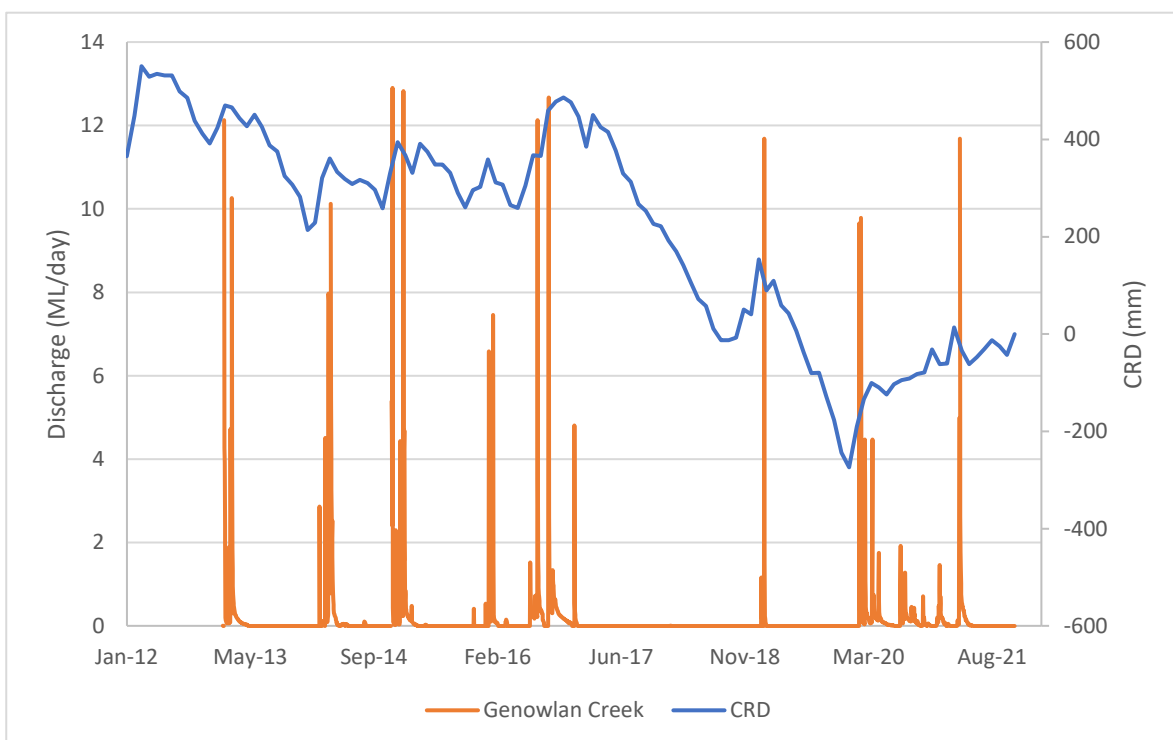


Figure 5.2 Recorded flows at Genowlan Creek

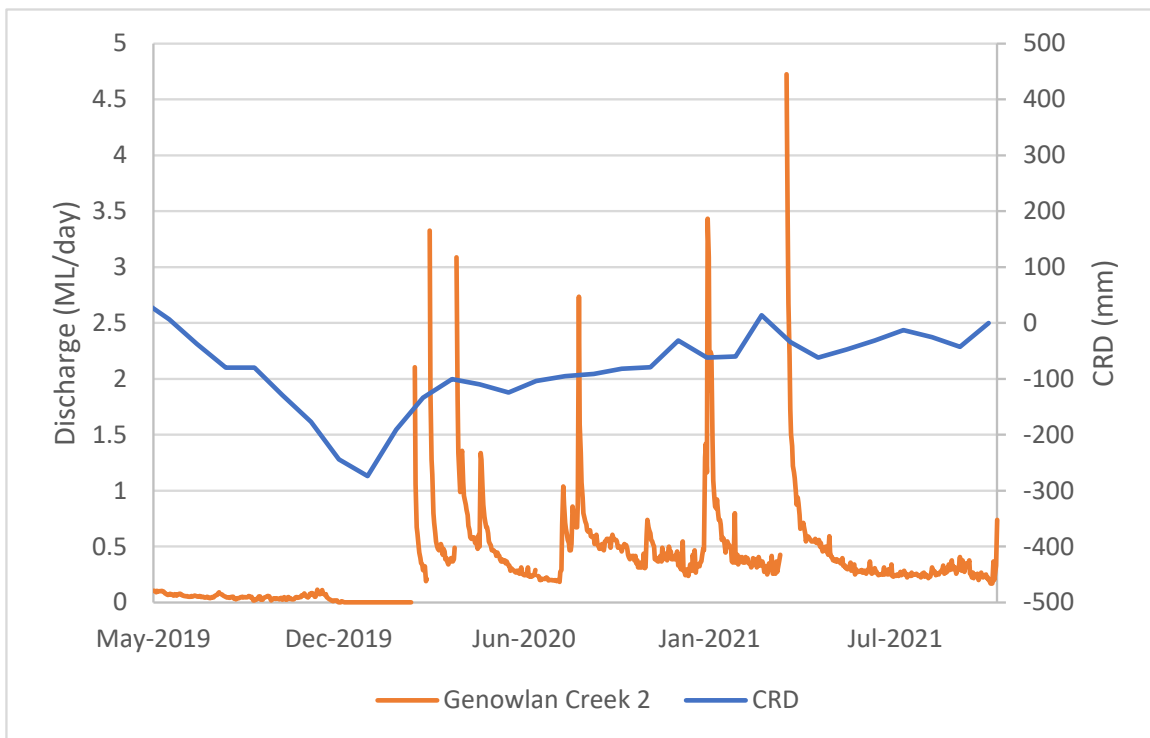


Figure 5.3 Recorded flows at Genowlan Creek 2

A review of the available streamflow data found no significant difference between the average annual runoff coefficient of the catchment of the Gap Creek gauge before and after secondary extraction, with the Genowlan Creek gauge used as a control.

5.2 Discharge water monitoring

5.2.1 LDP001

LDP001 discharge from the Production Dam to Airly Creek is measured continuously. Historical discharge data from December 2010 to December 2020 is presented in Figure 5.4. Water quality results for LDP001 discharges are presented in Table 5.2.

Historical discharge data is indicative of the Airly Mine water management system which is influenced by increased rainfall volume over several days rather than storms of extreme intensity. This outcome results in a greater emphasis on the appropriate management of water volumes rather than solely available storage volume. Discharges via LDP001 are likely to be rare, as predicted by the site water balance model (refer Section 3.5).

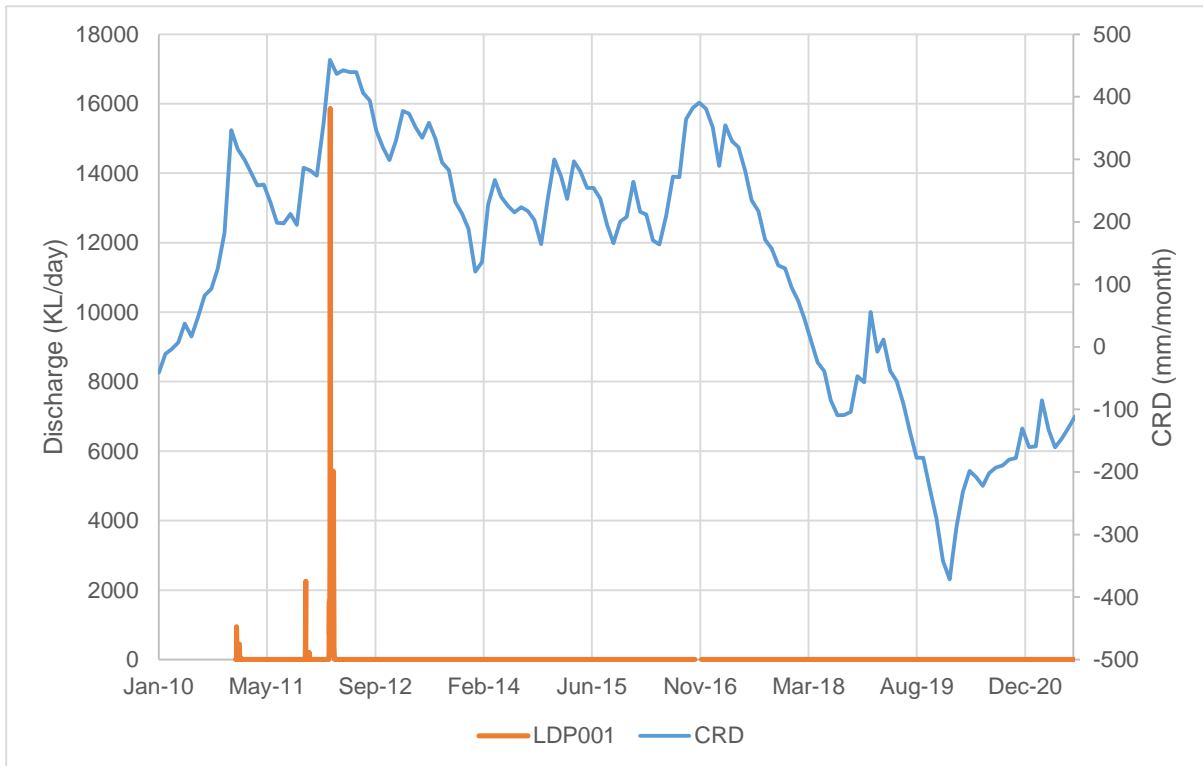


Figure 5.4 Recorded LDP001 discharge

Table 5.2 LDP001 discharge water quality

Parameter	Units	Sampling event							
		06/12/2010	06/01/2011	13/01/2011	28/02/2012	01/03/2012	02/03/2012	05/03/2012	06/03/2012
Physicochemical parameters									
EC	µS/cm	515	925	870	740	750	715	555	520
pH	pH units	7.1	7.9	7.6	8.9	8.8	8.5	7.9	8.2
TSS	mg/L	19	–	–	2	2	5	13	12
Turbidity	NTU	–	–	–	–	–	–	–	17.7
Metals									
Iron (dissolved)	mg/L	0.08	0.05	0.11	–	–	–	–	0.1
Iron (total)	mg/L	0.41	0.45	0.2	–	–	–	–	0.22
Manganese (dissolved)	mg/L	0.02	0.06	0.51	–	–	–	–	0.11
Manganese (total)	mg/L	0.02	0.09	0.53	–	–	–	–	0.15

Parameter	Units	Sampling event							
		06/12/2010	06/01/2011	13/01/2011	28/02/2012	01/03/2012	02/03/2012	05/03/2012	06/03/2012
Other parameters									
Oil and grease	mg/L	<2	<2	<2	<2	<2	<2	<2	<2

5.2.2 LDP002

One discharge event has occurred through LDP002 from the Stockpile Dam to Airly Creek. This discharge occurred in March 2021. Water quality data from this discharge event is shown in Table 5.3.

Table 5.3 LDP002 discharge volumes and water quality

Parameter	Units	Discharge event – 23/03/2021
pH	pH units	7.7
EC	µS/cm	235
TSS	mg/L	16
Turbidity	NTU	64.7
Oil and grease	mg/L	<1

5.2.3 LDP003

Six discharge events have occurred through LDP003 from the Train Loader Dam to Airly Creek, with the estimated volumes and water quality results presented in Appendix D.

Table 5.4 LDP003 discharge volumes and water quality

Parameter	Units	Discharge event					
		29/01/2013	14/03/2014	04/04/2014	08/12/2014	23/11/2017	11/01/2019
Volume	ML/day	0.0045	0.072	0.16	0.01	0.0012	0.036
Physicochemical parameters							
EC	µS/cm	230	226	96	223	126	190
pH	pH units	7.4	7.0	7.3	7.7	7.3	7.4
TSS	mg/L	121	714	468	219	88	32
Turbidity	NTU	161	708	569	436	147	84

Parameter	Units	Discharge event					
		29/01/2013	14/03/2014	04/04/2014	08/12/2014	23/11/2017	11/01/2019
Metals							
Iron (dissolved)	mg/L	–	0.2	0.22	0.76	–	0.38
Iron (total)	mg/L	–	2.1	3.74	5.52	–	–
Manganese (dissolved)	mg/L	–	0.079	0.039	0.001	–	0.02
Manganese (total)	mg/L	–	0.093	0.117	0.064	–	–
Other parameters							
Oil and grease	mg/L	<5	<5	<5	<5	<2	<2

5.3 Groundwater monitoring

5.3.1 Groundwater levels and quality

Appendix C presents the baseline groundwater level and quality data for VWPs, standpipe monitoring bores and the Village Spring. Table 5.5 presents the extent of baseline data for groundwater quality considered.

ARP07 has been consistently dry since installation and therefore no baseline groundwater data are presented for this site. Quality triggers have not been implemented at ARP08 due to insufficient baseline data. Water levels at ARP09 and ARP12 are highly variable, often dry and respond to periods of heavy rainfall. Therefore, no water level triggers have been proposed at ARP09 and ARP12.

Derived trigger levels are discussed in Section 6.1.4.

Table 5.5 Details of baseline groundwater quality data

Location	Period from	Period to	Number of monitoring events
AM2B-1 (production bore)	11/07/2012	04/08/2020	99
ARP05	11/07/2012	16/06/2021	68
ARP08	05/04/2017	22/12/2020	31
APR09	27/02/2020	20/12/2022	20
Nioka	18/12/2013	20/09/2022	19
Village Spring	09/08/2010	23/12/2020	126
ARP11	18/05/2017	23/10/2019	28
ARP12	27/02/2020	20/12/2022	34

Location	Period from	Period to	Number of monitoring events
ARP13SP	18/05/2017	22/12/2020	34
ARP14	17/05/2017	24/11/2020	36
ARP15SP	17/05/2017	22/12/2020	39
Kingdom	26/11/2019	11/12/2023	16
GW800787	14/12/2021	11/12/2023	8

Figure 5.5 presents the recorded flows at the Village Spring monitoring site and rainfall recorded at the Airly Mine surface facilities area, from February 2011 to December 2020. Flows at the Village Spring have decreased from February 2015 due to vandalism interfering with monitoring equipment and unauthorised use of water. Logging of flows resumed in February 2017. Between 1 January and 30 June 2020 no seepage was recorded due to a malfunctioning logger.

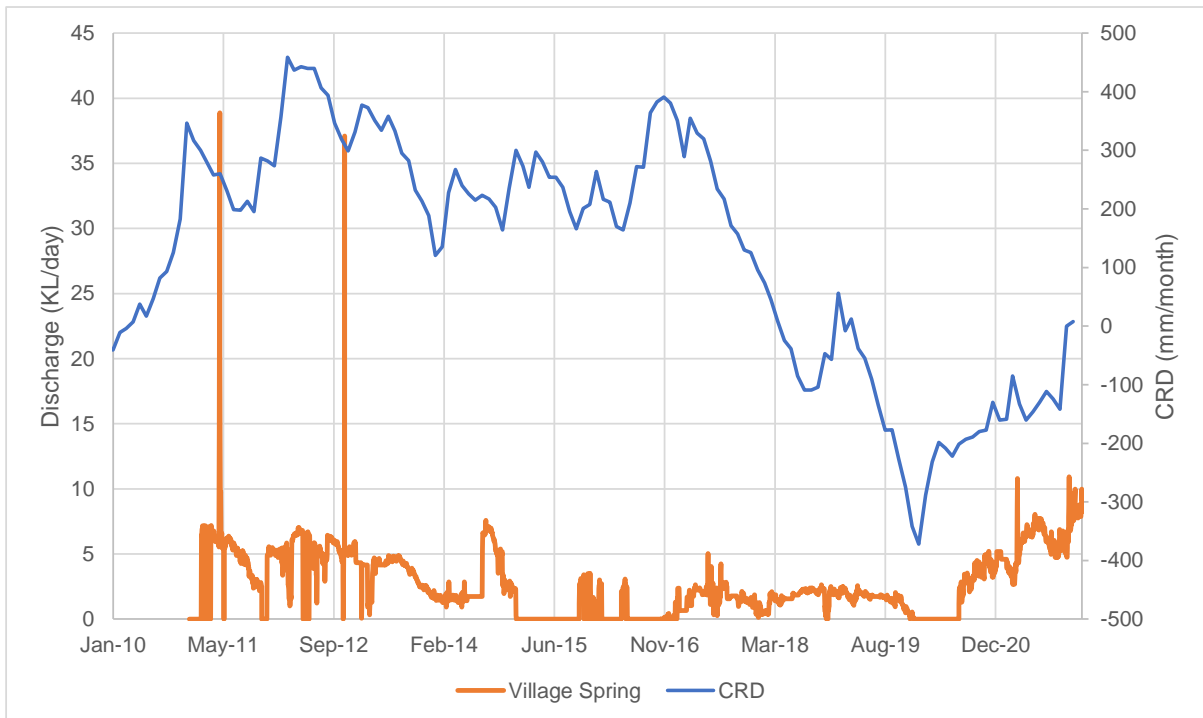


Figure 5.5 Recorded flows at Village Spring

5.3.2 Underground water transfers

To date, limited volumes of water has been transferred from the underground workings to the Dirty Water Dam at the surface.

5.3.3 Stygofauna

Stygofauna sampling was conducted over four sampling events between May 2013 and June 2014, as part of the EIS for the Airly Mine Extension Project (Cardno 2014). No stygofauna were collected from groundwater bores associated with Airly Mine during these sampling events. Additional post-EIS monitoring was undertaken in March and December 2016, February and August 2017, November 2018, April 2019 and October 2020. Stygofauna have been collected in low densities and diversity during stygofauna monitoring conducted between 2018 and 2020 (GHD 2019d, 2020, 2021).

5.4 Stream health monitoring

5.4.1 Geomorphic condition and watercourse stability

A baseline assessment of geomorphology at Airly Mine was undertaken for the Airly Mine Extension Project (GHD 2014e). Watercourse stability monitoring was last undertaken in 2018 (GHD 2018a). Geomorphic condition of the watercourses assessed in GHD (2018a) is presented in Figure 5.6.

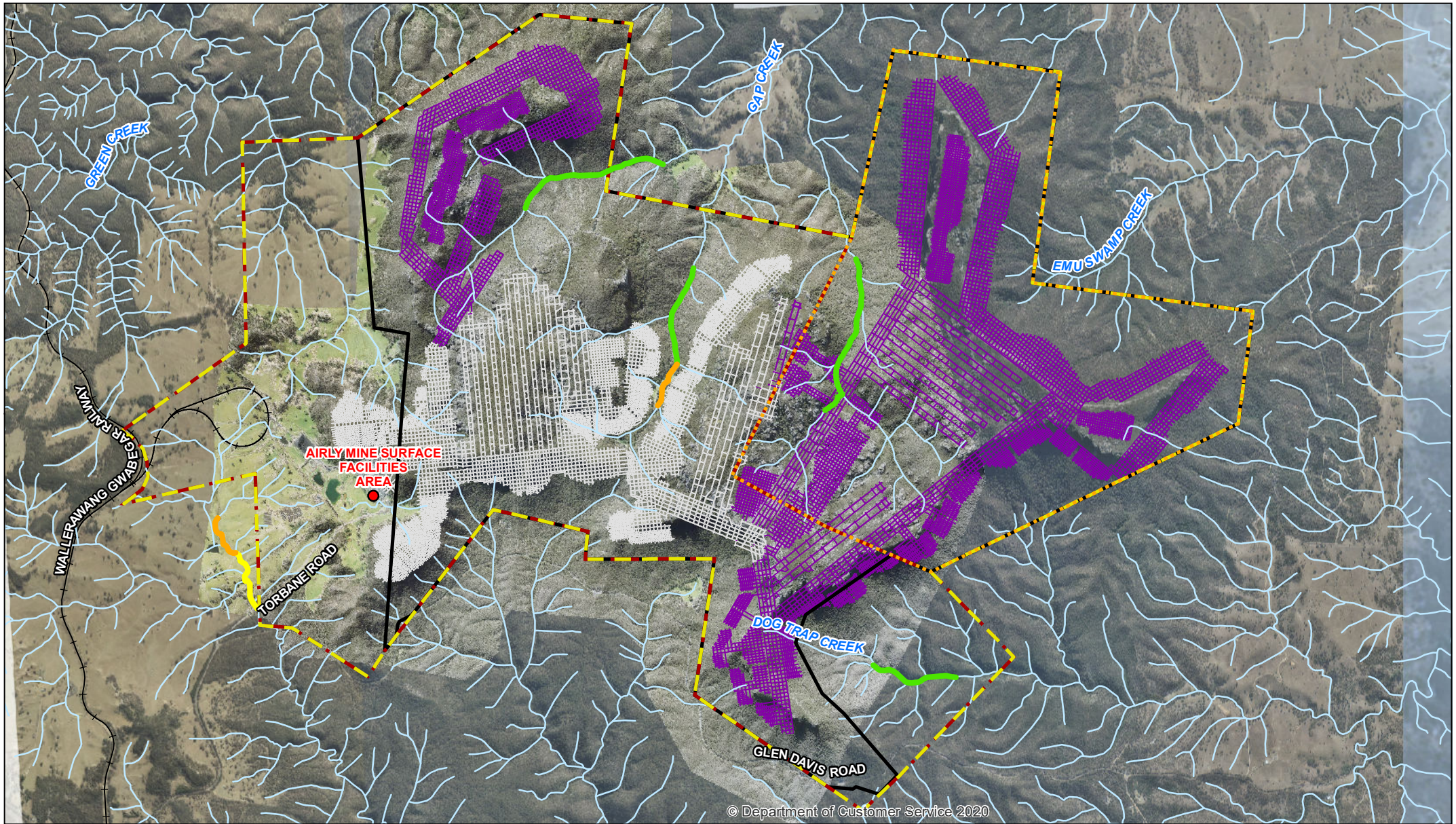
Geomorphic condition in Torbane and Airly Creeks was mostly moderate, though poor condition reaches were identified associated with active headcuts. Geomorphic condition in Gap, Genowlan and Dog Trap Creeks was good, with the exception of an upstream section of Gap Creek where land clearing has resulted in the channelisation of a narrow valley of fine-grained sediments. Apart from that poor condition reach, Gap, Genowlan and Dog Trap Creeks are characterised by confined, bedrock controlled valley settings, which are geomorphologically stable and subject to only slow rates of change. The potential impacts of subsidence on these creeks would most likely be observable in areas of bedrock outcropping in the substrate, where any cracks would be evident during inspections. Bedrock confined watercourses are also not prone to bed or bank scour.

5.4.2 Aquatic ecology

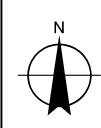
Aquatic ecology monitoring at Airly Mine has been undertaken within Gap Creek, Genowlan Creek, Airly Creek, Torbane Creek and Dog Trap Creek since 2013.

Overall, the aquatic habitat in Genowlan Creek was determined to be in the best condition (GHD 2017). The combination of low nutrient and metal concentrations and diverse habitat availability at the site supports a diverse macroinvertebrate community which is largely sensitive to pollution. The macroinvertebrate community in Gap Creek also contains pollution sensitive taxa and there is little disturbance related to human activities at the site, although water scarcity is a limiting constraint.

Airly Creek, Torbane Creek and Dog Trap Creek were more highly disturbed by grazing and agricultural land use compared to the Gap Creek and Genowlan Creek catchments. It is likely that these sites receive groundwater baseflow from the Shoalhaven Group, which is an early Permian marine formation in which groundwater has an elevated EC in the order of 4000 $\mu\text{S}/\text{cm}$. Monitoring sites in these catchments were dominated by pollution dominant taxa. The similarity of the macroinvertebrate communities in the Airly Creek sites upstream and downstream of the surface facilities area indicated that there was no impairment of the community at the downstream site associated with overland flows of discharges from Airly Mine.



Paper Size A4
 0 300 600 900 1,200 1,500
 Metres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56



LEGEND

- Airly Surface Facilities Area
- Approved development consent boundary
- ▨ Mining Lease ML1331
- ▨ Mining Lease ML 1814
- ▭ Authorisation A232
- Waterway
- Railway
- Existing workings
- Proposed workings
- Condition (2020)
- Good
- Moderate
- Poor



Airly Mine
 Water Management Plan

Geomorphic condition
 of watercourses

Job Number	22-12602550
Revision	0
Date	14 Jul 2023

Figure 5-5

G:\22\010500\1\GIS\Maps\Deliverables\Western\Airly\12602550\WMP\12602550_WMP010_WatercourseConditions_0.mxd
 Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au
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 Data source: LPI: DTDB 2012; Centennial: Aerial Imagery, boundaries, 2013. Created by: fmackay, TMorton

6. Response plans

6.1 Triggers

6.1.1 Surface water flow triggers

Surface water flow is measured at three gauges at the Airly Mine. A water balance model was established for the purpose of being able to predict what runoff could be in the future, should there be no substantial underlying catchment change affecting the catchments hydrology. This then allows comparison to future actual observed flow rates, to provide analysis of whether catchment changes have occurred. Details of this model, its development, and outcomes are included in Appendix J and are summarised below:

- Calibration of the model was undertaken to historical observations and conditions that were observed on site at the time of preparing the report. The calibrated model established a set of 'baseline' model parameters that reflect catchment conditions for the calibration period.
- The calibrated model and its parameters had a good statistical fit, indicating that the model was able to recreate observations at the three stream gauges within the expected parameter bounds. A range of model parameters that resulted in a good statistical fit was developed, forming an acceptable parameter space reflecting realistic catchment behavior for the underlying hydrological conditions of the calibration period.
- During quarterly monitoring, the baseline model could be run using more recent meteorological data, then predicted flows compared to observed streamflow at relevant gauges. Datasets which are in good agreement suggest no notable changes to catchment characteristics or the rainfall-runoff response, whereas deviation between two datasets may warrant further investigation of catchment behavior and be potentially associated with a mining-related activity.

.Relevant triggers and parameter spaces for surface water flow are detailed in Appendix J.

6.1.2 Surface water quality triggers

6.1.2.1 Airly Creek

Water quality monitored within Airly Creek is assessed against site-specific guideline values (SSGVs) derived for the catchment following the methodology presented by the ANZECC (2000) guidelines (GHD 2018b). SSGVs are outlined in Table 6.1.

Table 6.1 Site-specific guideline values for the assessment of Airly Creek water quality

Parameter	Units	SSGV
Physicochemical parameters		
EC	µS/cm	2709
pH	pH units	6.5–8.0
TSS	mg/L	25
Turbidity	NTU	25
Nutrients		
Ammonia	mg/L	0.32

Parameter	Units	SSGV
Total nitrogen	mg/L	0.7
Total phosphorus	mg/L	0.056
Dissolved metals		
Aluminium	mg/L	0.027
Antimony	mg/L	0.001
Barium	mg/L	0.017
Beryllium	mg/L	0.001
Boron	mg/L	0.09
Cobalt	mg/L	0.001
Copper	mg/L	0.001
Iron	mg/L	0.3
Lead	mg/L	0.001
Manganese	mg/L	1.2
Molybdenum	mg/L	0.001
Nickel	mg/L	0.008
Silver	mg/L	0.001
Zinc	mg/L	0.0076
Other parameters		
Oil and grease	mg/L	5

6.1.2.2 Gap Creek and Genowlan Creek

Water quality monitored within the Gap Creek and Genowlan Creek catchments is assessed against triggers developed with reference to historical monitoring data (i.e., baselines determined from the first two years of monitoring data only). Trigger values are developed on an exceedance of 80th percentile baseline concentrations as shown in Table 6.2 for parameters where sufficient historical data is available. For pH, a range of trigger values are used, based on the 20th percentile and 80th percentile historical values.

Table 6.2 Water quality trigger values for the assessment of water quality at Gap Creek and Genowlan Creek

Parameter	Units	Trigger value		
		Gap Creek	The Grotto	Genowlan Creek 2
Physicochemical parameters				
EC	µS/cm	178	60	52
pH	pH units	6.2–7.2	5.4–6.1	5.6–6.6
TDS	mg/L	130	56	41
Dissolved metals				
Arsenic	mg/L	0.001	0.001	0.001
Cadmium	mg/L	0.0001	0.0001	0.0001

Parameter	Units	Trigger value		
		Gap Creek	The Grotto	Genowlan Creek 2
Chromium	mg/L	0.001	0.001	0.001
Copper	mg/L	0.002	0.001	0.002
Iron	mg/L	0.39	0.51	0.06
Lead	mg/L	0.001	0.001	0.001
Manganese	mg/L	0.052	0.010	0.014
Mercury	mg/L	0.0001	0.0001	0.0001
Nickel	mg/L	0.002	0.001	0.002
Zinc	msg/L	0.014	0.011	0.012

6.1.3 Discharge water triggers

Water quality limits are specified by EPL 12374 for LDP001, LDP002 and LDP003, which are provided in Table 6.3. These limits do not apply when the discharge occurs solely because of rainfall measured at the site which exceeds 44 mm over any consecutive five-day period.

Table 6.3 Licensed discharge point water quality concentration limits

Parameter	Units	90th percentile concentration limit	100th percentile concentration limit
LDP001			
Ammonia	mg/L	–	0.32
Arsenic (dissolved)	mg/L	–	0.024
EC	µS/cm	2244	–
Copper (dissolved)	mg/L	–	0.013
Nickel (dissolved)	mg/L	–	0.1
Nitrogen (total)	mg/L	2	–
Oil and grease	mg/L	–	10
pH	pH units	–	6.5–9.0
Phosphorus (total)	mg/L	0.5	–
TSS	mg/L	–	50
Turbidity	NTU	–	40
Zinc (dissolved)	mg/L	–	0.072
LDP002 and LDP003			
Oil and grease	mg/L	–	10
pH	pH units	–	6.5–9.0
TSS	mg/L	–	50
Turbidity	NTU	–	40

6.1.4 Groundwater triggers

6.1.4.1 Groundwater levels

Groundwater level trigger values have been defined with reference to observed groundwater levels and groundwater level drawdown predictions within the 2021 model update (Section 3.3.2). Trigger values for groundwater levels are presented in Table 6.4 and have been defined as observed drawdown exceeding the maximum drawdown predicted in the monitored strata. Note trigger values have been defined based on positive pressure data only.

A number of VWPs have been dry since installation or soon after installation (see Table 4.3). The absence or loss of water at these locations reflects the naturally low groundwater pressures resulting from the limited extent of the aquifer and extensive groundwater seepage/drainage area across the slopes of Mount Airly and Genowlan Mountain. In the absence of reliable monitoring data, trigger values have not been defined at these dry locations.

Further, there are a number of VWPs and standpipe monitoring bores where the drawdown predicted by the updated hydrogeological model (Section 3.3.2) would result in the VWP or bore becoming dry. The intent of the trigger values is to identify unexpected trends in groundwater levels. As these monitoring locations are predicted to become dry, no trigger values have been assigned. These monitoring locations include VWPs in the Marrangaroo Formation at ARP02 and ARP03, VWPs in the Irondale Seam at ARP06 and ARP08, VWP in the Lithgow Seam at ARP15 and the standpipe ARP13 that is installed in the Lithgow Seam.

Groundwater pressure within the Lithgow Seam at ARP04 has decreased, due to mining, below the level of the logger and is no longer trackable hence no trigger value is presented. The updated hydrogeological model indicated that the Lithgow Seam at ARP04 would be depressurised by mining. The VWP installed in the Marrangaroo Formation at ARP01 has been malfunctioning since January 2018, assumedly damaged due to formation shifts occurring due to mining in the vicinity. A consistent baseline pressure is yet to be established in the Shoalhaven Group and in the Devonian Strata at ARP13. The development of trigger values is to be revisited on review of the next six months monitoring data (January 2022).

Standpipe bores ARP05, ARP07, ARP09 and ARP12 have been dry since installation or periodically go dry due to periods of low or below average rainfall (Appendix C). Standpipe monitoring bore ARP11 has also dried since October 2019. Drying conditions in the upper formations (alluvial) reflect drying climatic conditions and water level trigger values have therefore not been defined.

Table 6.4 Groundwater level trigger values

Monitoring location	Strata	Minimum observed level (m AHD)	Predicted drawdown (m) ¹	Trigger value (m AHD) ²
ARP04	Marrangaroo Formation	743.1 ³	8.9	734
	Shoalhaven Siltstone	669.4	<2.6 ²	666.8
ARP06	Narrabeen Sandstone	868.0	3	865
ARP13	Devonian strata	571.8	1.8 ²	570
ARP14	Genowlan Creek alluvium	782.4	<2.0 ⁵	781.0 (well dry)
ARP15SP	Narrabeen Sandstone	831.4	<3 ²	828.4

1. Drawdown as predicted by the updated hydrogeological model (2021).
2. Maximum predicted drawdown in monitored strata from updated hydrogeological model (2021).
3. Pre-mining level.

6.1.4.2 Groundwater quality

Groundwater quality trigger values have been developed on an exceedance of 80th percentile concentrations from baseline groundwater monitoring data (baseline determined as the first two years of monitoring data only). Trigger values are developed as shown in Table 6.5 for parameters where sufficient baseline data is available. For pH, a tolerable range is used, based on the 20th percentile and 80th percentile baseline values. Limited data are available at ARP05 from the first 24 months and therefore trigger values at ARP05 are based on an exceedance of the 80th percentile of available data.

ARP12 SSGVs were developed from 34 data points recorded between February 2020 and December 2022. Nioka trigger values were developed using 19 data points recorded between December 2013 and September 2022, although pH trigger values were derived from March 2018 due to nil data between 2013 and 2018. Therefore, the data is not considered a true representation of baseline conditions but is relied on in the absence of earlier records.

SSGVs at GW800787, Kingdom and ARP09 were each derived using less than 24 data points (8, 16 and 20, respectively). The developed triggers therefore do not strictly conform to ANZG (2018) and may be amended in future once additional monitoring has occurred. Regardless, they are considered sufficient for use as SSGVs, being more appropriate than DGVs, for the interim. GW800787 trigger values were developed from data recorded between December 2021 and December 2023. Kingdom trigger values were developed from data recorded between November 2019 and December 2023. ARP09 trigger values were developed from data recorded between February 2020 and December 2022.

Due to the naturally elevated EC and metal concentrations at the production bore, trigger values for the production bore have not been considered.

Table 6.5 Groundwater quality trigger values

Parameter	Units	Trigger value										
		ARP05	ARP09	Village Spring	ARP11	ARP12	ARP13SP	ARP14	ARP15SP	Nioka	Kingdom	GW80078
Physicochemical parameters												
EC	µS/cm	146	56	487	1760	79	760	82	109	1669	1346	744
pH	pH units	5.8–6.0	4.79 - 5.33	7.8–8.3	6.6–7.2	5.21 - 6.4	6.7–7.2	5.7–7.2	5.9–7.5	7.04 - 7.57	6.72 - 7.24	6.79 - 7.37
TDS	mg/L	176	35	300	1170	48	463	74	71	1160	735	461
TSS	mg/L	–	-	16	–	-	–	–	–	–	–	–
Dissolved metals												
Arsenic	mg/L	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001
Cadmium	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.003	0.002	0.001	0.002	0.001	0.002	0.001	0.009	0.004	0.02	0.002
Iron	mg/L	0.08	0.74	0.05	1.14	1.19	1.28	0.9	1.54	0.21	0.13	0.18
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001
Manganese	mg/L	0.009	0.017	0.004	0.343	0.025	0.31	0.081	0.282	0.018	0.007	0.039
Mercury	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.003	0.002	0.004	0.006	0.001	0.003	0.002	0.011	0.001	0.004	0.005
Zinc	mg/L	0.081	0.032	0.026	0.016	0.182	0.033	0.033	0.067	0.08	0.024	0.024

6.1.4.3 Groundwater inflows

Groundwater inflows are estimated from the transfers between the surface and underground workings, which are metered (i.e., groundwater inflows = transfer from underground workings to surface – transfer from surface to underground workings). The estimated groundwater inflows are then compared to the predicted groundwater inflows, as presented in Figure 3.3. Triggers are based on an estimated groundwater inflow volume exceeding predictions by 10% (Stage 1 trigger) or 20% (Stage 2 trigger) over three consecutive months. If observed inflows exceed licensed volume under the WALs held by Airly Mine (refer Section 1.2.5), then additional WALs will be required to be purchased to cover the excess groundwater volume.

Mining at Airly Mine is not predicted to impact at Village Spring as there is an offset boundary around the New Hartley Shale Interaction Zone.

6.1.5 Nissan Hut Dam level triggers

Surface water level trigger for Nissan Hut Dam have been as the recorded water level not declining below the baseline rate, beyond that explained by climatic influence (i.e., changes in rainfall and / or evaporation). Manual gauging of the dam began in January 2022 with continuous level monitoring commencing in May 2022. Therefore, the data record is too short to ascertain a baseline rate. Further, mining commenced in the vicinity of Nissan Hut Dam in March 2022. Until such time that a stabilised water level can be determined effectively representing “baseline”, any drop below the base of the monitoring device will be the trigger for further investigation.

6.2 Performance criteria

Performance criteria have been developed from baseline information and the performance measures specified by Table 1 and Table 6 of development consent SSD-5581 presented in Table 1.3. The performance criteria have been developed to ensure that impacts as a result of mining operations are not greater than those predicted by the environmental impact assessments for the approved Airly Mine Extension Project and subsequent modifications. The triggers presented in Section 6.1 have been developed to prompt specific actions (identified in the TARPs provided in Appendix F) to prevent the exceedance of the performance criteria. Further information on the approach used to develop performance criteria is provided in the *Western Operations: Regional Water Management Plan*.

6.2.1 Surface site operations

Performance criteria for surface water management are provided in Table 6.6.

Table 6.6 Surface site operations criteria

Aspect	Criteria
Water management – general	Minimise the use of clean water on site. Minimise the use of the supplementary water supply from the production bore.
Surface storages	Storages sized in accordance with Landcom (2004) and DECC (2008) and maintained within the capacity of each storage.

Aspect	Criteria
Erosion and sediment control	<p>Minimising disturbance area.</p> <p>Surface disturbance and other construction activities are to be managed in accordance with the approach and guidelines outlined in Section 4.7.</p> <p>Design, install and maintain erosion and sediment controls in accordance with Landcom (2004) and DECC (2008).</p> <p>Where construction works are significant, an erosion and sediment control plan and construction environmental management plan will be prepared.</p>
Mine water storages	<p>Design, install and maintain mine water storage infrastructure to ensure no unlicensed or uncontrolled discharge of mine water off-site.</p> <p>Minimise discharges to surface waters as far as reasonable and practicable.</p> <p>New on-site storages (including mine infrastructure dams, groundwater storage and treatment dams) are suitably treated to comply with a permeability standard of $< 1 \times 10^{-9}$ m/s.</p> <p>Achieve an improvement in the quality of water held in the Production Dam generally in accordance with Figure 6-7 in Appendix F of the EIS (surface water impact assessment) over the life of the mine.</p>
Hydrocarbon management	<p>Chemical and hydrocarbon storage to be undertaken in accordance with Australian Standard AS1940:2004.</p>

6.2.2 Watercourses

Performance criteria for watercourses are provided in Table 6.7.

Table 6.7 Watercourse criteria

Aspect	Criteria
Waterfront land and watercourses	<p>Design, install and maintain any infrastructure within 40 m of watercourses generally in accordance with NOW (2012a; 2012b).</p> <p>Design, install and maintain creek crossings in accordance with NSW Fisheries (2003a; 2003b).</p>
Flow volume	<p>No greater consequences than predicted in the EIS to water flows (including baseflow).</p>
Water quality	<p>No greater environmental consequences than predicted in the EIS for watercourses other than Gap Creek and Genowlan Creek. Within or below SSGVs provided in Table 6.1 for Airly Creek.</p> <p>Negligible environmental consequences to water quality for Gap Creek and Genowlan Creek. Within or below triggers provided in Table 6.2.</p>

6.2.3 Discharge management

Performance criteria for discharge management are provided in Table 6.8.

Table 6.8 Discharge management criteria

Aspect	Criteria
Flow volume	No greater impacts than predicted in the EIS in Airly Creek between LDP001 and Point 4 (refer Appendix 9 of EIS). Negligible environmental consequences for flow in Airly Creek where it enters the Gardens of Stone National Park and Greater Blue Mountains World Heritage Area.
Water quality	Within or below water quality limits for LDPs provided in Table 6.3. No greater impacts than predicted in the EIS for water flow and quality in Airly Creek between LDP001 and Point 4 (refer Appendix 9).

6.2.4 Groundwater environment

Performance criteria for the groundwater environment are provided in Table 6.9.

Table 6.9 Groundwater environment criteria

Aspect	Criteria
Groundwater level	Above trigger values (in m AHD) provided in Table 6.4. No complaints regarding groundwater access.
Groundwater quality	Within or below trigger values provided in Table 6.5. Current beneficial usage category is maintained. No complaints regarding groundwater quality.
Groundwater inflows	Consistent with hydrogeological model predictions.

6.2.5 Nissan Hut Dam

No relevant performance criteria for Nissan Hut Dam are included in development consent SSD-5581. Performance criteria for water levels within Nissan Hut Dam have been developed, provided in Table 6.10.

Table 6.10 Nissan Hut Dam level criteria

Aspect	Criteria
Nissan Hut Dam water level	Trigger level exceedance defined in Section 6.1.5. No complaints regarding recreational use or firefighting access.

6.2.6 Stream health

Performance criteria developed for stream health are provided in Table 6.11.

Table 6.11 Stream health criteria

Aspect	Criteria
Bed and bank stability	Negligible environmental consequences to bed and bank stability for Gap and Genowlan Creeks. Maintain or improve baseline channel stability.
Incisional processes and instabilities	Occurrence of erosional processes does not occur as a result of subsidence.
Stream gradient	Change in stream gradient does not vary beyond predictions of subsidence modelling.
Watercourse subsidence	No connective cracking between the surface and underground workings. Subsidence does not vary beyond predictions of modelling.
Instream/riparian vegetation	RCE scores relating to riparian and instream vegetation within historical range and/or consistent with reference sites.

6.3 Trigger action response plans

TARPs have been provided in Appendix F for:

- Surface site operations
- Watercourses
- Nissan Hut Dam water level
- Discharge management
- Groundwater environment
- Stream health

7. Site-specific reviews and reports

7.1 Surface water and groundwater monitoring

Quarterly reports are prepared to detail the results of surface water and groundwater monitoring as well as an annual report for inclusion in the Annual Review for Airly Mine. Results are compared to historical monitoring data and applicable trigger values, as presented in Section 6.1. Compliance with the performance criteria for surface water and groundwater quality presented in Section 6.2 is also assessed.

7.2 Watercourse stability monitoring

A report is prepared following watercourse stability monitoring that describes the monitoring undertaken. The report includes an assessment of the geomorphic condition of each monitored reach and compliance with the performance criteria relating to watercourse stability presented in Section 6.2.5.

7.3 Aquatic ecology monitoring

A report is prepared annually that describes the aquatic ecology monitoring undertaken during the previous year. The report includes an assessment of any impacts from Airly Mine discharges or other operations on the condition of aquatic flora and fauna. A summary of the aquatic ecology monitoring results is provided as part of the Annual Review for Airly Mine.

7.4 Site water balance

The site water balance is reviewed and revised annually as a minimum or as necessary when there are changes to operations. The results of the site water balance are reported in the Annual Review for Airly Mine.

7.5 Environmental auditing

Centennial Airly environment personnel conduct site inspections to assess compliance and performance against environmental requirements.

The development consent for Airly Mine specifies the requirements for external independent environmental audits. An independent environmental audit must be undertaken within the first year after a new consent is granted and then every three years thereafter.

7.6 Hydrogeology model

The hydrogeological model validation program compares actual and modelled mine groundwater inflows and monitored and modelled groundwater level predictions on an annual basis.

Where the validation process identifies significant variances between monitored and predicted mine groundwater inflows or that the hydrogeological model is underestimating drawdown in groundwater level, then a recalibration process may be required to be undertaken in consultation with an independent reviewer. A summary of the hydrogeological model validation will be prepared as part of the Annual Review for Airly Mine. The annual review will include comparison of predicted drawdowns against groundwater level observations.

As part of any Independent Environmental Audit of Airly Mine, an independent expert is required to carry out a review of the groundwater management plan, including the hydrogeological model. Appendix F provides the independent review of the groundwater management plan carried out in May 2018, along with a table outlining how the outcomes of the review have been addressed in the WMP.

7.7 Document control

Centennial Airly will ensure that this WMP is readily accessible to Centennial employees and contractors. It is the responsibility of the Environment and Community Coordinator to ensure that any revised edition of this document is made readily accessible to all on-site Centennial employees and contractors. The revision procedure involves:

- Master copy of the WMP will be updated as necessary.
- Each version of the WMP will be clearly dated, with the version of the report noted. The updated version of the WMP may be issued to stakeholders for comment.
- The most current version of the WMP will be made readily available to all employees and contractors via electronic means and a hard copy on-site.

8. Action plan

WMP section	Requirement	Frequency
Site inspections		
Section 4.1	Site inspection of water management and sediment control structures. Maintenance of structures as necessary.	Weekly (minimum) or as soon as practicable following rainfall events that exceed 20 mm in 24 hours.
Surface water quality		
Section 4.2.1	Water quality monitoring of Production Dam, Stockpile Dam, Train Loader Dam, Dirty Water Dam, Office Tank for parameters specified in Table 4.1.	Monthly/annually
	Compare monitoring results to historical results and analyse for trends.	Quarterly/annually
Section 4.2.1	Water quality monitoring of Airly Creek Upstream and Airly Creek sites for parameters specified in Table 4.1.	Monthly
	Compare monitoring results to SSGVs presented in Table 6.1 and respond according to TARPs in Appendix F.	Quarterly
Section 4.2.1	Water quality monitoring of Gap Creek, the Grotto and Genowlan Creek 2 sites for parameters specified in Table 4.1.	Monthly/annually
	Compare monitoring results to trigger values presented in Table 6.2 and respond according to TARPs in Appendix F.	Quarterly/annually
Surface water flow		
Section 4.2.2	Continuous flow monitoring of Gap Creek, Genowlan Creek and Genowlan Creek 2 sites.	Continuous (automated)
	Compile surface water flow monitoring and rainfall data. Compare results with historical monitoring and respond according to TARPs in Appendix F.	Quarterly

WMP section	Requirement	Frequency
Discharges		
Section 4.3	Water quality monitoring of any discharges for parameters specified in Table 4.2.	Monthly during discharge
	Continuous flow monitoring.	Continuous (automated)
Groundwater quality		
Section 4.4.1	Water quality monitoring of groundwater bores for parameters as specified in Table 4.4.	Monthly/quarterly/annually
	Compare monitoring results to trigger values presented in Table 6.5 and respond according to TARPs in Appendix F.	Quarterly/annually
Groundwater levels		
Section 4.4.1	Piezometric pressure monitoring in VWPs and groundwater level monitoring in standpipes.	Six to 12 hours (automated)
	Download data loggers and compile monitoring data. Compare results to trigger values presented in Table 6.4 and respond according to TARPs in Appendix F.	Quarterly
Section 4.4.1	Continuous monitoring of seepage from Village Spring.	Continuous (automated)
	Compare monitoring results to historical results and analyse for trends.	Quarterly

WMP section	Requirement	Frequency
Underground water transfers		
Section 4.4.2	Monitoring of all transfers of water to and from the underground workings.	Daily (automated)
Groundwater inflows		
Section 6.1.4	Estimate groundwater inflows from the metered transfers between the surface and underground workings (refer Section 6.1.4).	Monthly
	Compare estimated groundwater inflows with the hydrogeological model results presented in Figure 3.3 and respond according to TARPs in Appendix F.	Monthly
	Compare estimated groundwater inflows with WAL allocation and respond according to TARPs in Appendix F.	Annually
Watercourse stability		
Section 4.6.1	Watercourse stability monitoring of third order streams as shown in Figure 4.3 and in areas where subsidence survey monitoring indicates greater than predicted subsidence. Respond according to TARPs in Appendix F.	Every two years
Aquatic ecology		
Section 4.6.2	Aquatic ecology monitoring as presented in Section 4.6.2. Respond according to TARPs in Appendix F.	Every six months

WMP section	Requirement	Frequency
Reporting		
Western Operations: Regional Water Management Plan	<p>An Annual Review must be prepared that:</p> <ul style="list-style-type: none"> • Reviews the performance of the site against the requirements of the <i>Western Operations: Regional Water Management Plan</i> and the site-specific water management plan (this document). • Provides an overview of environmental management actions taken. • Summaries the monitoring results over the 12 month reporting period. 	Annually
Western Operations: Regional Water Management Plan	An annual return must be prepared for EPL 12374 on compliance with the requirements of the licence including a summary of environmental monitoring.	Annually
Western Operations: Regional Water Management Plan	Discharge monitoring data must be made publicly available on the Centennial website.	Monthly
Western Operations: Regional Water Management Plan	<p>A logbook/record must be kept for WALs 24386 and 36565 that includes the following details:</p> <ul style="list-style-type: none"> • The date and period of time during which groundwater was taken under the WAL. • The volume of water taken. • The approval number of the water supply work used to take the water. • The purpose for which the water was taken. 	As required when groundwater is taken
Western Operations: Regional Water Management Plan	The Natural Resource Access Regulator (NRAR) must be notified in writing immediately upon becoming aware of a breach of any conditions set out in WALs.	Immediately upon becoming aware of any breach
Western Operations: Regional Water Management Plan	The EPA must be notified of incidents causing or threatening material harm to the environment immediately after the person becomes aware of the incident. Notifications must be made by telephoning the Environment Line service on 131 555. Written details about the notification to the EPA must be provided within seven days of the incident.	Immediately upon becoming aware of any incident

WMP section	Requirement	Frequency
Western Operations: Regional Water Management Plan	<p>A record of any complaints in relation to pollution arising from any site activities must be kept. The record must include the following details:</p> <ul style="list-style-type: none"> • The date and time of the complaint. • The method by which the complaint was made. • Any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect. • The nature of the complaint. • The action taken by Centennial in relation to the complaint, including any follow-up contact with the complainant. • If no action was taken by Centennial, the reasons why no action was taken. 	As required when a complaint is made
Section 7.1	Prepare a surface water and groundwater monitoring report.	Quarterly/annually
Section 7.2	Prepare a watercourse stability monitoring report.	Every two years
Section 7.3	Prepare an aquatic ecology monitoring report.	Annually
Model reviews		
Section 7.4	Review and revise site water balance model, with results to be included in the Annual Review.	Annually or as necessary

9. References

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ZOIC Environmental Pty Ltd (2019) Re: External review of Proposed Monitoring of Selected Landholder Wells, Airly Mine, letter dated 18 September 2019.

ZOIC Environmental Pty Ltd (2021) Re: External Review of the Airly Mine Annual Review for 2020 Relevant to Local Landholders, letter dated 8 July 2021.

Appendices

Appendix A – Correspondence with regulators

SUBMISSION FOR APPROVAL DETAILS				
Revision	Circulation date	Feedback date	Approval date	
0	28 April 2017			
1				
2	28 July 2017	1 June 2018		
3	23 July 2018		7 September 2018	
4	30 October 2019			
5	29 March 2021			
6	20 August 2021	3 November 2021		
7	23 February 2023	31 March 2023		
8	2 June 2023	15 January 2024		
9				
CONSULTATION DETAILS				
Department	Circulation date	Feedback date		
Commonwealth Department of the Environment and Energy	28 March 2017			
NSW Environment Protection Authority	28 March 2017			
	23 June 2017			
NSW Department of Primary Industries – Water	28 March 2017	25 May 2017		
	28 July 2017	13 September 2017		
WaterNSW	28 March 2017	25 May 2017		
	23 June 2017			
NSW Office of Environment and Heritage	23 June 2017	27 June 2017		
NSW Department of Planning and Environment	20 August 2021	3 November 2021		

Airly Mine
Water Management Plan

	NSW Department of Planning and Environment – Water NSW Department of Planning and Environment – Biodiversity and Conservation Department of Planning	23 February 2023	31 March 2023
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Appendix B – Consultation outcomes

Comment	Response
Department of Primary Industries – Water (letter dated 25 May 2017)	
Since the performance criteria form the basis of gauging the effectiveness of the WMP, a summary of the approach used to develop Section 6.2 – Performance Criteria should be provided instead of referring to the Regional Water Management Plan. The approach used in developing the performance criteria establishes the WMP rationality and enable it to be a complete stand-alone document.	Section 6.2 has been amended to include more detail regarding the approach used to develop the water management performance criteria.
The document should provide a definition to PIRMP (Pollution Incident Response Management Plan: EPA-2012) in the Trigger Action Response Plan (TARP) and list the government agencies as per the PIRMP requirements. It needs to be clear which agencies are responsible for the PIRMP requirements.	A definition of PIRMP has been added to the TARP and the list of abbreviations. Airly Mine's PIRMP is a separate management plan to the WMP. A copy of the PIRMP (both hardcopy and electronic) is available at the site as well as on the Centennial website. Details of the relevant government authorities and contact details for reporting pollution incidents are provided in the PIRMP.
Details of the TARP should be in the main body of the WMP since it is the action plan proposed to be implemented in case of trigger levels in the Performance Criteria not being met. Documents that form the Appendices are considered technical documents in support of but not essential part of the main report document.	TARPs have been provided in an appendix to allow operational staff to access the plans easily. This structure is consistent with other management plans for Airly Mine as well as other Centennial sites.
The groundwater level performance criteria which states "Within or above trigger values provided in Table 6.3" could be misinterpreted as it implies that the groundwater level drawdown 'above' the trigger values could also mean higher groundwater level drawdown than the trigger levels. It is recommended to clarify this statement to include trigger groundwater level as groundwater elevation in AHD. It is suggested that the performance criteria statement changed to ' <i>Within or above groundwater trigger values as elevation in AHD provided in Table 6-3 (Groundwater Trigger Values)</i> '.	Groundwater level trigger values provided in Table 6.4 have been provided as groundwater elevation in m AHD. The performance criteria for groundwater level has been amended to clearly refer to the trigger values provided in Table 6.4.

Comment	Response
<p>Section 7 – Specific reviews and reports list the proposed reports under the subheadings stygofauna monitoring, site water balance and hydrogeology model. This section needs to include all the proposed reports including incident reporting, groundwater monitoring report, water management plan review, annual environmental report (Annual Review) and include a discussion on report frequency, chronological order and sequence and report recipients (i.e. list of reviewing government agencies).</p>	<p>The <i>Western Operations: Regional Water Management Plan</i> was developed to define the water management requirements across Centennial sites within the Western Coalfield and to standardise the management of water. As such, all reporting procedures that are required across all Centennial sites, including annual reviews, annual returns for EPLs, environmental monitoring, incidents and complaints, are detailed in the Regional Water Management Plan. Only reporting requirements that are specific to Airly Mine are provided within this WMP.</p>
<p>It is suggested: Figures 1.2, 2.5, 3.2, 4.1, 4.2, 4.3, 4.4 and 5.5 are amended so that the names of the creeks are legible. The creek names on these figures are blurred. A brighter coloured blue is used to clearly show the location of the creeks on Figures 4.1, 4.2, 4.3 and 4.4. Figure 2.5 is amended to distinguish between any existing and proposed workings associated with the extension project (SSD-5581).</p>	<p>Figures have been amended to make waterways and names clearer. Figure 2.6 has been amended to include the life of mine workings for Airly Mine.</p>
<p>It is suggested Section 2.5 includes a summary table which identifies all the proposed monitoring associated with the creek systems for the Airly Mine proposal and identifies the relevant WMP sections.</p>	<p>Table 2.2 has been added to Section 2.5 to provide a summary of the surface water monitoring undertaken.</p>
<p>It is suggested Section 4.2.1 explains why surface water quality monitoring is not proposed to be undertaken at the Torbane Creek aquatic ecology baseline monitoring site.</p>	<p>Although the upper reaches of Torbane Creek is located within the Airly Mine boundary, the creek is not planned to be undermined, with no subsidence impacts predicted for this catchment. As such, no routine water quality monitoring is proposed for Torbane Creek. Monitoring of subsidence and watercourse stability will detect any changes to the waterway, with additional monitoring triggered within the TARP (provided in Appendix F) as required.</p>
<p>Section 4.2.2 notes continuous flow monitoring is currently undertaken at Gap Creek and Genowlan Creek (page 40). It is unclear why flow monitoring is not proposed, for example on Torbane Creek as Section 4.5.2 indicates this creek is subject to potential subsidence as a result of mining and it will be monitored for watercourse stability. The WMP needs to address this.</p>	<p>As discussed above, no impacts are predicted for Torbane Creek as a result of mining operations at Airly Mine. As such, no routine flow monitoring is proposed for Torbane Creek. Monitoring of subsidence and watercourse stability will detect any changes to the waterway, with additional monitoring triggered within the TARP (provided in Appendix F) as required.</p>

Comment	Response
Section 4.5.1 notes watercourse stability monitoring is undertaken on third order streams within the site boundary (page 46). It is suggested this section includes details on when the watercourse stability monitoring commenced.	Section 4.6.1 has been amended to provide details on the commencement of the watercourse stability monitoring program.
It is unclear if this monitoring is meant to be undertaken on all third order streams within the site boundary, or if it is to only be undertaken along the three sections of creeks which are shown in purple on Figure 4.3. Figure 4.3 shows there are some other third order creeks which are not being monitored. It is recommended Section 4.5.1 explains why monitoring is not undertaken along the other third order streams.	Figure 4.3 has been updated to include all third order streams within the Airly Mine boundary.
Based on Section 4.5.1 and Figure 4.3, the monitoring of watercourse stability appears to involve visual inspections along the full length of the watercourses which are shown in purple on Figure 4.3. The WMP should clarify this.	This is correct. As stated in Section 4.6.1, watercourse stability monitoring is undertaken on third order streams within the site boundary, as shown in Figure 4.3.

Comment	Response
<p>Section 4.5.1 indicates watercourse stability monitoring for Airly Mine will be undertaken every two years (page 46). The WMP for Springvale Mine extension indicates such monitoring would be undertaken monthly so there is quite a difference between the frequency of this monitoring between Springvale Mine and Airly Mine. It is unclear why there is such a difference in the frequency of monitoring between the two mines.</p>	<p>The watercourse stability monitoring programs at Airly Mine and Springvale Mine are not directly comparable, due to a number of operational and environmental variables, including mine design and mining method, geology, sensitivity of environmental features and predicted subsidence impacts.</p> <p>A key aspect of the mine plan for Airly Mine is the protection of sensitive surface features by implementing extraction methods that are expected to lead to very low levels of subsidence (less than 125 mm). High-confidence survey methods are used to monitor subsidence and confirm the very low levels of subsidence expected. The conditions of development consent SSD-5581 associated with subsidence are strict and require Centennial to achieve no greater subsidence impacts or environmental consequences than predicted in the EIS (Golder Associates 2014).</p> <p>As assessment of waterway geomorphology impacts as a result of the Airly Mine Extension Project was undertaken by GHD (2014e). The third order watercourses that overlie the approved mine workings are limited to Gap Creek and Genowlan Creek, with restricted mining approved under these watercourses in order to protect these sensitive surface features. Based on the assessment by GHD (2014e), any impacts to the morphology of surface waterways are likely to be negligible and not measurable.</p> <p>In addition to watercourse stability monitoring of third order streams every two years, monitoring will also be undertaken in areas where subsidence survey monitoring indicates greater than predicted subsidence. This additional monitoring is triggered within the TARP (provided in Appendix F) as required.</p>
<p>The WMP should provide details as to when subsidence impacts and any residual subsidence impacts are expected to finish.</p>	<p>Subsidence impacts and expected timing of any impacts is provided within the relevant Extraction Plan.</p>
<p>It is suggested Section 4.5.1 is cross referenced to Section 5.4.1.</p>	<p>Cross-reference between monitoring requirements and baseline results has been made in Section 4.</p>
<p>It is suggested Section 4.5.2 is cross referenced to Section 5.4.2.</p>	

Comment	Response
<p>Section 4.5.2 notes the monitoring of baseline sites is planned to cease following the spring 2017 round. The section indicates the waterways associated with the baseline sites are subject to potential subsidence as a result of mining. It is unclear why the aquatic ecology monitoring is not proposed to continue at these sites to detect any change that may occur as a result of the mine extension project (page 47).</p>	<p>Monitoring of baseline sites is planned to cease following 2017 as sufficient baseline aquatic ecology data for these sites will exist.</p> <p>As discussed above, the mine plan for Airly Mine has been designed to result in minimal subsidence impact, with limited mining under sensitive surface features. The Aquatic Ecology and Stygofauna Assessment for the Airly Mine Extension Project (Cardno 2014) concluded that impacts to aquatic ecology are unlikely.</p>
<p>Section 5.4.2 notes the aquatic habitat was determined to be in the best condition in the baseline site of Genowlan Creek. Ongoing monitoring of this site would assist to identify and assess any potential impacts caused by mine subsidence. It is suggested the WMP explains why ongoing monitoring of the baseline sites is not required.</p>	<p>Monitoring of subsidence will be used to detect any changes to surface features, with additional monitoring triggered within the TARP (provided in Appendix F) as required. Additional aquatic ecology monitoring would be undertaken to understand any impacts by comparison with the baseline dataset.</p> <p>Note that aquatic ecology monitoring of Airly Creek background and impact sites (Airly Creek Upstream and Airly Creek) will continue to monitor any impacts as a result of discharges from the site.</p>
<p>Figures 4.1 and 4.4 indicate: Flow and water quality monitoring is not being undertaken at the aquatic ecology baseline site on Torbane Creek. It is suggested the WMP explains why flow and water quality monitoring is not being undertaken at Torbane Creek, especially as headward erosion is evident along the tributaries of Torbane Creek.</p> <p>The water quality monitoring site at the Grotto does not have aquatic ecology monitoring associated with it. If water quality is potentially impacted by the project it is recommended aquatic ecology monitoring is undertaken to assess the impact on stream health.</p>	<p>As discussed above, no impacts are predicted for Torbane Creek as a result of mining operations at Airly Mine. As such, no routine water quality or flow monitoring is proposed for this waterway. Monitoring of subsidence and watercourse stability will detect any changes to the waterway, with additional monitoring triggered within the TARP (provided in Appendix F) as required.</p> <p>If water quality monitoring at the Grotto is outside or above the values specified in Table 6.2, the TARP for watercourse quality (provided in Appendix F) will trigger the action to undertake additional monitoring (including aquatic ecology monitoring) where relevant.</p>
<p>Section 5.4.1 refers to localised bank erosion and that these reaches are typically associated with degraded riparian vegetation conditions (page 55). The WMP should clarify if it is proposed to stabilise the areas with existing localised bank erosion and revegetate the riparian corridors that have been identified as degraded.</p>	<p>No works are currently proposed by Centennial to remediate any waterways with existing erosion. Monitoring of subsidence and watercourse stability will detect any changes to the waterway, with corrective actions triggered within the TARP (provided in Appendix F) as required, including stabilisation works.</p>

Comment	Response
<p>The section notes poor condition reaches are associated with active headcuts and headward erosion was evident along Gap Creek and tributaries of Torbane Creek and Airly Creek (page 55). The WMP should clarify if it is proposed to remediate the areas identified with headward erosion.</p>	
<p>Department of Primary Industries – Water (letter dated 13 September 2017)</p>	
<p>DPI Water recommends that water quality be used to establish thresholds in the Trigger Action Response Plan (TARP). This is required to monitor and assess the hydrological connection between the mine and overlying shallow aquifer and surface water systems.</p>	
<p>NSW Department of Planning and Environment (email dated 1 June 2018)</p>	
<p>It is recommended that Figures be updated to include the approved Development Consent boundary and relevant figures (for example groundwater monitoring locations) include the current and project extension workings and surface infrastructure.</p>	<p>All figures have been updated to show the approved development consent boundary, existing and approved underground workings and surface infrastructure where appropriate.</p>
<p>Where commitments are met through a reference to another document (for example the Regional Water Management Plan), it is recommended to either attach the document or provide further description (strategic focus) of how the matter will be managed.</p>	<p>This site-specific WMP for Airly Mine is an appendix to the <i>Western Operations: Regional Water Management Plan</i>. The relationship of this plan to other management plans is provided in Section 1.3.</p>
<p>It is recommended that the WMP be updated to describe further how the outcomes geomorphic condition and watercourse stability monitoring described in Section 4 are incorporated into triggers and performance criteria for watercourses and stream health.</p>	<p>A baseline assessment of geomorphology at Airly Mine to determine the existing condition of creeks was undertaken for the Airly Mine Extension Project (GHD 2014e). No measurable impacts to waterway geomorphology were predicted by GHD (2014e) as a result of mining or discharges from the surface facilities area. Table 6.11 provides the performance criteria developed for geomorphic condition and watercourse stability based on the existing conditions and subsidence modelling predictions. The outcomes of the monitoring described in Section 4.6.1 are compared to the performance criteria, with specific actions identified in the TARPs provided in Appendix F triggered to prevent exceedance of the performance criteria.</p>

Comment	Response
NSW Department of Planning and Environment (letter dated 3 November 2021)	
<p>Section 1: Can you please show evidence of approval from the Secretary for these people to undertake this review (Condition 13A, Schedule 4)</p>	<p>CVs for relevant personnel who are responsible for updating the WMP have been provided to regulator for approval in December 2022 as part of the Point Hatteras Extraction Plan process.</p>
<p>Can you please show evidence of consultation with DAWE, EPA and NSW Water (Condition 13A, Schedule 4) for the changes in this revision of the WMP.</p>	<p>The WMP has been provided to Water NSW, DPE Water and Department of Climate Change, Energy, the Environment and Water as part of the Point Hatteras Extraction Plan process.</p>
<p>Table 3-2: Can you please give justification/reasoning as to why the dam size of the Train Loader Dam has increased</p>	<p>The size of the Train Loader Dam was increased to reduce the likelihood of discharges via LDP003 into Airly Creek during high rainfall events.</p>
<p>Table 4-1: Why have some surface water quality been removed from the plan</p>	<p>As stated within the body of the text, numerous analytes within the suite have a history of being undetected/below detection levels. On this basis, their inclusion in the analytical suite is no longer warranted. Further, ongoing monitoring monitors for changing impacts and therefore reliance on key indicators of water quality is sufficient. The reduction in the analytical suite is consistent with recommendations presented by independent reviews by Jacobs (2018), ZOIC (2019) and SLR (2021) which endorsed both the reduced frequency of sampling and the reduced suite by removing elements that were not typical indicators of general water quality, did not have associated guideline values and/or were unlikely to be associated with mining influence (i.e., nutrients likely to be resultant of surrounding agricultural land use).</p>
<p>Table 4-3: What is the plan for the dysfunctional VWPs</p>	<p>Dysfunctional VWPs will be decommissioned in accordance with industry standards outlined in NUDLC (2020).</p>

Comment	Response
<p>Table 4-4: Why have some of the groundwater quality parameters been removed from the plan</p>	<p>As stated within the body of the text, numerous analytes within the suite have a history of being undetected / below detection levels. On this basis, their inclusion in the analytical suite is no longer warranted. Further, ongoing monitoring monitors for changing impacts and therefore reliance on key indicators of water quality is sufficient. The reduction in the analytical suite is consistent with recommendations presented by independent reviews by Jacobs (2018), ZOIC (2019) and SLR (2021) which endorsed both the reduced frequency of sampling and the reduced suite by removing elements that were not typical indicators of general water quality, did not have associated guideline values and/or were unlikely to be associated with mining influence (i.e., nutrients likely to be resultant of surrounding agricultural land use).</p>
<p>NSW Department of Planning and Environment: Water (letter dated 31 March 2023)</p>	
<p>That Centennial Coal quantifies the maximum groundwater take consistent with the definition in the NSW Aquifer Interference Policy (AIP). Sufficient entitlement must be held in a water access license to account for the water take in each water source prior to the take occurring.</p> <p>The Water Management Plan (WMP) outlines that groundwater inflows have been estimated 'from transfers between the surface and underground workings, which are metered (i.e., groundwater inflows = transfer from underground workings to surface – transfer from surface to underground workings)'. This is not consistent with the definition of groundwater inflows in the AIP which states that the removal of water from a water source is the water leaving the aquifer and entering the void.</p>	<p>The following has been added to Section 3.3.1:</p> <p><i>Mine dewatering infrastructure provides metering of all mine dewatering to facilitate reporting to WAL requirements. However, to date, inflows to the mined voids have predominantly been too low to be measured (e.g., 0 ML/year reported for 2020, 2021 and 2022) and not sufficient to require mine dewatering. Monitoring results indicate that groundwater inflow volumes and process water used in underground operations is entrained in the ROM coal. As a result, all groundwater inflows and additional water is removed from the site as product coal moisture, with no water available to be reclaimed and reused as process water. 20 ML and 0.3 ML were transferred to surface in 2018 and 2019, respectively, however total volumes were reportedly surface water accumulations entering the from the facilities area. Inflows are reported to increase in response to rainfall events but remain below measurable volumes.</i></p>

Comment	Response
<p>That Centennial Coal provide the 2021 groundwater model supported by an external Independent Review to assess the suitability of the groundwater trigger levels and monitoring regime.</p> <p>The WMP states that the hydrogeological model, developed as part of the Airly Mine Extension Project, was updated to reflect the 2021 mine plan and schedule. This updated hydrogeological model has been used to produce revised drawdown predictions, upon which groundwater trigger levels and the future usability of current monitoring sites has been assessed.</p> <p>However, the updated hydrogeological model and the external independent review has not been made available to DPE Water to assess the suitability of the WMP and its monitoring provisions against the updated groundwater level drawdown projections.</p>	<p>The following reports can be submitted to the DPE:</p> <ul style="list-style-type: none"> • Hydro Algorithmics (2019) Letter Report for Airly Mine Modification MOD3 – Groundwater Assessment Peer Review, dated 24 July 2019, reference HA2019/08 • GHD (2020b) Airly Mine Groundwater Model Review, prepared by GHD Pty Ltd for Centennial Coal Company Limited <p>It is noted the model is likely to undergo update and recalibration in 2024 prior to the next scheduled independent review.</p>
<p>That Centennial Coal provides an explanation for the difference between modelled and observed groundwater inflows shown in Figure 3.3 of the WMP.</p> <p>A comparison between modelled and observed groundwater inflows was shown in Figure 3.3 of the WMP. It shows that minimal observed groundwater inflows have occurred since January 2012 and are much lower than the modelled groundwater inflows. No explanation has been provided nor referenced to explain this discrepancy.</p>	<p>Section 3.3.2 has been amended as follows:</p> <p><i>The mine footprint and schedule were amended in the groundwater model in 2021 in accordance with the updated Airly Mine Plan (ref: AIR_2021 BGT PO2 G01 R00 S15 -20210629.dwg).</i></p> <p><i>Application of the new plan resulted in changes to the modelled drainage system footprint which represents the mined voids and, subsequently, the fracture zones represented in the model. Additionally, the operational timing of the drainage system was amended in line with the new mining schedule. No other changes to model parameters were applied. The amendments were minimal did not constitute preparation of a stand-alone monitoring report.</i></p> <p><i>Incorporation of the updated mine plan resulted in a reduction in the estimated peak inflows from the previous estimate of 76 ML (2030) to 67 ML (2029) occurring because of decreased subsidence impacts (Figure 3.3). Despite the reduction, the model continues to present overly conservative inflow estimates.</i></p>

Comment	Response
	<p><i>The model assumes aquifer saturation from below the water table in the upper alluvial strata. It is likely the simulated storativity is too high with actual saturation zones and permeabilities being lower than represented in the model. This may be resulting from overestimated storage coefficients, hydraulic conductivities and / or anisotropy ratios, the latter of which may currently be underestimating lateral flow and discharge at mesa faces.</i></p> <p><i>While the model has been calibrated to water levels informed by the monitoring network, it is clear achieving calibration is non-unique. In this instance, given the low stored water volumes and low risk nature of dewatering impacts, further work, which could be extensive, towards a more unique model and more representative inflow estimates is considered unwarranted.</i></p>

Comment	Response
<p>That Centennial Coal revise the site water balance predictions to include data from all previous years of operation, not just the wet year of 2022.</p> <p>A summary of the site water balance results (Table 3.3 of the WMP, Table 1 in the appendix of this memo appendix) for future conditions is based on the annual site water balance for 2022. DPE Water does not agree that using the site water balance for one year of operation is appropriate to determine a probable site water balance for future conditions. Future water balances should be predicted using multiple years of data.</p>	<p>Section 3.5 has been updated to reference the latest water balance review (GHD, 2019e) and state the following:</p> <p><i>The water management system for Airly Mine was developed in GoldSim and simulated over the projected life of the mine, from 2018 until 2040. To assess the impact of rainfall on the site, modelling for the approved and proposed conditions was completed by using a historical time series of daily rainfall data extending over 130 years. A total of 130 simulations were applied, with each simulation modelling a different rainfall pattern from the record. Future predictions are based on the mean of a set of probabilistic results and approved annual site operations (GHD, 2019e). Approved annual site operations include predicted groundwater inflows, production rates, staffing, annual water transfer limits and pumping/overflow rules.</i></p> <p><i>Overall, the forecast indicated sufficient water sources to meet process water requirements or a process water deficit of up to 42 ML/year in a “dry” year (GHD, 2019e). No water surplus was predicted and no increase in the frequency or magnitude, nor a deterioration of water quality, of potential discharges.</i></p> <p>It is further noted that the results for the year of operation presented in Table 3.3 of the WMP are the mean of a set of probabilistic results and representative of probable site operations for the year 2022, prepared prior to 2022 and before the draft of this WMP.</p> <p>The site water balance has been prepared for all years of operation, not just the year 2022. The mean modelled water balance is predicted based on multiple years of data, including 130 years of rainfall data, in addition to the approved annual site operations. Approved annual site operations include predicted groundwater inflows, production rates, staffing, annual water transfer limits and pumping/overflow rules. The presentation of water balance results in this WMP will continue to be updated to reflect future mean annual water balance under approved conditions. The presented model results in Section 3.5 have therefore been updated to reflect average near-future site conditions (2026).</p>

Comment	Response
<p>That Centennial Coal include monitoring of surface water discharge at “the Grotto” monitoring site.</p> <p>Section 4.2.2 of the WMP states that ‘There is no flow monitoring of the Grotto currently undertaken’ (pg 44). This contradicts the requirements of Schedule 4, Condition 13(c)(ii) of the Development consent SSD 5581 that continuous flow monitoring should occur at the Grotto. No justification has been provided as to why monitoring has not occurred at this site. The monitoring site ‘Genowlan Creek 2’ is located downstream of the Grotto, hence is not considered to meet this monitoring requirement.</p>	<p>Section 4.2.2 updated to state the following:</p> <p><i>There is no flow monitoring directly of the Grotto to avoid disturbing the site’s natural aesthetics. The Grotto is often dry however flows to Genowlan Creek when wet. The Genowlan Creek flow monitoring points is <300m downstream and suffices monitoring of the Grotto. Monitoring of Genowlan Creek and Genowlan Creek 2 is intended to identify any potential impacts to flows in the creek as a result of mining operations.</i></p>
<p>That Centennial Coal provide more detail on which groundwater monitoring sites will be lost due to mine work progression and which monitoring sites will become dry if the updated 2021 groundwater model level drawdown predictions occur.</p> <p>It has been noted in the WMP that groundwater monitoring sites screened within the Lithgow Seam will be lost as mine working progress. It has also been noted that some groundwater monitoring sites are expected to become dry if the updated groundwater level drawdown predictions, produced by the 2021 groundwater model, occur. It has not been explained how these monitoring sites will be replaced (if applicable) and when the monitoring site replacement will occur so that sufficient time is provided to produce site-specific trigger levels before the other monitoring sites are lost.</p>	<p>Table 4.3 states the status of the groundwater monitoring network (i.e., obsolete, dry or functioning). Locations deemed obsolete are no longer required as mining activities in those locations have ceased and subsidence impacts are at maximum.</p> <p>The remaining network suffices monitoring requirements considering:</p> <ul style="list-style-type: none"> • Mining the Lithgow Seam has produced negligible inflows (rock groundwater sources are low yielding / less productive) • Risk to dewatering of overlying alluvials relates solely to subsidence impacts and future mining limited to <125mm subsidence • Future mining does not present risk to regional aquifers that occur within the Shoalhaven Group and lower Devonian being below the target coal seam. <p>Installation of new monitoring points is not required however, would be prevented by a lack of access given steep terrain and vegetation coverage.</p>

Comment	Response
<p>That Centennial Coal define what period of data is used to develop trigger levels for surface water flows. It is not clear if this is based on the first two years of data only, or the entire monitoring record.</p> <p>The WMP outlines that water quality trigger values within the Gap Creek and Genowlan Creek catchments is ‘...assessed against triggers developed with reference to historical monitoring data.’ Clarification is needed as to what period ‘historical monitoring data’ refers to (that is, the whole monitoring period versus a particular monitoring period window) before DPE Water can comment on the suitability of these surface water quality trigger values.</p>	<p>No triggers have been developed for surface water flows.</p> <p>Section 6.1.1.2 has been amended to clarify water quality triggers are developed from the first two years of monitoring data only and reads as follows:</p> <p><i>Water quality monitored within the Gap Creek and Genowlan Creek catchments is assessed against triggers developed with reference to historical monitoring data (i.e., baselines determined from the first two years of monitoring data only). Trigger values are developed on an exceedance of 80th percentile baseline concentrations as shown in Table 6.2 for parameters where sufficient historical data is available. For pH, a range of trigger values are used, based on the 20th percentile and 80th percentile historical values.</i></p>
<p>That Centennial Coal revises the trigger values for groundwater quality so that it incorporates at least the first two years of baseline monitoring.</p> <p>The WMP outlines that groundwater quality trigger values have been developed using the historical groundwater monitoring data. In particular ‘Trigger values are based on an exceedance of 80th percentile of concentrations recorded in the last 24 months respectively...’. DPE Water does not agree that this method is suitable for developing trigger values, particularly when it is evident that groundwater quality changes have occurred at some monitoring sites during the preceding 24 months (2020 to 2022). Trigger levels should incorporate at least the first two years of data and a minimum of 8 monitoring points. Monitoring data from additional years can be incorporated to update trigger levels provided it can be adequately determined that the data is within expected natural variation.</p>	<p>Section 6.1.3.2 has been amended to clarify water quality triggers are developed from the first two years of monitoring data only and reads as follows:</p> <p><i>Groundwater quality trigger values have been developed on an exceedance of 80th percentile concentrations from baseline groundwater monitoring data (baseline determined as the first two years of monitoring data only). Trigger values are developed as shown in Table 6.5 for parameters where sufficient baseline data is available. For pH, a tolerable range is used, based on the 20th percentile and 80th percentile baseline values. Limited data are available at ARP05 from the first 24 months and therefore trigger values at ARP05 are based on an exceedance of the 80th percentile of available data.</i></p>

Comment	Response
<p>That Centennial Coal include a quality assurance methodology and plan for the next version of the WMP. It is not clear if QA/QC analysis has been performed on the monitoring data to confirm the suitability of the data to characterise site conditions, to develop trigger values, and for conducting statistical analysis.</p>	<p>Section 4.5 Quality Assurance has been added to this version stating the following:</p> <p><i>A series of QA procedures are implemented to maintain the quality of data collected. QA procedures include compliance to the following:</i></p> <ul style="list-style-type: none"> • <i>Use of standard field operating procedures (SOPs)</i> • <i>Completed field records</i> • <i>Documented calibration of field instruments</i> • <i>Use of dedicated sampling materials and decontamination of re-used sampling equipment</i> • <i>Use of laboratory supplied sampling containers and appropriate storage</i> • <i>Completed chain of custody documentation</i> • <i>Laboratory and testing method accreditation</i> • <i>Laboratory QC analysis</i> • <i>Laboratory limits of reporting below assessment criteria</i> <p><i>Continued monitoring serves to confirm the representativeness of surface and groundwater conditions. The comparison of each event's dataset to previous records serves as a continual practice of quality assessment sufficing the collection of field QC samples.</i></p>
<p>That Centennial Coal improve the graphical representation of the monitoring data for visibility and interpretability, and to allow easy reference to trigger levels.</p> <p>It is currently difficult to see how water level and water quality data relates to trigger levels and how the monitoring parameters are varying over time. The monitoring data time series graphs should be updated to improve how third parties interpret the data. This should include the use of contrasting colours, applying consistent x-axis time scales, ensuring the y-axis range encompasses all monitoring data values, and utilising semi-log plots when monitoring data spans over several orders of magnitude.</p>	<p>All graphics presented in Appendices C, D and E have been updated as requested.</p>

Comment	Response
<p>That Centennial Coal expand the reported summary statistics to include the minimum and maximum values, along with the interquartile range.</p> <p>Summary statistics have not been adequately applied to describe the range and variation of monitoring data. The maximum and minimum values for each monitoring characteristic should be reported alongside the count and median values. Consideration should also be given to the suitability of quoting an interquartile range.</p>	<p>Summary statistics tables in Appendices C, D and E have been updated to include minimum and maximum values.</p>
<p>That Centennial Coal conduct statistical trend analysis on the monitoring data to identify increasing, steady, and decreasing trends in monitoring data.</p> <p>Statistical trend analysis has not been used to identify and describe changes in the monitoring data. Conducting statistical trend analysis can assist in identifying changes to monitoring parameters before trigger limits are reached.</p>	<p>Statistical trend analysis using the non-parametric Mann Kendall (MK) method will be applied in analysing time-series water quality data in the 2023 Annual Review to quantitatively determine if the measured concentrations of a groundwater parameter are increasing, decreasing, or stable over time.</p>
<p>That Centennial Coal analyse and explain the identified water level and quality changes.</p> <p>There are geochemical changes evident in the monitoring data time series graphs. No reason for the variability has been supplied, nor a reference to relevant monitoring reports. This may be available in the next Annual Report (last one publicly available was published in March 2022). This could also be available in previously published monitoring reports and should be referenced within the WMP.</p>	<p>Trends in decreasing pH and increasing metal concentrations have been identified in alluvial bores ARP12 and ARP14 as well as in surface water from Genowlan Creek during 2022. Such trends have triggered the need for further investigation as per the Stage 1 TARP.</p> <p>A stand-alone report will be prepared and submitted as an addendum to the 2023 Annual Review, summarising a review of water level and physico-chemical parameter changes.</p>
NSW Department of Planning and Environment (letter dated 15 January 2024)	
<p>The Department has carefully reviewed the document and is satisfied that it meets the requirements of the relevant conditions in Development Consent (SSD-5581), however notes that several of the trigger action response plans (TARPs) presented in Appendix F could be improved by incorporating measurable triggers and temporal scales. For example:</p> <ul style="list-style-type: none"> • Water flow TARP (F2) - trigger should include a measurable (e.g. percentage) reduction in flow compared to historical baseline results over a number of consecutive months; 	<p>A new section has been added to Section 6.1, specifically Section 6.1.1 Surface water flow triggers, supported by the Surface Water Balance Modelling Report presented in Appendix J.</p> <p>TARP F2 and F5 have been amended in Appendix F.</p> <p>Additionally, newly developed groundwater quality triggers have been included in 5.3.1 and Sections 6.1.4</p>

Comment	Response
<ul style="list-style-type: none">Groundwater level TARP (F5) - trigger should incorporate a temporal scale (e.g. a number of consecutive months) to avoid over-reporting.	

Appendix C – Baseline groundwater data

C.1 Groundwater bore database search

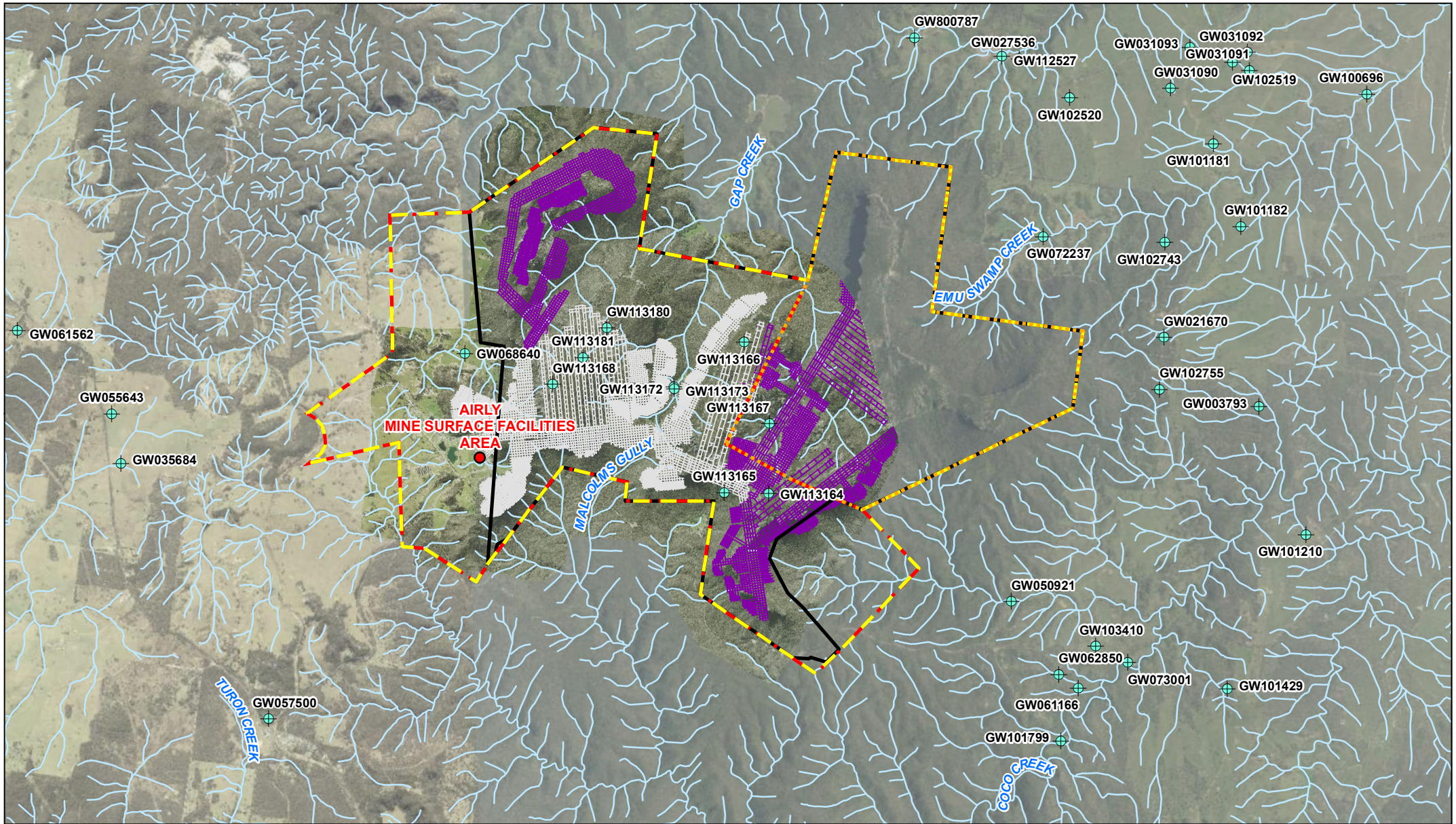
Bore	Licence	Location		Use	Depth (m)	SWL (bgl)	Salinity	Yield (L/s)	Aquifer
		m N	m E						
GW003793	–	6332960	232004	Stock	39.6	–	–	–	Boulders/rock/porphyry
GW021670	10BL013665	6333911	230707	Stock	92.9	50.5	Unknown	0.38	Sandstone/shale/sandstone limestone/andesite
GW027536	10BL020891	6337711	228733	Domestic/stock	5.7	–	–	–	–
GW031090	10BL023864	6337305	230795	Stock	92.9	48.7	Stock	0.15	Shale/limestone water supply
GW031091	10BL023863	6337551	231879	Stock	54.8	–	–	–	–
GW031092	10BL023865	6337796	231846	Stock	32	14.6	Stock	0.25	Limestone decomposed/limestone conglomerate
GW031093	10BL023866	6337868	231065	Stock	100.5	–	–	–	Limestone conglomerate
GW035684	80BL029547	6332387	776371	Stock	6.4	–	–	–	–
GW042703	10BL105058	6341429	222760	Domestic/irrigation/stock	8	5	0–500 ppm	20.83	Clay/gravel water supply
GW050921	10BL109475	6330307	228627	Stock	10.5	4.1	Good	0.25	Sandstone boulder/clay gravel/sandstone siltstone/sand gravel
GW055643	10BL120830	6333068	776287	Domestic/stock	38.1	12.2	Good	0.10–0.30	Clay/shale sandy/shale
GW057500	80BL125680	6328790	778189	Domestic	30	10	Unknown	1.26	Overburden/shale
GW061166	10BL132888	6329130	229541	Domestic/stock	47.5	6.1	Good	0.5	Clay/shale
GW061562	80BL134157	6334274	775075	Domestic/stock	70	29	Good	0.22–9.00	Shale/sandstone/conglomerate
GW062850	–	6329308	229277	Irrigation	15	–	–	–	Limestone/fissure

Airly Mine
Water Management Plan

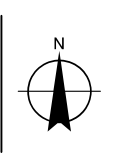
Bore	Licence	Location		Use	Depth (m)	SWL (bgl)	Salinity	Yield (L/s)	Aquifer
		m N	m E						
GW068640	10BL141250	6333693	221173	Test bore	78.5	19.08	1990	1.00–2.15	Clayey sand and gravel/siltstone/sandstone/quartz/shale
GW072237	10BL154338	6335284	229060	Domestic/irrigation/stock	55	17	Fresh	2.00–6.00	Sandy gravel/shale
GW073001	–	6329474	230214	Domestic/stock	24	9	–	0.5	Weathered basalt/blue basalt
GW100696	10BL155172	6337232	233478	Domestic/stock	6	–	–	–	Sand/gravel
GW101181	–	6336551	231387	Domestic/stock	33	5	Good	2.5	Conglomerate
GW101182	10BL158364	6335420	231755	Domestic/stock	40	12	Good	2	Clay/conglomerate
GW101210	10BL158255	6331220	232649	Domestic/stock	91.4	–	–	–	Clay and boulders/granite
GW101429	10BL157957	6329110	231573	Domestic/stock	64	39.6	–	3.79	Sandstone/shale
GW101799	10BL157241	6328406	229304	Domestic	30	7	Brackish	0.25–0.38	Weathered shale/shale
GW102519	10BL159353	6337661	231646	Domestic/stock	93	66	–	2	Shale/granite
GW102520	10BL159354	6337175	229423	Domestic/stock	42	22	Good	0.8	Shale/granite
GW102743	10BL159493	6335206	230723	Domestic/stock	49	7.5	Good	1.43	Shale soft/shale hard
GW102755	10BL159449	6333200	230648	Domestic/stock	42	26	6,000 ppm	0.5	Soft shale/hard grey shale
GW103410	10BL159909	6329698	229776	Domestic/stock	106	54	–	0.38	Shale/limestone
GW112527	10BL604088	6337744	228496	Domestic/stock	42	6	–	5	Siltstone
GW800787	80BL236772	6338000	227305	Domestic/stock	41	14	Fresh	0.08–1.56	Sandstone/shale
GW113168	10BL604518	6333269	222372	Monitoring bore	–	–	–	–	–
GW113181	10BL604520	6333638	222783	Monitoring bore	–	–	–	–	–
GW113180	10BL604520	6334042	223113	Monitoring bore	–	–	–	–	–

Airly Mine
Water Management Plan

Bore	Licence	Location		Use	Depth (m)	SWL (bgl)	Salinity	Yield (L/s)	Aquifer
		m N	m E						
GW113173	10BL604521	6333235	224023	Monitoring bore	–	–	–	–	–
GW113172	10BL604521	6333209	224030	Monitoring bore	–	–	–	–	–
GW113166	10BL605352	6333846	224983	Monitoring bore	–	–	–	–	–
GW113167	10BL605352	6332729	225330	Monitoring bore	–	–	–	–	–
GW113165	10BL605352	6331793	224713	Monitoring bore	–	–	–	–	–
GW113164	10BL605352	6331775	225314	Monitoring bore	–	–	–	–	–



Paper Size A4
 0 500 1,000 1,500 2,000 2,500
 Metres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56



LEGEND

- Airly Surface Facilities Area
- Approved development consent boundary
- Mining Lease ML 1331
- Mining Lease ML 1814
- Authorisation A232
- Existing workings
- Proposed workings
- ⊕ Registered Groundwater Bores
- ~ Waterway

CENTENNIAL

Airly Mine
Water Management Plan

Job Number 22-12602550
 Revision 0
 Date 14 Jul 2023

Registered Groundwater Bores Figure B-1

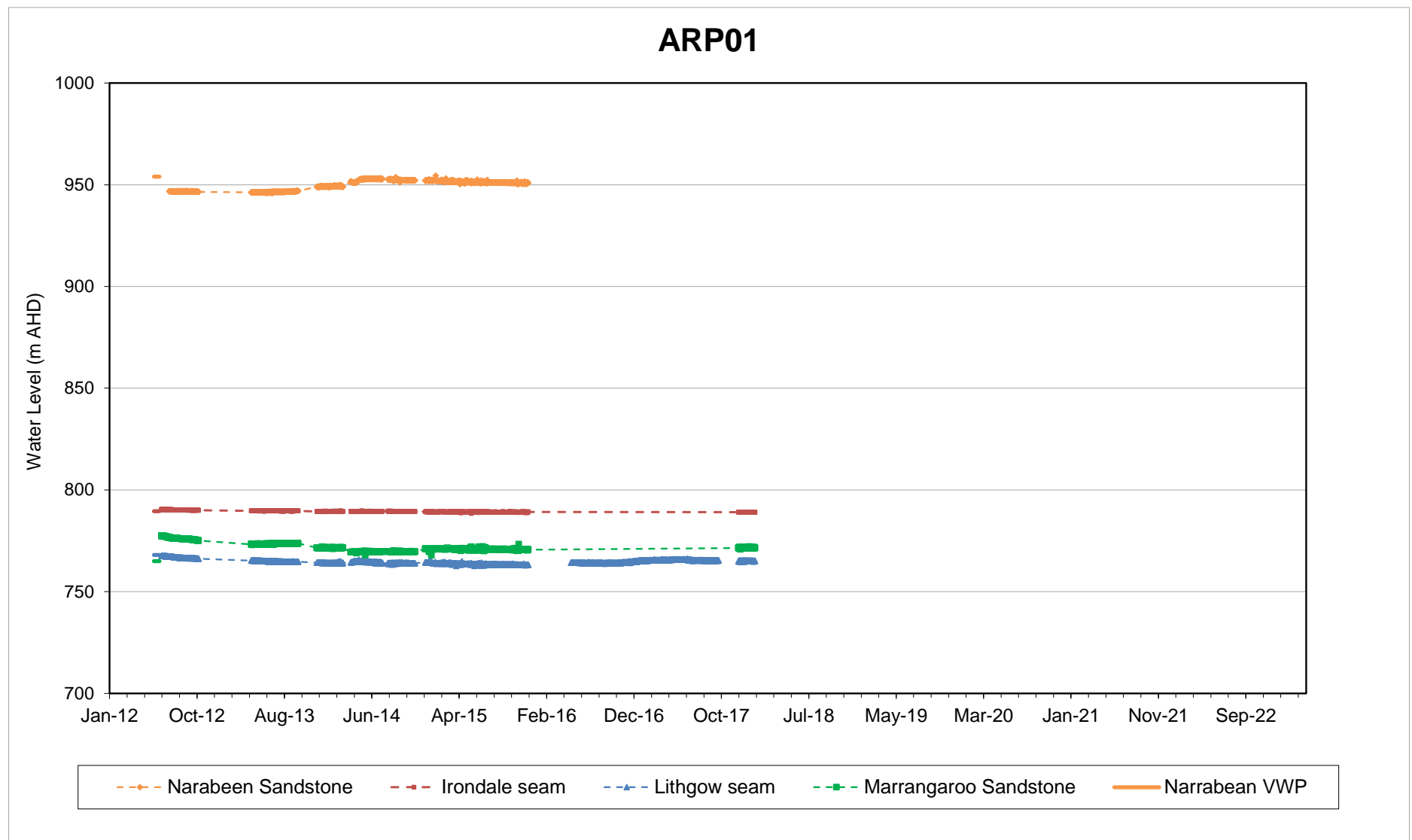
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Data source: LPI: DTDB 2012; Centennial: Aerial Imagery, boundaries, 2013. NSW-OoW: groundwater bores, 2013. Created by: fmackay, tmorton

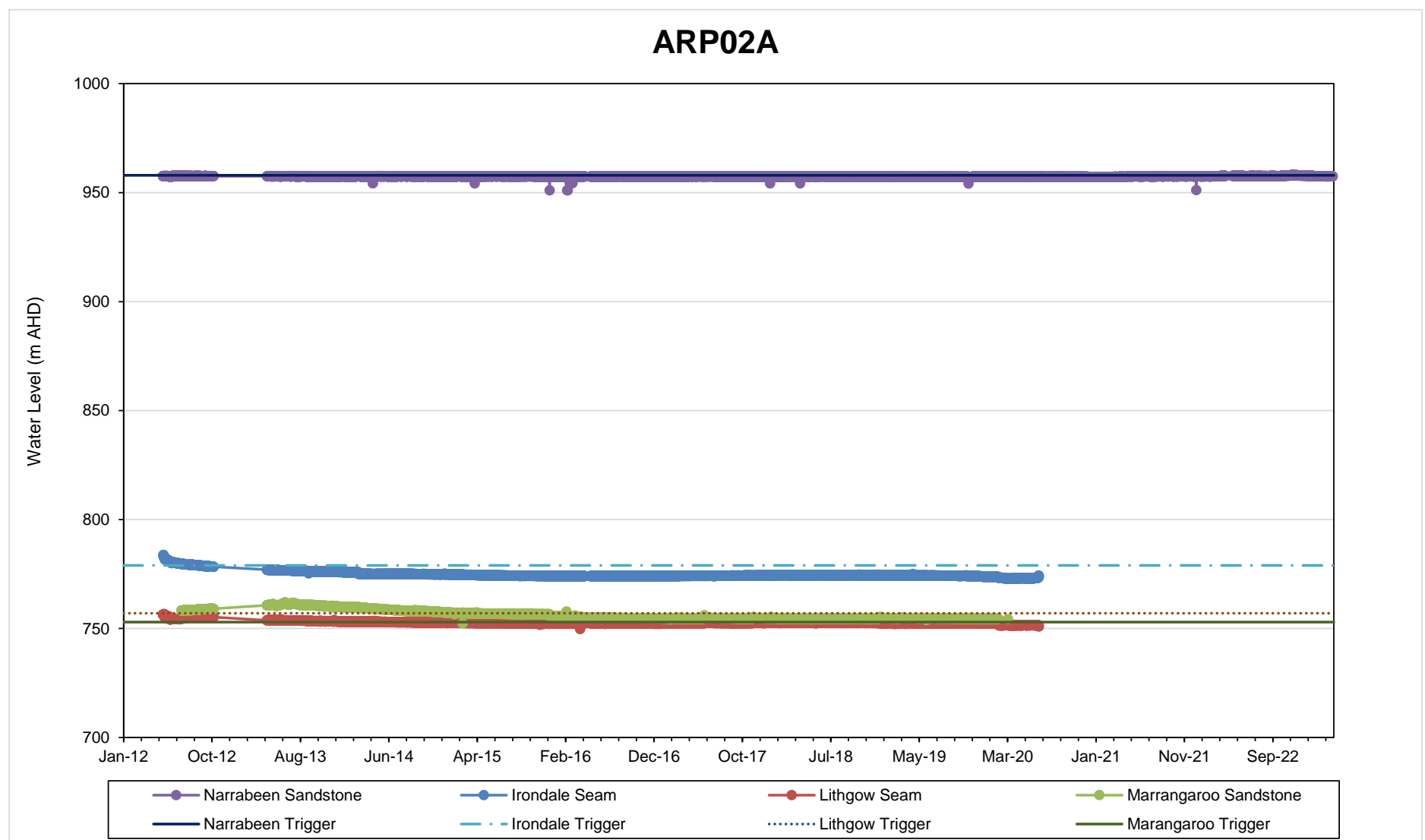
C.2 Groundwater hydrographs

ARP01



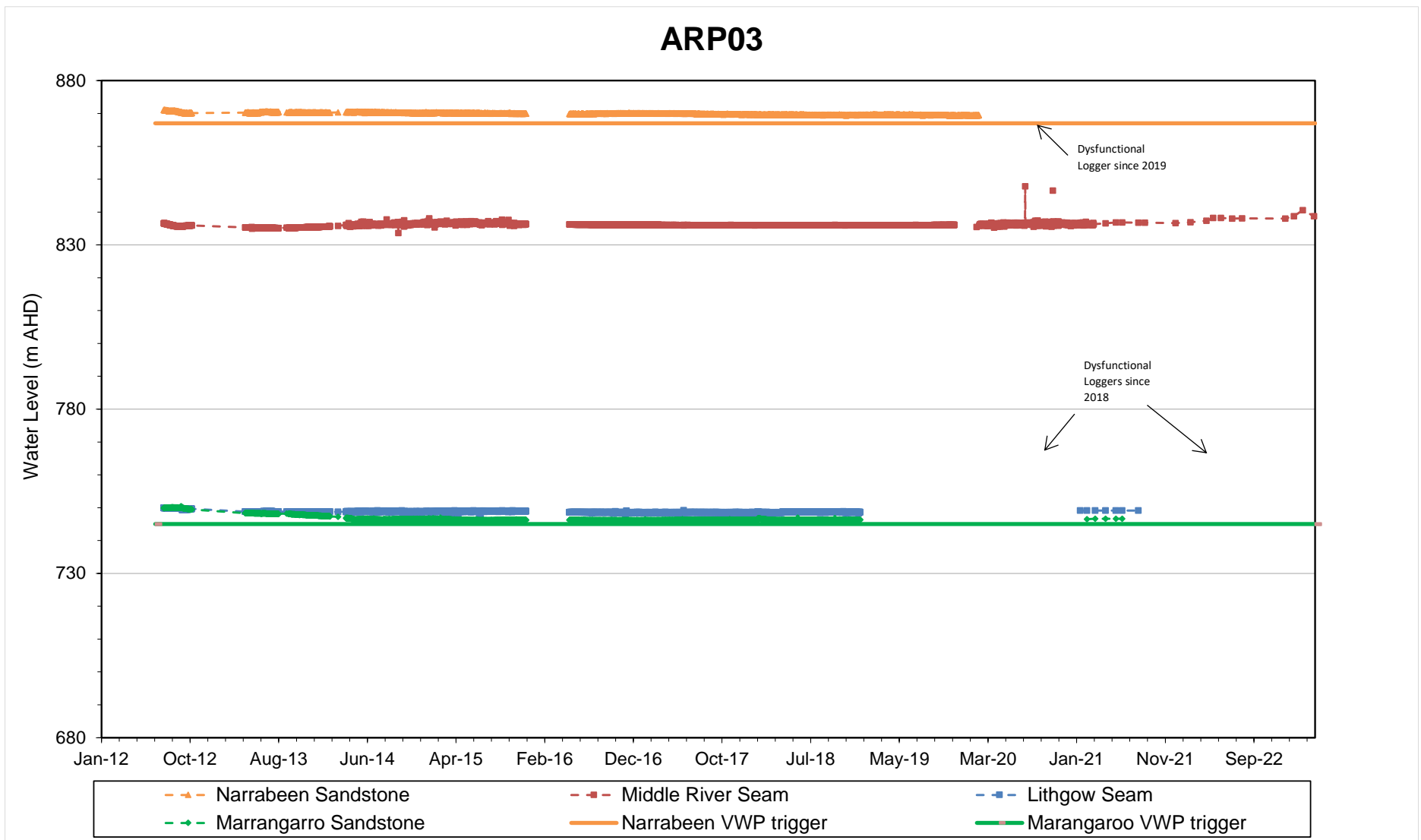
Pressure consistently negative in Narrabeen Sandstone and Lithgow Seam. VWP pressure consistently negative in the Irontdale Seam and Marrangaroo Sandstone since October 2014, indicative of dry or depressurised strata.

ARP02



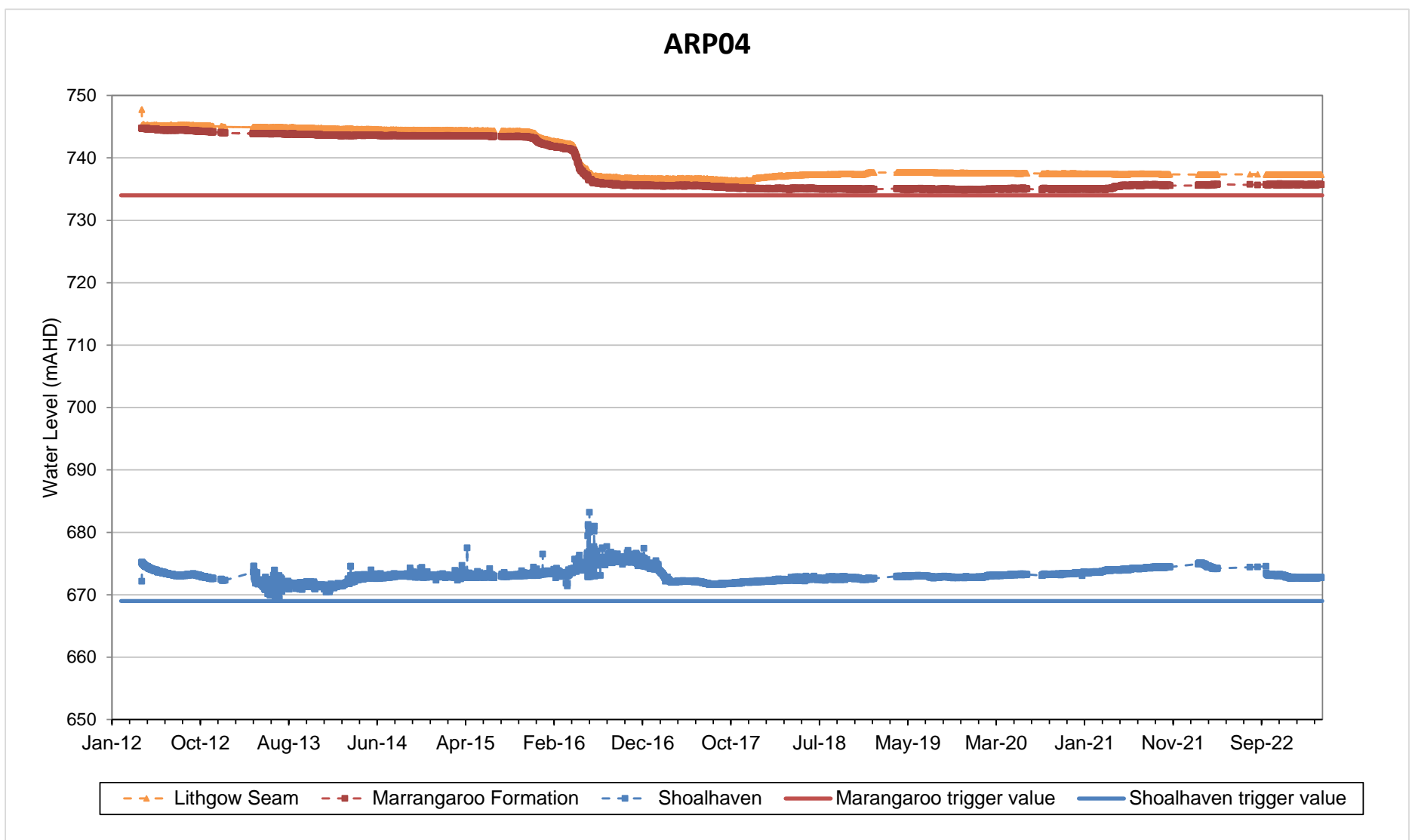
Pressure has been negative at the VWP installed in the Narrabeen Sandstone and Lithgow Seam. Pressure has been negative in the Irontdale Seam since July 2012 (two months after installation), indicative of dry or depressurised strata.

ARP03



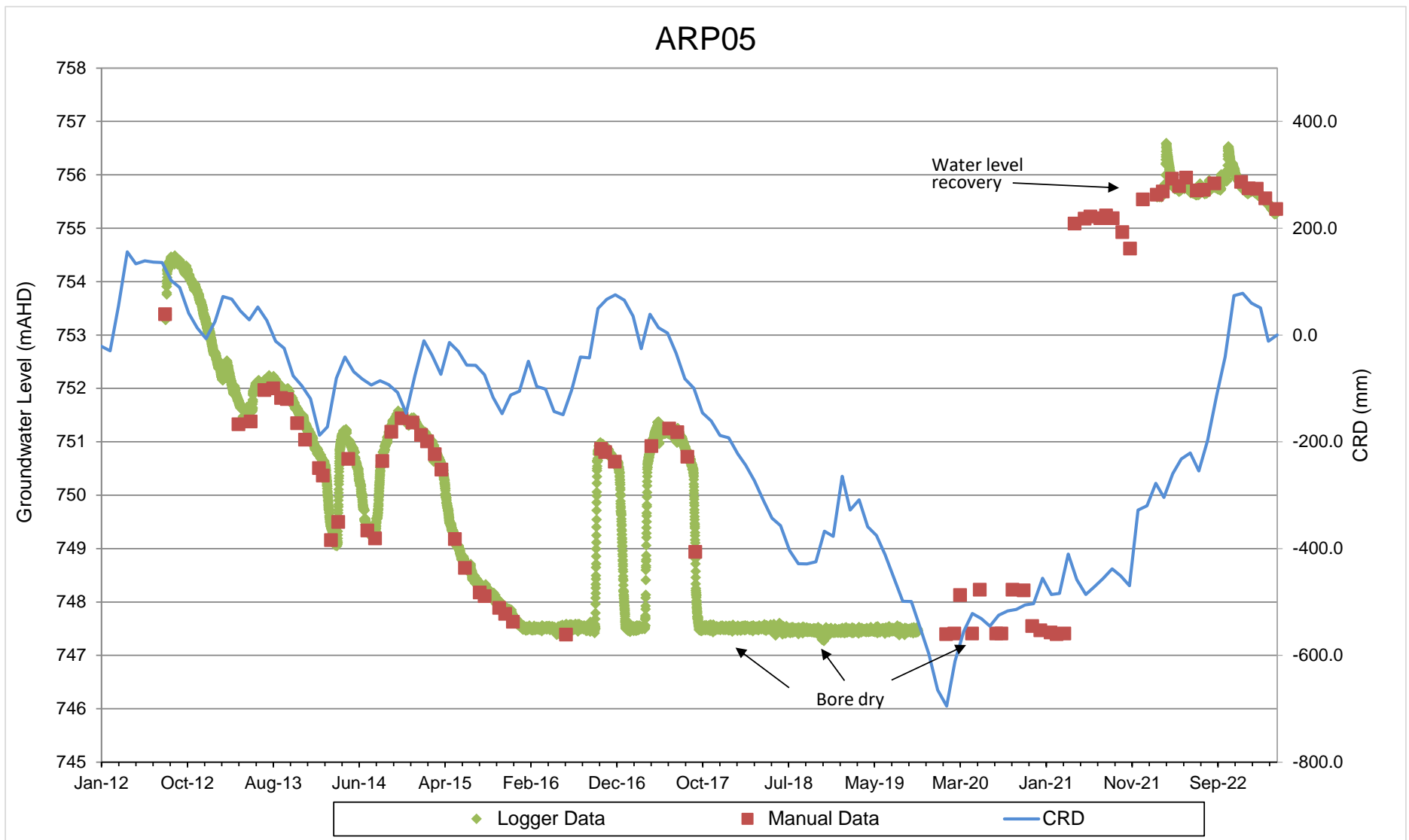
Pressure has typically been negative in the Middle River Seam. Pressure has been negative in the Lithgow Seam since October 2012 (approximately two months after undermining). The logger in the Upper Sandstone has been dysfunctional since February 2020.

ARP04

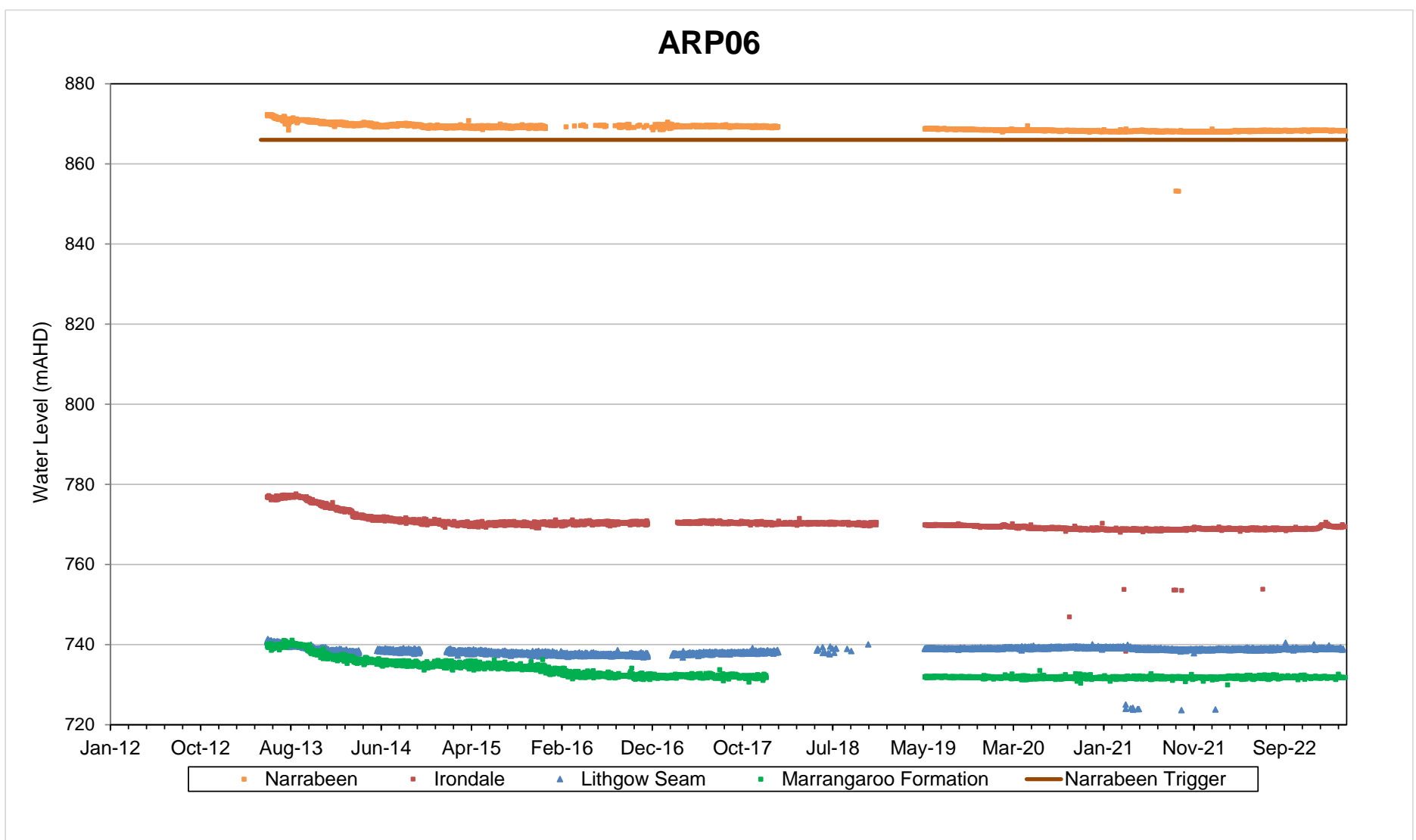


Pressure has been negative in the Lithgow Seam at ARP04 since June 2016.

ARP05

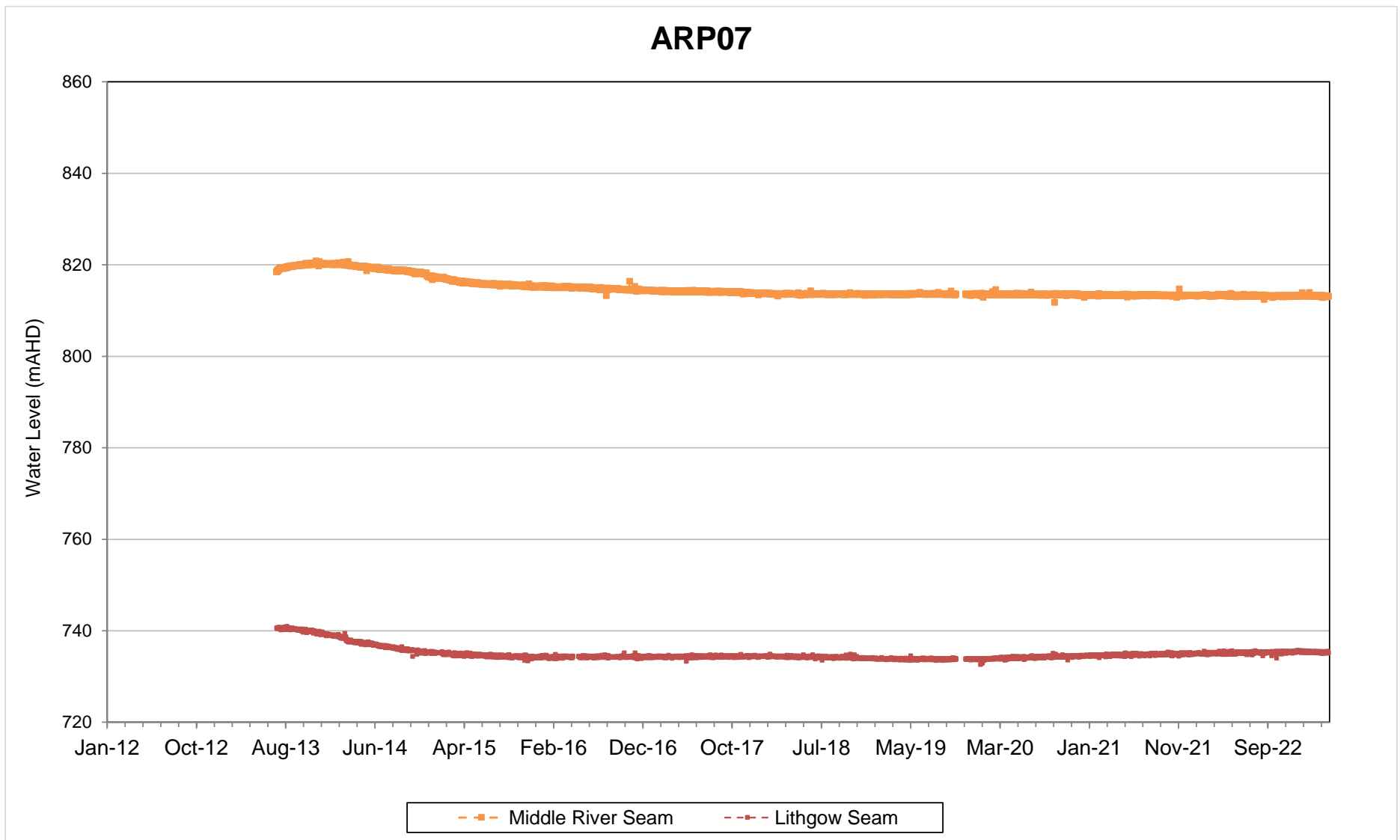


ARP06

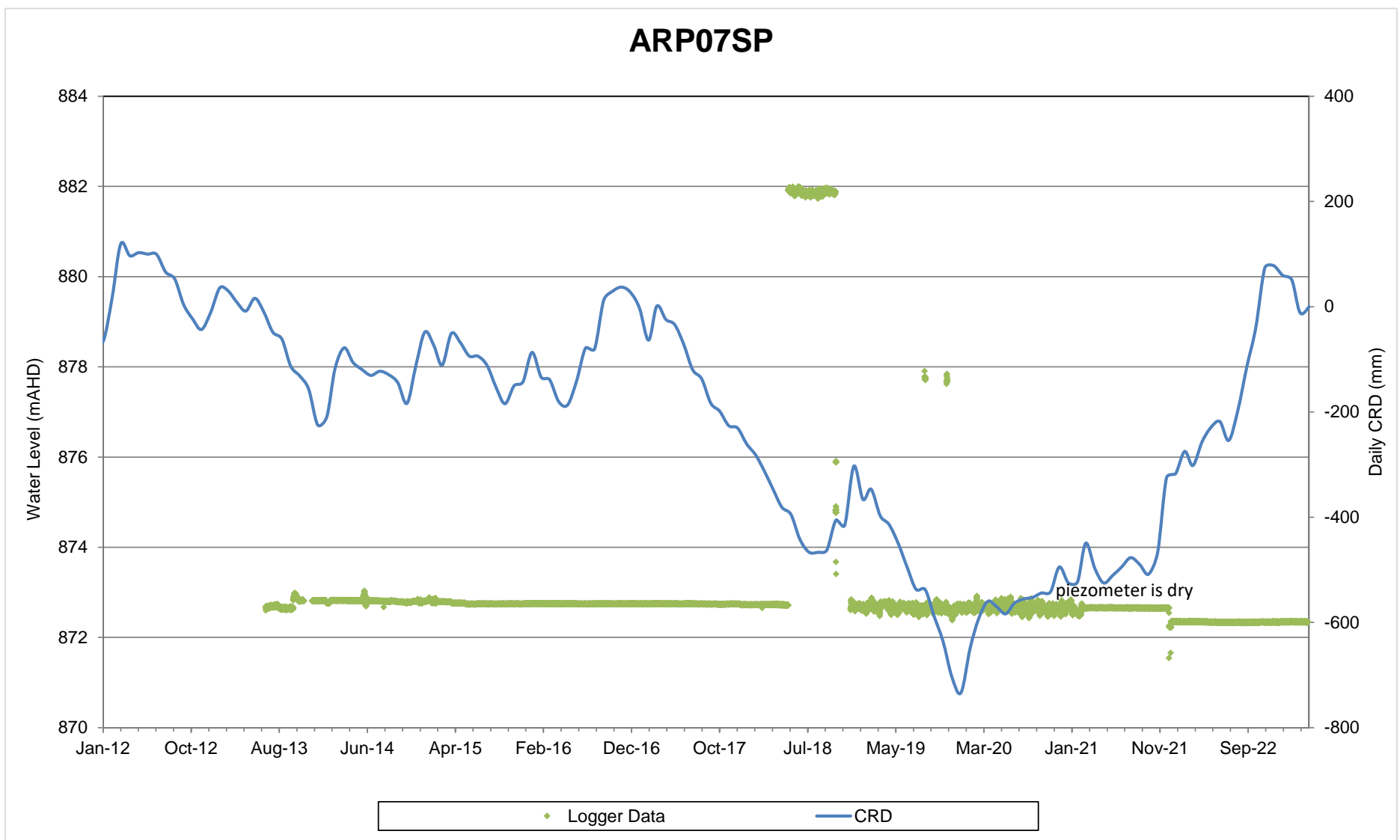


Pressure consistently negative at ARP06 in the Lithgow Seam, in the Irondale Seam since December 2013 and in the Marrangaroo Formation since December 2015.

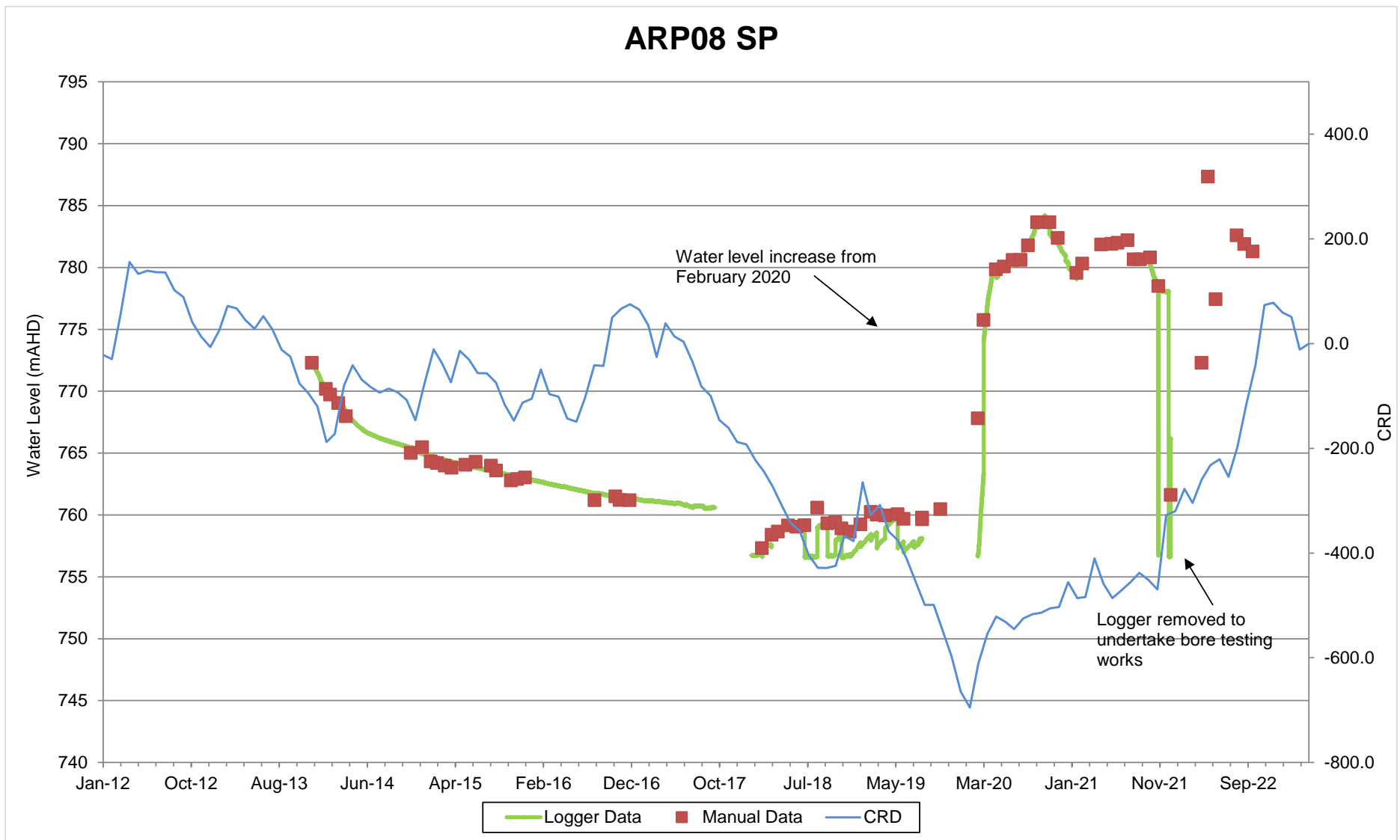
ARP07



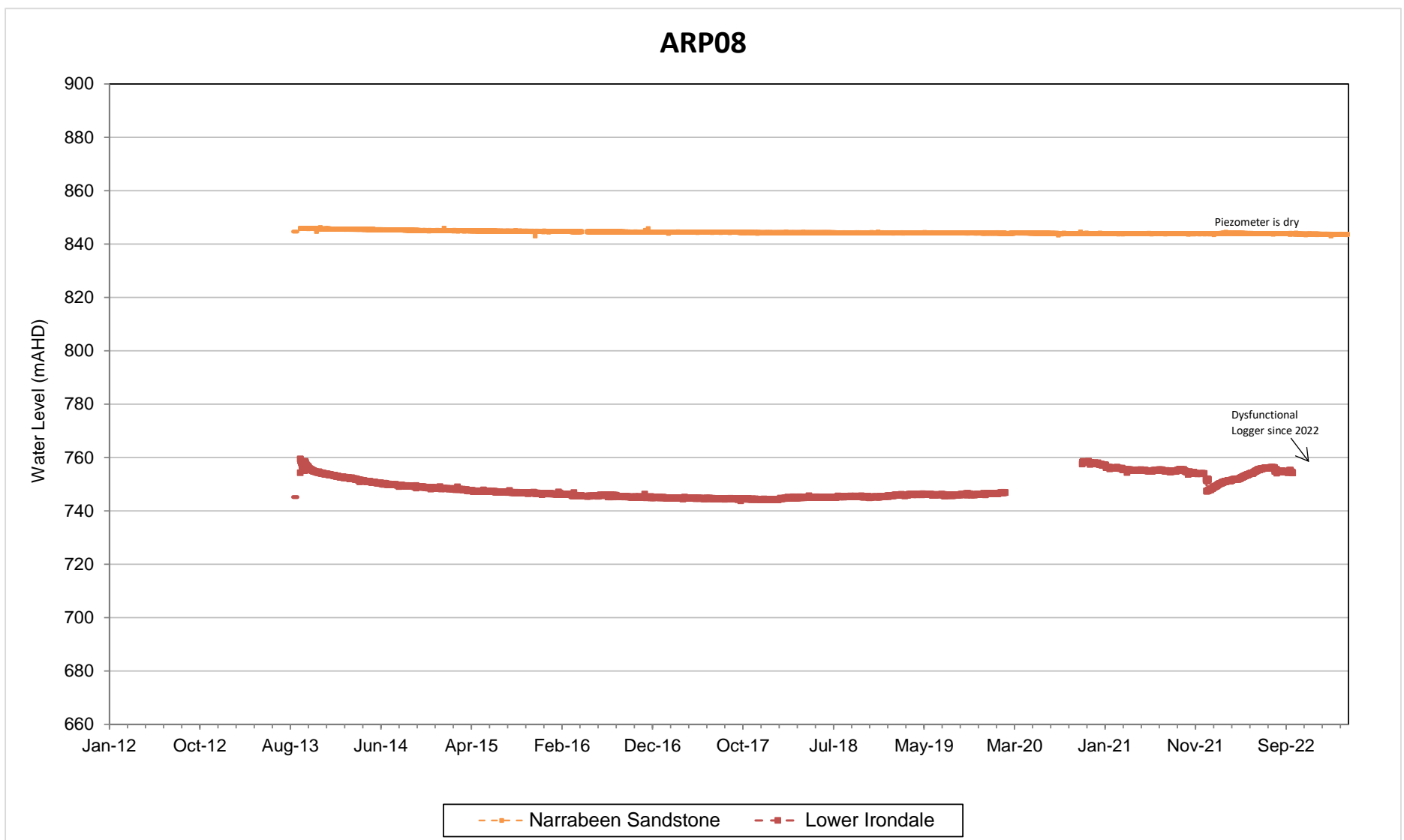
ARP07SP



ARRP08SP

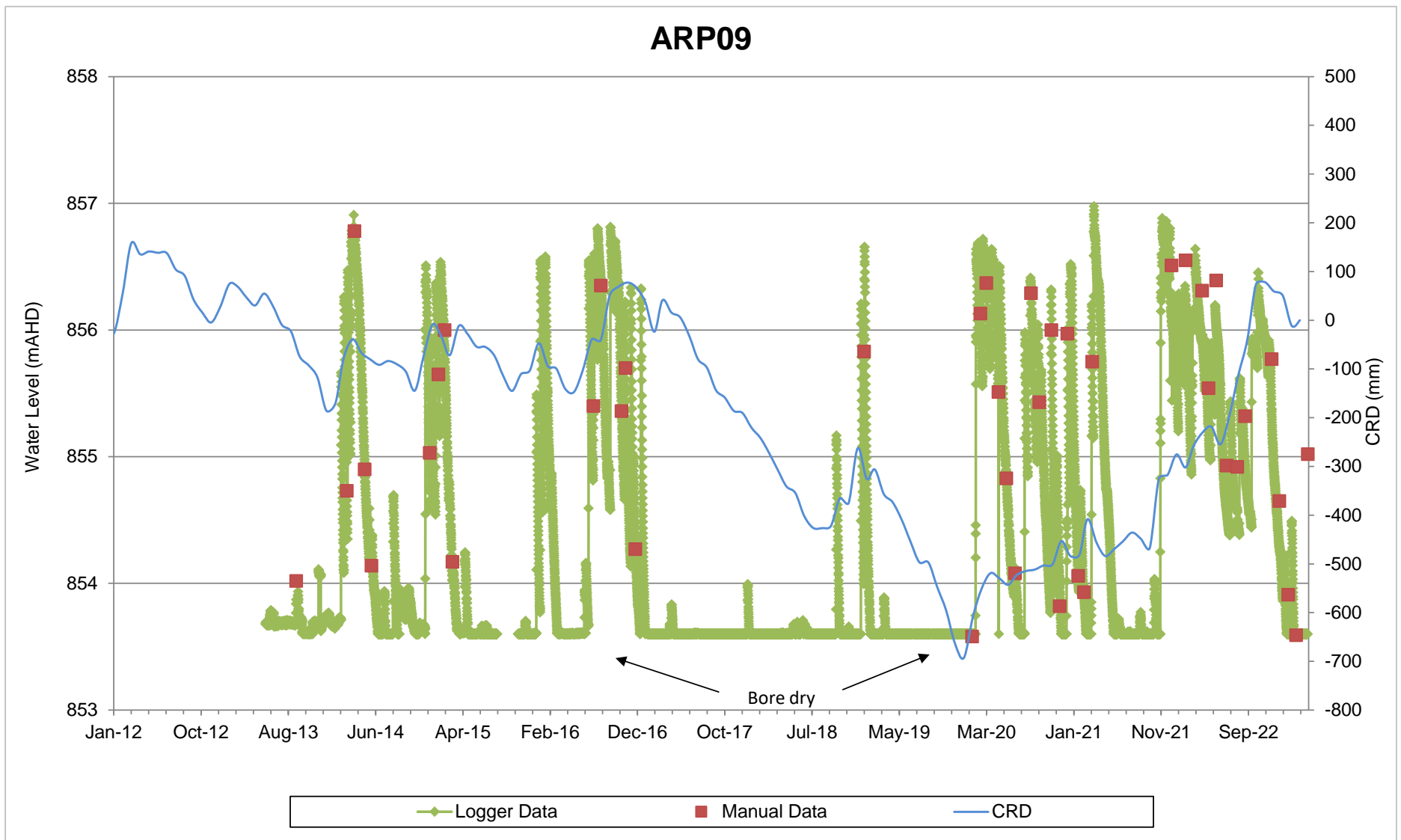


ARP08

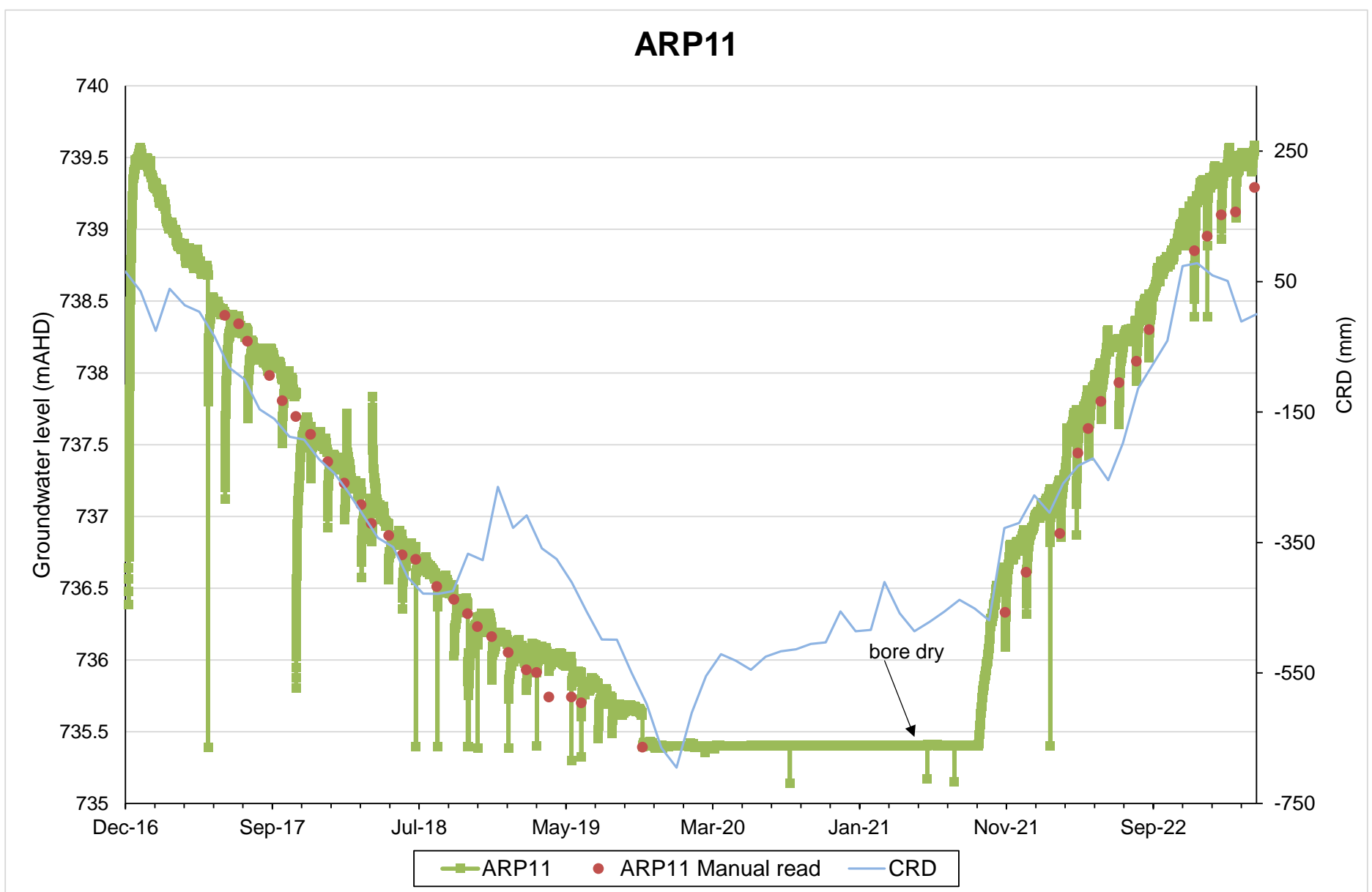


Pressures have been negative at ARP08 in the Narrabeen Sandstone since May 2016 and in the Lower Irondale Seam between November 2016 and December 2018.

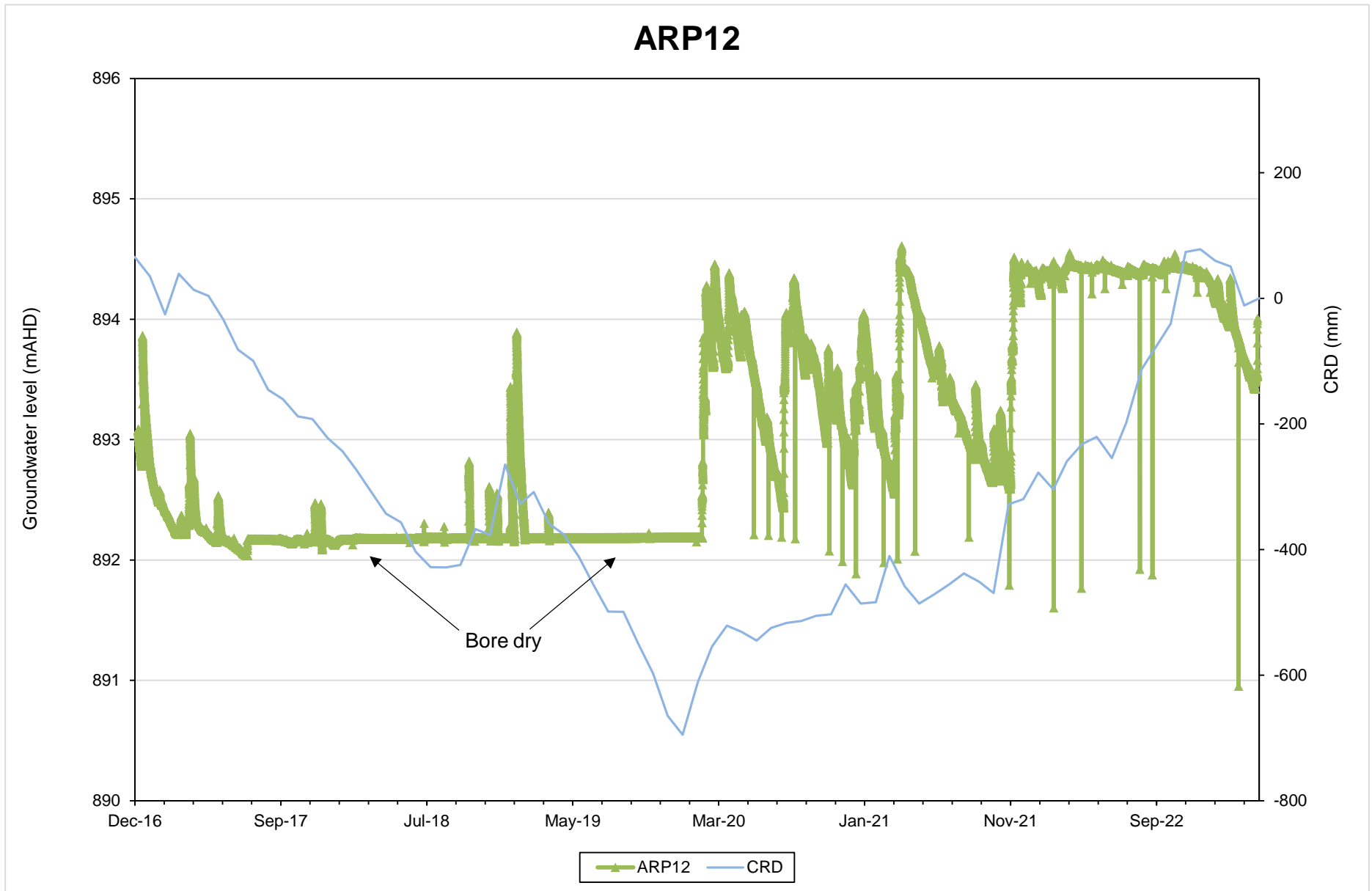
ARP09



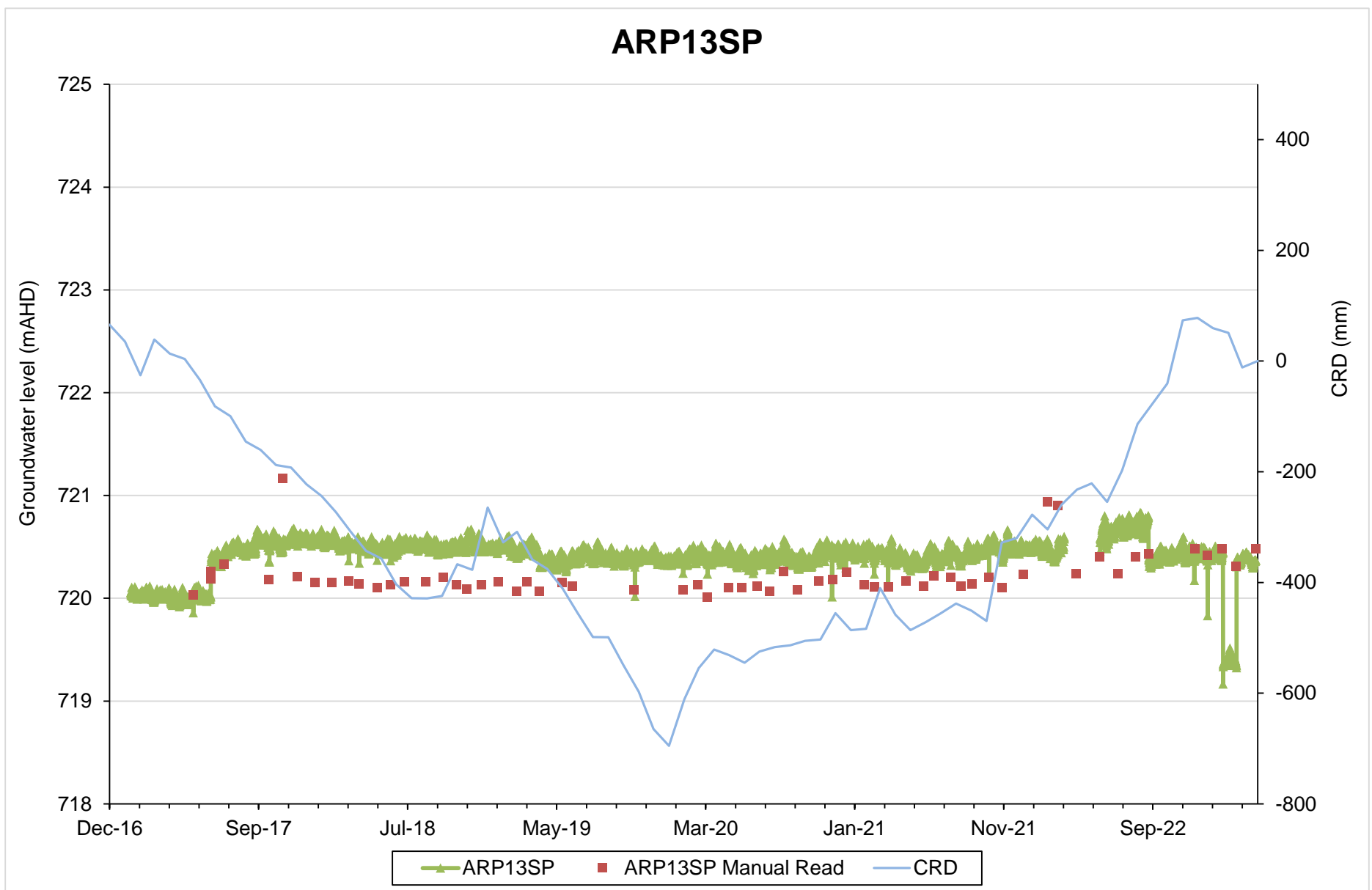
ARP11



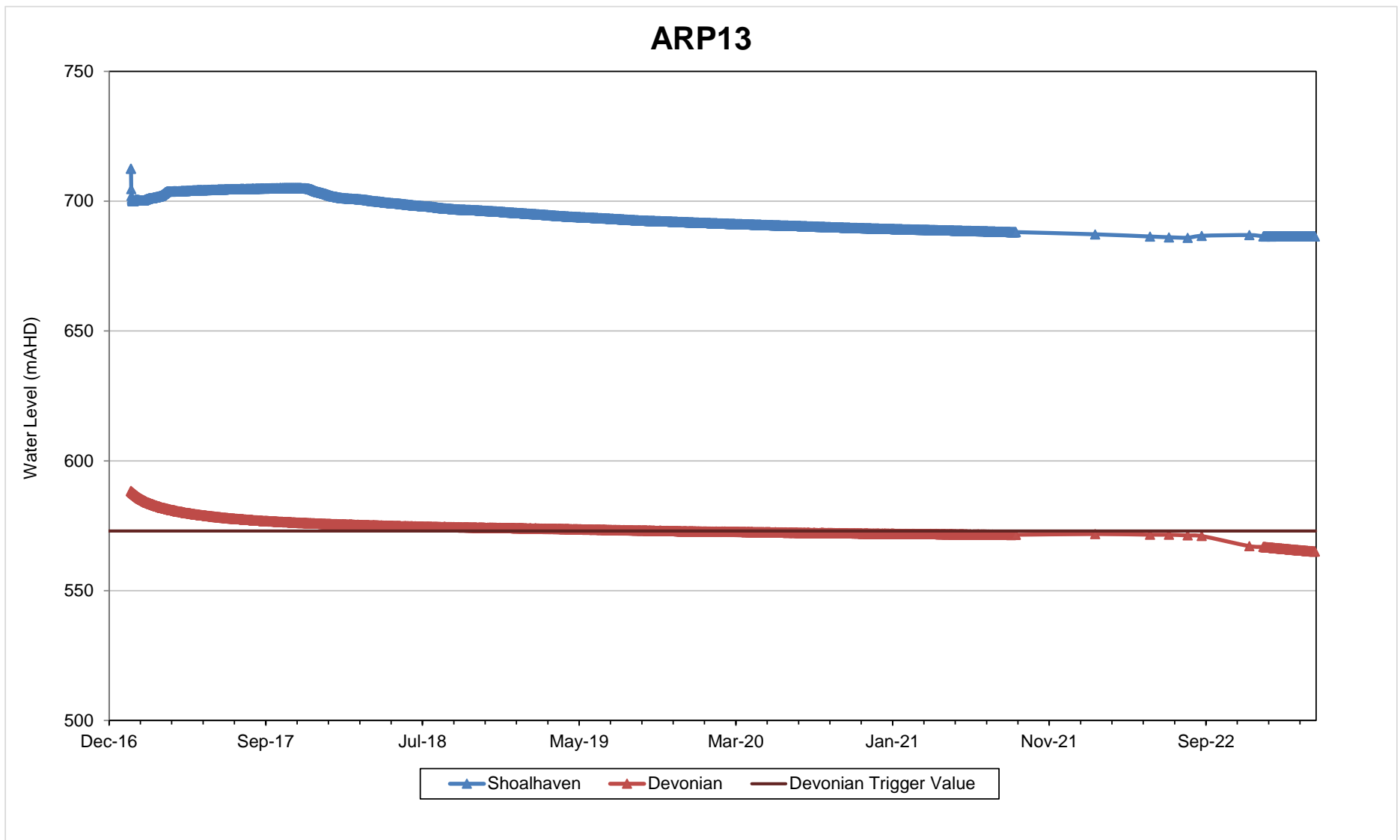
ARP12



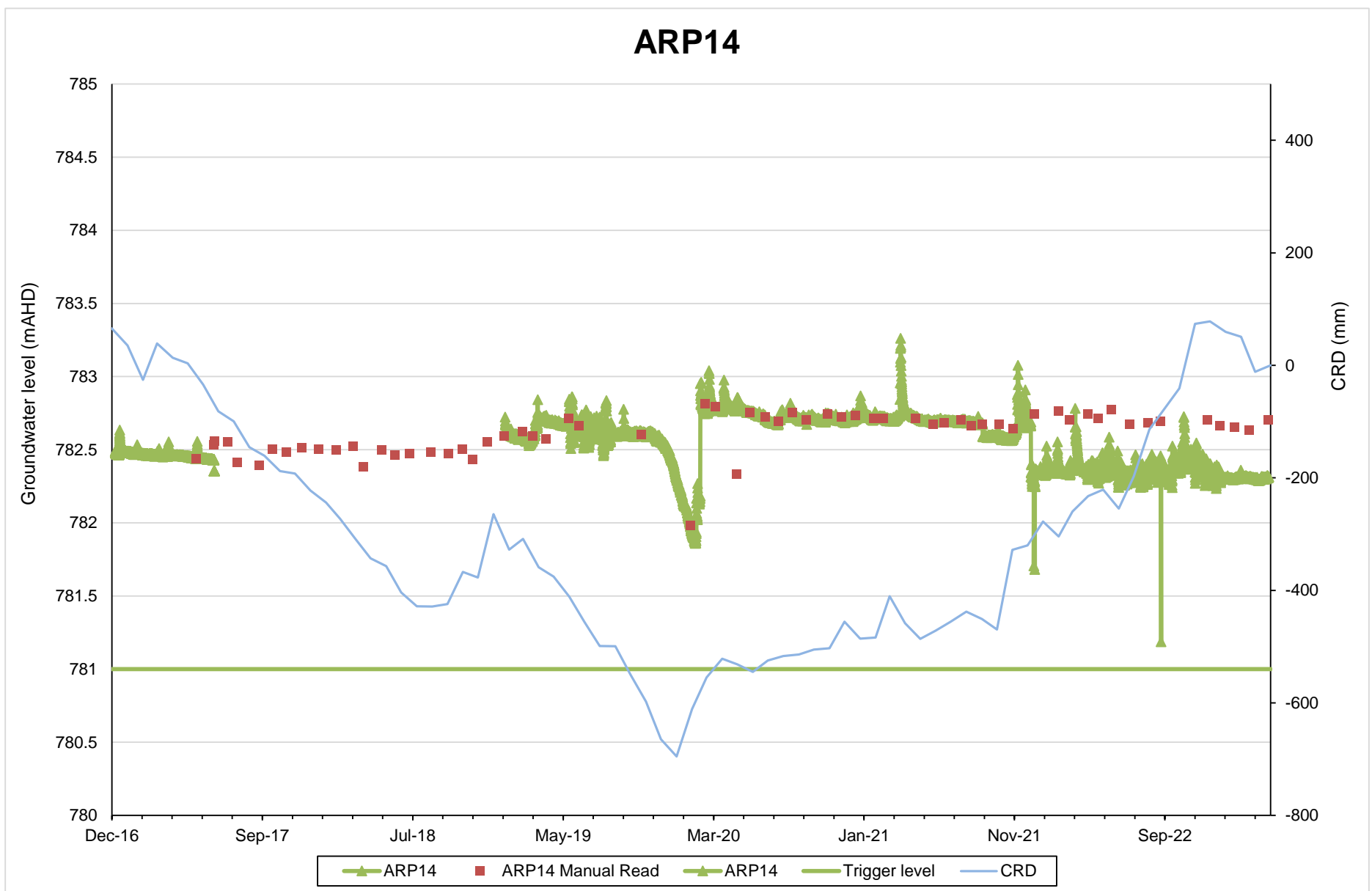
ARP13SP



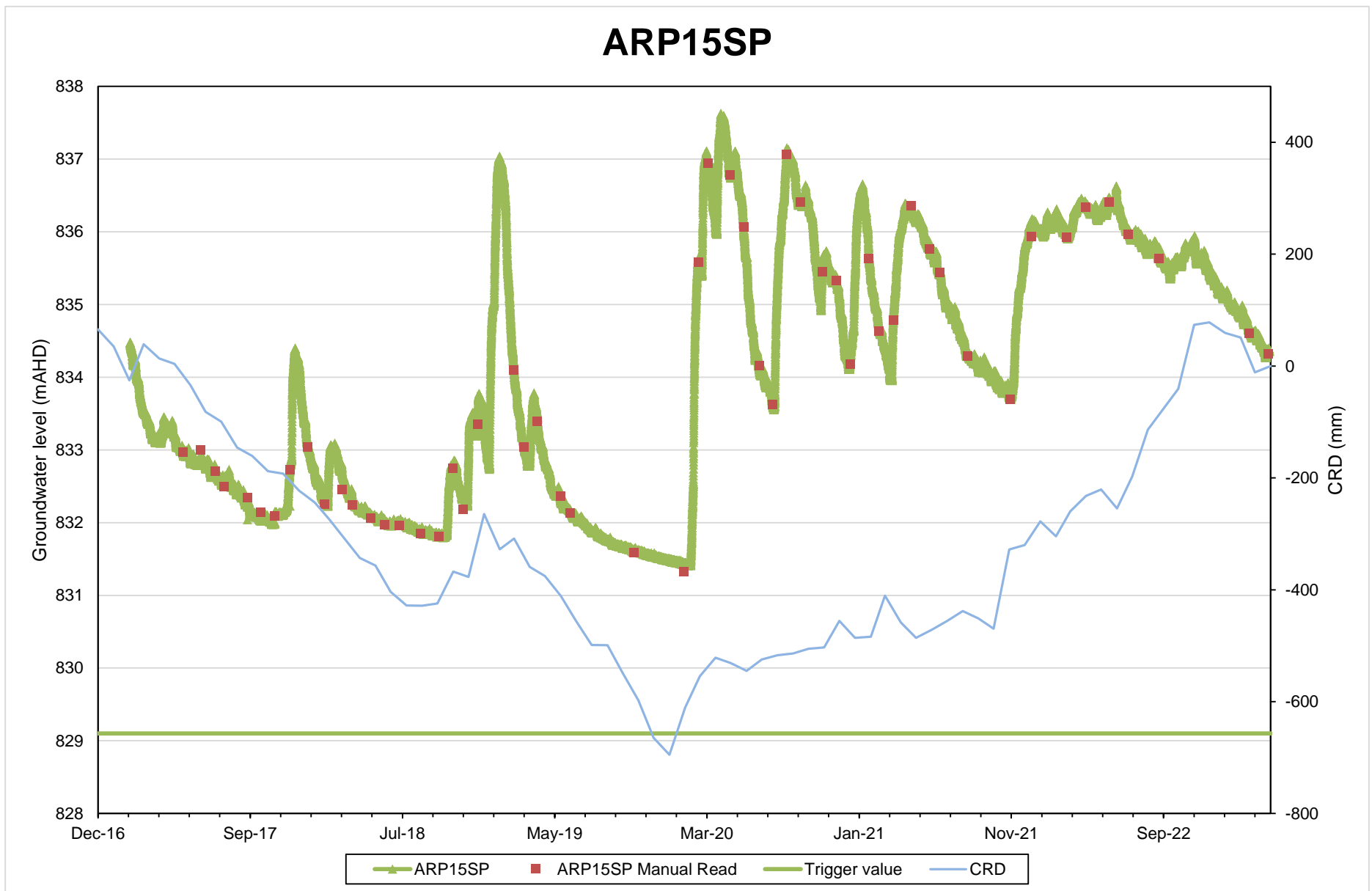
ARP13



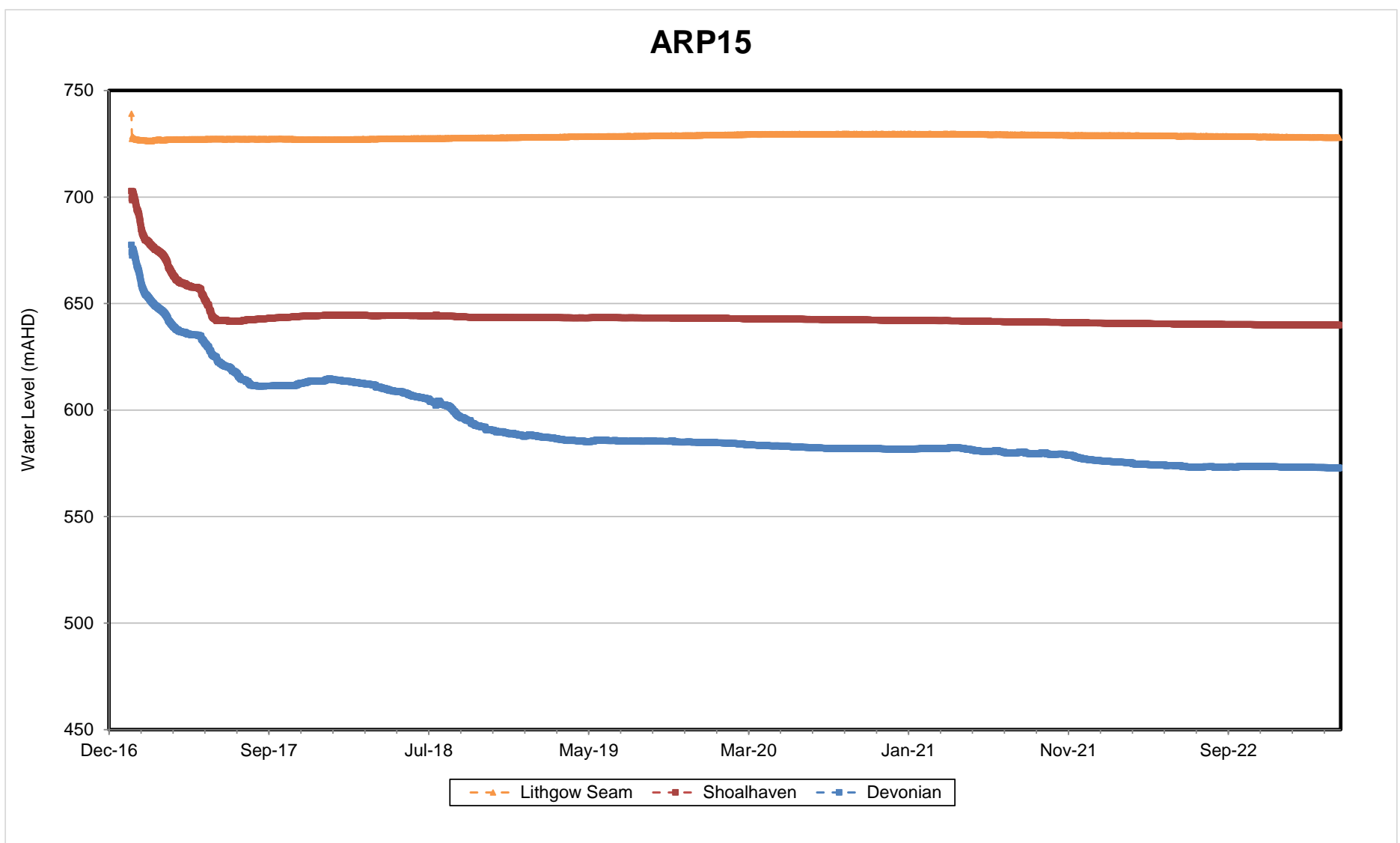
ARP14



ARP15SP

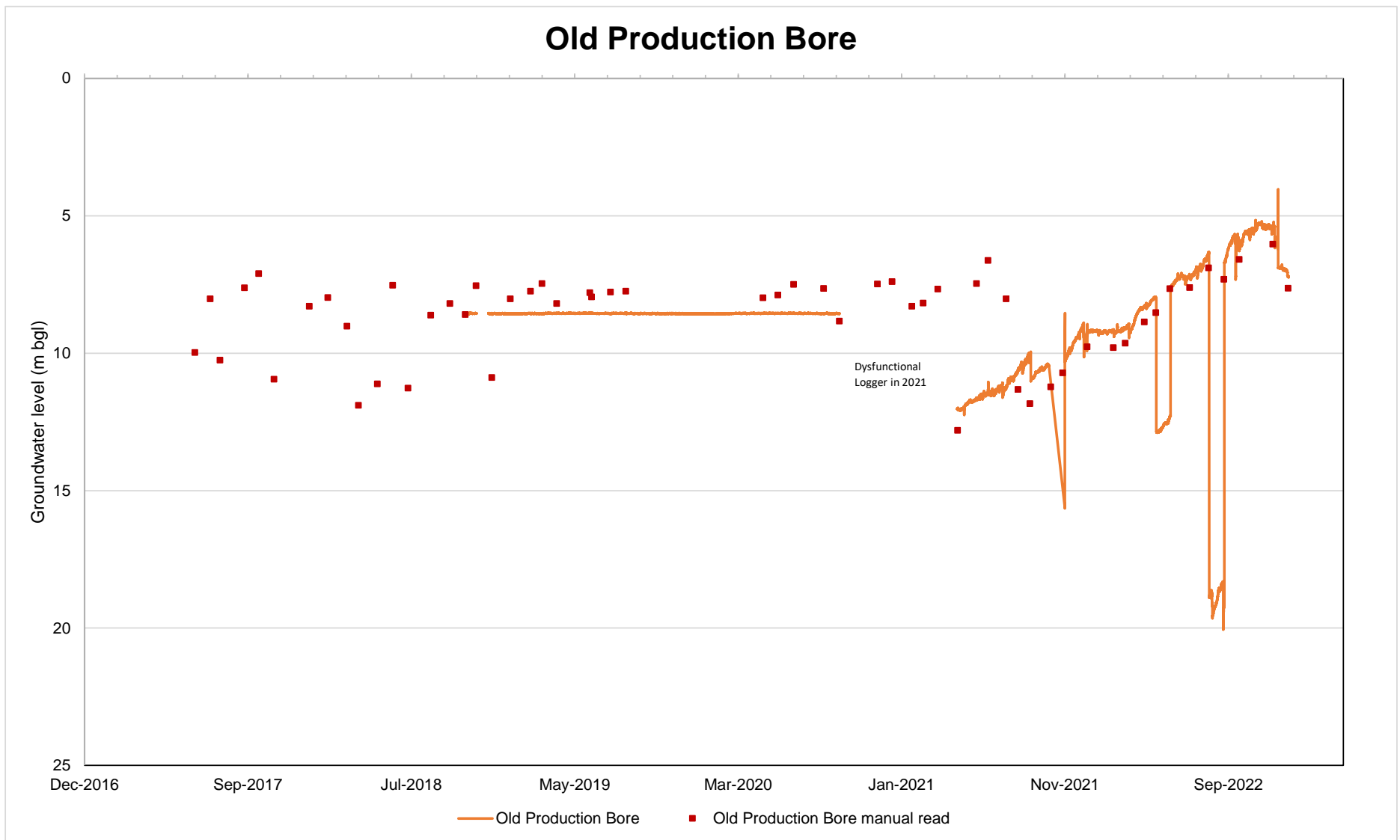


ARP15



Pressures have been negative at ARP15 in the Shoalhaven Group since June 2017.

Old Production Bore



C.3 Groundwater bore install depths

Monitoring type	Location	Period of data	Lithology	Bore install level (m AHD)
VWP	ARP01	June 2012–2018 All loggers dysfunctional since 2018	Narrabeen Sandstone (74 m bgl)	953.96
			Irondale Seam (238.5 m bgl)	789.5
			Lithgow Seam (260 m bgl)	768.0
			Marrangaroo Formation (263 m bgl)	765.0
	ARP02	May 2012–present Marrangaroo Formation, Irondale and Lithgow Seam dysfunctional since 2020.	Narrabeen Sandstone (65 m bgl)	957.68
			Irondale Seam (243 m bgl)	779.68
			Lithgow Seam (266 m bgl)	756.7
			Marrangaroo Formation (270 m bgl)	752.7
	ARP03	July 2012–present No data obtained from reader box fault in Lithgow Seam, Marrangaroo Formation and Narrabeen Sandstone.	Narrabeen Sandstone (136 m bgl)	865.7
			Middle River Seam (165 m bgl)	836.7
			Lithgow Seam (252 m bgl)	749.7
			Marrangaroo Formation (257 m bgl)	744.66
	ARP04	April 2012–present	Lithgow Seam (25 m bgl)	737.7
			Marrangaroo Formation (28.5 m bgl)	734.2
			Shoalhaven Siltstone (210.3 m bgl)	561.36
ARP06	June 2013–present	Narrabeen Sandstone (230 m bgl)	846.0	
		Irondale Seam (252 m bgl)	774.5	
		Lithgow Seam (288 m bgl)	741	
		Marrangaroo Formation (295 m bgl)	733.5	
ARP07	July 2013–present (dry)	Middle River Seam (168 m bgl)	824.6	
		Lithgow Seam (252 m bgl)	740.6	
ARP08	September 2013– present	Narrabeen Sandstone (183 m bgl)	844.7	
		Irondale Seam (282.5 m bgl)	745.2	
ARP13	December 2016– present	Shoalhaven Group (120 m bgl)	665.6	
		Devonian strata (280 m bgl)	505.6	
ARP15 ¹	January 2017– present	Lithgow Seam (125 m bgl)	721.7	
		Shoalhaven Group (200 m bgl)	646.7	
		Devonian strata (365 m bgl)	481.7	
Bore/standpipe	Old Production bore	May 2017- present	Shoalhaven Group (37-69 m bgl)	NA
	ARP05	August 2012–present	Gap Creek alluvium (8–11 m bgl)	747.05
	ARP07	July 2013–present (dry)	Narrabeen Sandstone (110–119 m bgl)	730.58
	ARP08	September 2013– present	Lithgow Seam (301–305 m bgl)	712.2
	ARP09	June 2013–present (mostly dry)	Genowlan Creek alluvium (3–4 m bgl)	850.86
	ARP11	January 2017– present	Permian strata (1.25–15.3 m bgl)	734.77
	ARP12	January 2017– present (mostly dry)	Genowlan Creek alluvium (0.5–2.6 m bgl)	891.72
	ARP13SP	January 2017– present	Lithgow Seam (67.5–70.5 m bgl)	704.81
	ARP14	January 2017– present	Genowlan Creek alluvium (0.5–2.3 m bgl)	781.54
	ARP15SP	January 2017– present	Narrabeen sandstone (10–16 m bgl)	813.7
Seepage	Village Spring	February 2011–present	Permian Siltstone	-
	Mine workings	December 2009–present	Lithgow Seam	-

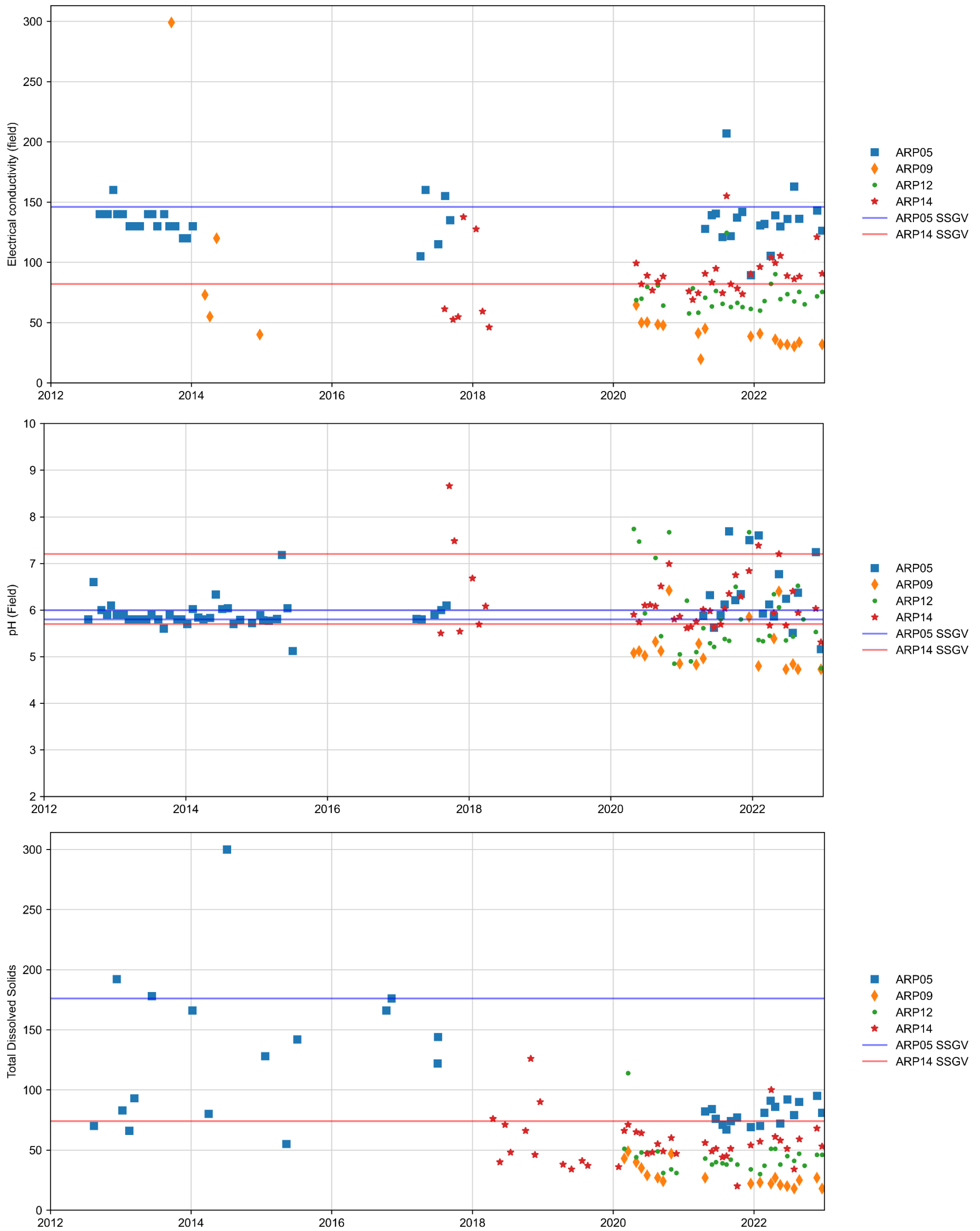
¹ Logger box damaged by tree fall January 2021

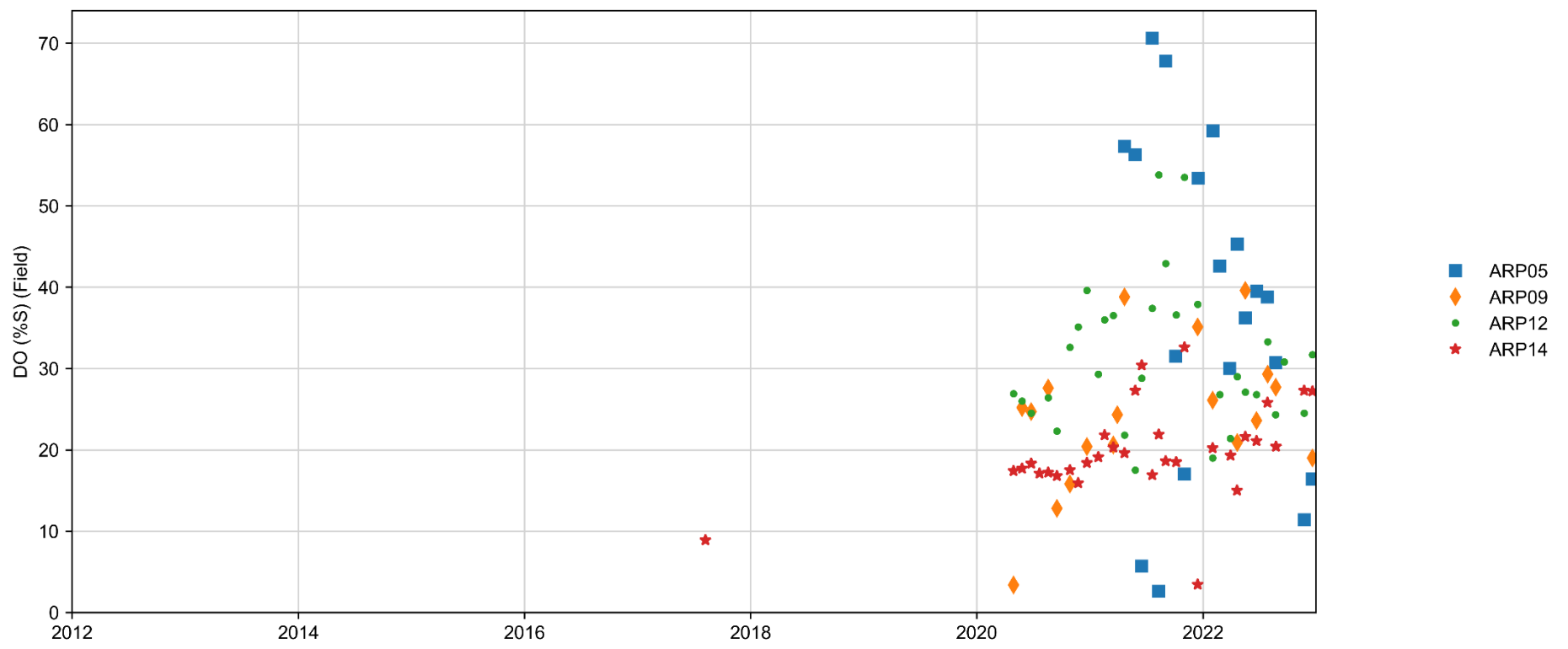
C.4 Statistical summary of water quality results – Alluvial bores

Parameters	Units	ARP09				ARP05				ARP12				ARP14			
		Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max
Physiochemical Parameters																	
Dissolved Oxygen (Field)	mg/L	19	1.39	2.62	33.7	22	0.27	4.035	55.5	33	1.87	3.09	7.14	33	1.54	2.01	224
Electrical conductivity (field)	µS/cm	22	19.6	43.1	299	44	89.3	135.45	1430	31	57.6	69.8	124.5	37	46.1	86	155
pH (Field)	pH units	19	4.73	5.08	6.42	62	5.12	5.895	7.69	34	4.75	5.49	7.74	40	5.31	5.995	8.66
Total Dissolved Solids	mg/L	19	18	27	49	34	55	83.5	300	28	30	41.5	114	40	20	52	126
Major Ions																	
Alkalinity (Carbonate as CaCO ₃)	mg/L	24	1	1	1	67	1	1	1	35	1	1	1	63	1	1	1
Alkalinity (Bicarbonate as CaCO ₃)	mg/L	24	1	5	13	66	18	27	61	35	1	10	35	63	6	14	40
Alkalinity (Hydroxide as CaCO ₃)	mg/L	23	1	1	1	67	1	1	1	35	1	1	1	63	1	1	1
Alkalinity (total as CaCO ₃)	mg/L	23	1	5	13	66	18	27	61	35	1	10	35	62	6	14	40
Calcium (Filtered)	mg/L	24	1	1	6	63	3	6	13	35	1	1	2	63	1	3	14
Magnesium (Filtered)	mg/L	24	1	1	1	63	2	4	5	35	1	2	4	63	1	2	8
Potassium (Filtered)	mg/L	24	1	1	2	63	1	2	4	35	1	1	2	63	1	2	3
Sodium (Filtered)	mg/L	24	3	4.5	10	63	6	12	21	35	3	7	19	63	5	7	64
Chloride	mg/L	24	5	8	18	66	4	19	28	35	5	12	39	63	6	12	19
Sulfate (Filtered)	mg/L	23	1	1	9	26	1	6	8	35	1	2	10	63	1	2	7
Metals (Dissolved)																	
Aluminium (Filtered)	mg/L	4	0.27	0.575	0.88	11	0.01	0.06	0.89	3	0.12	0.14	0.29	5	0.05	0.06	0.18
Arsenic (Filtered)	mg/L	28	0.001	0.001	0.001	67	0.001	0.001	0.006	35	0.001	0.001	0.001	62	0.001	0.001	0.001
Cadmium (Filtered)	mg/L	28	0.0001	0.0001	0.0001	67	0.0001	0.0001	0.0002	35	0.0001	0.0001	0.0001	62	0.0001	0.0001	0.0004
Chromium (III+VI) (Filtered)	mg/L	28	0.001	0.001	0.002	67	0.001	0.001	0.001	35	0.001	0.001	0.002	62	0.001	0.001	0.001
Cobalt (Filtered)	mg/L	3	0.001	0.001	0.001	7	0.001	0.001	0.002	3	0.001	0.001	0.001	5	0.001	0.001	0.002
Copper (Filtered)	mg/L	28	0.001	0.0015	0.013	67	0.001	0.002	0.012	35	0.001	0.001	0.004	62	0.001	0.001	0.033
Iron (Filtered)	mg/L	28	0.05	0.245	2.62	66	0.05	0.05	0.39	35	0.05	0.57	4.68	62	0.05	0.51	2.55
Lead (Filtered)	mg/L	28	0.001	0.001	0.001	67	0.001	0.001	0.003	35	0.001	0.001	0.001	62	0.001	0.001	0.002
Manganese (Filtered)	mg/L	27	0.004	0.013	0.067	65	0.001	0.005	0.032	35	0.001	0.006	0.048	62	0.007	0.06	0.74
Mercury (Filtered)	mg/L	28	0.0001	0.0001	0.0001	65	0.0001	0.0001	0.0001	35	0.0001	0.0001	0.0001	62	0.0001	0.0001	0.0001
Nickel (Filtered)	mg/L	28	0.001	0.001	0.006	66	0.001	0.002	0.062	35	0.001	0.001	0.004	62	0.001	0.001	0.011
Zinc (Filtered)	mg/L	28	0.008	0.027	0.093	66	0.002	0.0345	1.25	35	0.007	0.048	0.628	62	0.005	0.019	0.386

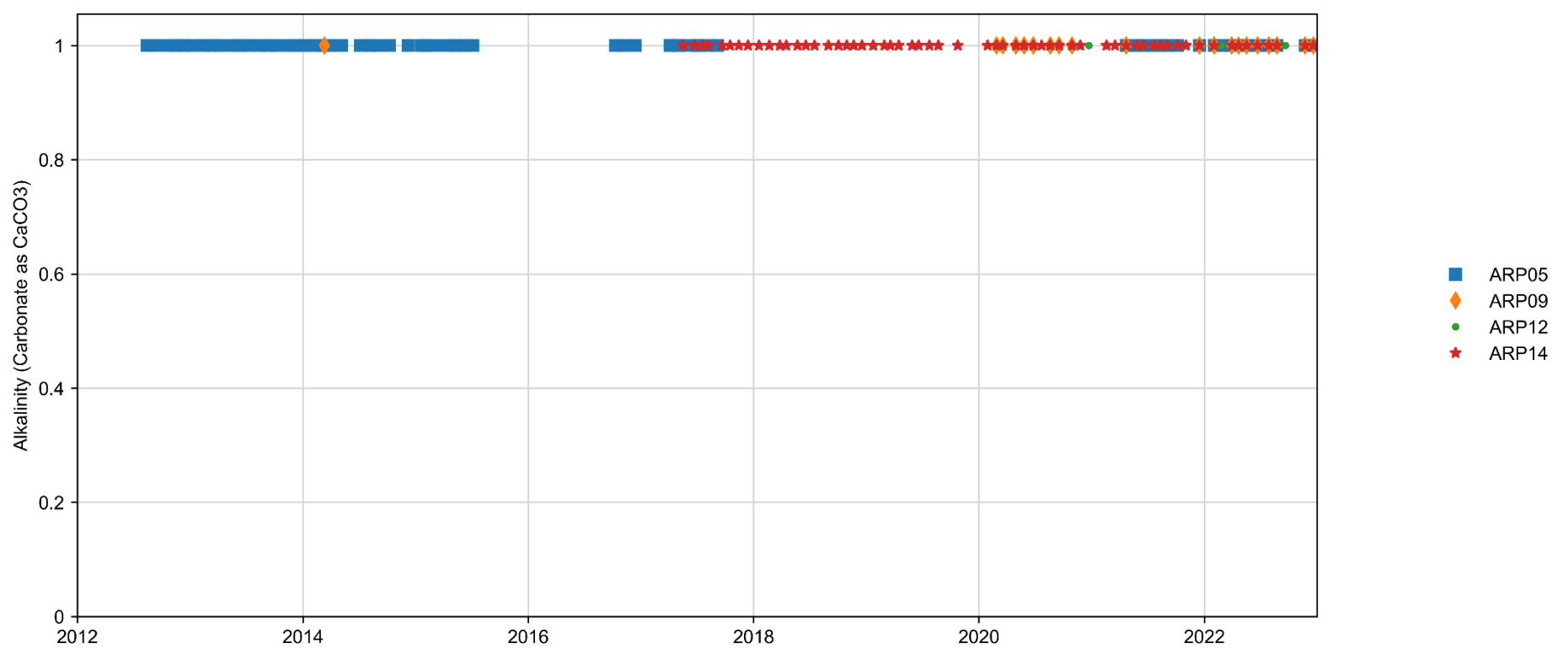
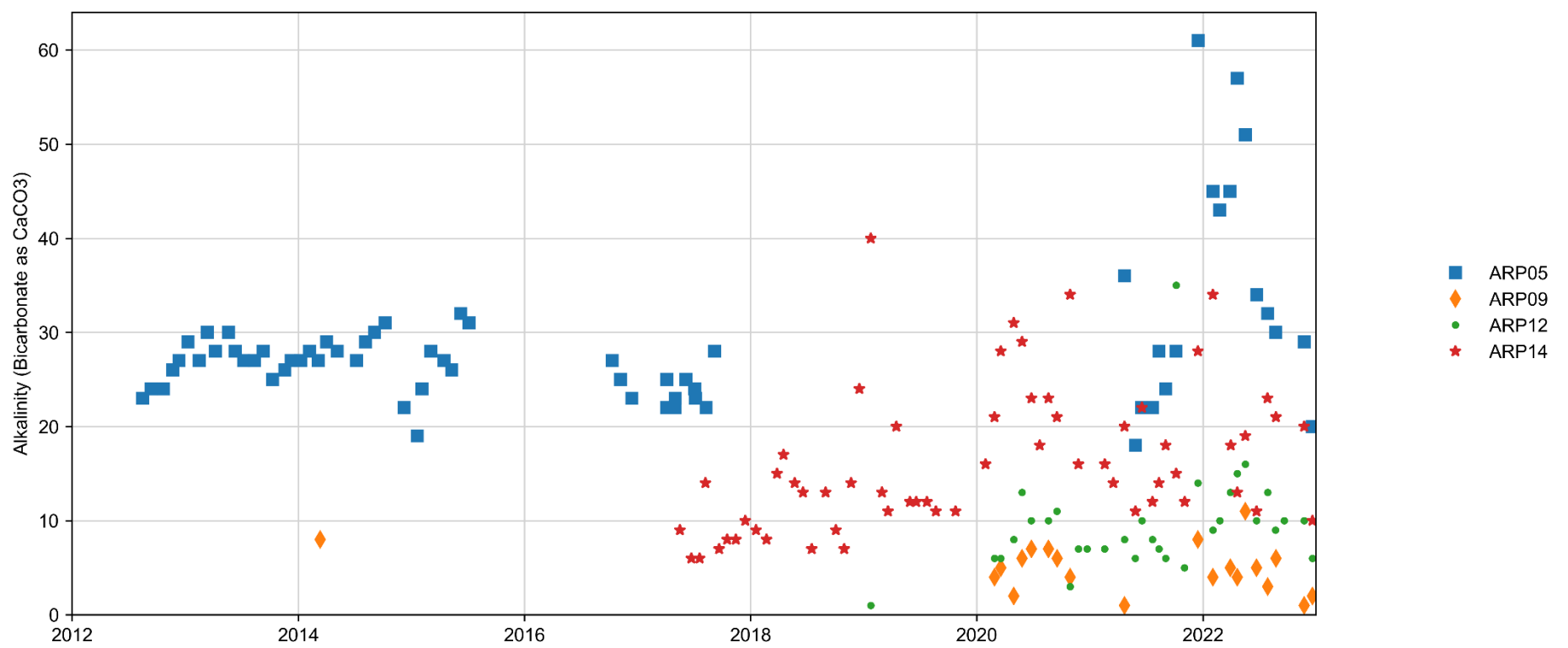
C.5 Timeseries of water quality results – Alluvial bores

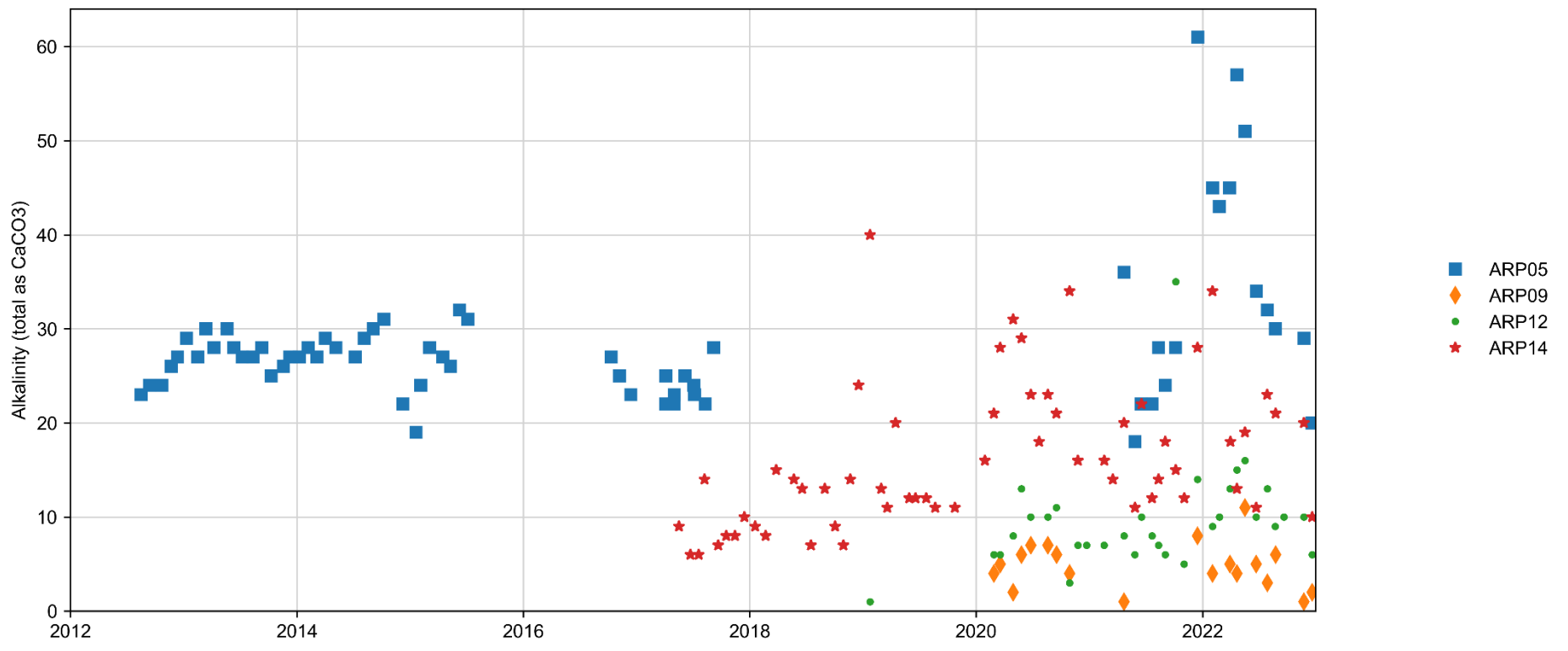
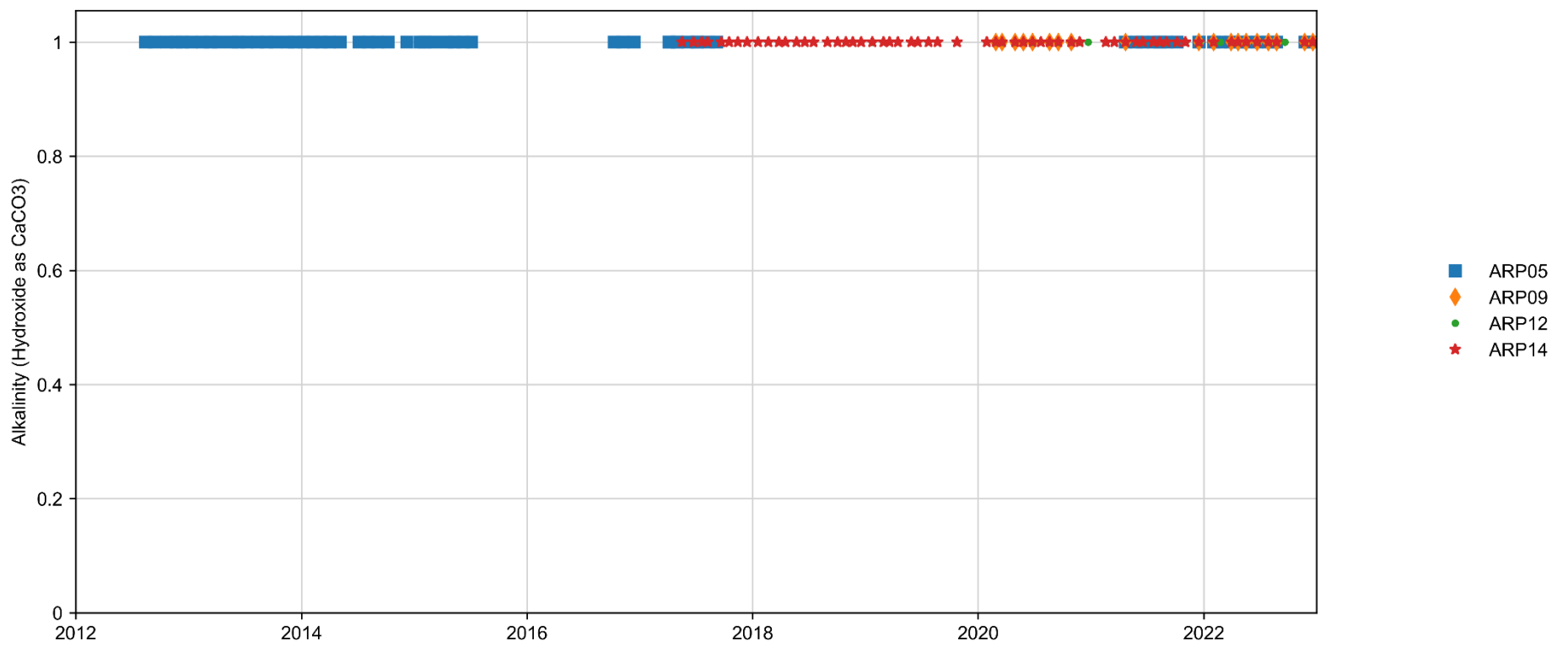
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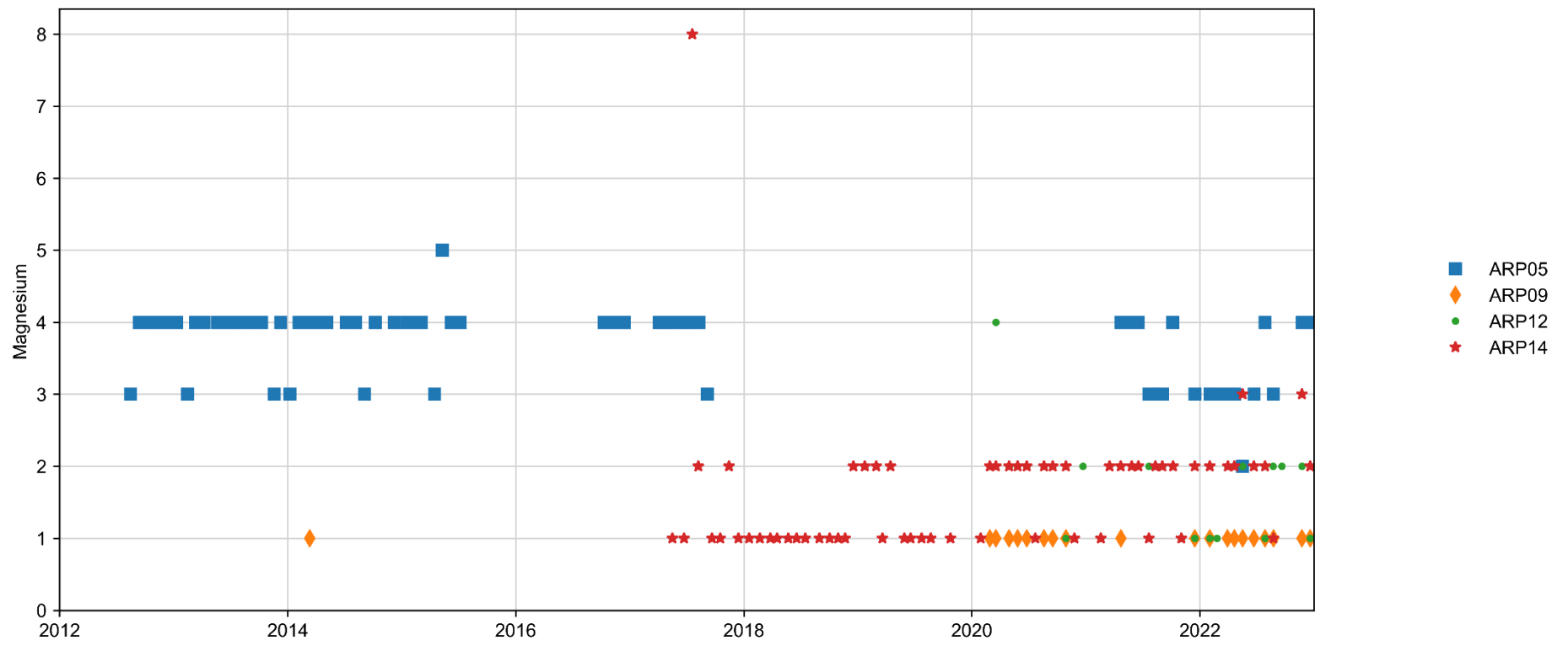
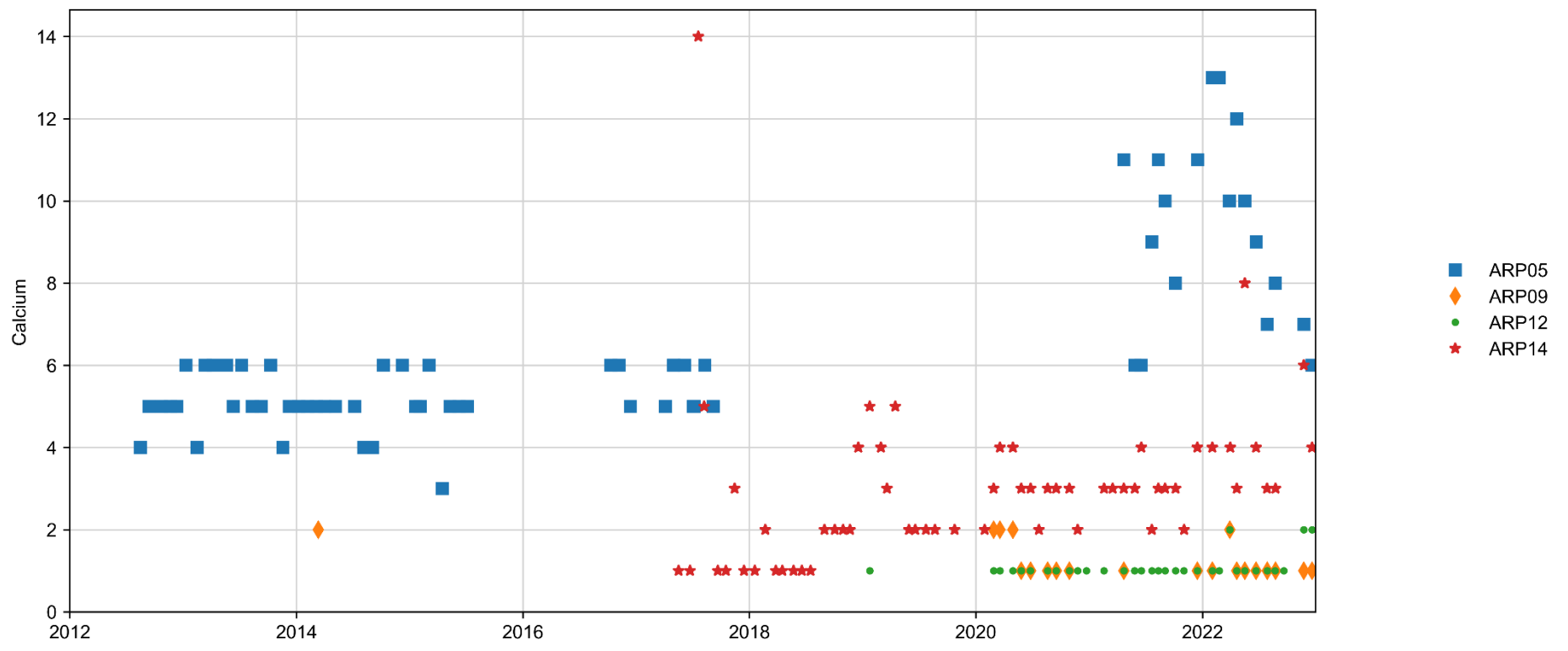
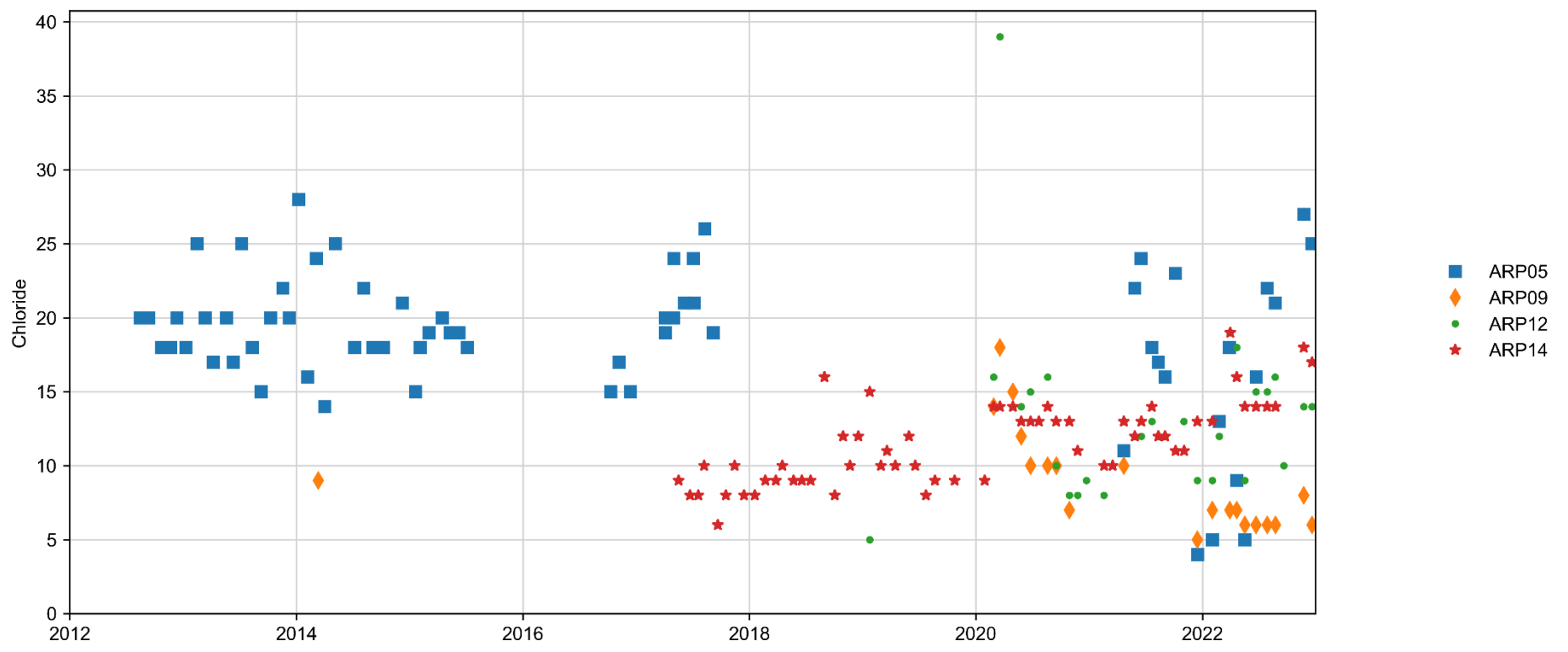


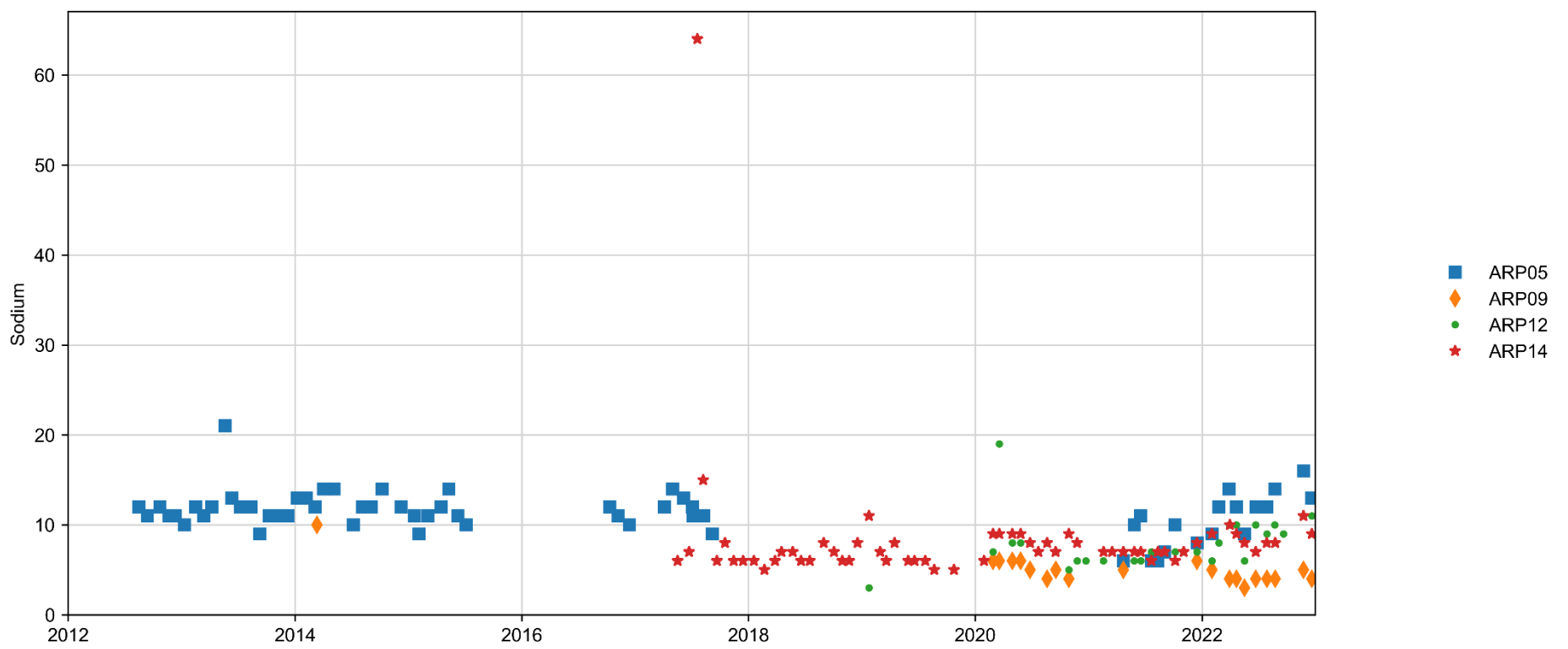
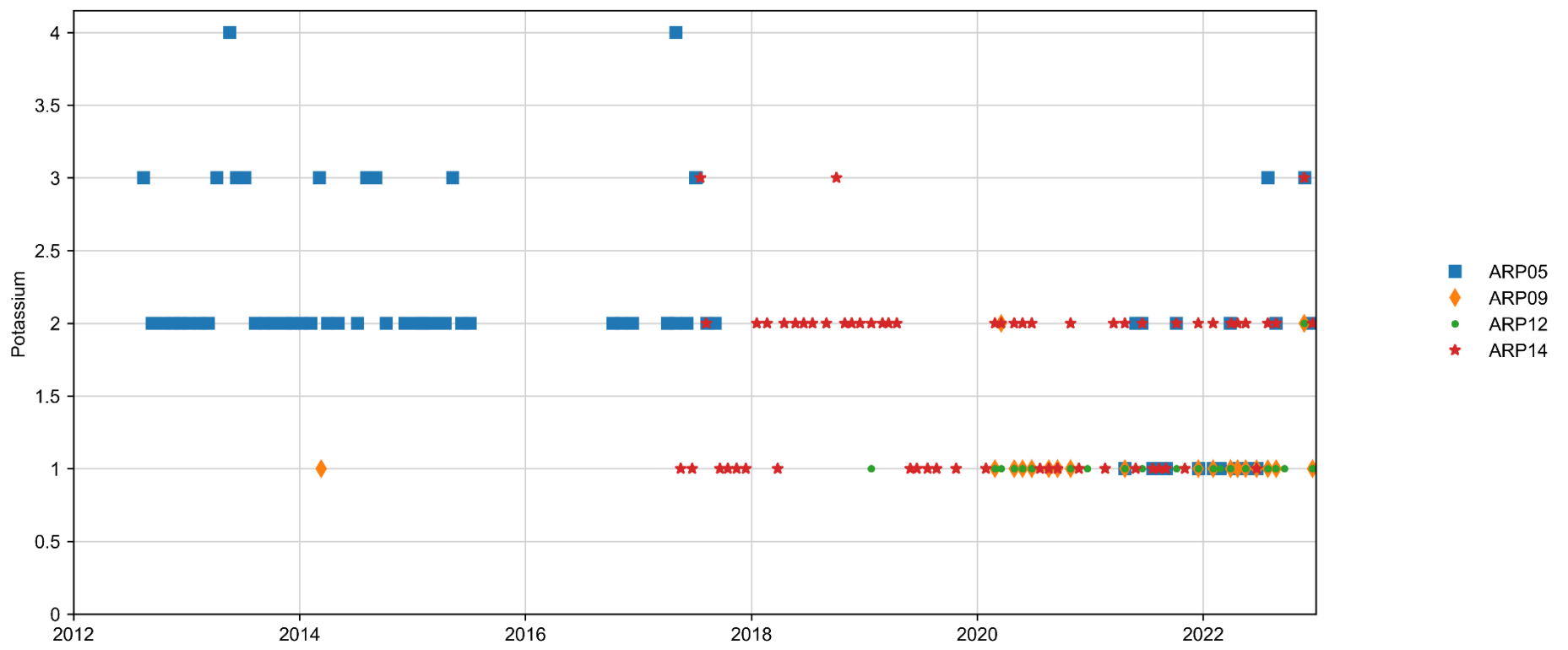


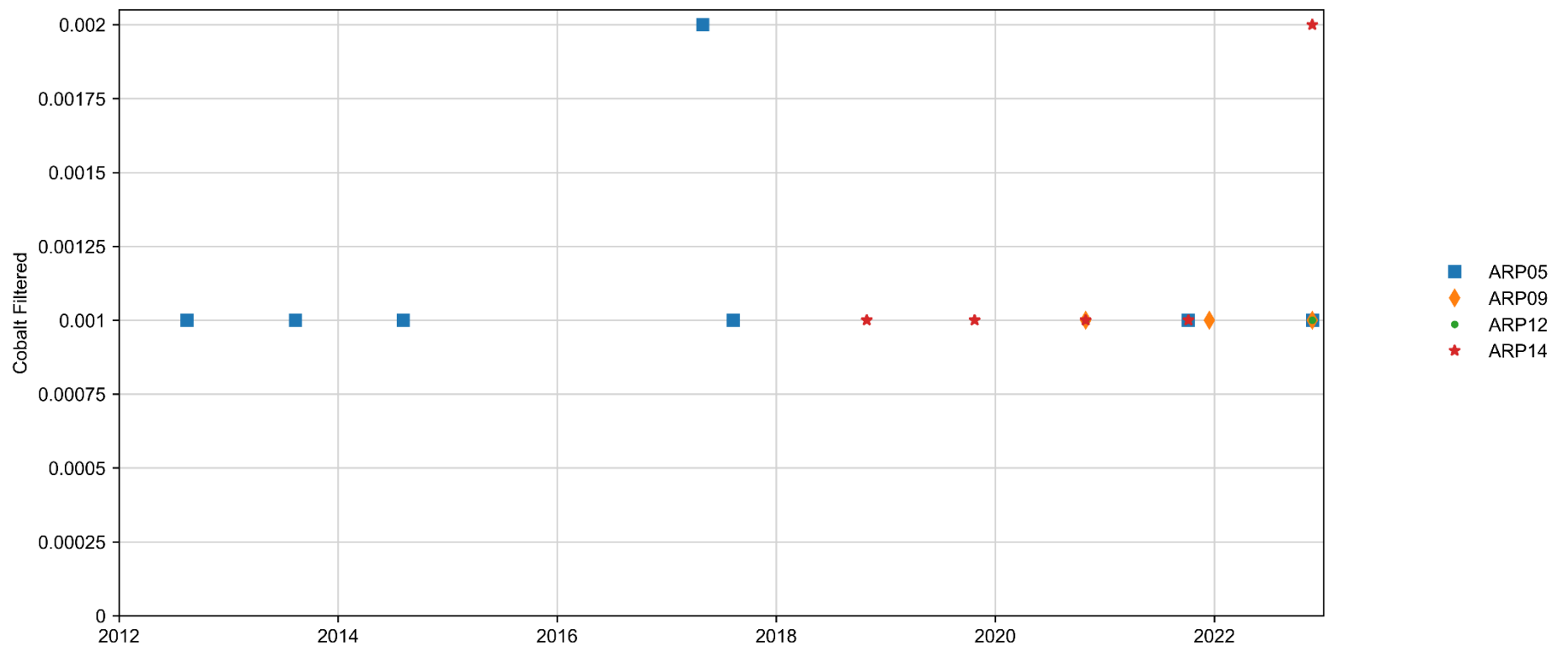
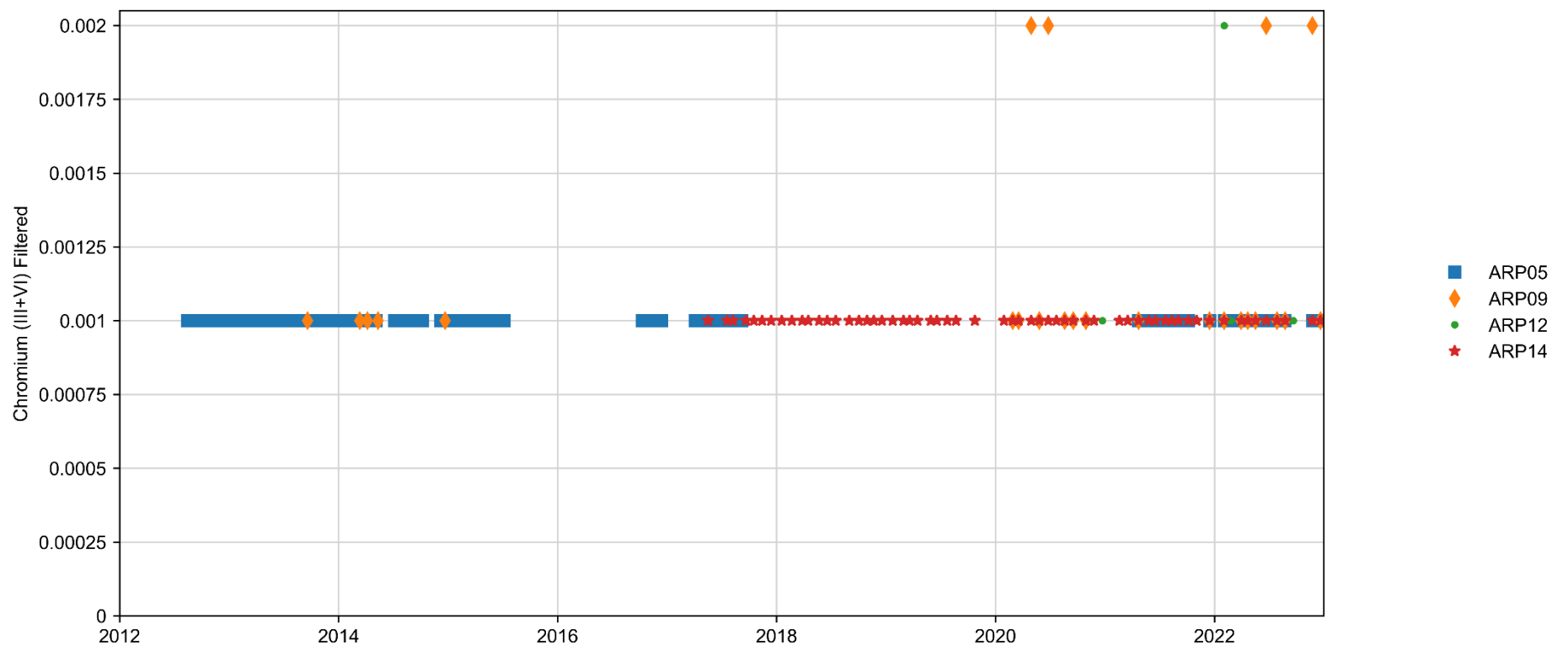
Major Ions

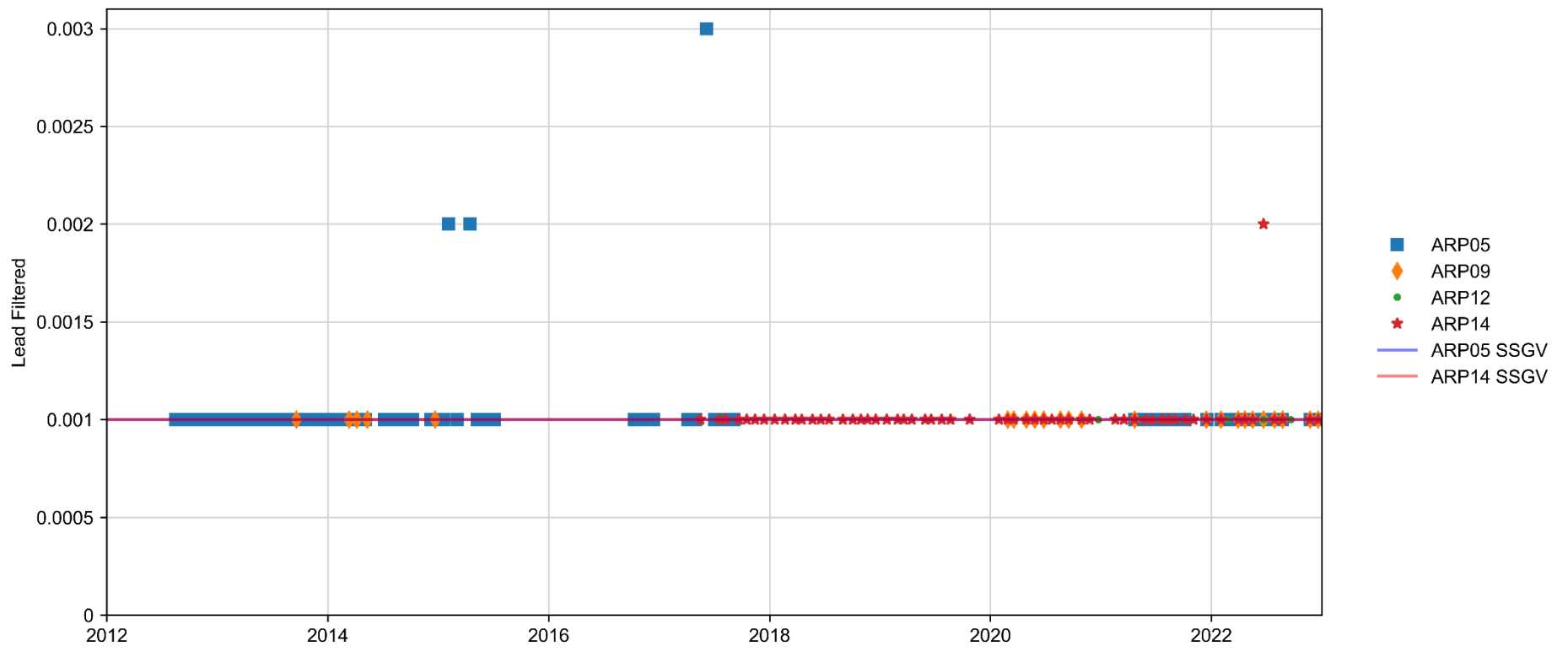
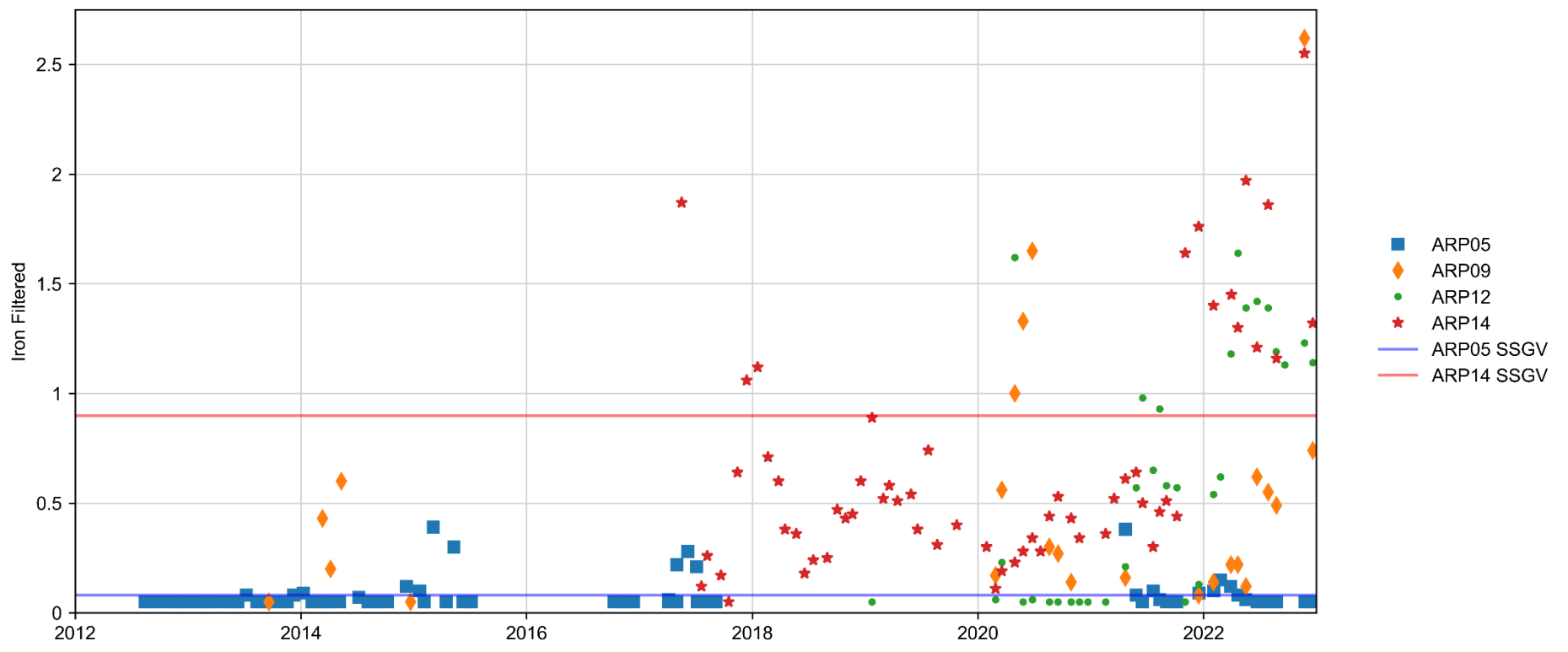
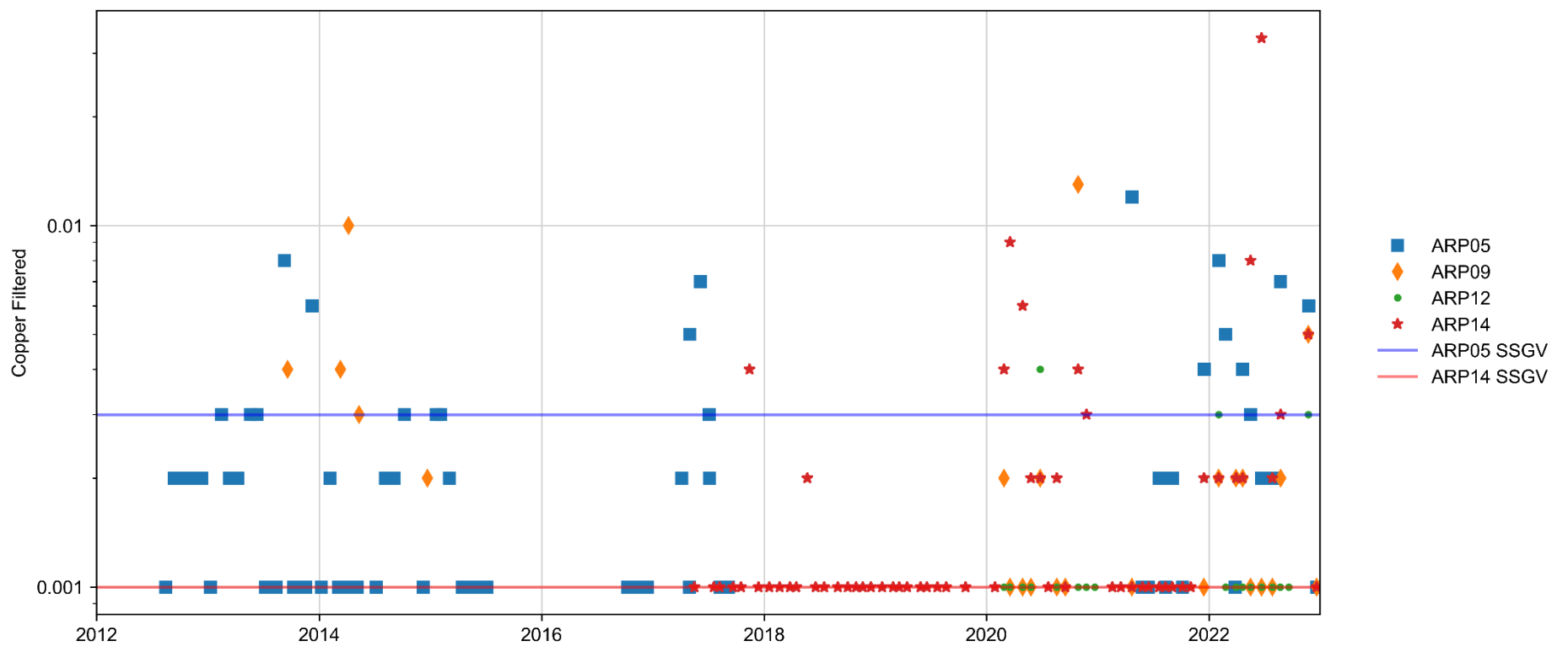


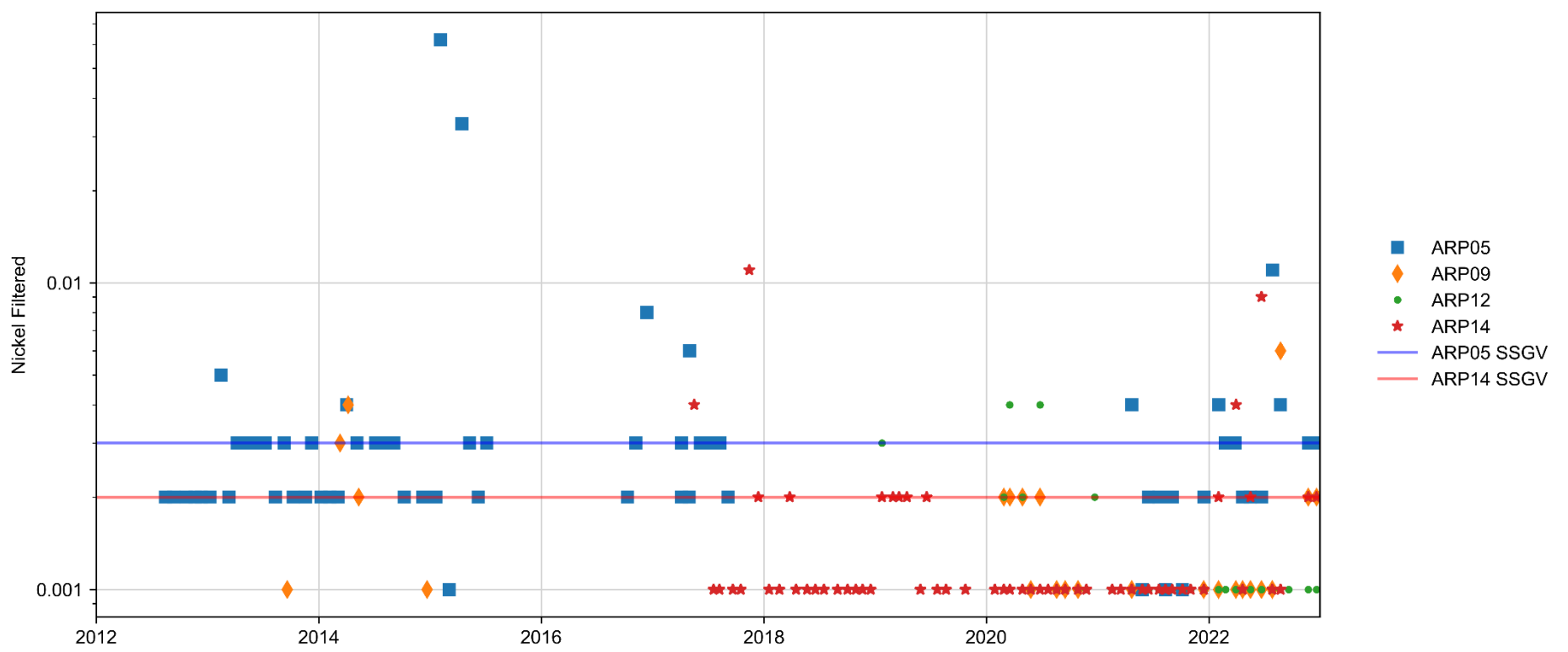
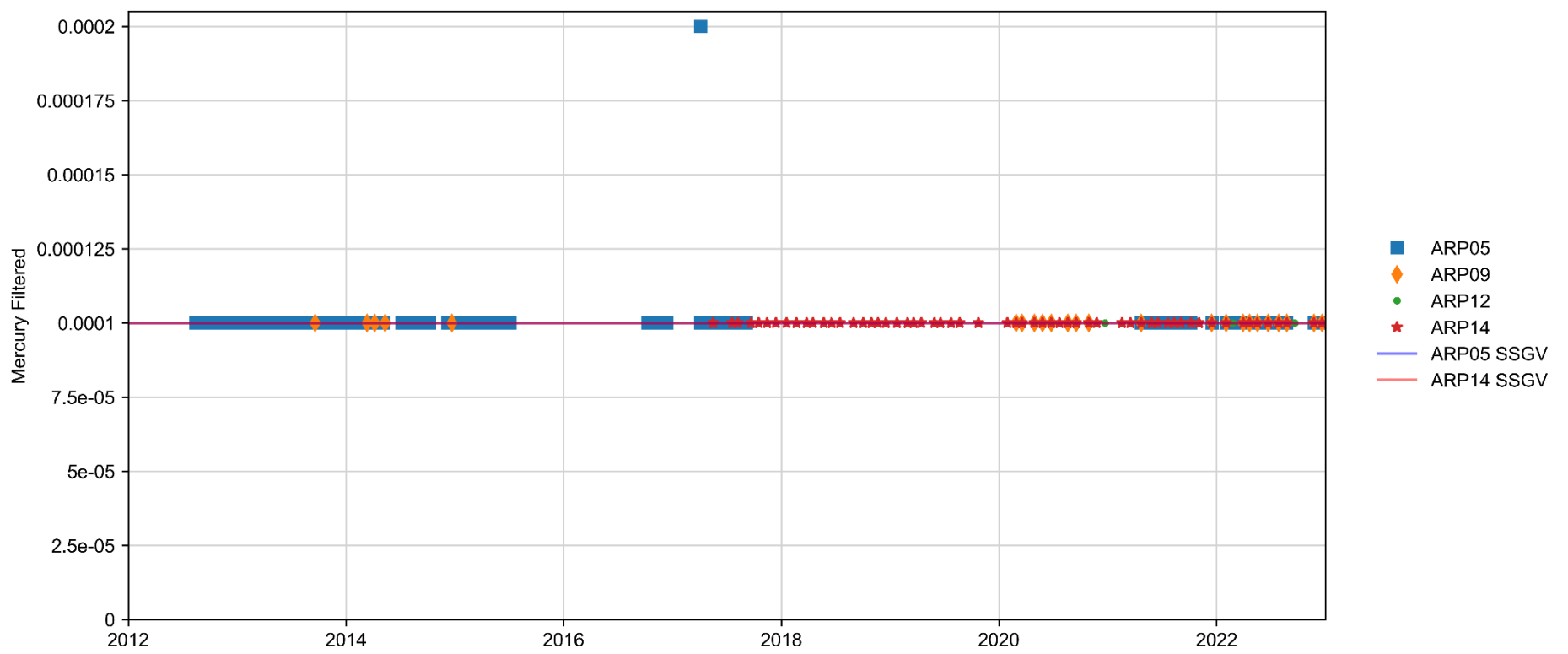
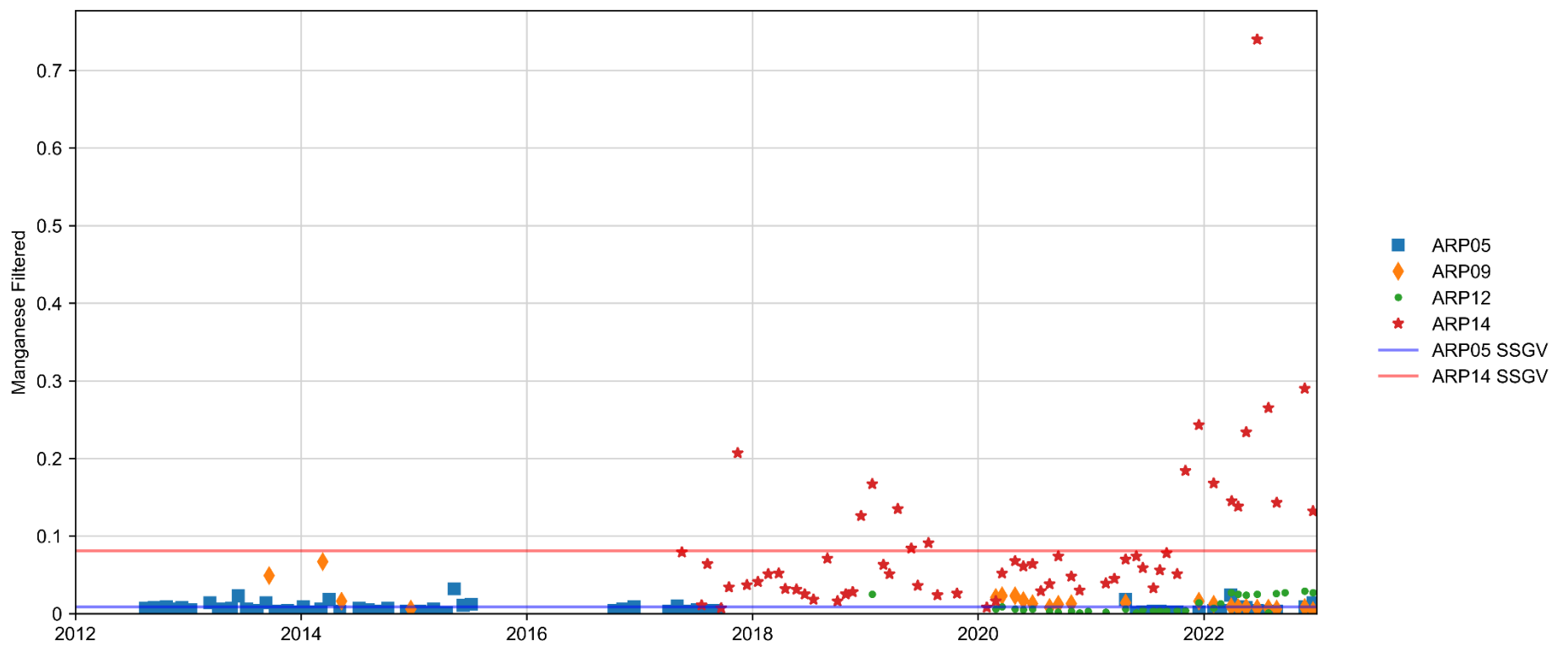


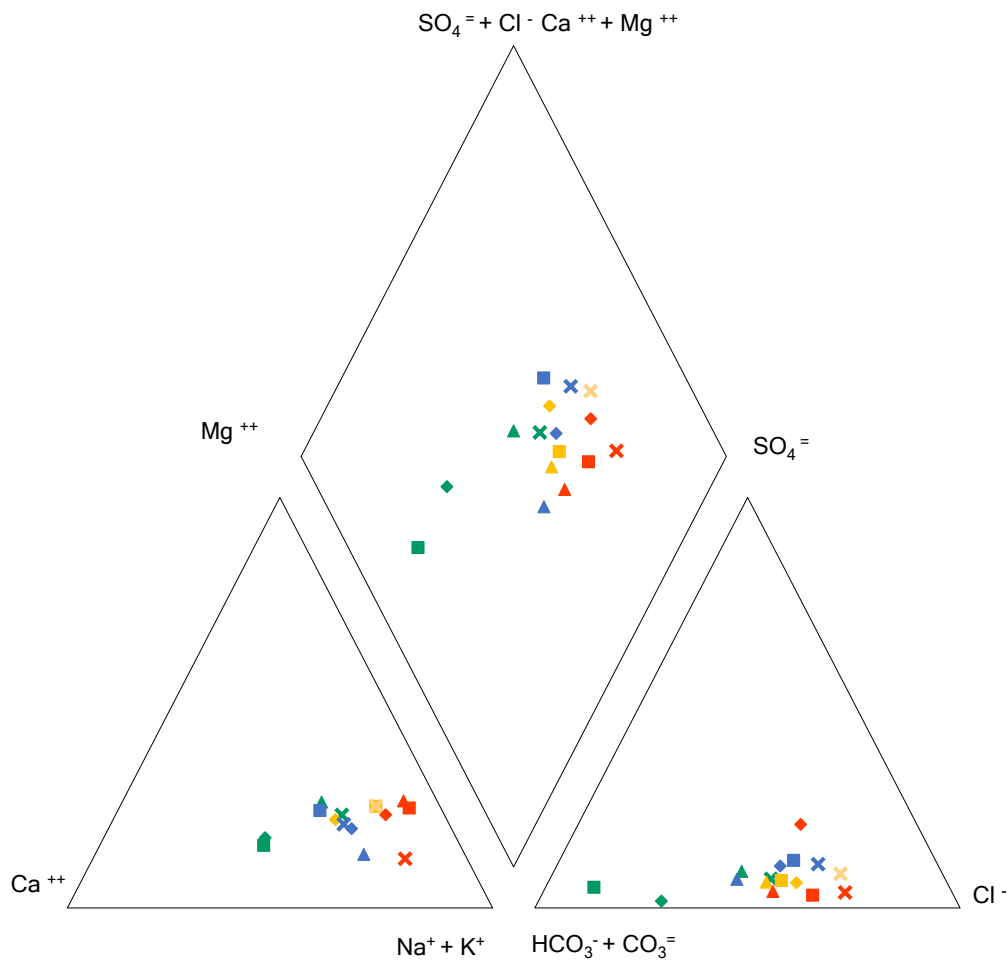
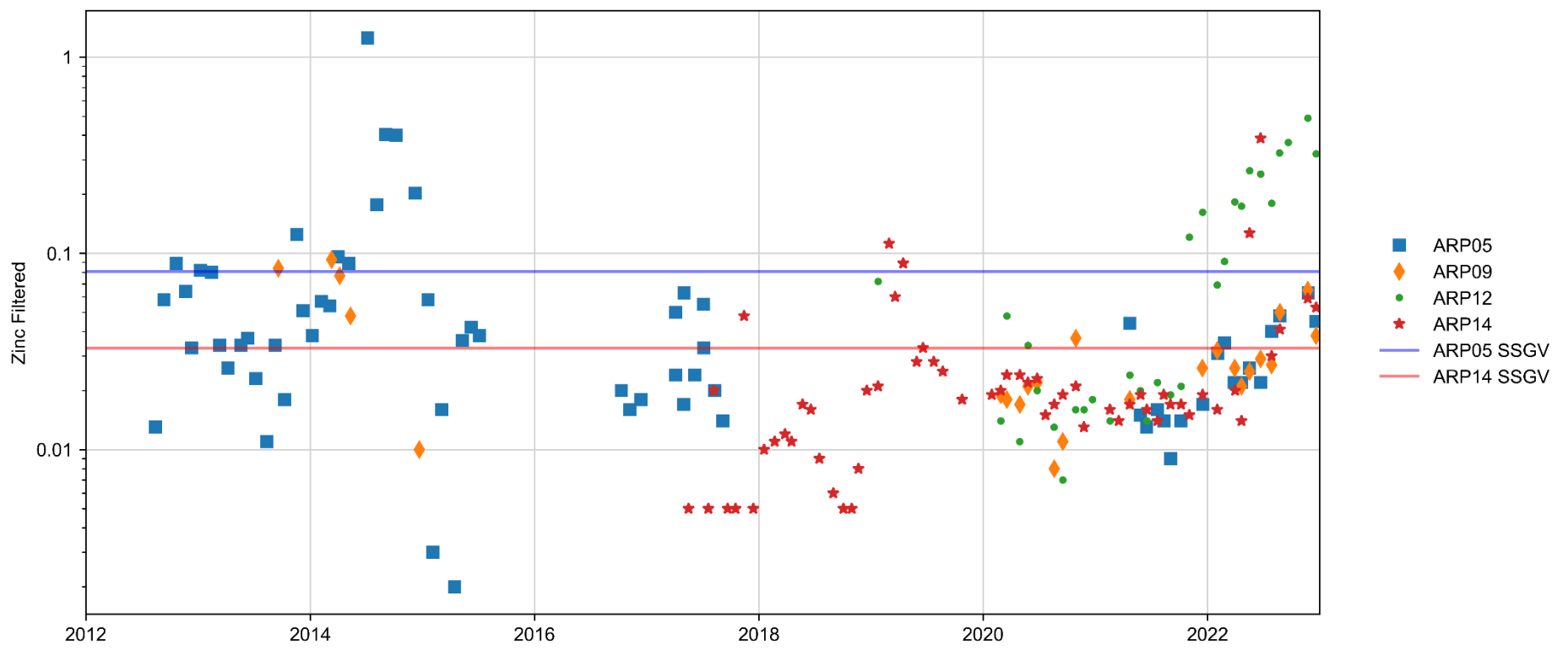












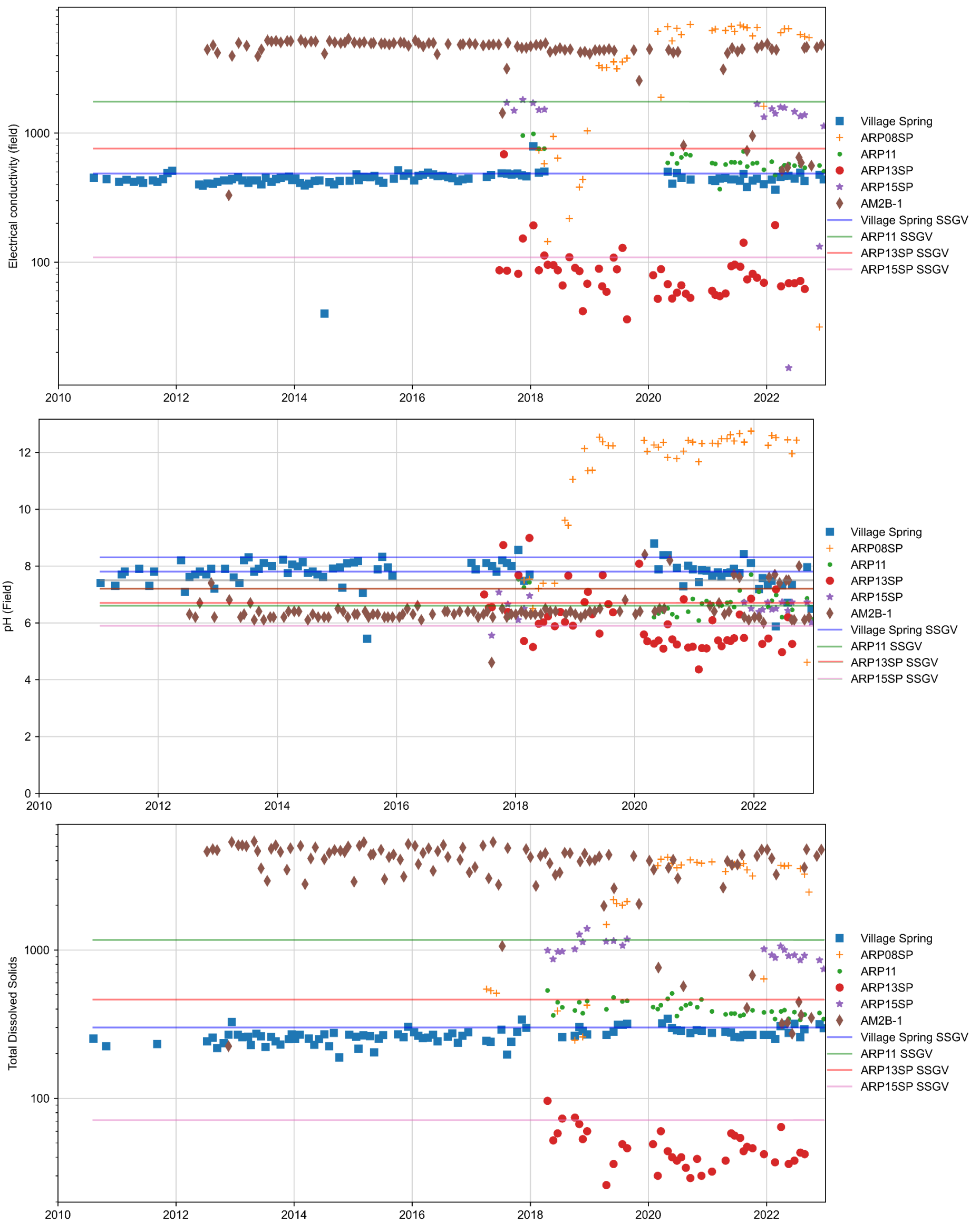
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- ◇ Genowlan Creek Alluvium ARP09 March 2022
- Genowlan Creek Alluvium ARP09 June 2022
- ▲ Genowlan Creek Alluvium ARP09 August 2022
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- ◇ Genowlan Creek Alluvium ARP12 March 2022
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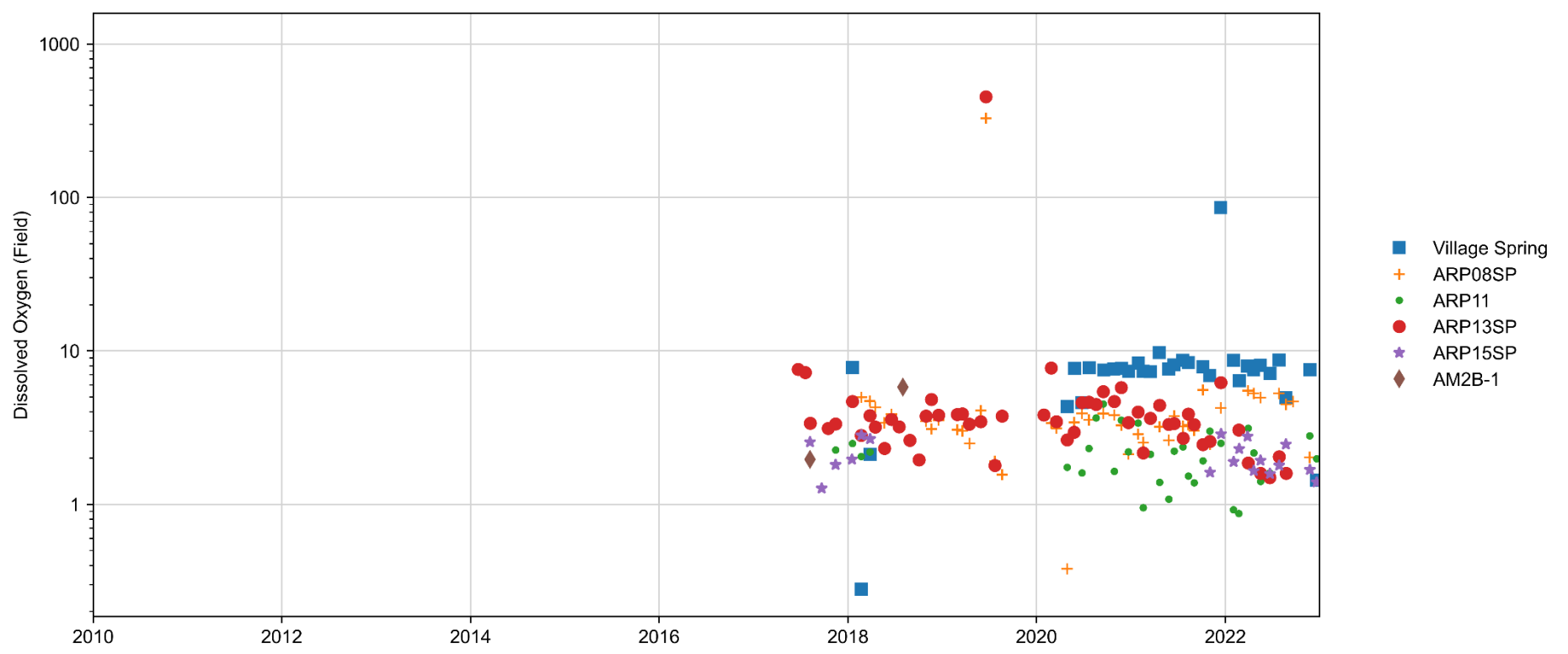
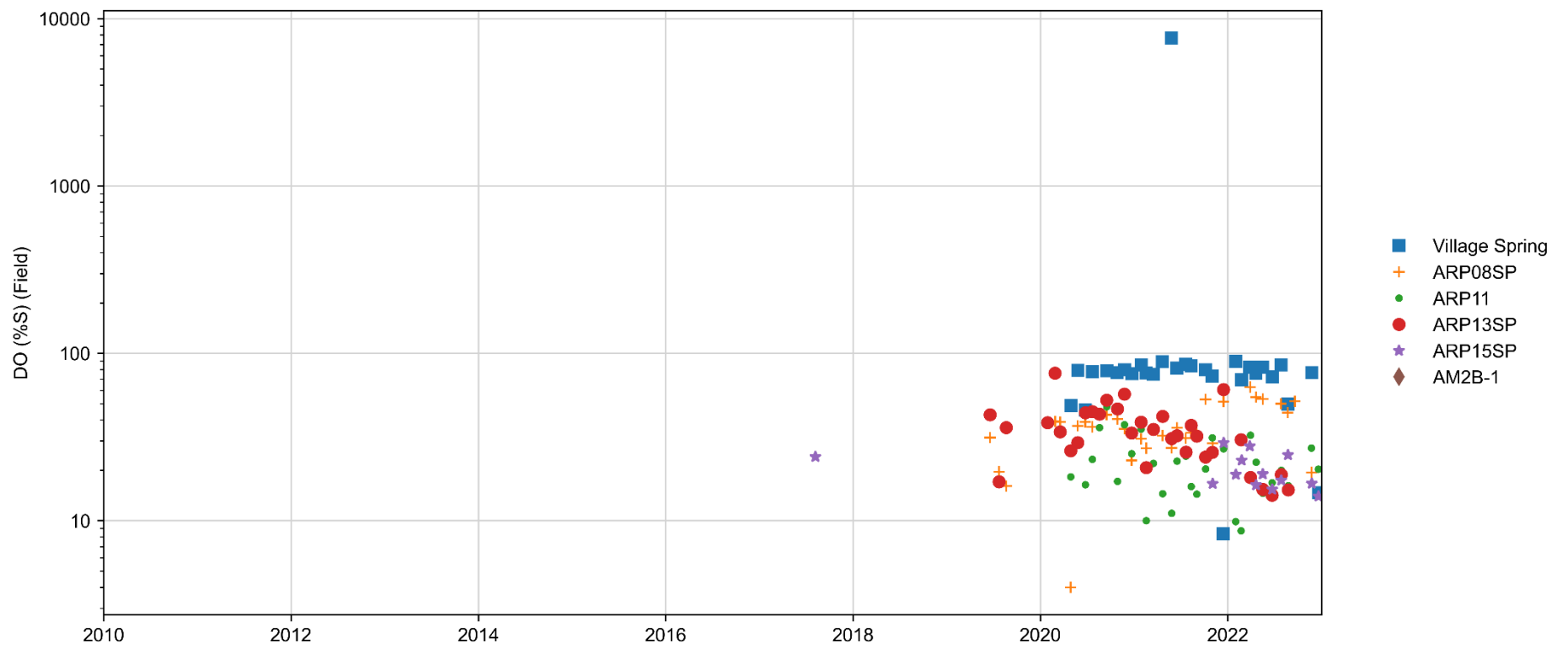
C.6 Statistical summary of water quality results – Fractured Rock Bores

Parameters	Units	ARP08				Village Spring				ARP11				ARP13				ARP15			
		Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max
Physiochemical Parameters																					
Dissolved Oxygen (Field)	mg/L	42	0.38	3.385	327	32	1.44	7.59	85.9	33	1.87	3.09	7.14	34	0.87	2.14	4.51	29	1.49	3.36	1050
Electrical conductivity (field)	µS/cm	41	31.4	5490	65544	107	40	440	789	31	57.6	69.8	124.5	35	368.6	583.3	987	32	52.3	72.55	193.5
pH (Field)	pH units	44	4.61	12.245	12.75	89	5.44	7.8	8.79	34	4.75	5.49	7.74	38	6.08	6.66	7.7	35	4.36	5.42	8.99
Total Dissolved Solids	mg/L	36	246	3495	4210	97	188	267	344	28	30	41.5	114	42	338	392.5	533	37	26	44	96
Major Ions																					
Alkalinity (Carbonate as CaCO3)	mg/L	45	1	52	159	117	1	1	26	35	1	1	1	62	1	1	51	58	1	1	1
Alkalinity (Bicarbonate as CaCO3)	mg/L	45	1	1	437	117	128	203	269	35	1	10	35	62	220	329.5	416	58	1	12	447
Alkalinity (Hydroxide as CaCO3)	mg/L	45	1	1210	1670	117	1	1	2	35	1	1	1	62	1	1	1	58	1	1	1
Alkalinity (total as CaCO3)	mg/L	45	146	1260	1700	116	128	203	269	35	1	10	35	61	220	330	416	57	1	12	447
Calcium (Filtered)	mg/L	46	4	417.5	630	109	34	44	60	35	1	1	2	62	9	53	72	58	2	3	81
Magnesium (Filtered)	mg/L	46	1	1	46	109	15	19	25	35	1	2	4	62	12	24	28	58	1	1	33
Potassium (Filtered)	mg/L	46	10	13	28	109	6	8	12	35	1	1	2	62	20	25	82	58	1	1	6
Sodium (Filtered)	mg/L	46	20	30	99	109	9	13	25	35	3	7	19	62	17	26	104	58	4	7	180
Chloride	mg/L	45	1	8	30	54	7	14	23	35	1	2	10	62	4	5.5	24	58	1	3	101
Sulfate (Filtered)	mg/L	45	1	8	30	54	7	14	23	35	1	2	10	62	4	5.5	24	58	1	3	101
Metals (Dissolved)																					
Aluminium (Filtered)	mg/L	5	0.17	0.59	1.4	14	0.01	0.01	0.01	3	0.12	0.14	0.29	5	0.01	0.01	0.01	4	0.02	0.025	0.03
Arsenic (Filtered)	mg/L	45	0.001	0.001	0.001	128	0.001	0.001	0.001	35	0.001	0.001	0.001	62	0.001	0.001	0.005	57	0.001	0.001	0.002
Cadmium (Filtered)	mg/L	45	0.0001	0.0001	0.0002	127	0.0001	0.0001	0.0001	35	0.0001	0.0001	0.0001	62	0.0001	0.0001	0.0001	57	0.0001	0.0001	0.0007
Chromium (III+VI) (Filtered)	mg/L	45	0.001	0.003	0.018	128	0.001	0.001	0.001	35	0.001	0.001	0.002	62	0.001	0.001	0.002	57	0.001	0.001	0.009
Cobalt (Filtered)	mg/L	4	0.001	0.001	0.001	14	0.001	0.001	0.002	3	0.001	0.001	0.001	5	0.001	0.001	0.004	4	0.001	0.0025	0.007
Copper (Filtered)	mg/L	45	0.004	0.041	0.328	128	0.001	0.001	0.004	35	0.001	0.001	0.004	62	0.001	0.001	0.005	57	0.001	0.001	0.098
Iron (Filtered)	mg/L	45	0.05	0.05	1.6	127	0.05	0.05	0.16	35	0.05	0.57	4.68	62	0.05	0.08	2.44	57	0.05	0.2	3.69
Lead (Filtered)	mg/L	45	0.001	0.002	0.022	128	0.001	0.001	0.005	35	0.001	0.001	0.001	62	0.001	0.001	0.003	57	0.001	0.001	0.023
Manganese (Filtered)	mg/L	45	0.001	0.001	0.435	118	0.001	0.002	0.017	35	0.001	0.006	0.048	62	0.016	0.117	0.736	57	0.028	0.114	1.39
Mercury (Filtered)	mg/L	45	0.0001	0.0001	0.0006	128	0.0001	0.0001	0.0001	35	0.0001	0.0001	0.0001	62	0.0001	0.0001	0.0001	57	0.0001	0.0001	0.0001
Nickel (Filtered)	mg/L	45	0.004	0.008	0.148	128	0.001	0.005	0.058	35	0.001	0.001	0.004	62	0.001	0.002	0.016	57	0.002	0.005	0.078
Zinc (Filtered)	mg/L	45	0.015	0.039	0.117	128	0.003	0.024	0.065	35	0.007	0.048	0.628	62	0.005	0.02	0.172	57	0.005	0.041	0.619

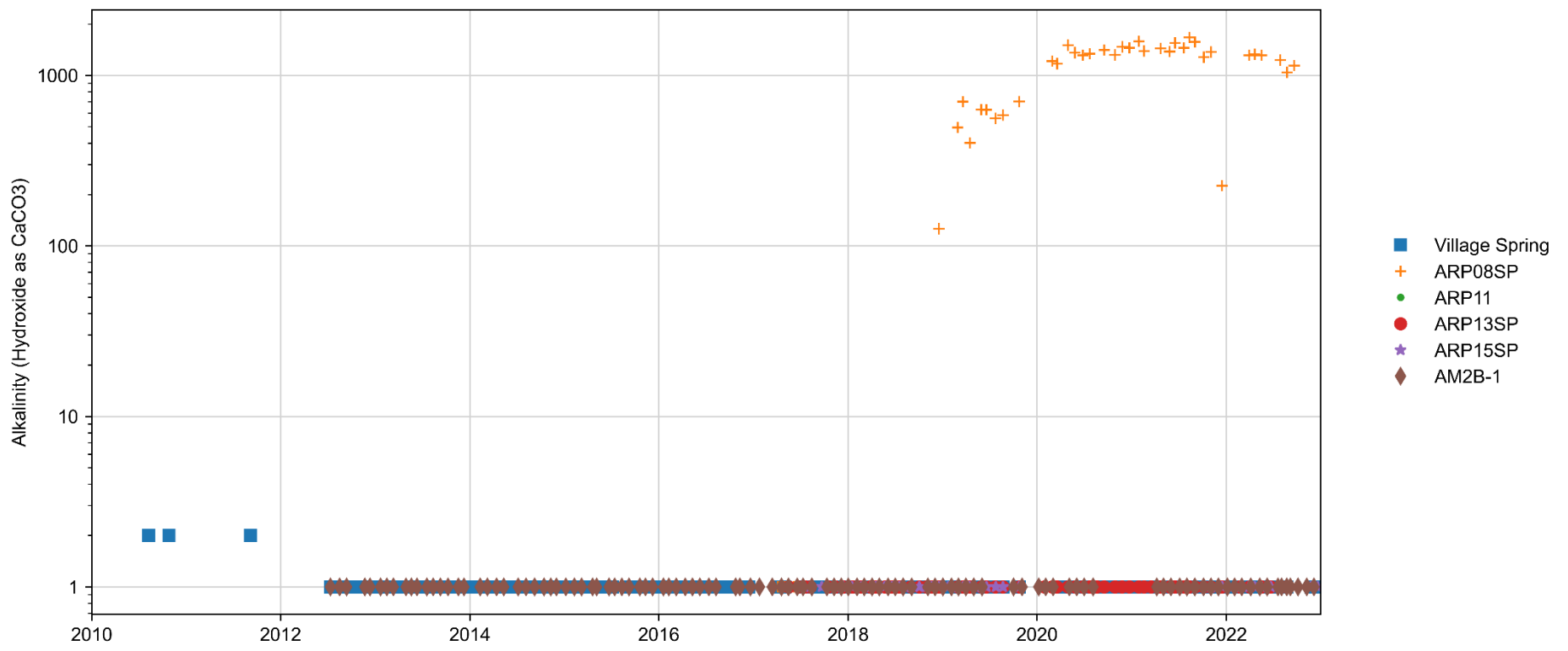
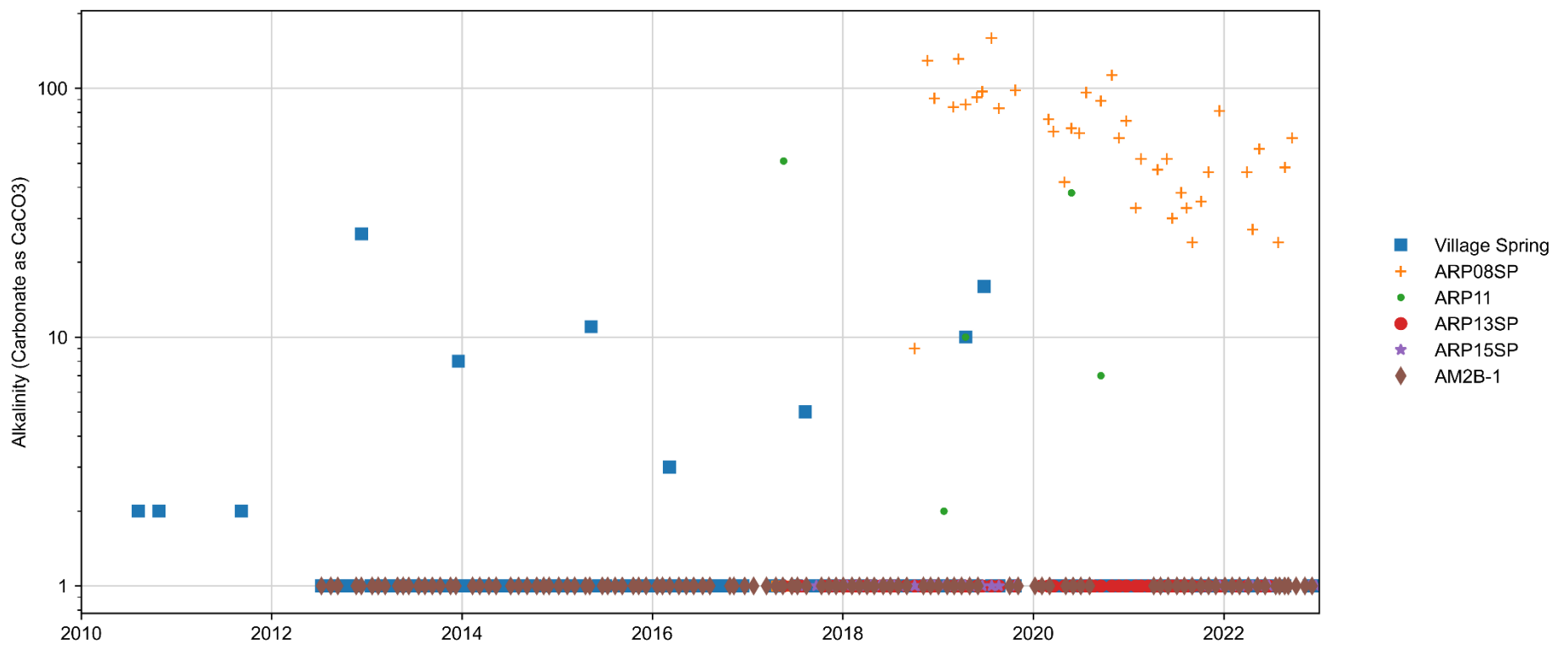
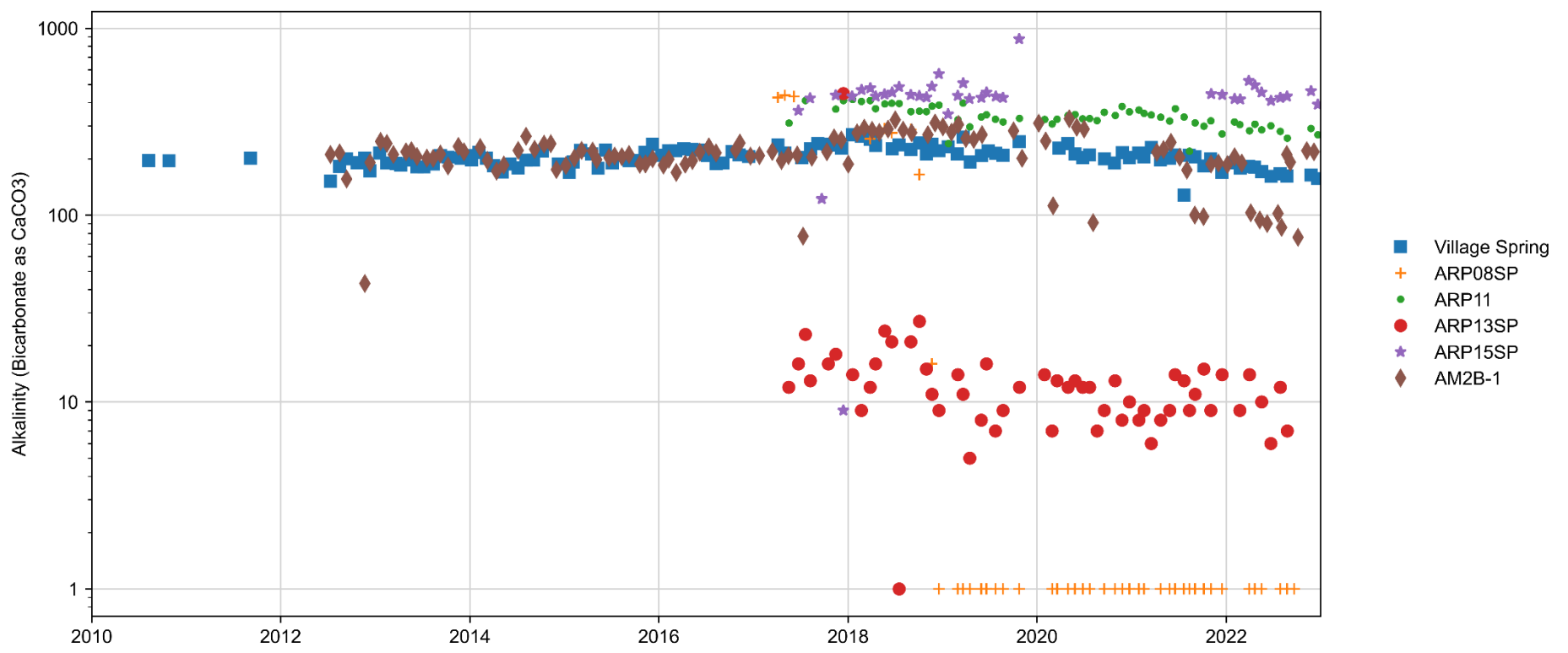
C.7 Timeseries of water quality results – Fractured rock bores

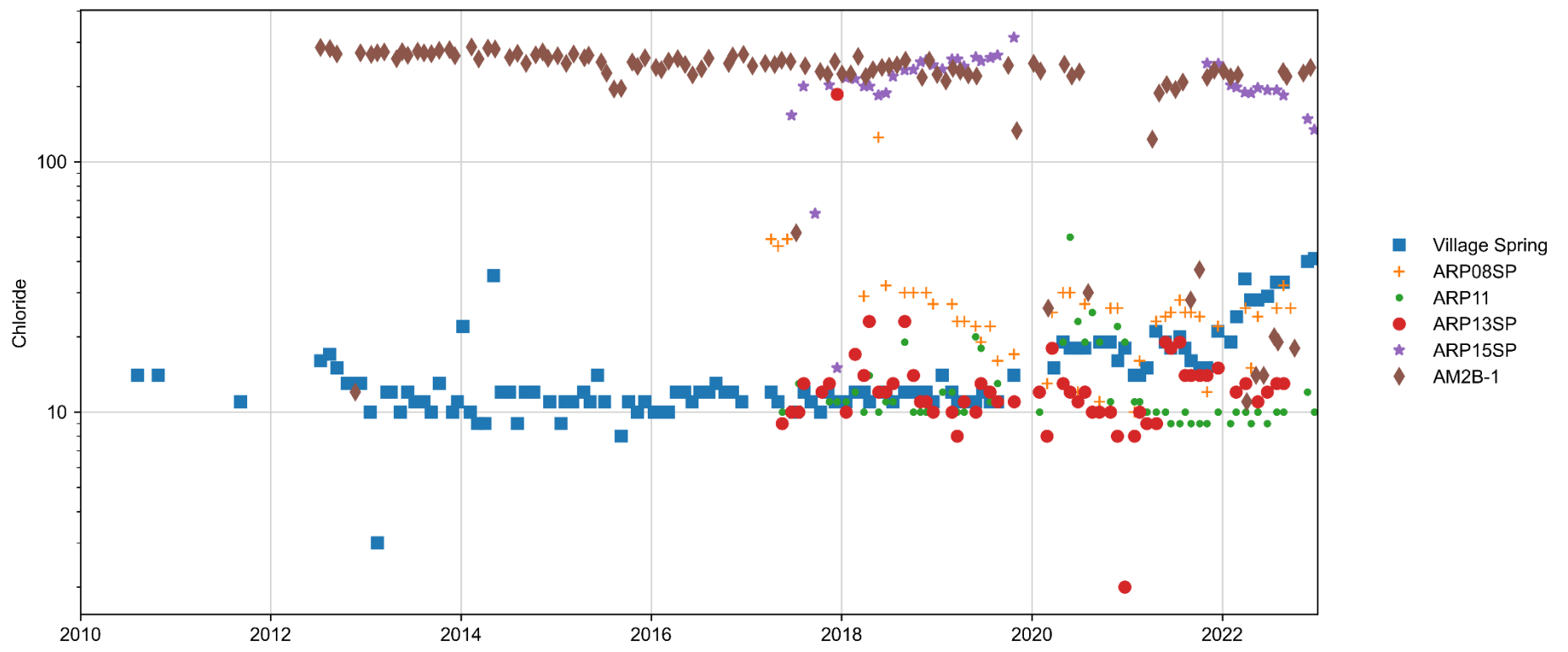
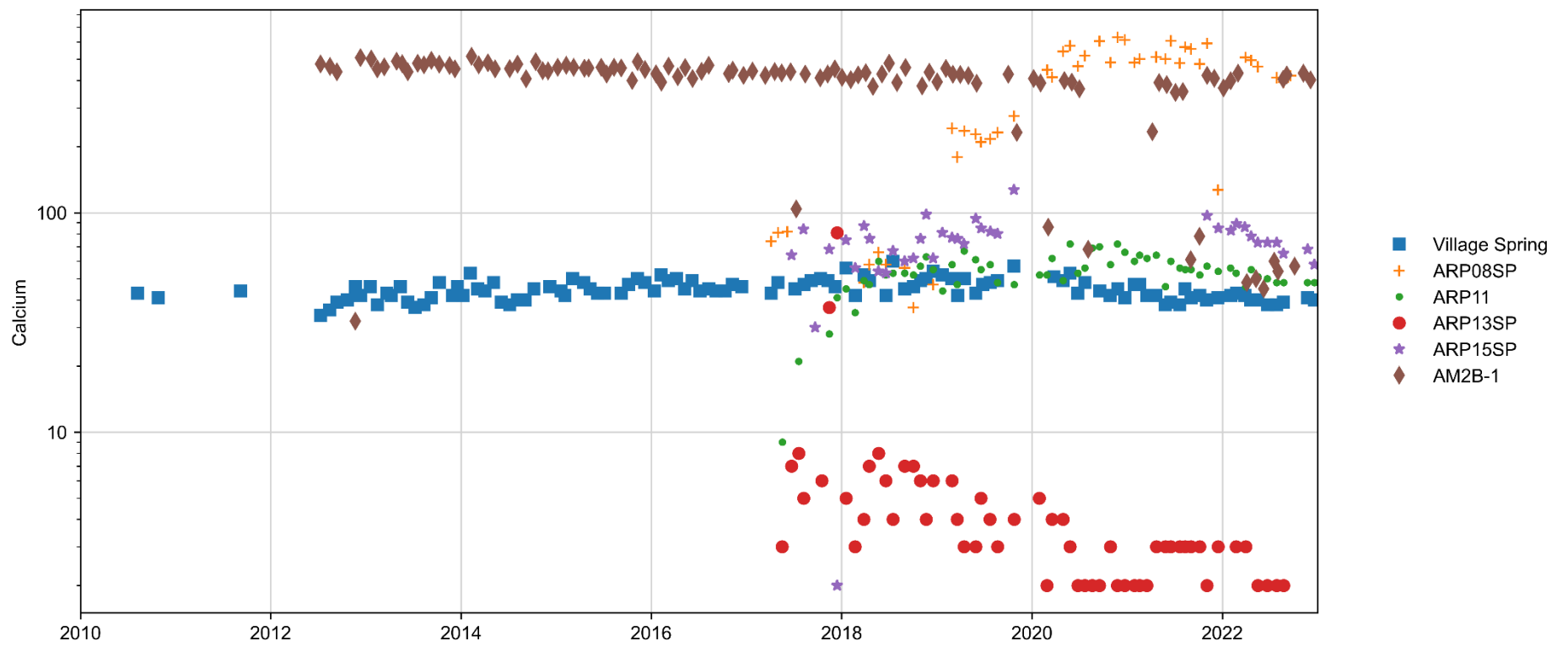
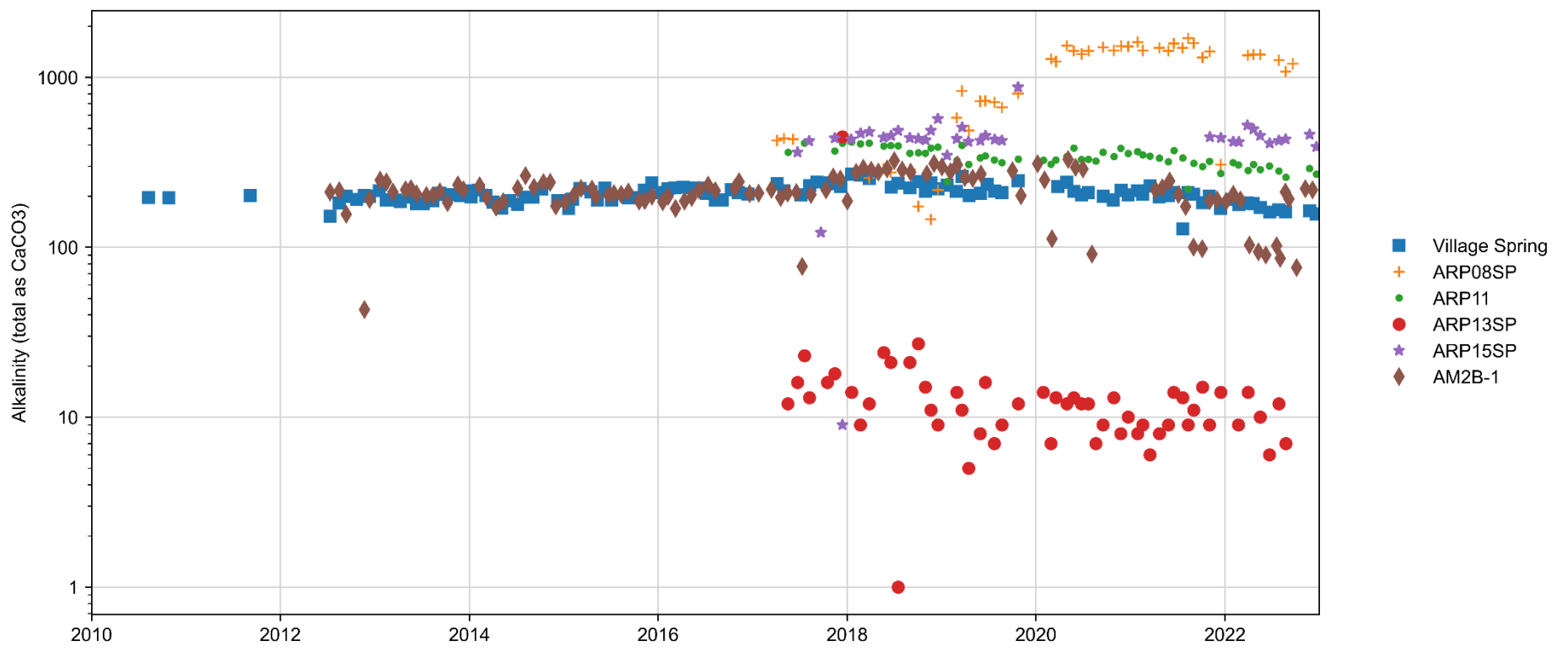
Physicochemical

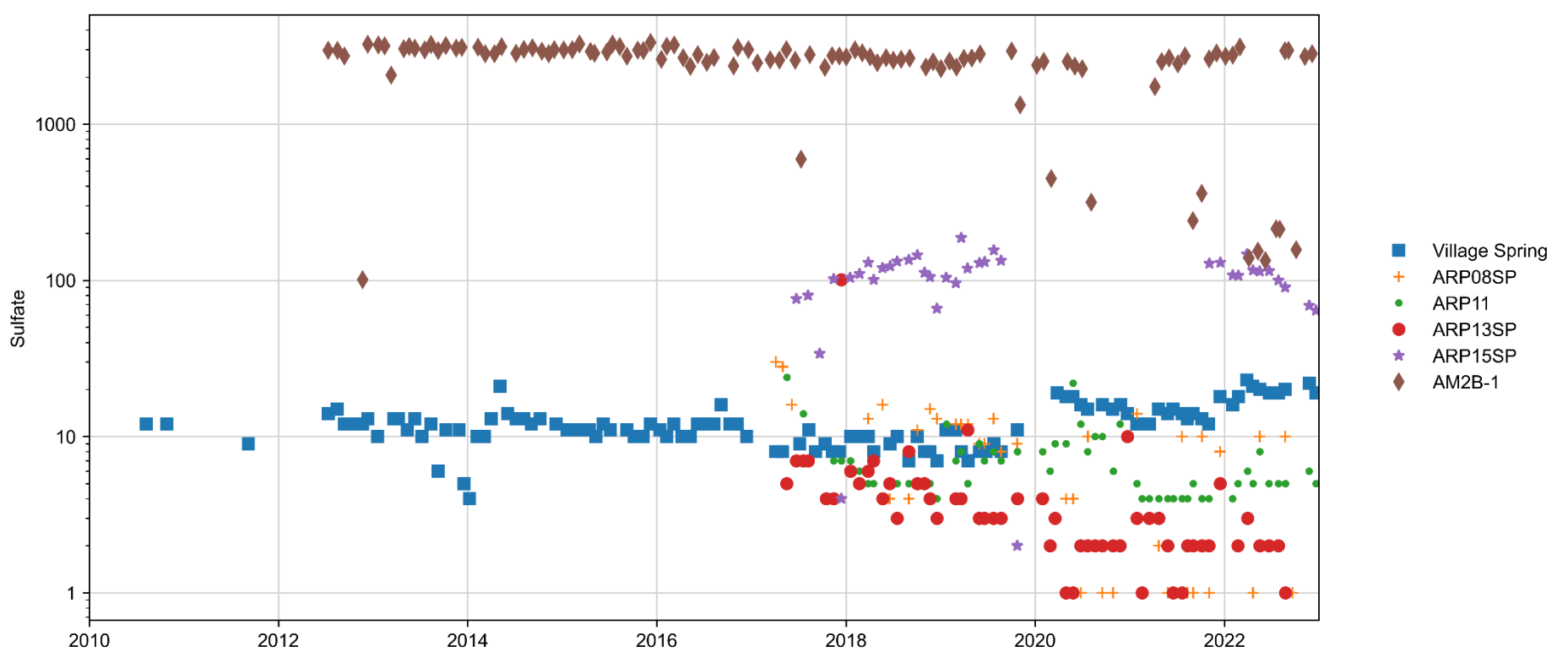
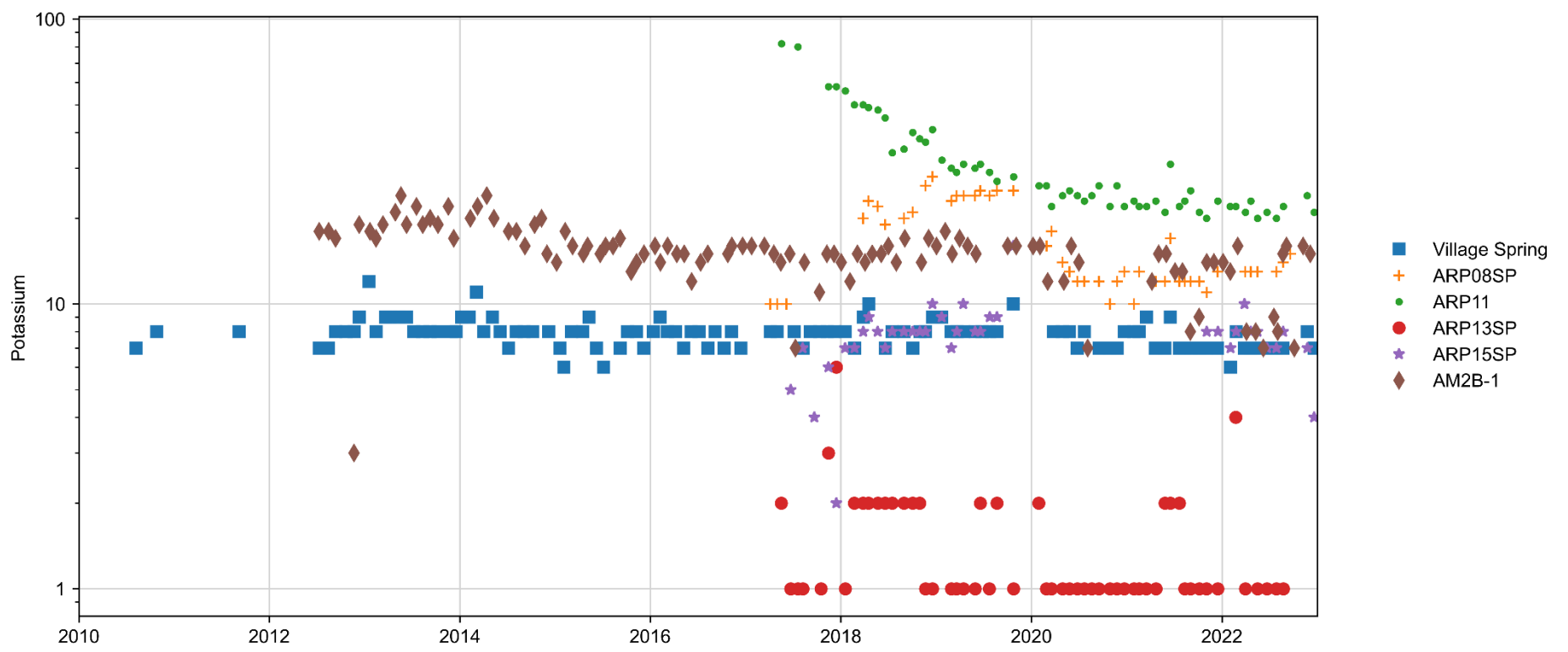
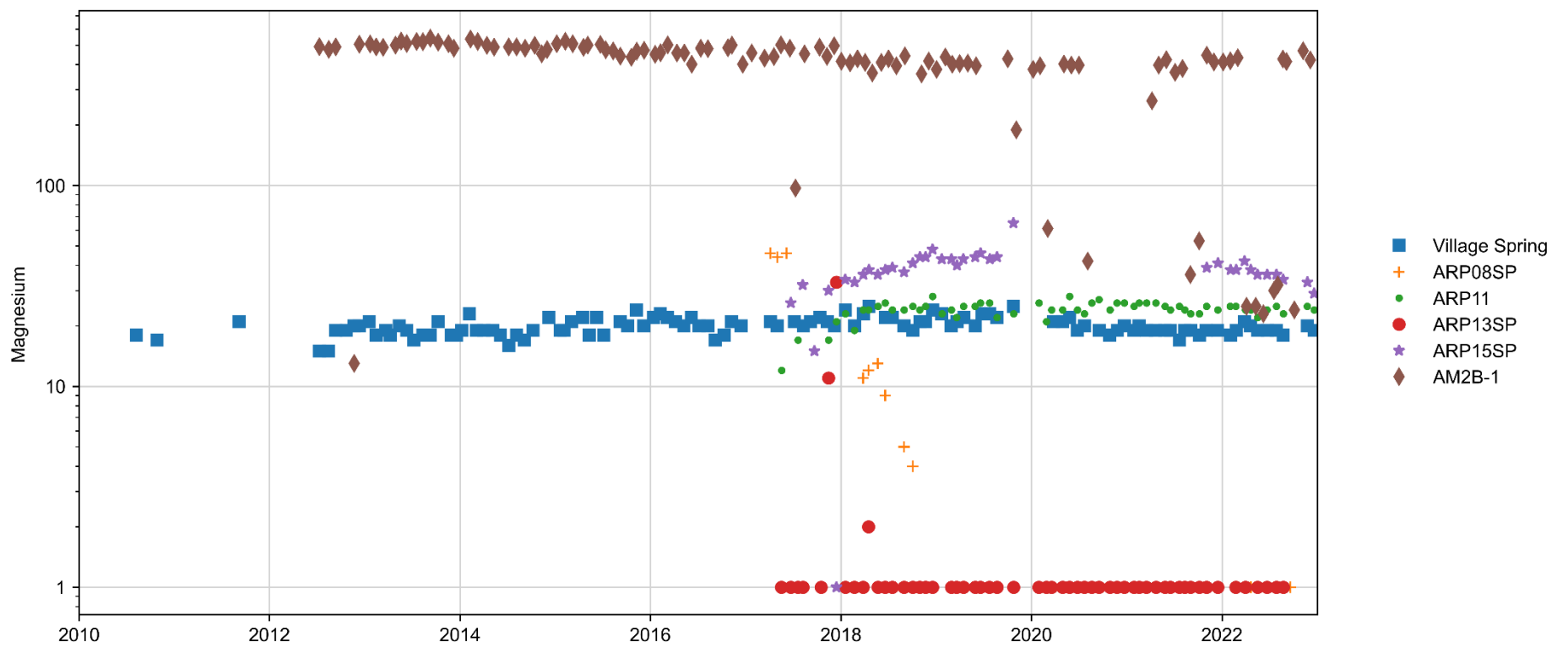




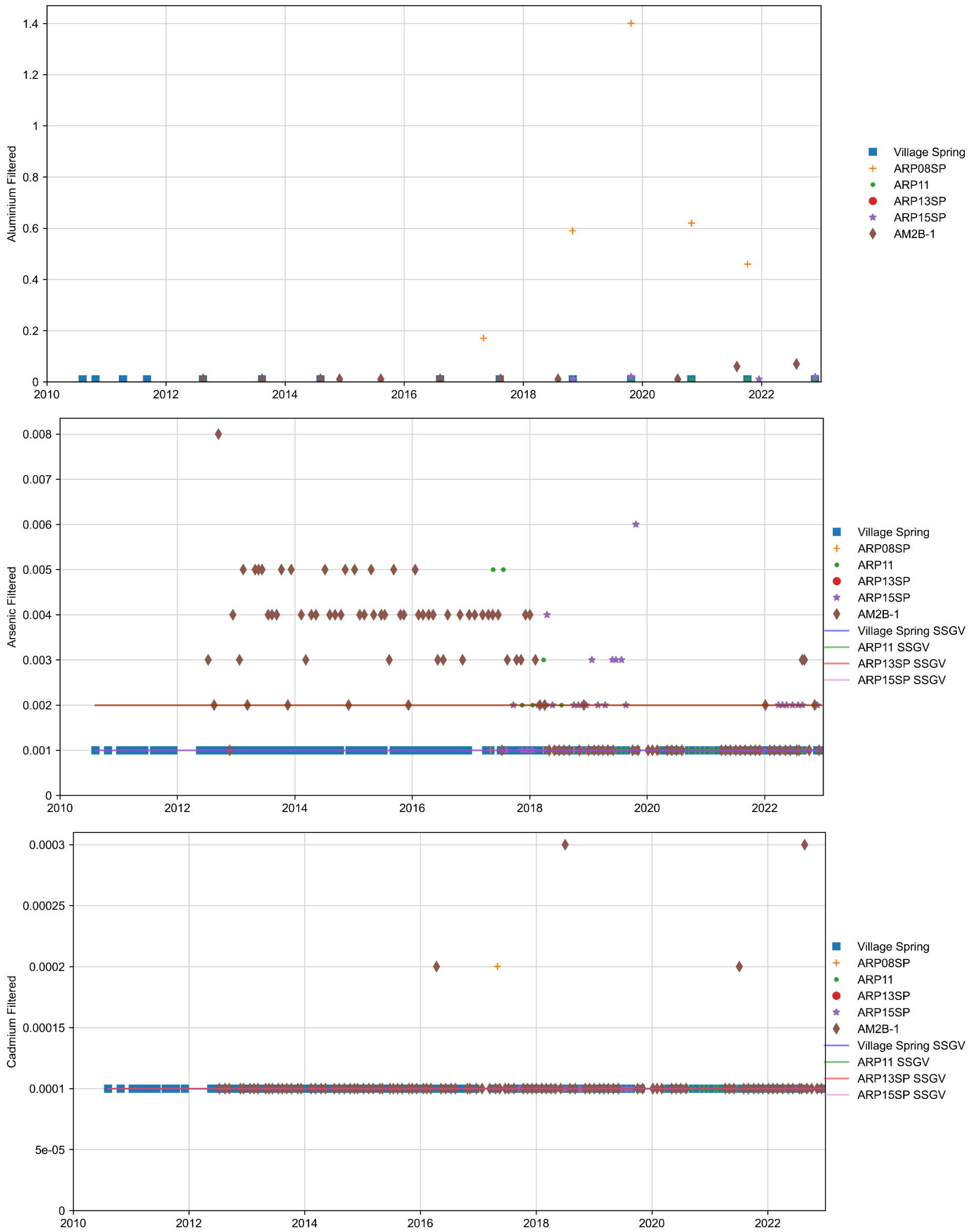
Major Ions

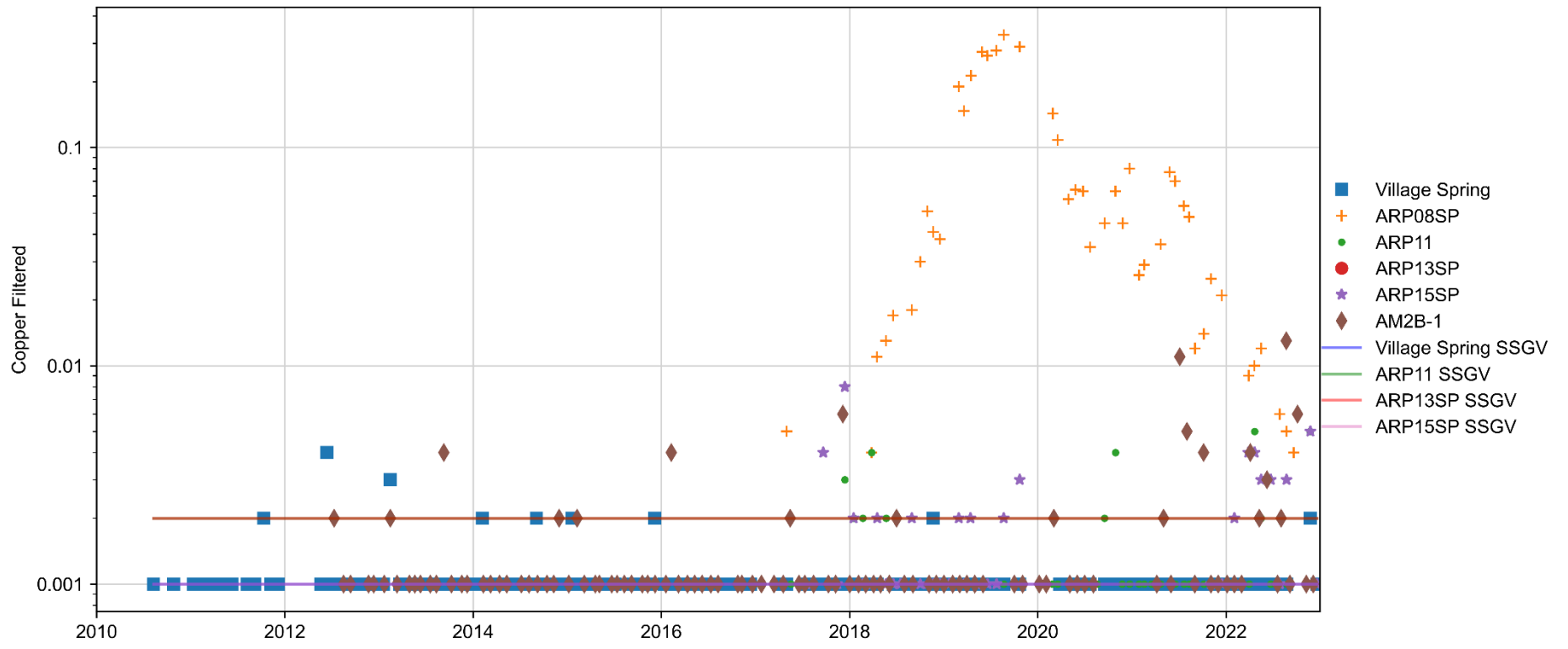
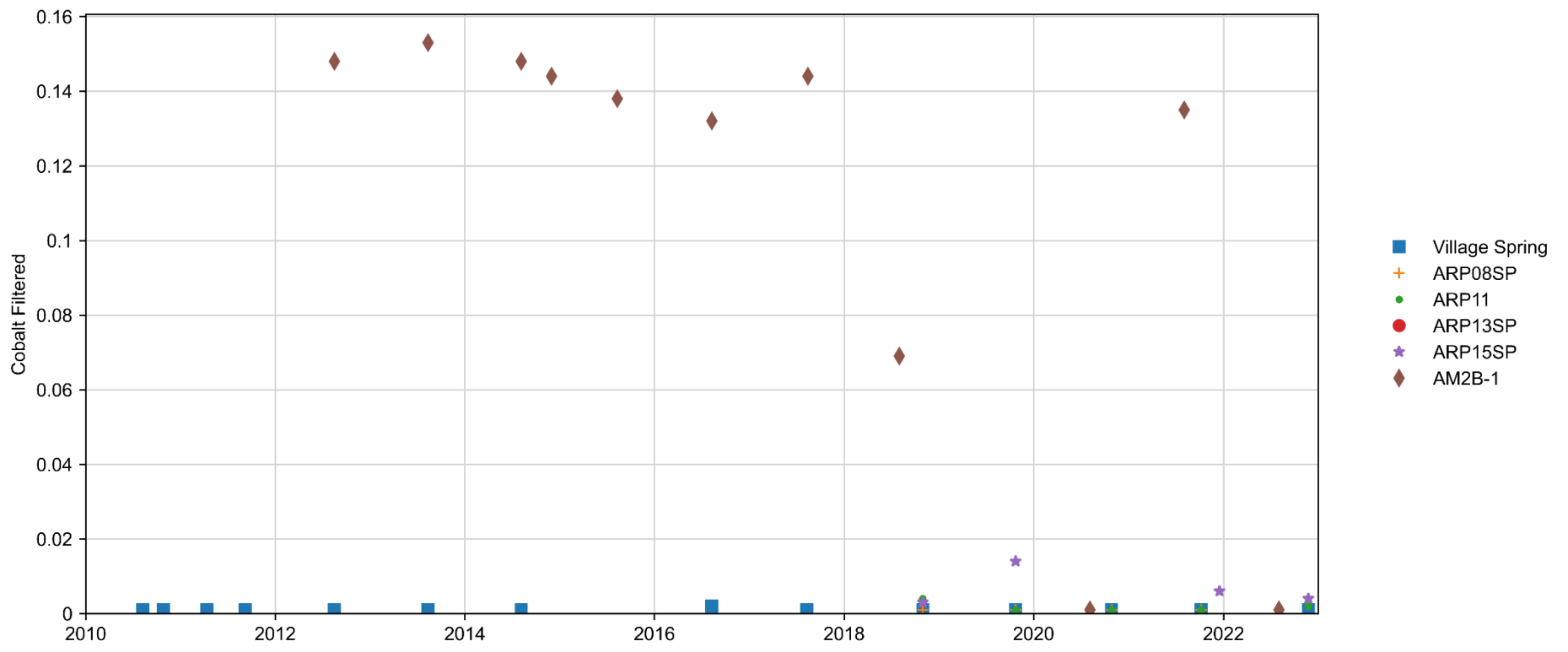
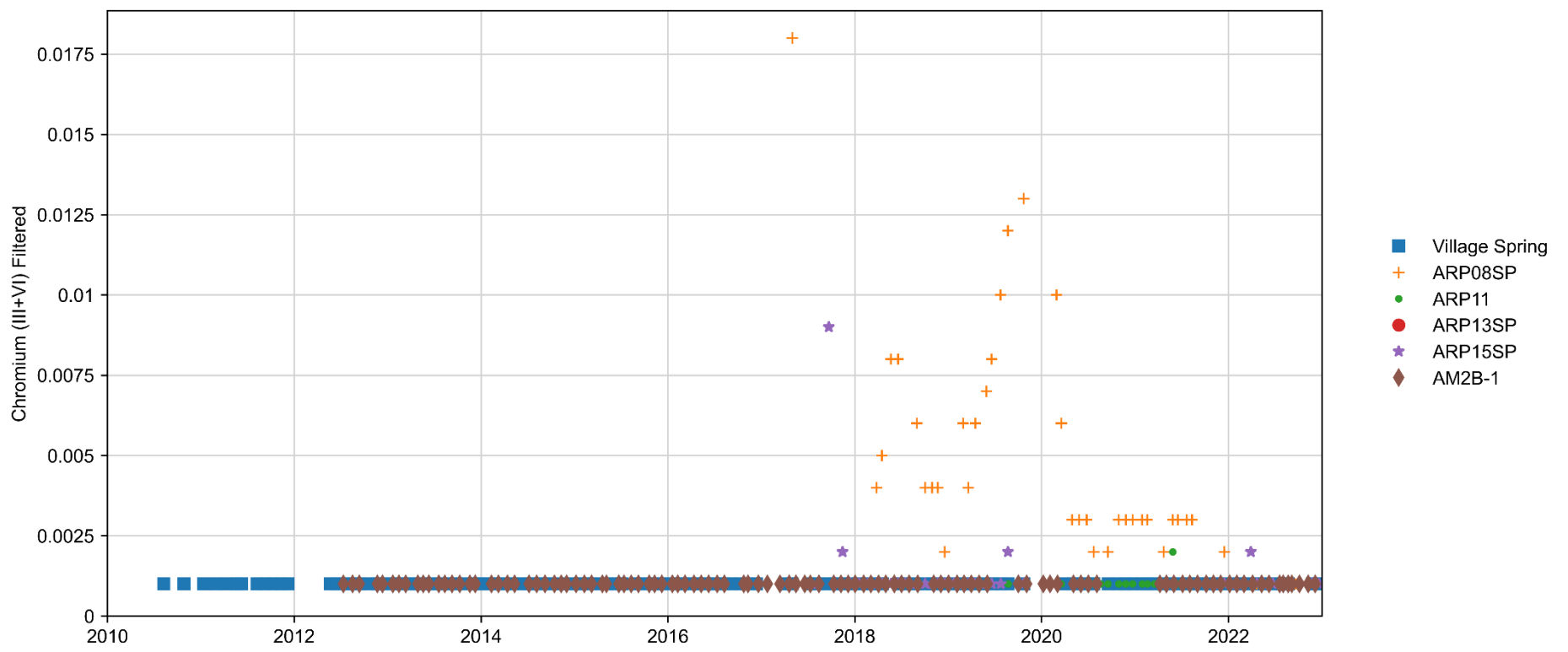


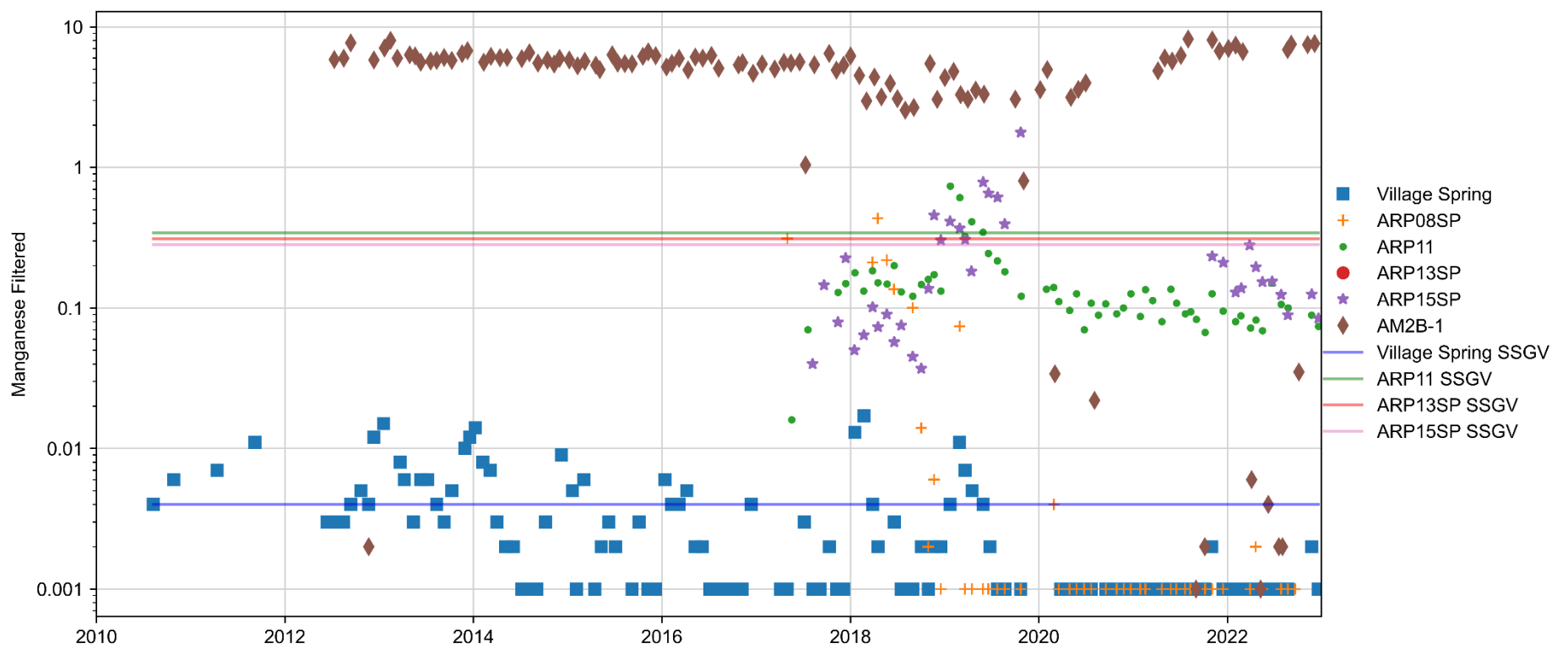
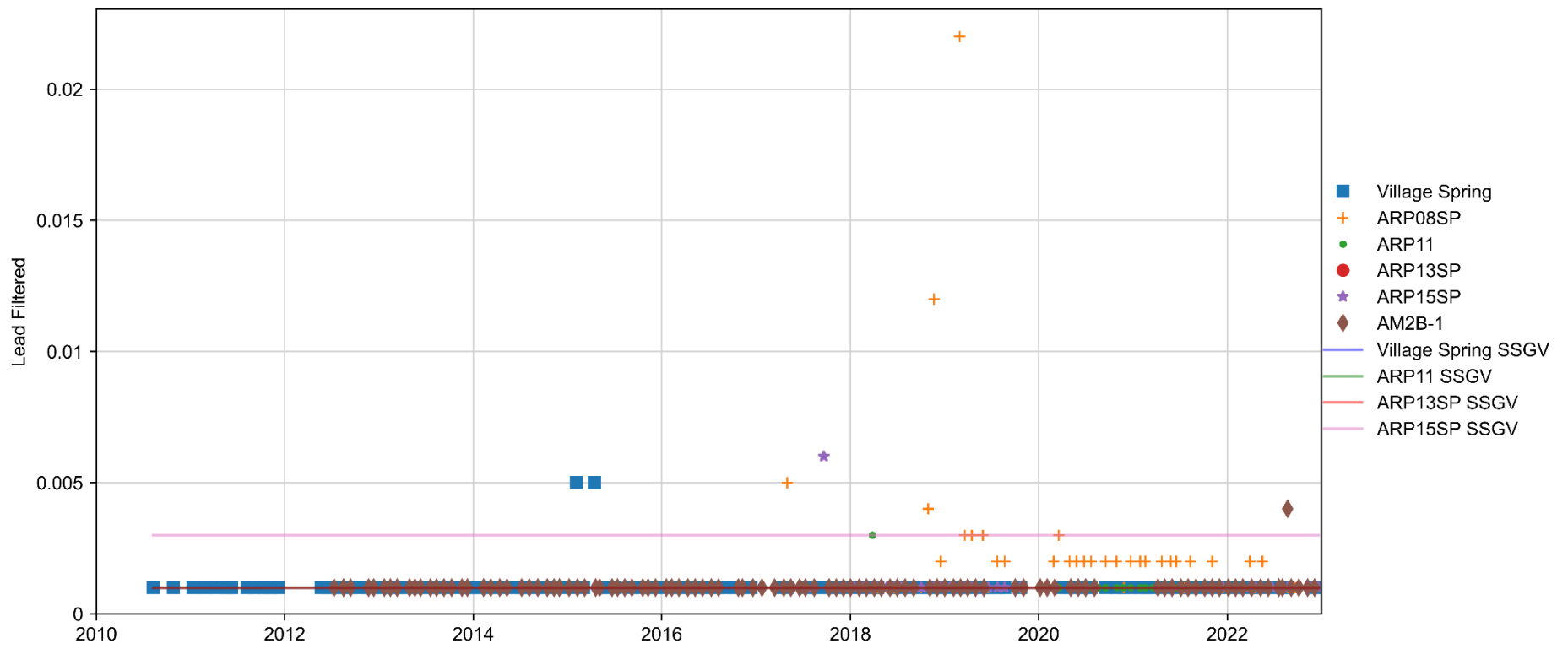
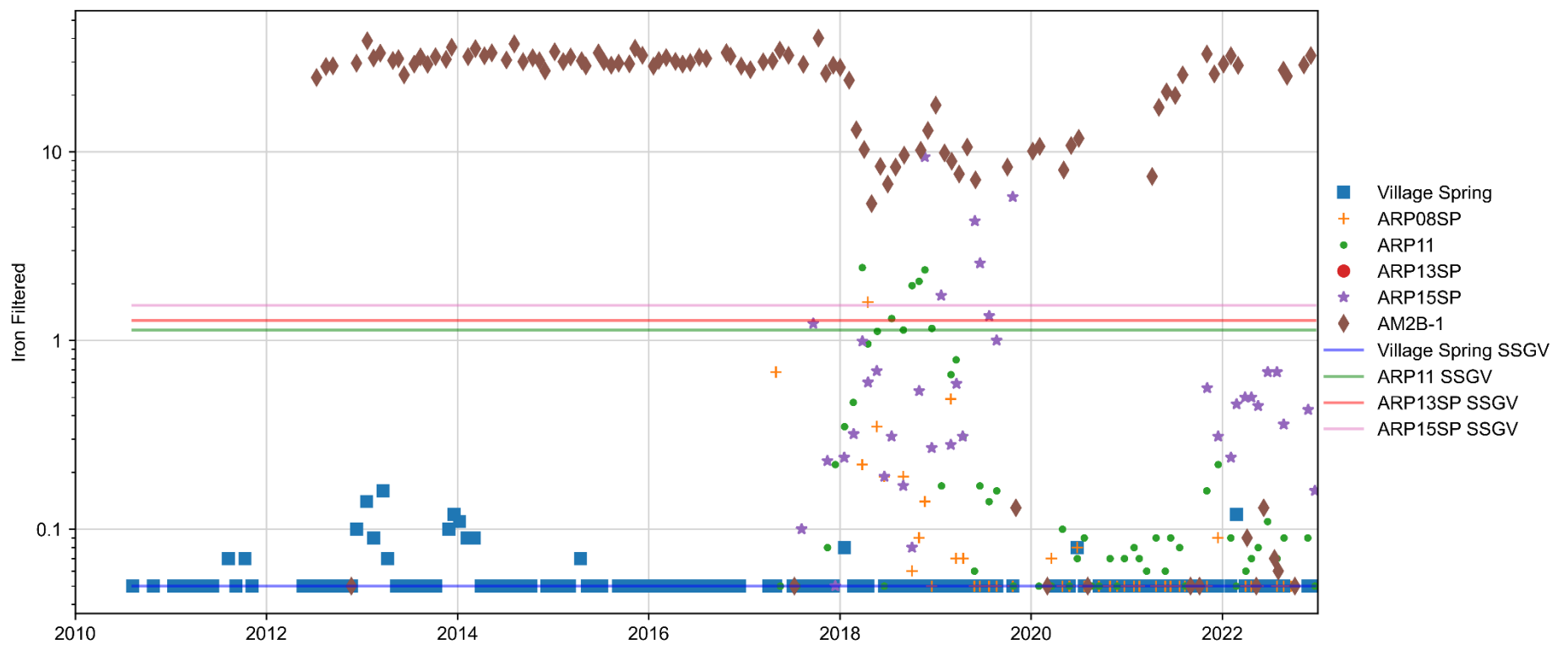


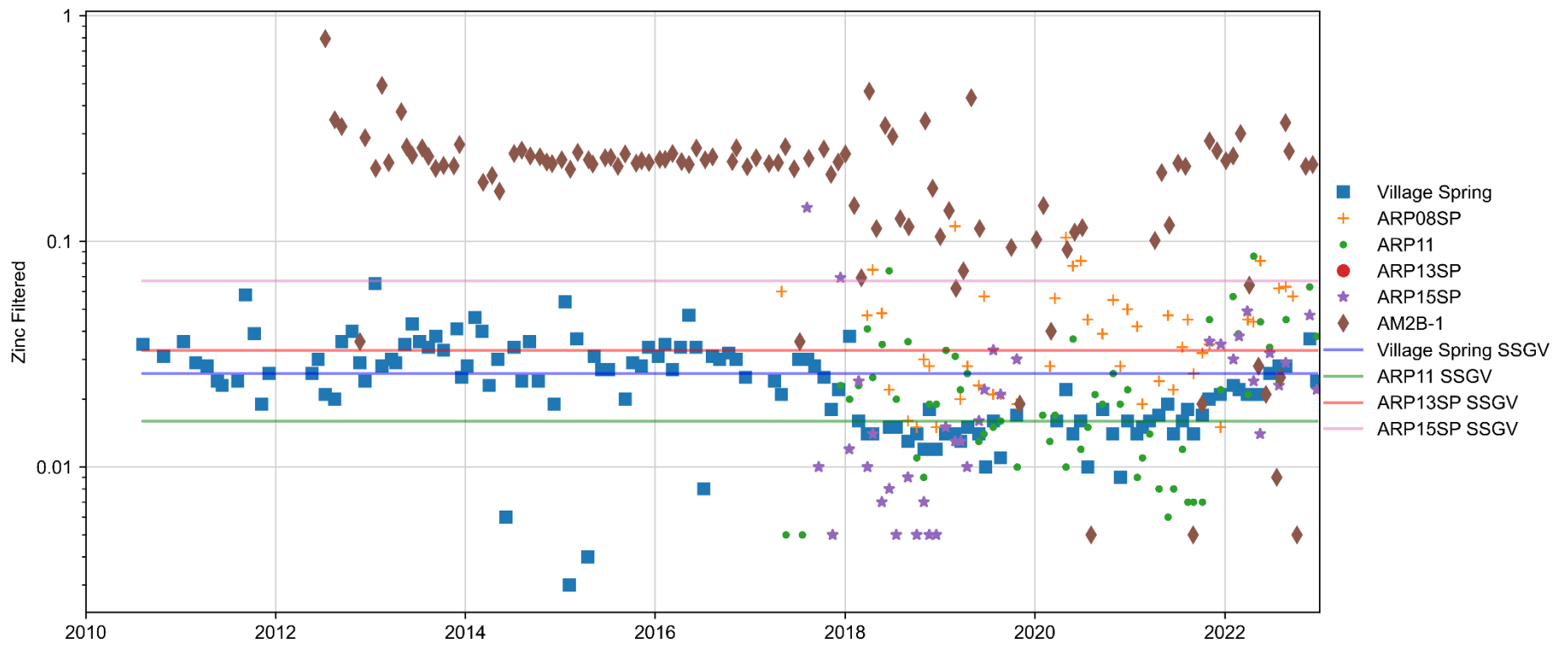
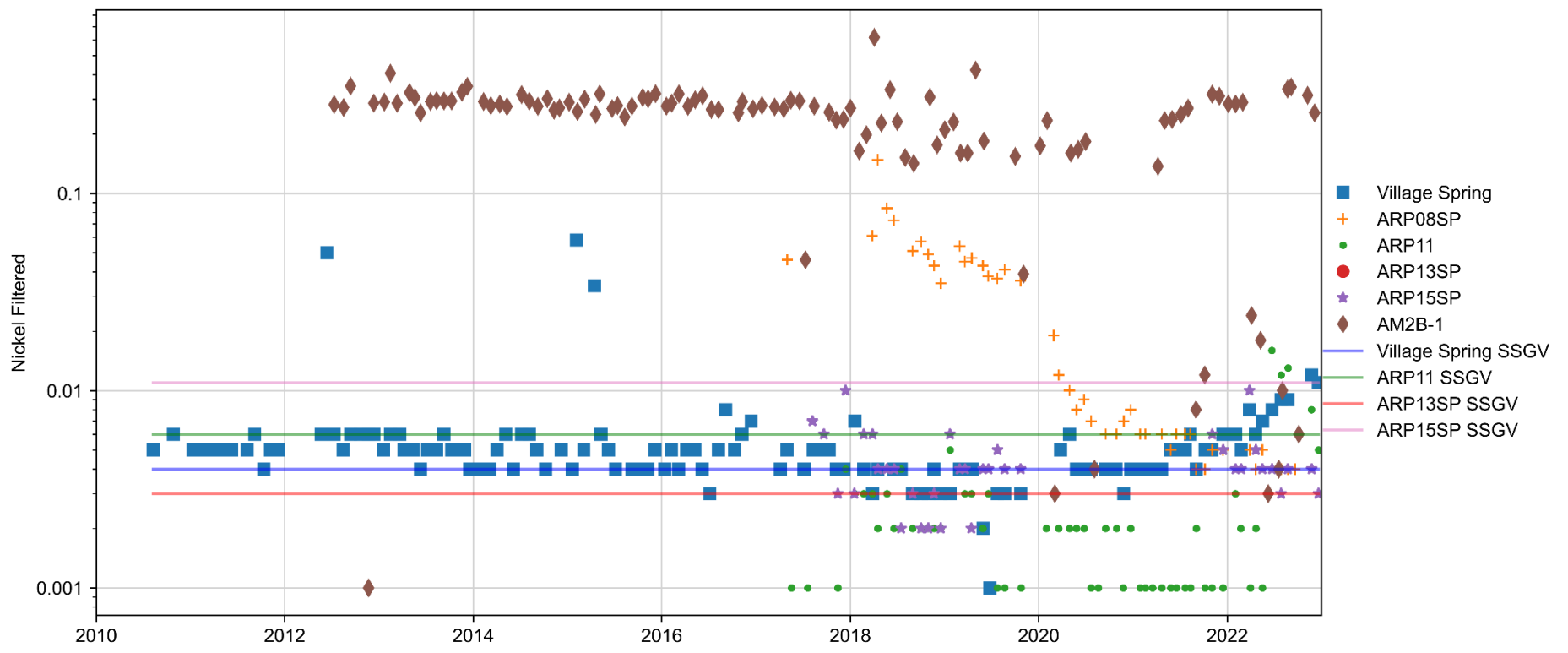
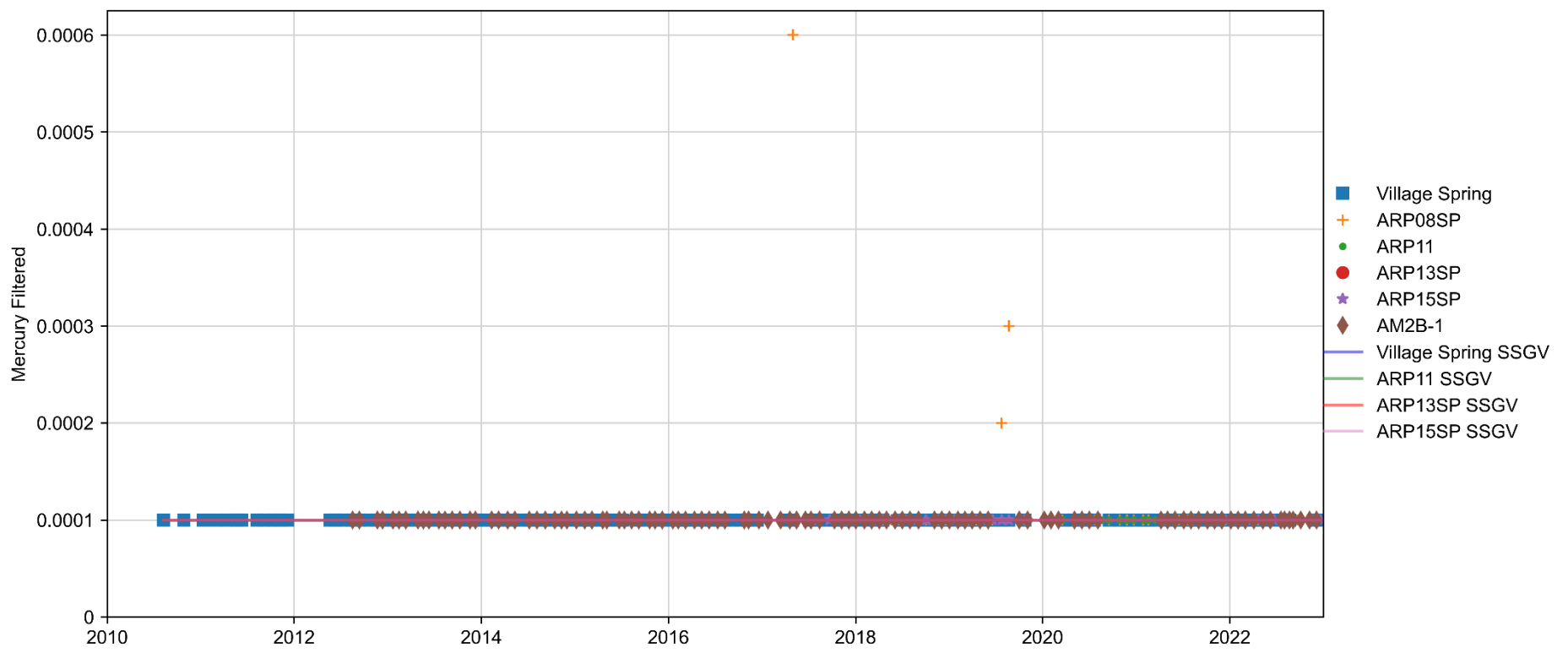


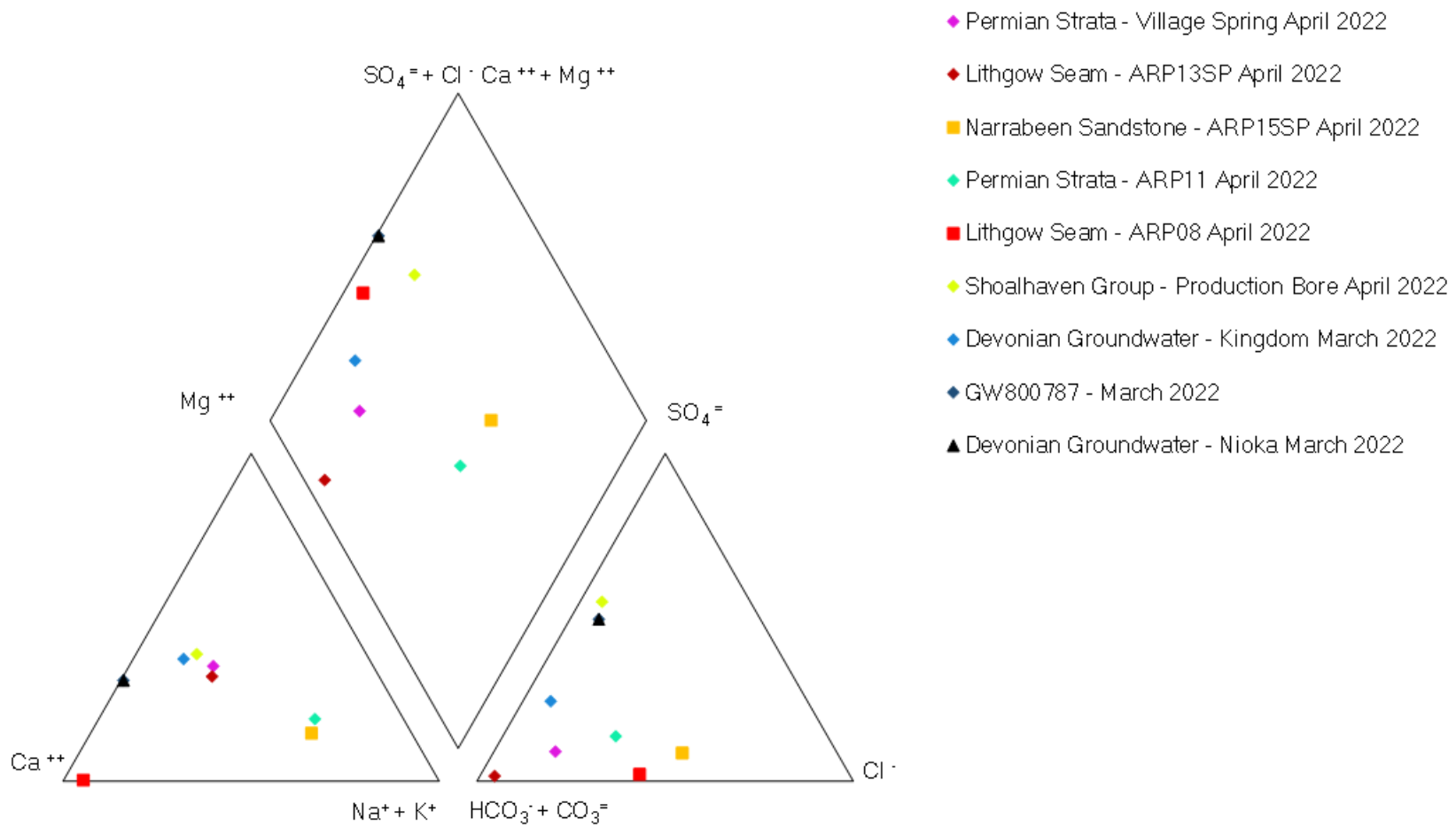
Dissolved metals







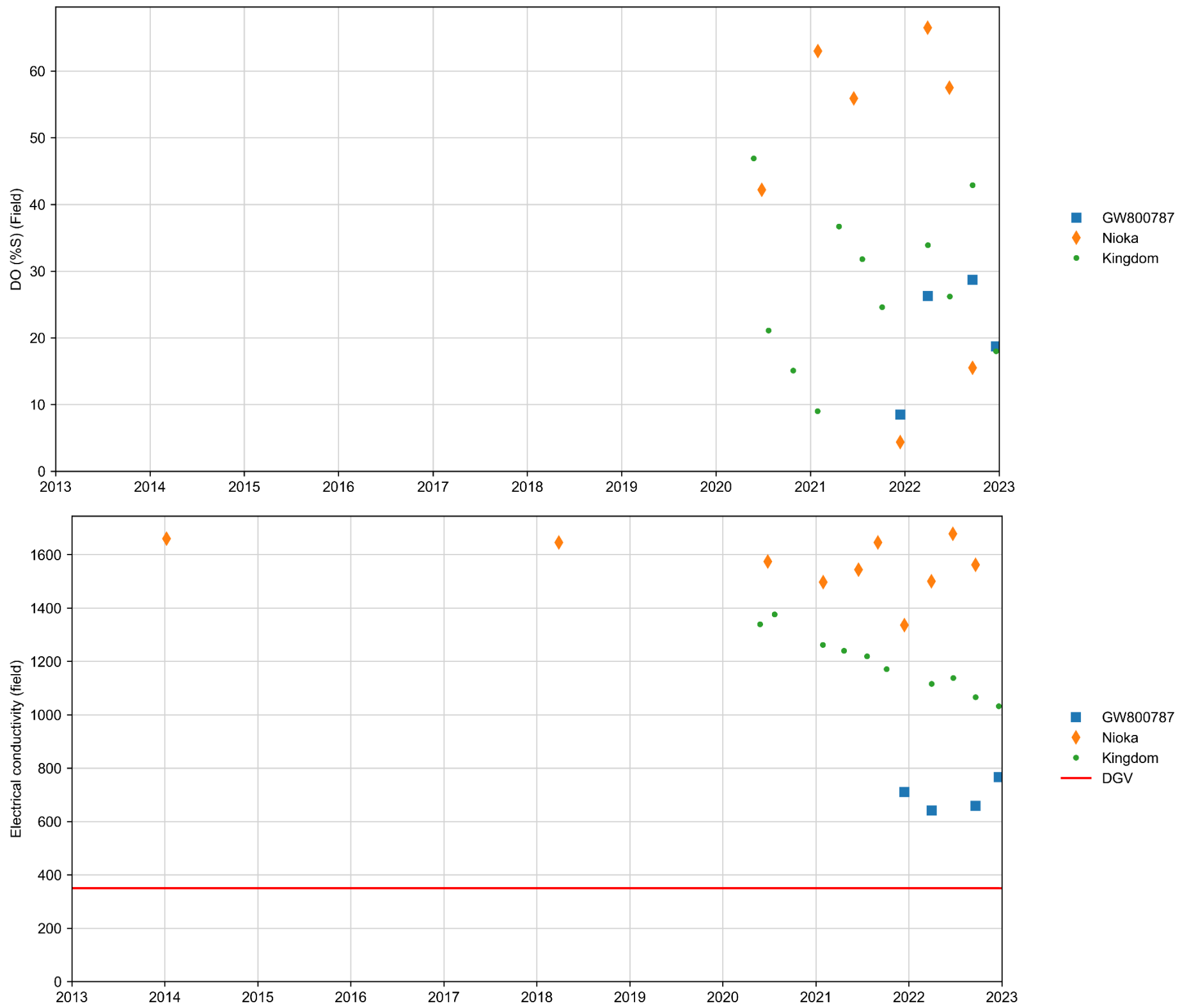


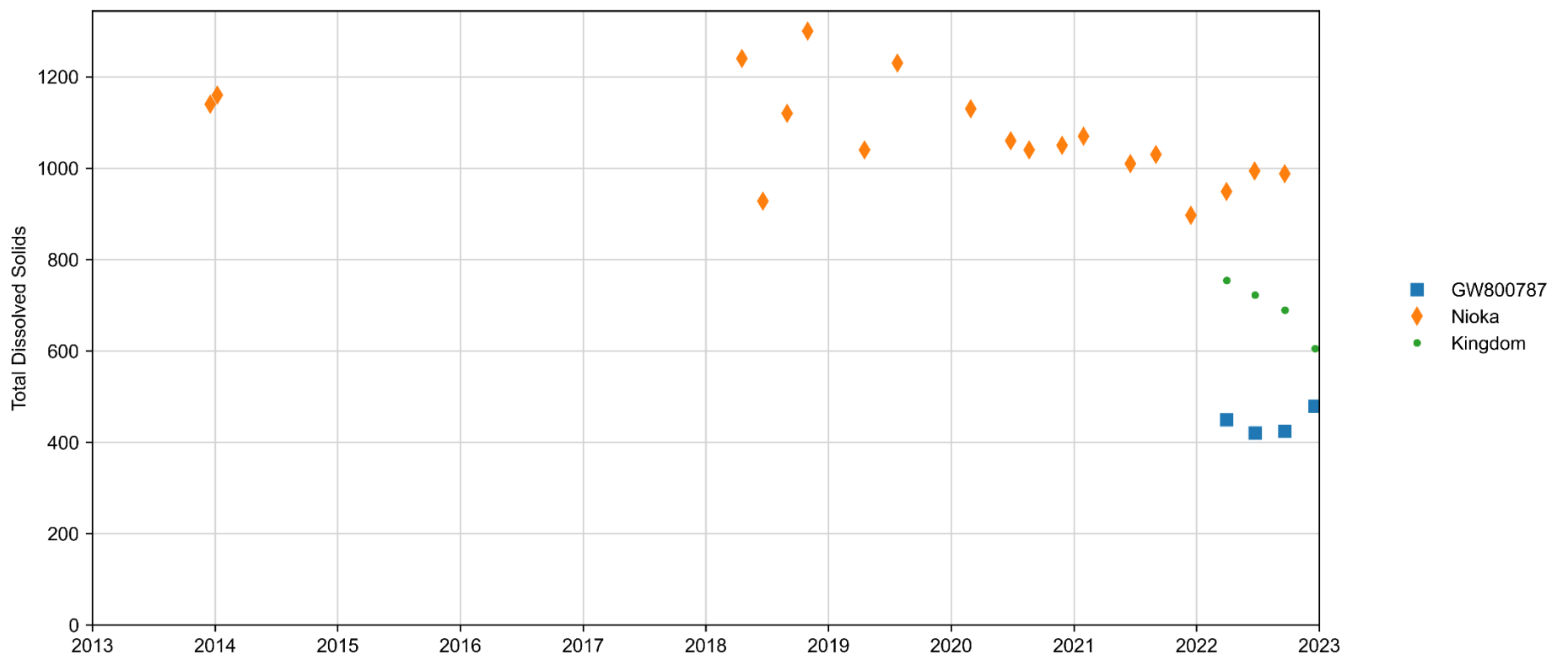
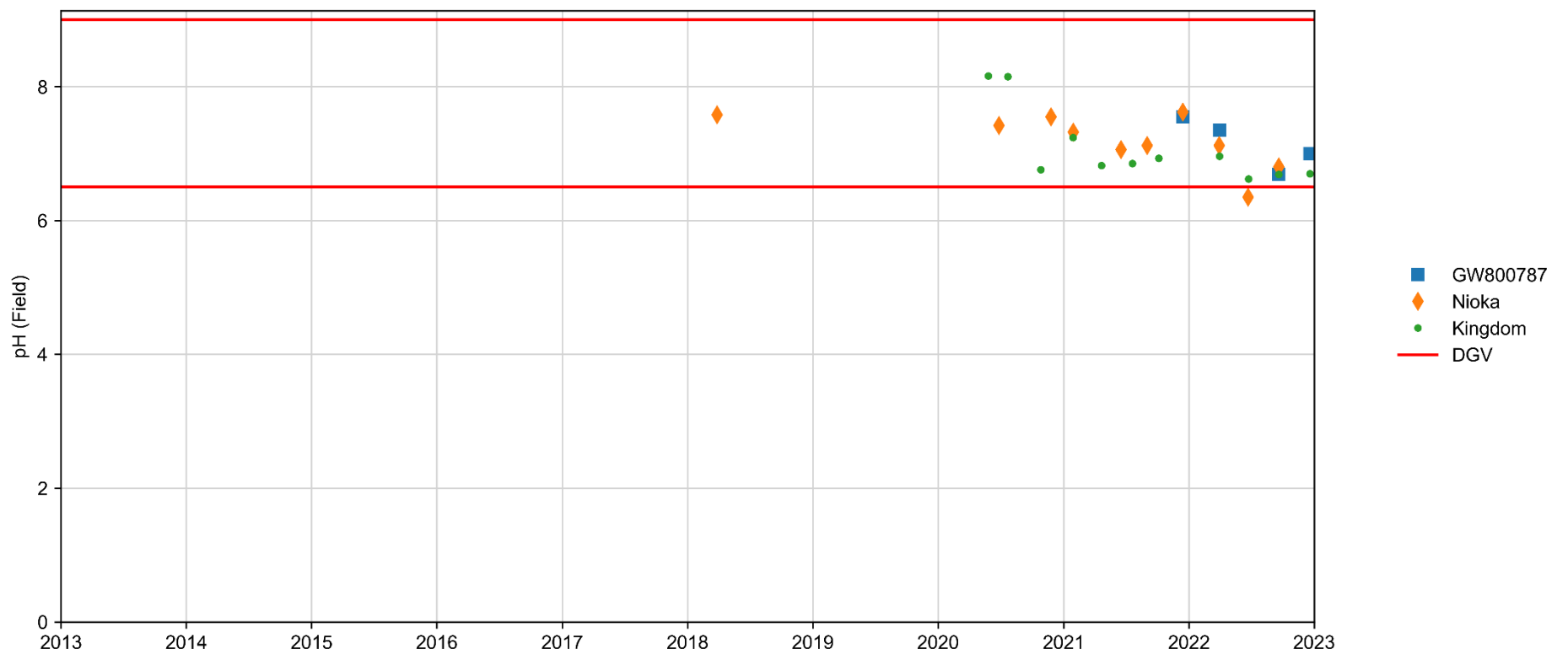


C.8 Statistical summary of water quality results – Landholder bores

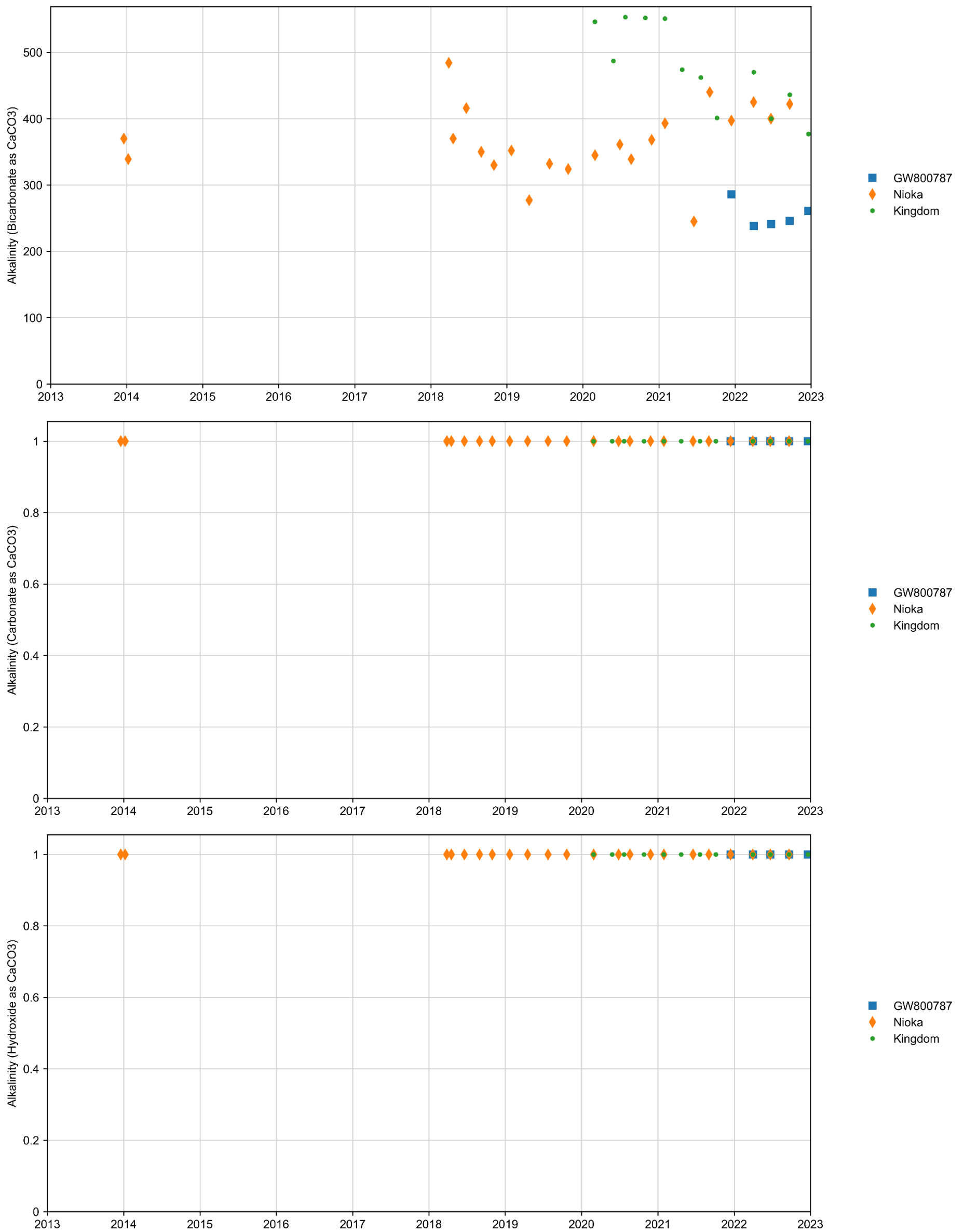
Parameters	Units	Kingdom				Nioka				GW800787			
		Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max
Physiochemical Parameters													
Dissolved Oxygen (Field)	mg/L	11	11.71	1138	1376	23	1.41	5.59	49.5	6	0.74	2.46	4.65
Electrical conductivity (field)	µS/cm	12	6.62	6.89	8.16	23	1019	1562	1678	6	551	650	766
pH (Field)	pH units	12	6.62	6.89	8.16	23	6.35	7.12	7.62	6	6.69	7.175	7.55
Total Dissolved Solids	mg/L	12	0.8	705.5	754	23	897	1050	1300	4	420	436.5	479
Major Ions													
Alkalinity (Carbonate as CaCO ₃)	mg/L	13	1	1	1	23	1	1	1	6	1	1	1
Alkalinity (Bicarbonate as CaCO ₃)	mg/L	13	1	1	1	23	245	368	484	6	238	253.5	286
Alkalinity (Hydroxide as CaCO ₃)	mg/L	13	377	470	553	23	1	1	1	6	1	1	1
Alkalinity (total as CaCO ₃)	mg/L	13	480	503	574	22	245	364.5	484	6	238	253.5	286
Calcium (Filtered)	mg/L	13	110	120	142	23	139	166	213	6	70	77.5	85
Magnesium (Filtered)	mg/L	13	110	120	142	23	40	56	86	6	26	28	32
Potassium (Filtered)	mg/L	13	50	60	92	23	1	2	3	6	3	3	3
Sodium (Filtered)	mg/L	13	5	5	6	23	64	119	153	6	23	26	30
Sulfate (Filtered)	mg/L	13	33	39	81	21	379	495	563	6	57	65	111
Metals (Dissolved)													
Aluminium (Filtered)	mg/L	13	0.01	0.01	0.01	22	0.01	0.01	0.06	6	0.01	0.01	0.01
Arsenic (Filtered)	mg/L	13	0.001	0.001	0.001	23	0.001	0.001	0.002	6	0.001	0.001	0.001
Cadmium (Filtered)	mg/L	13	0.0001	0.0001	0.0001	23	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001
Chromium (III+VI) (Filtered)	mg/L	13	0.001	0.001	0.001	23	0.001	0.001	0.001	6	0.001	0.001	0.001
Cobalt (Filtered)	mg/L	5	0.001	0.001	0.001	22	0.001	0.001	0.001	5	0.001	0.001	0.001
Copper (Filtered)	mg/L	13	0.001	0.01	0.039	23	0.001	0.001	0.02	6	0.001	0.001	0.013
Iron (Filtered)	mg/L	13	0.05	0.05	0.44	23	0.05	0.09	1.81	6	0.07	0.12	0.31
Lead (Filtered)	mg/L	13	0.001	0.001	0.001	23	0.001	0.001	0.001	6	0.001	0.001	0.001
Manganese (Filtered)	mg/L	13	0.001	0.001	0.016	23	0.001	0.004	0.362	6	0.022	0.0245	0.041
Mercury (Filtered)	mg/L	5	0.0001	0.0001	0.0001	23	0.0001	0.0001	0.0001	5	0.0001	0.0001	0.0001
Nickel (Filtered)	mg/L	13	0.001	0.002	0.059	23	0.001	0.001	0.006	6	0.001	0.001	0.012
Zinc (Filtered)	mg/L	13	0.005	0.009	0.034	23	0.005	0.022	0.195	6	0.007	0.0145	0.022

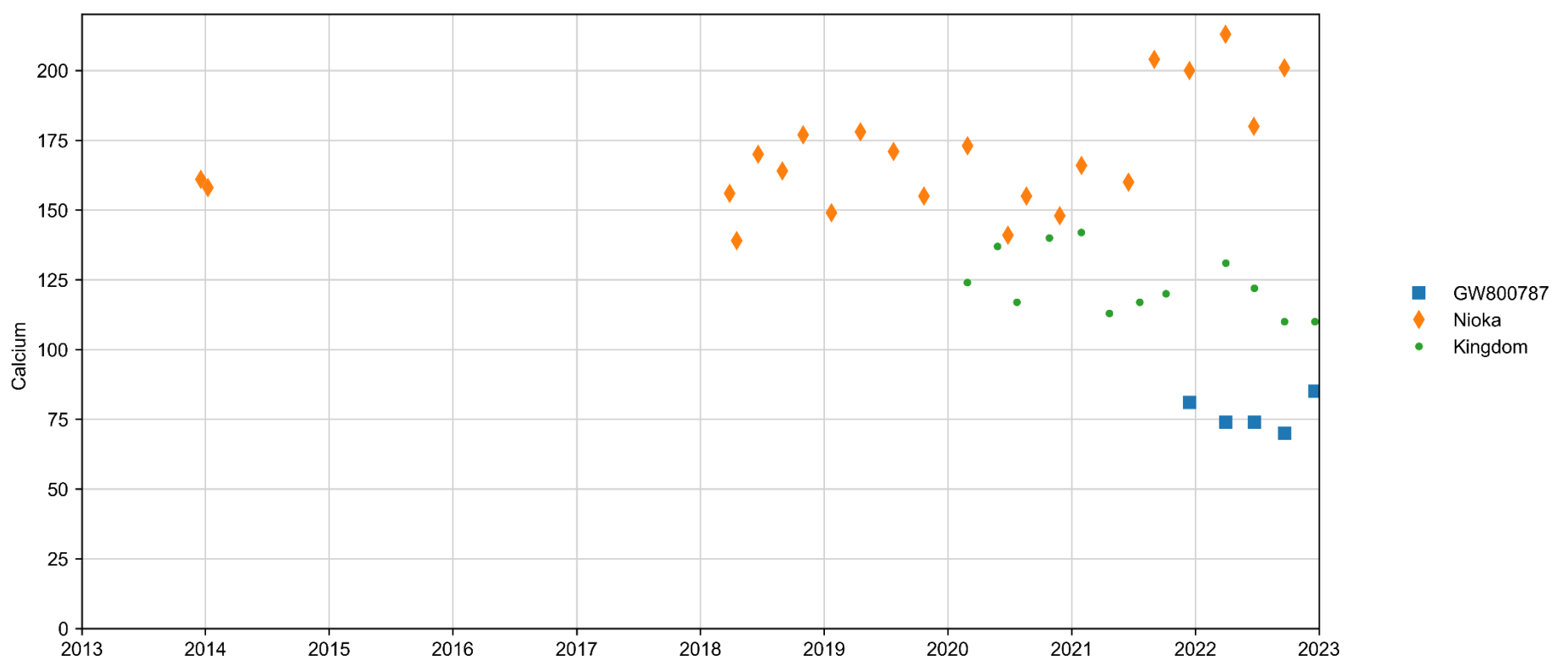
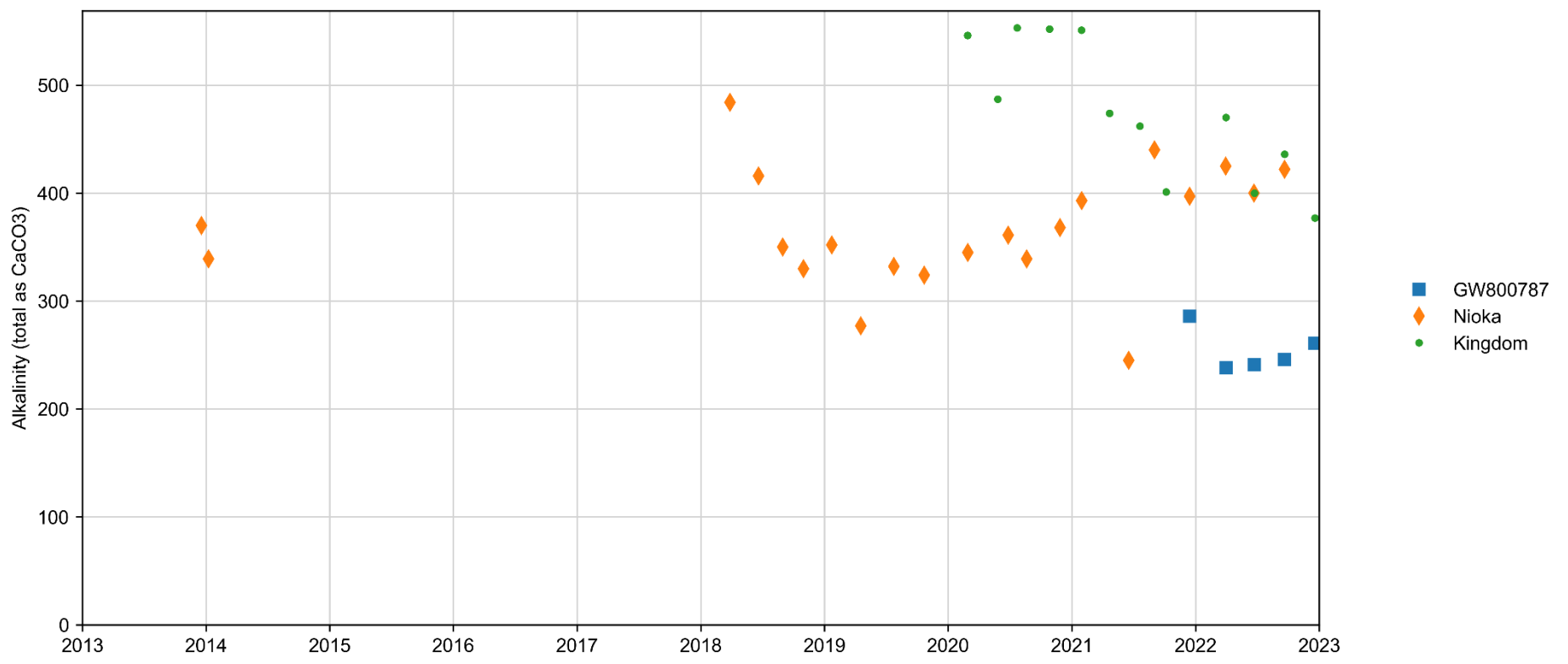
C.9 Timeseries of water quality results – Landholder bores

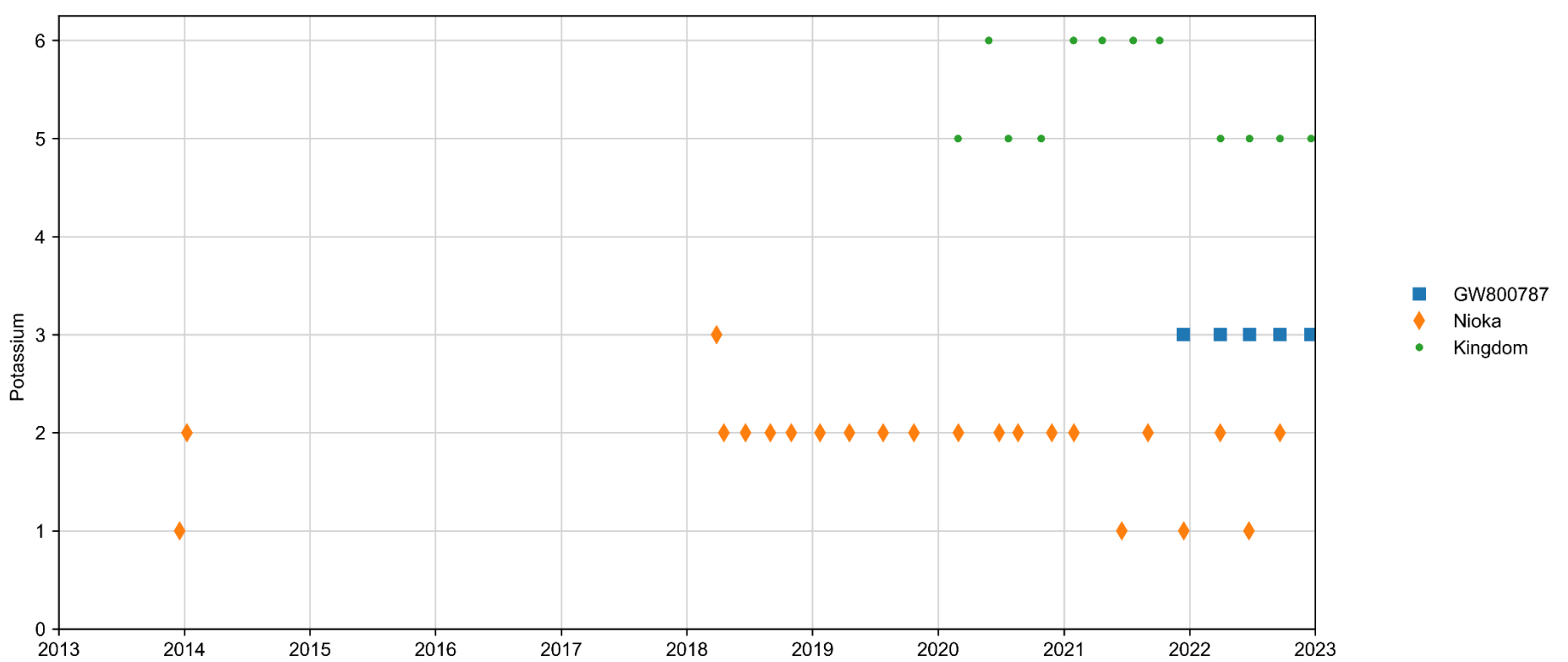
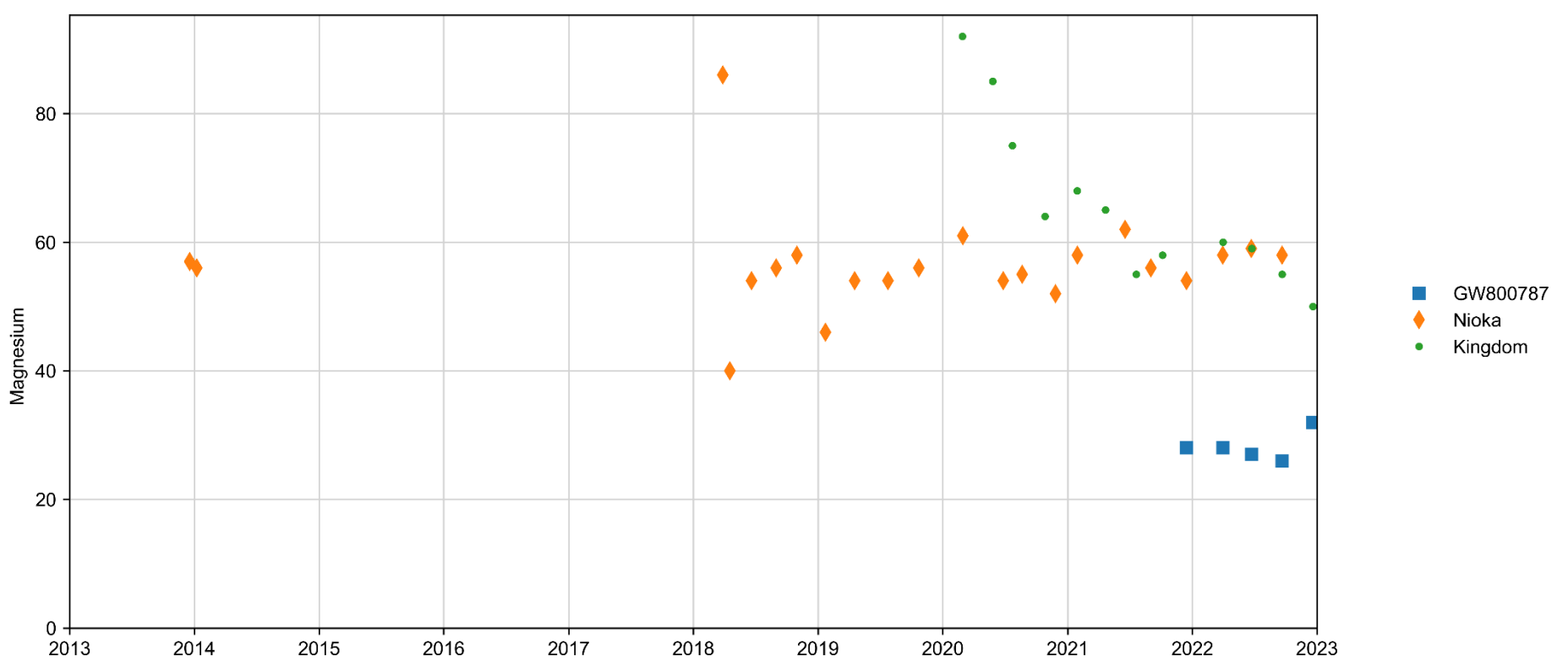
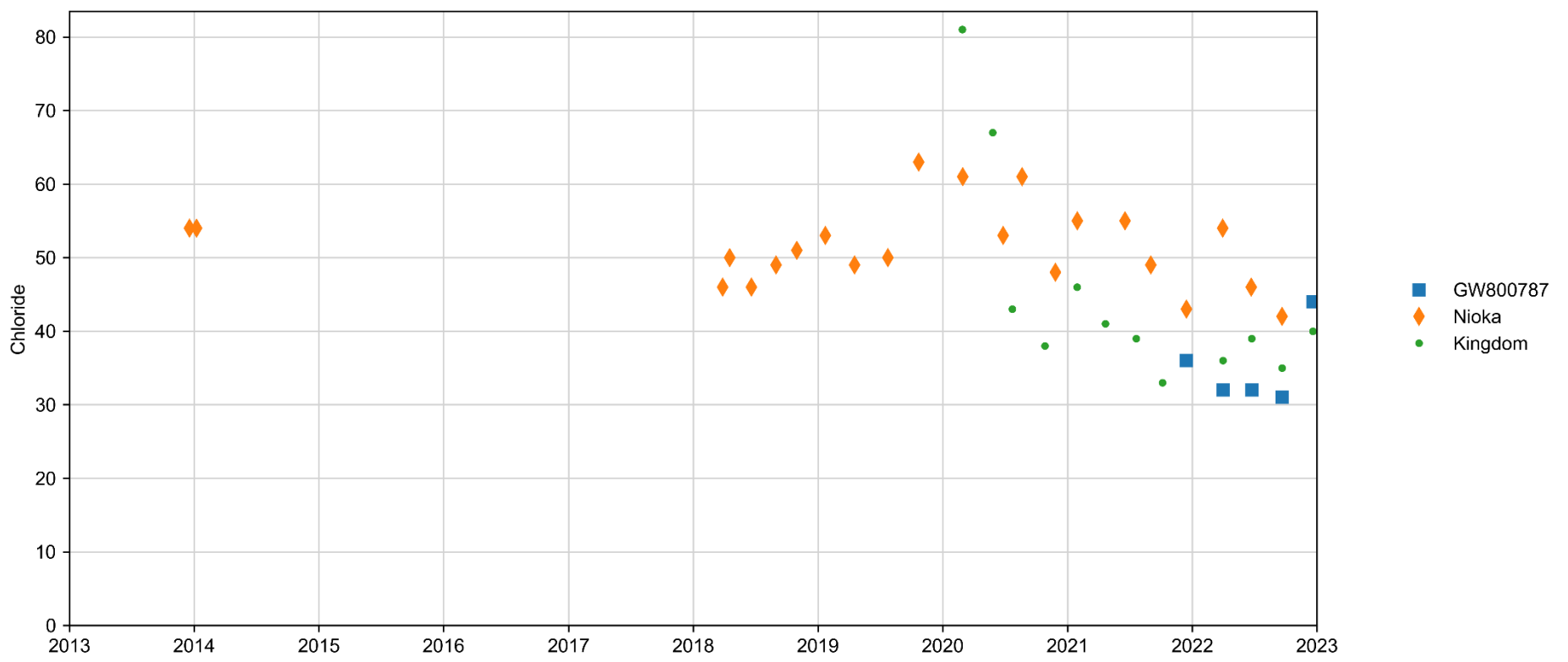


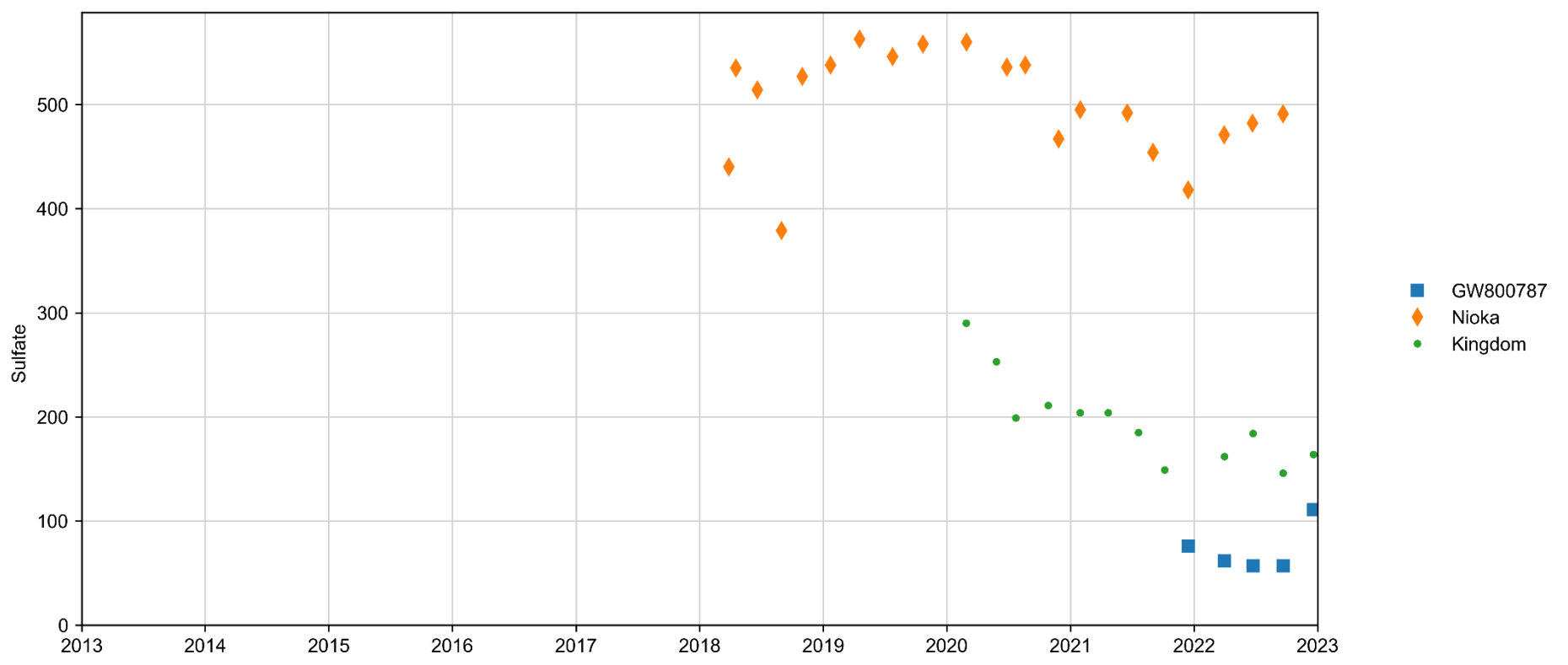
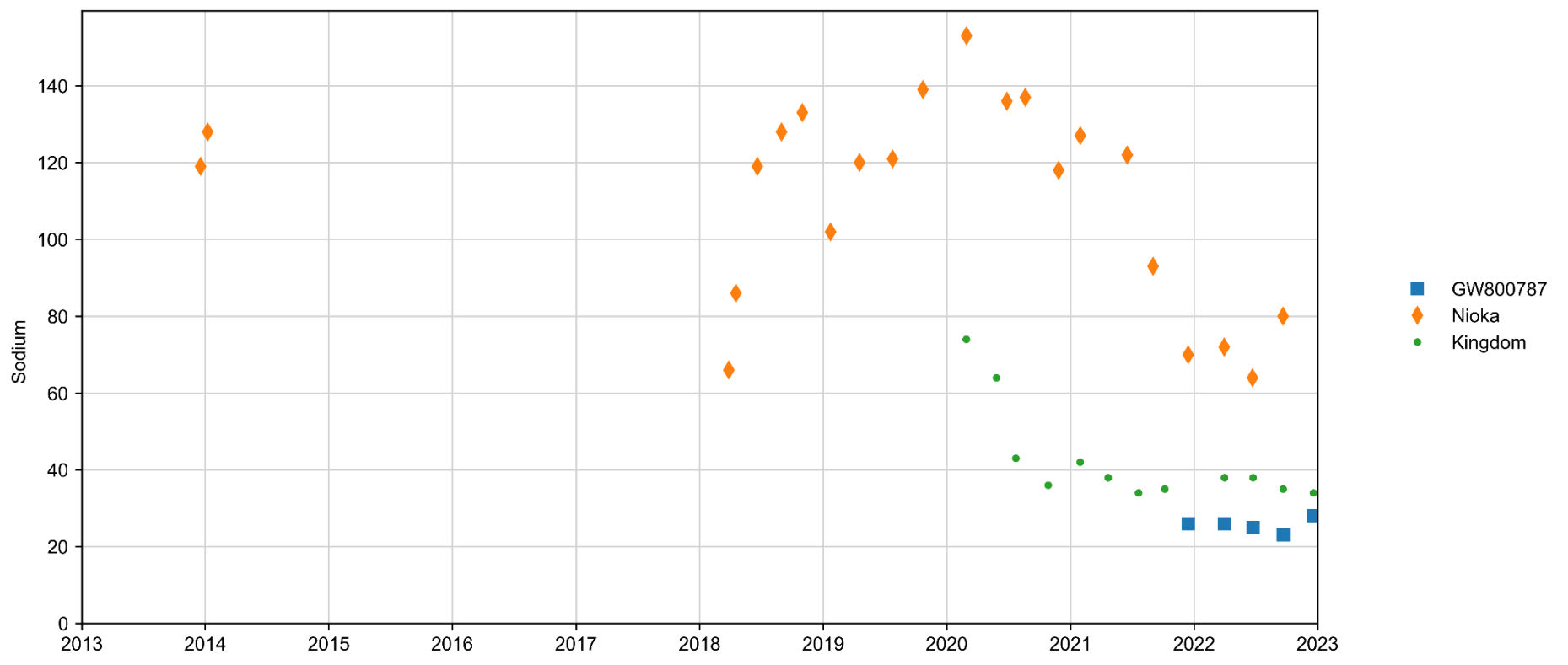


Major ions

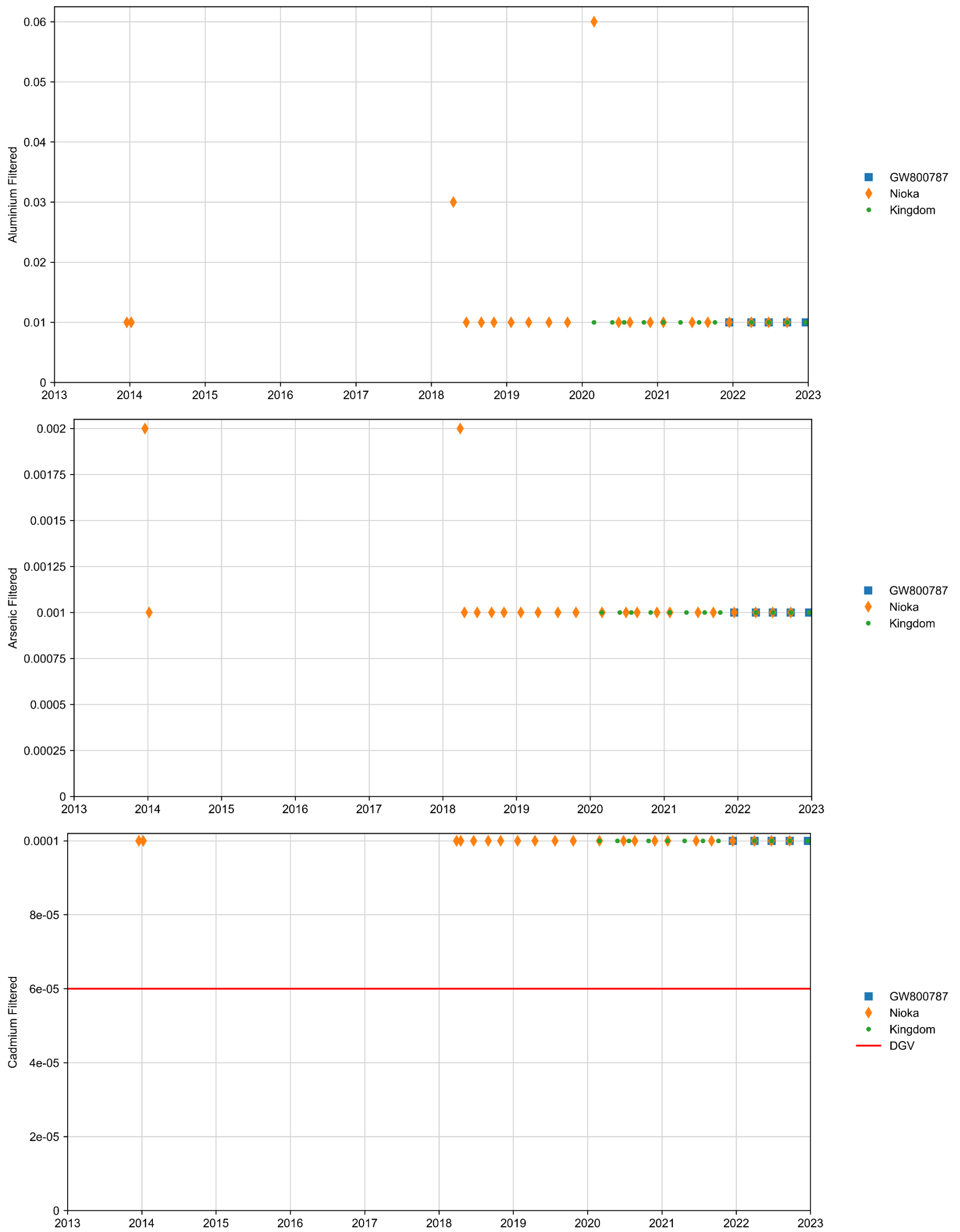


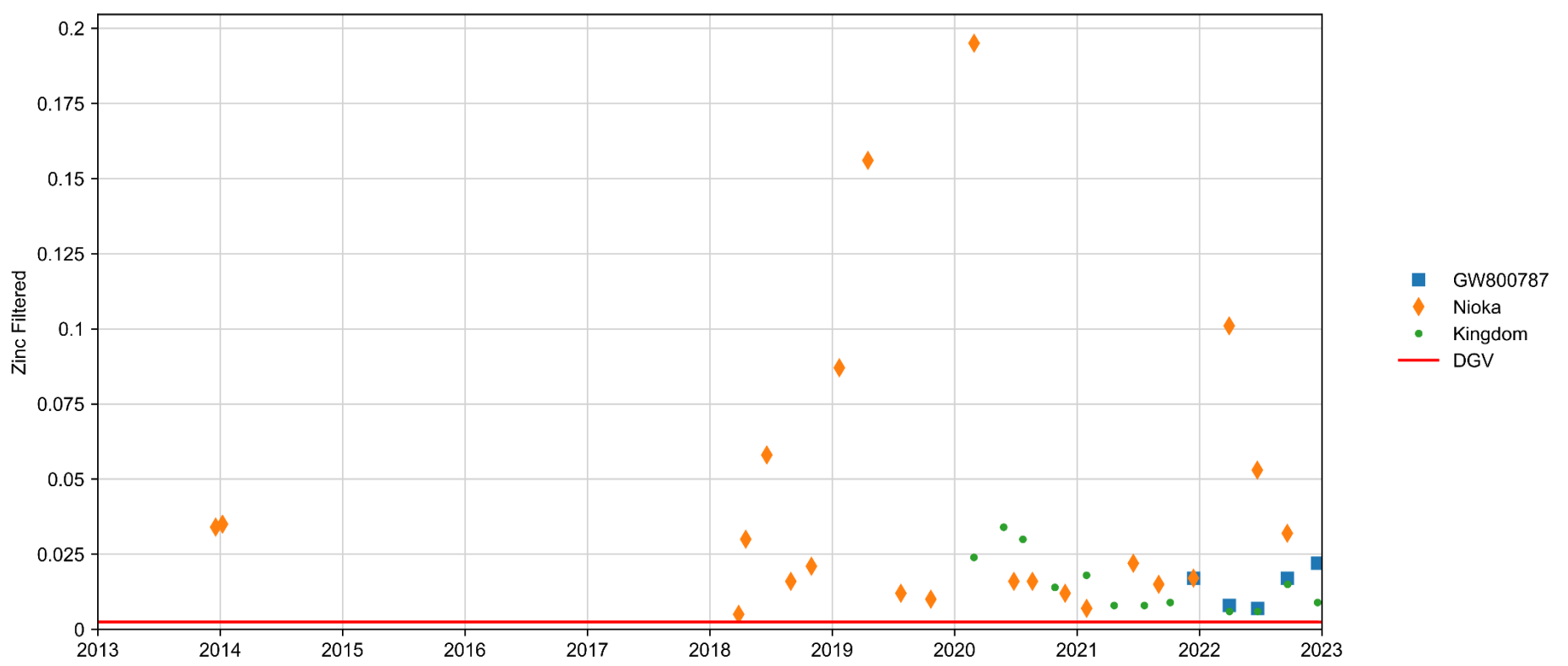
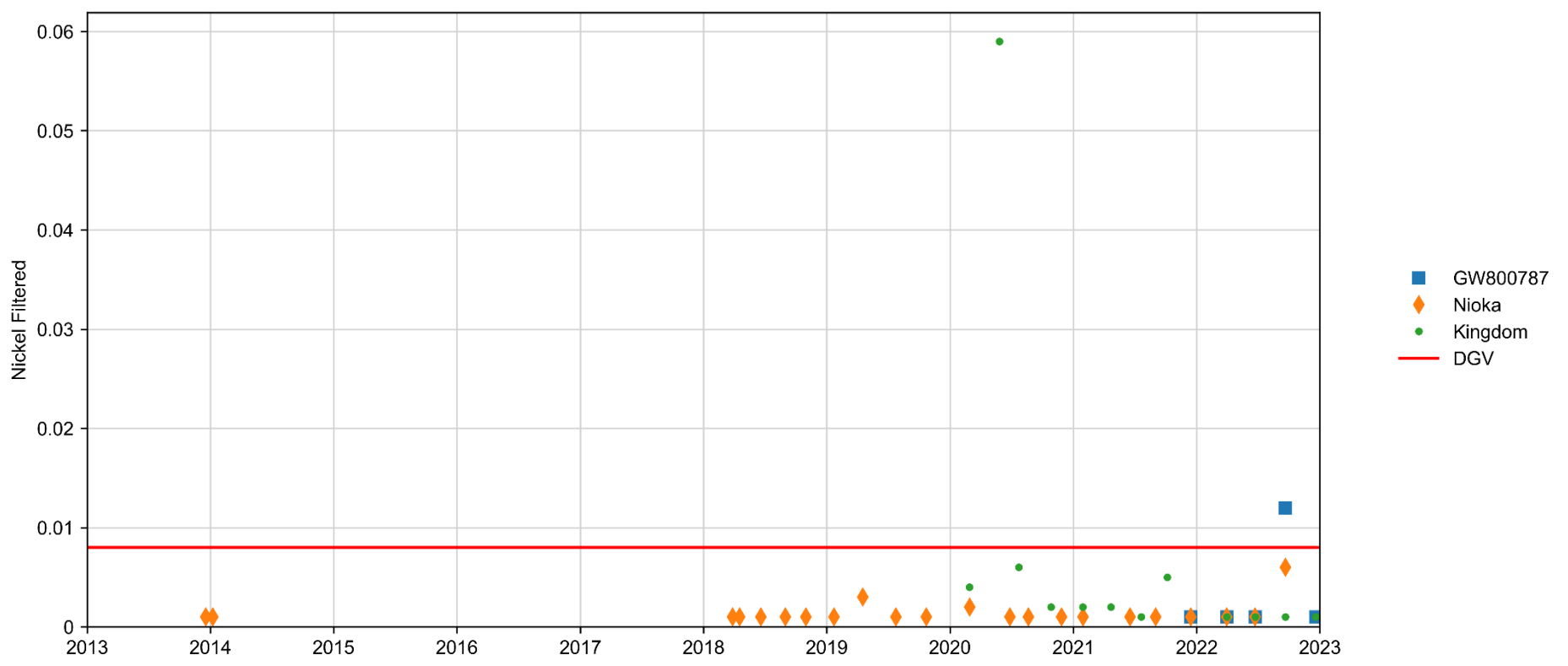
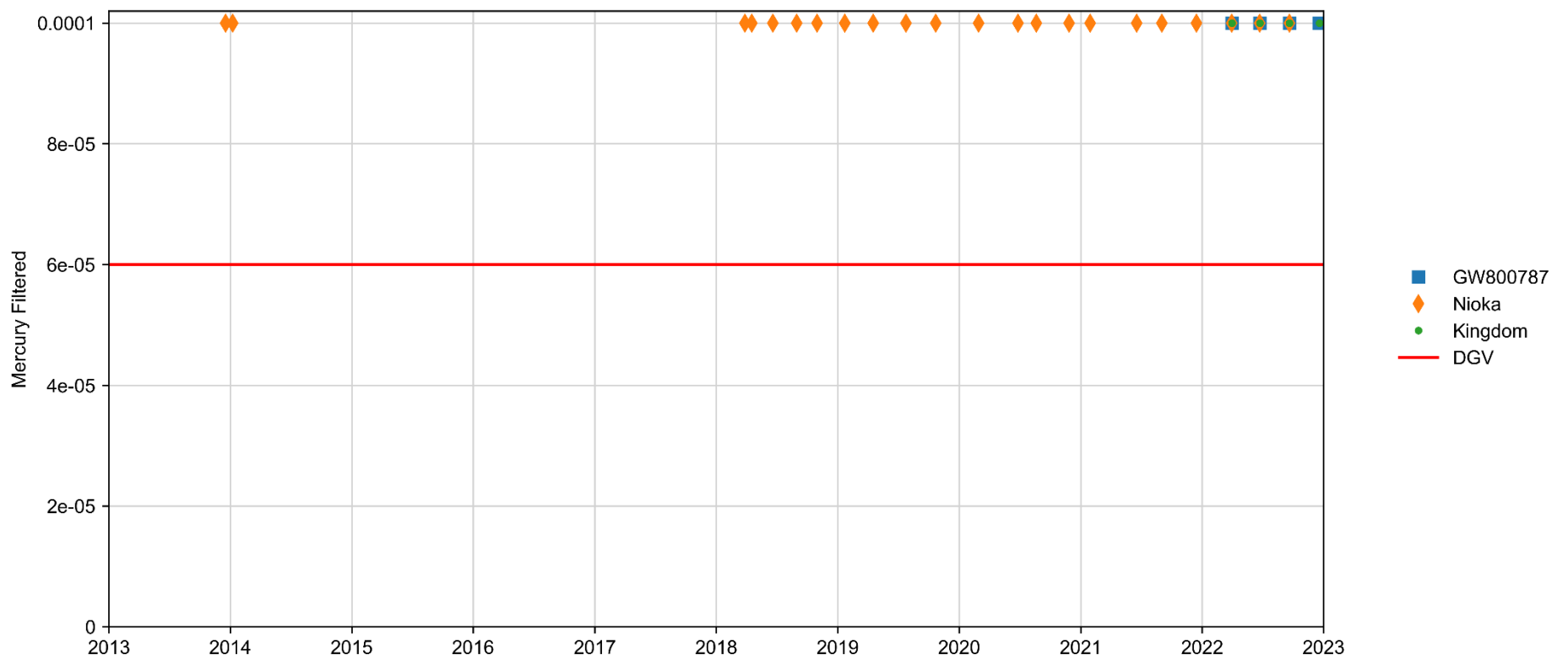






Dissolved metals





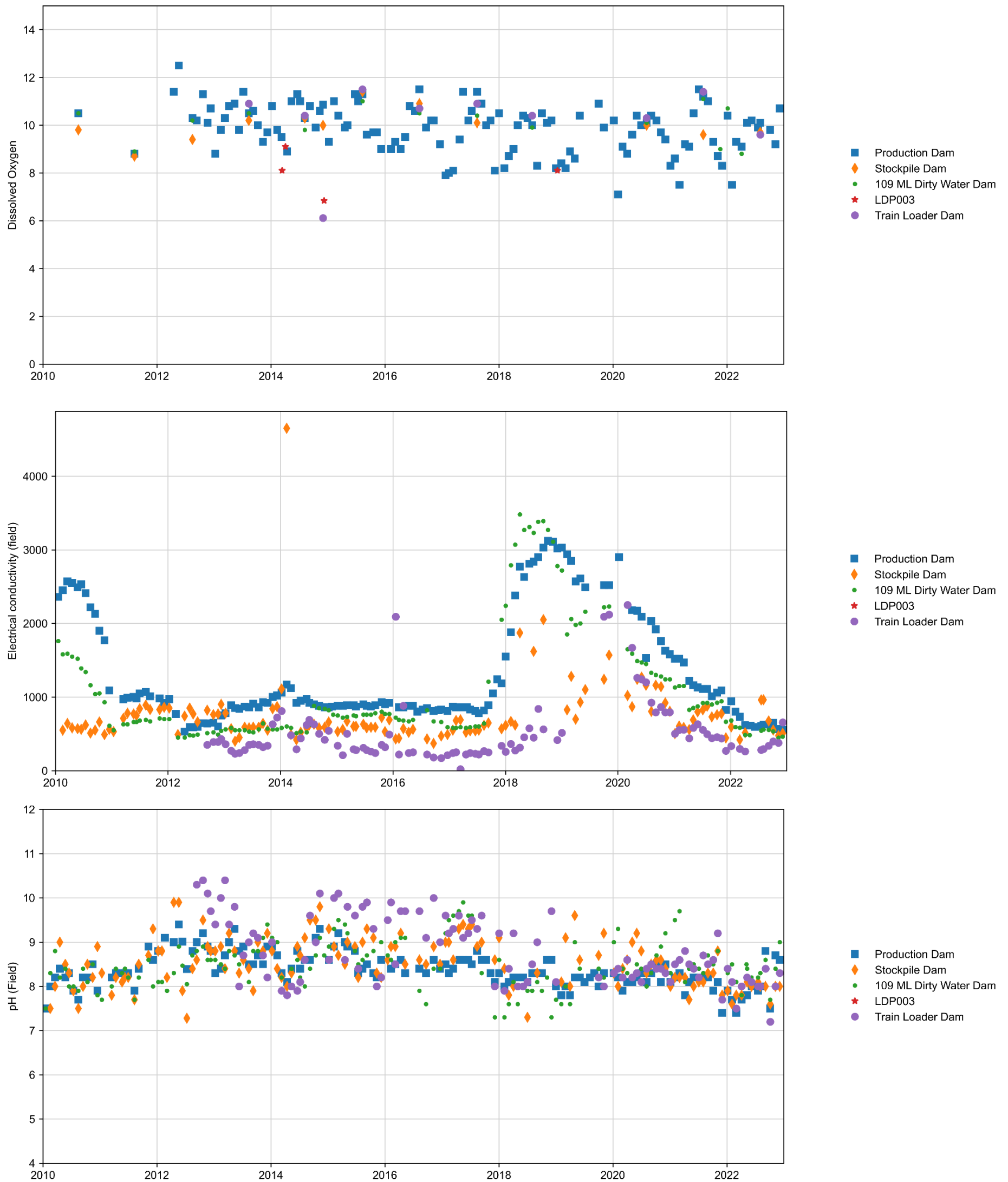
Appendix D – Surface water – onsite storages

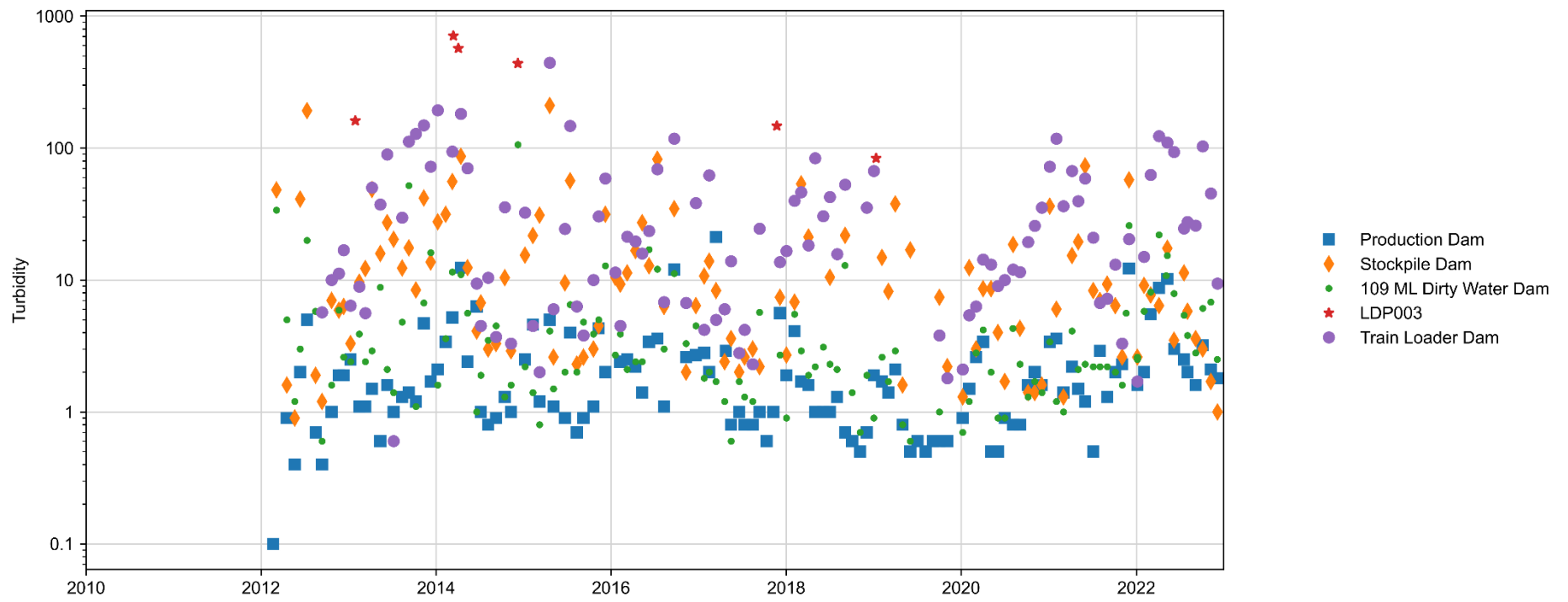
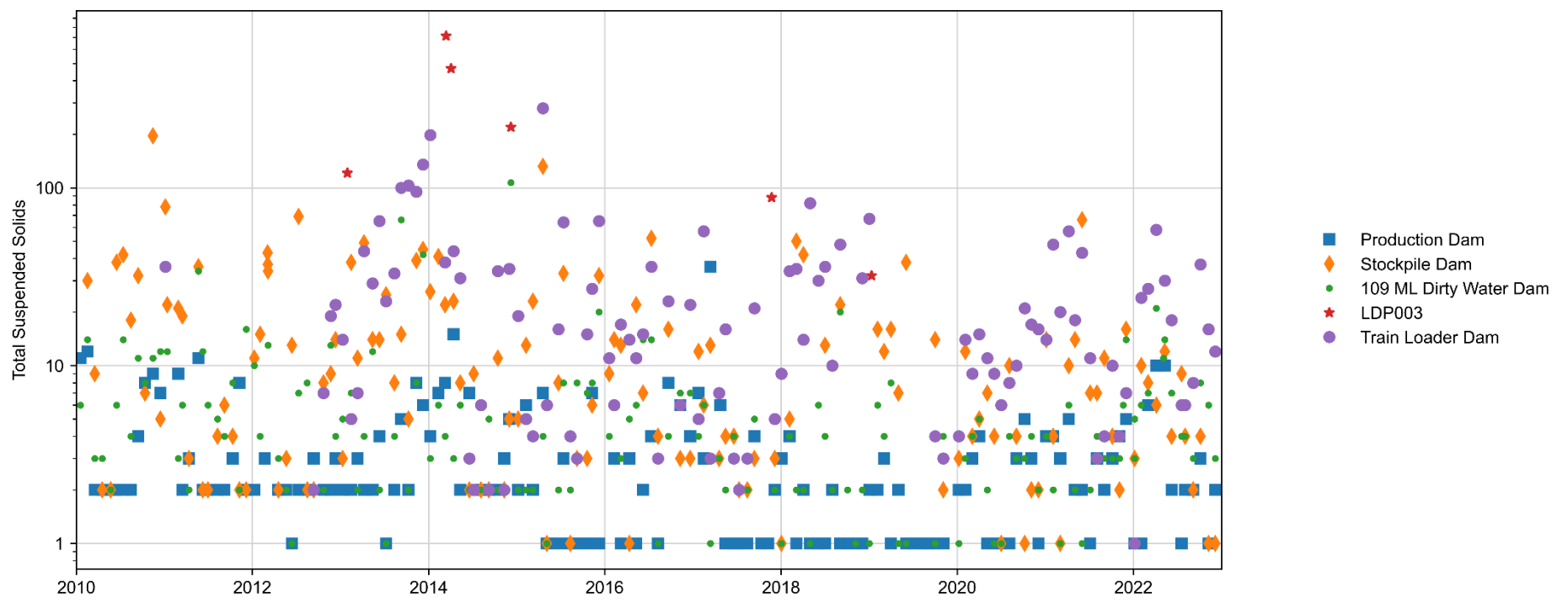
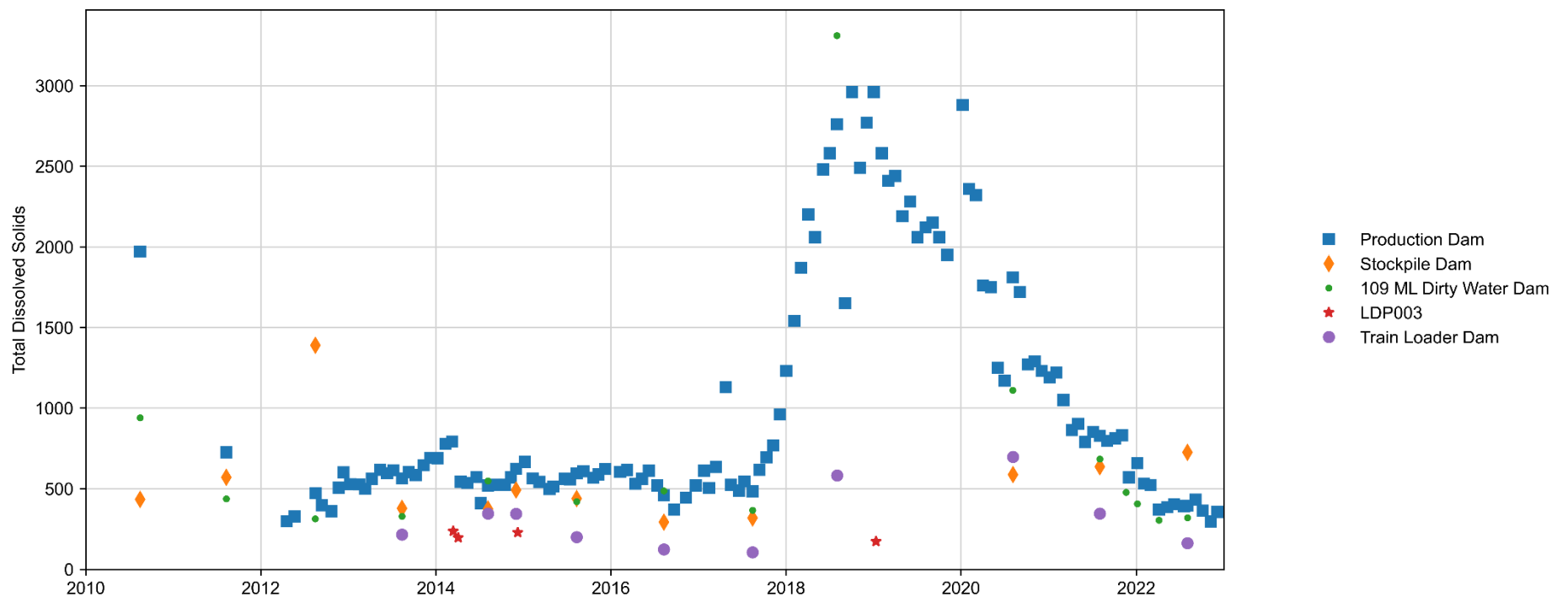
D.1 On-site storages – statistical summary of water quality results

Parameters	Units	Production Dam				Stockpile Dam				Train Loader Dam				Dirty Water Dam			
		Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max
Physiochemical Parameters																	
Dissolved Oxygen (Field)	mg/L	17	7.5	10	10.5	-	-	-	-	1	10.4	10.4	10.4	1	9.9	9.9	9.9
Electrical conductivity (field)	µS/cm	148	530	930	3120	132	370	630	4650	104	20	390	2250	144	446	720	3480
pH (Field)	pH units	149	7.4	8.3	9.4	139	7.28	8.5	9.9	109	7.2	8.6	10.4	150	7.3	8.4	9.9
Total Dissolved Solids	mg/L	129	297	616	2960	12	293	465.5	1390	10	106	279.5	697	15	305	438	3310
Total Suspended Solids	mg/L	154	1	2	36	147	1	8	196	113	1	15	280	154	1	4	107
Turbidity	NTU	129	0.1	1.6	21.2	118	0.9	8.25	210	111	0.6	19.4	443	128	0.6	2.55	106
Nutrients																	
Ammonia as N	mg/L	132	0.01	0.01	0.76	12	0.01	0.01	0.05	10	0.01	0.02	0.03	15	0.01	0.01	0.1
Nitrate as N	mg/L	131	0.01	0.01	0.31	12	0.01	0.02	0.48	10	0.01	0.01	0.26	15	0.01	0.02	0.11
Nitrite as N	mg/L	131	0.01	0.01	0.03	12	0.01	0.01	0.01	10	0.01	0.01	0.01	15	0.01	0.01	0.01
Nitrogen (Total oxidized as N)	mg/L	131	0.01	0.01	0.31	12	0.01	0.02	0.49	10	0.01	0.01	0.26	17	0.01	0.02	0.11
Nitrogen (Total)	mg/L	131	0.1	0.3	1	12	0.1	0.35	1.6	10	0.1	0.4	0.6	143	0.1	0.3	1.2
Phosphorus (Total)	mg/L	127	0.01	0.01	0.27	12	0.01	0.01	0.1	10	0.01	0.01	0.07	138	0.01	0.01	0.28
Major Ions																	
Alkalinity (Carbonate as CaCO3)	mg/L	129	1	1	24	12	1	1	9	10	1	1	11	15	1	1	3
Alkalinity (Bicarbonate as CaCO3)	mg/L	132	55	95	155	12	31	82.5	127	10	35	72.5	115	16	2	79.5	127
Alkalinity (Hydroxide as CaCO3)	mg/L	132	1	1	2	12	1	1	2	10	1	1	1	15	1	1	2
Alkalinity (total as CaCO3)	mg/L	131	55	95	155	12	40	82.5	127	10	35	76	115	15	48	82	127
Calcium	mg/L	132	40	55	267	12	41	50.5	94	10	15	35	80	15	37	55	283
Magnesium	mg/L	131	27	58	304	12	20	32.5	60	10	11	17.5	58	15	22	38	309
Potassium	mg/L	128	6	8	18	12	5	7.5	11	10	2	4.5	10	15	5	8	13
Sodium	mg/L	131	19	45	162	12	11	27.5	40	10	7	13	32	15	15	22	125
Sulfate	mg/L	70	128	583.5	1910	4	173	303.5	389	5	32	170	412	8	112	209	1870
Metals (Dissolved)																	
Iron (Filtered)	mg/L	154	0.05	0.05	0.1	144	0.03	0.05	0.42	112	0.05	0.05	0.34	154	0.05	0.05	0.2
Manganese (Filtered)	mg/L	154	0.001	0.0235	0.513	145	0.001	0.01	3.28	112	0.001	0.011	1.14	155	0.001	0.01	0.242
Metals (Total)																	
Aluminium	mg/L	133	0.01	0.03	0.59	13	0.06	0.1	0.78	10	0.06	0.205	0.75	16	0.02	0.085	21
Arsenic	mg/L	132	0.001	0.001	0.002	13	0.001	0.001	0.001	10	0.001	0.001	0.002	16	0.001	0.001	0.001
Cadmium	mg/L	133	0.00005	0.0001	0.0006	13	0.0001	0.0001	0.0009	10	0.0001	0.0001	0.0001	16	0.0001	0.0001	0.0005
Cobalt	mg/L	133	0.001	0.001	0.001	13	0.001	0.001	0.001	10	0.001	0.001	0.001	16	0.001	0.001	0.003
Lead	mg/L	133	0.001	0.001	0.11	14	0.001	0.001	0.16	10	0.001	0.001	0.002	17	0.001	0.001	0.03
Mercury	mg/L	132	0.0001	0.0001	0.0001	13	0.0001	0.0001	0.0001	10	0.0001	0.0001	0.0001	16	0.0001	0.0001	0.0001
Nickel	mg/L	132	0.001	0.003	0.008	13	0.001	0.001	0.003	10	0.001	0.002	0.024	16	0.001	0.003	0.455
Silver	mg/L	131	0.0001	0.001	0.011	12	0.001	0.001	0.002	9	0.001	0.001	0.003	16	0.001	0.001	0.003
Zinc	mg/L	131	0.005	0.005	0.048	13	0.005	0.005	0.01	10	0.005	0.005	0.008	16	0.005	0.005	0.077
Barium	mg/L	133	0.012	0.044	0.084	13	0.024	0.045	0.09	10	0.028	0.049	0.086	16	0.024	0.0435	0.09
Boron	mg/L	133	0.05	0.05	0.09	13	0.05	0.05	0.05	10	0.05	0.05	0.05	16	0.05	0.05	0.05
Other																	
Oil and grease	µg/L	154	2000	5000	27000	147	2000	5000	17000	113	2000	5000	13000	155	2000	5000	16000

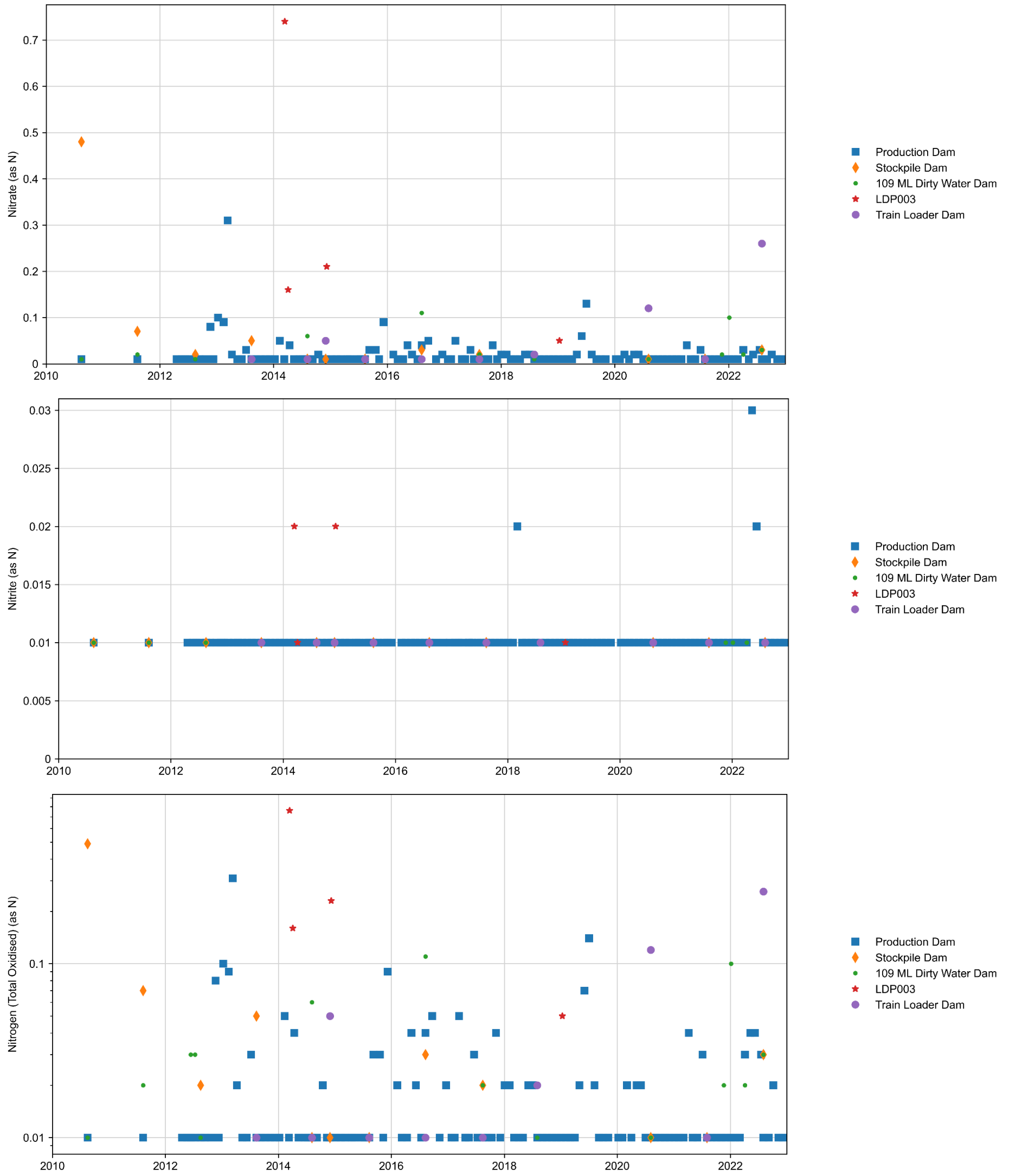
D.2 Chemical time series graphs

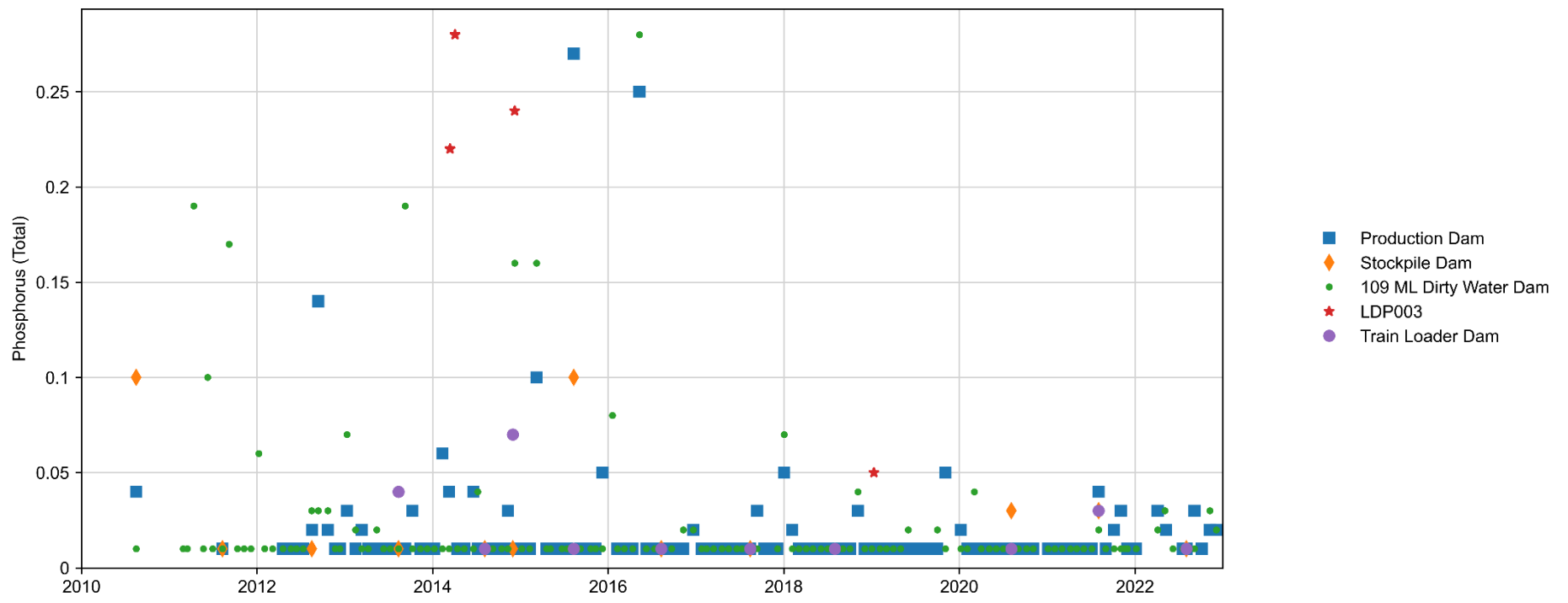
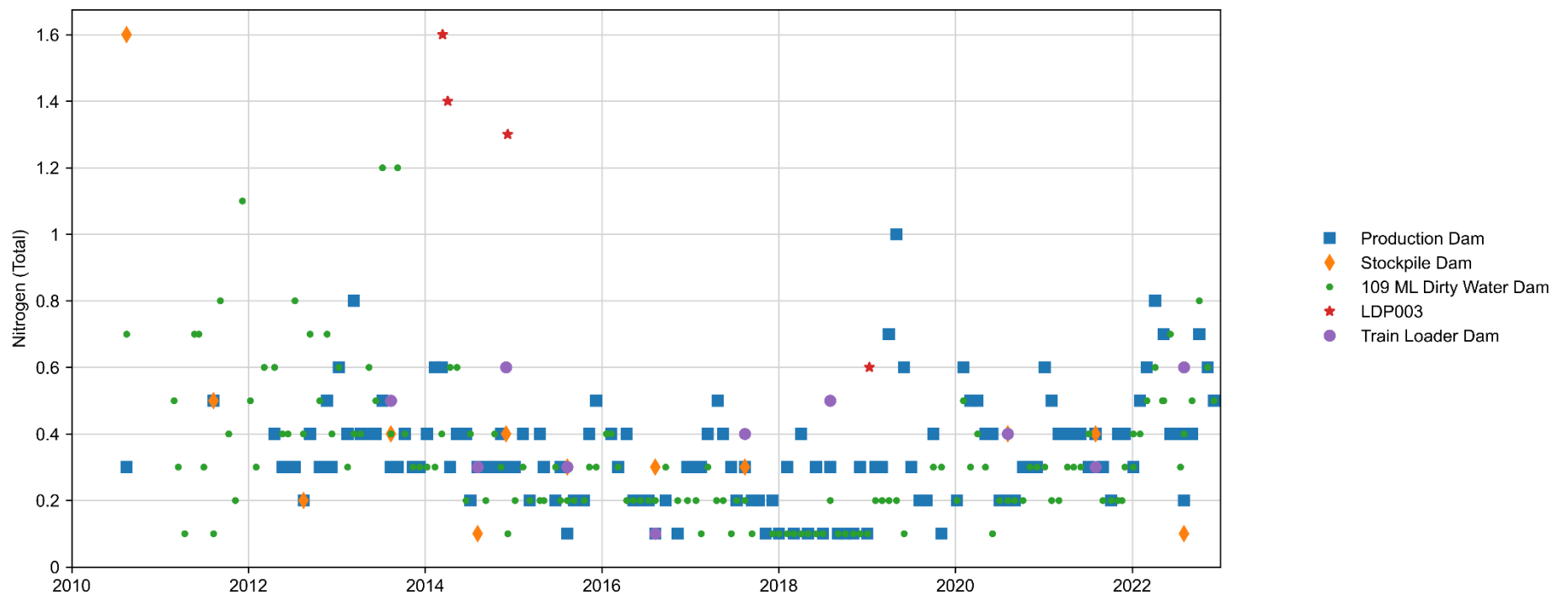
Physicochemical Parameters



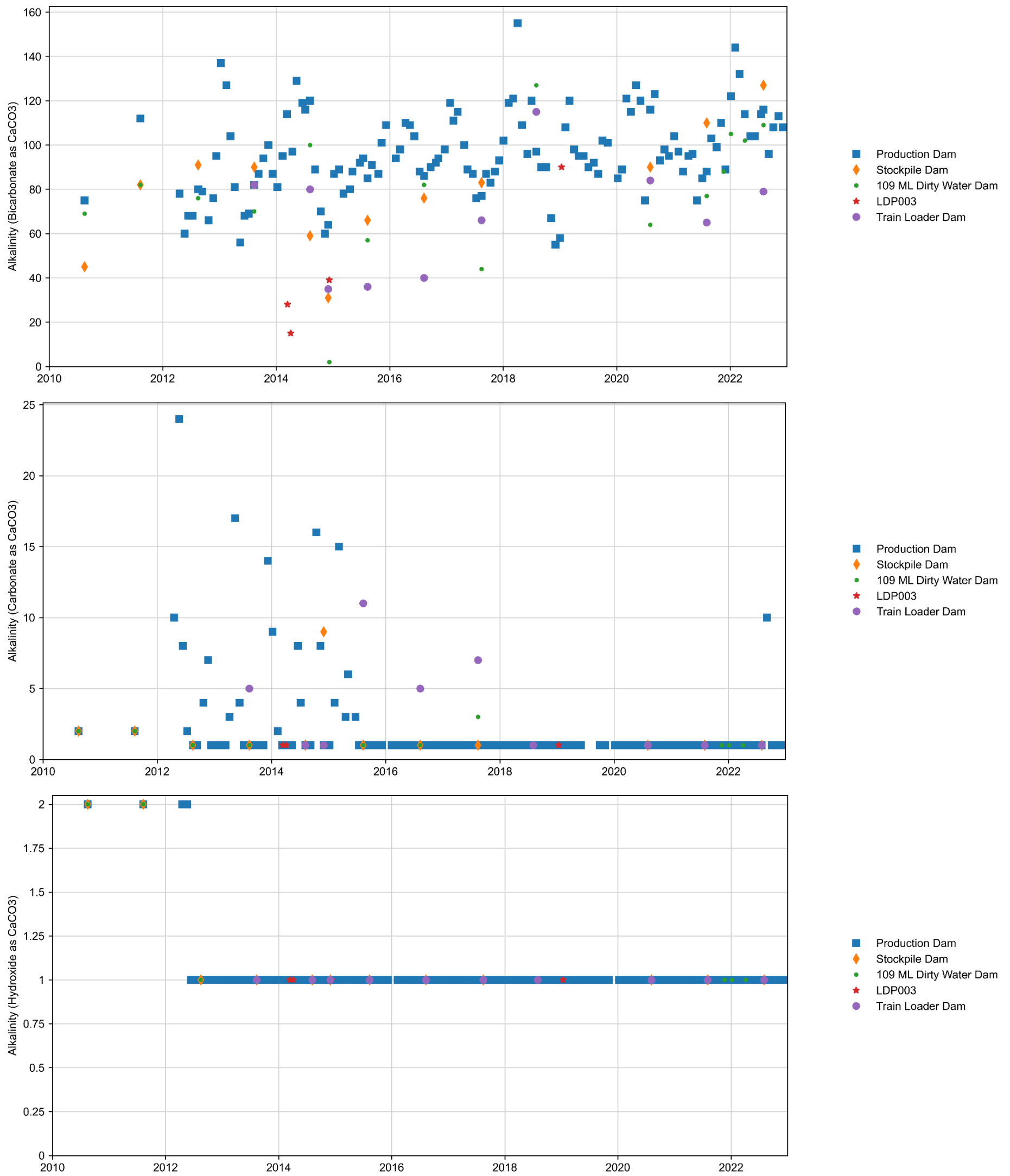


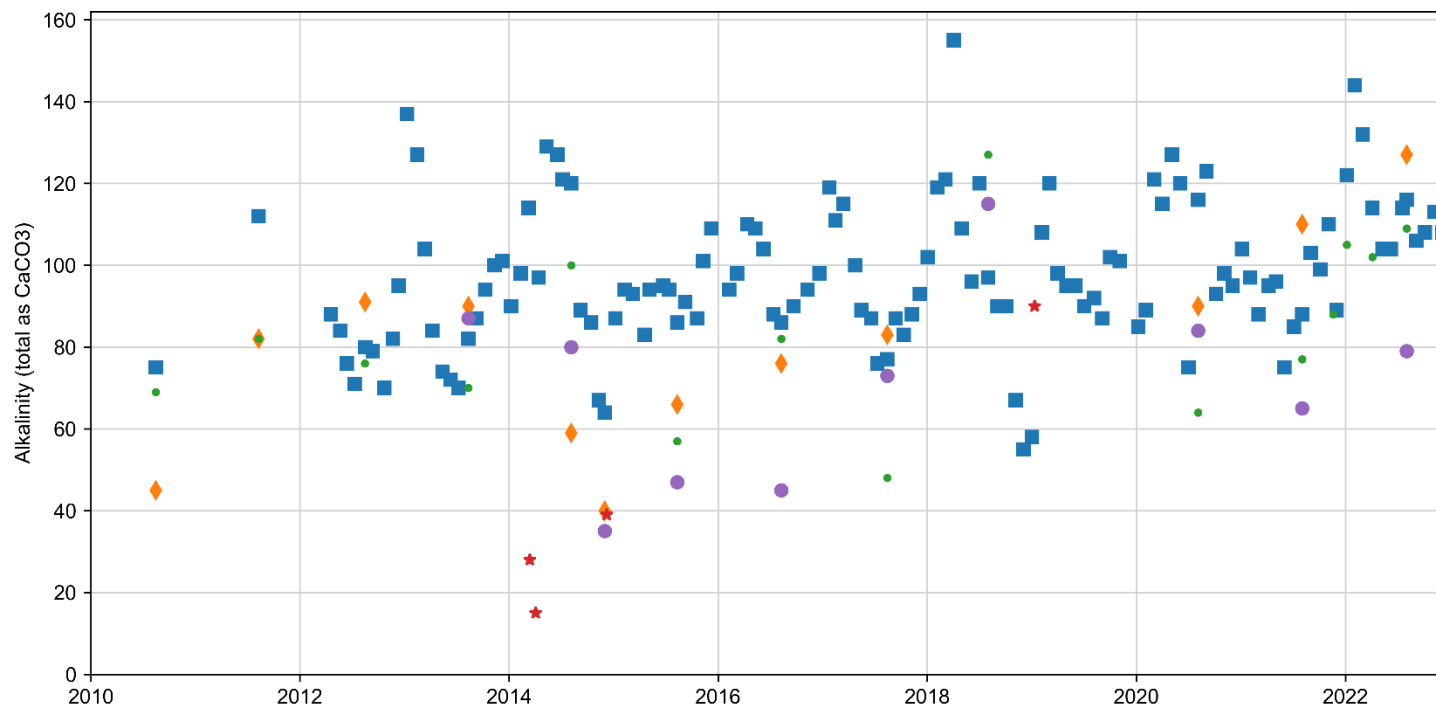
Nutrients



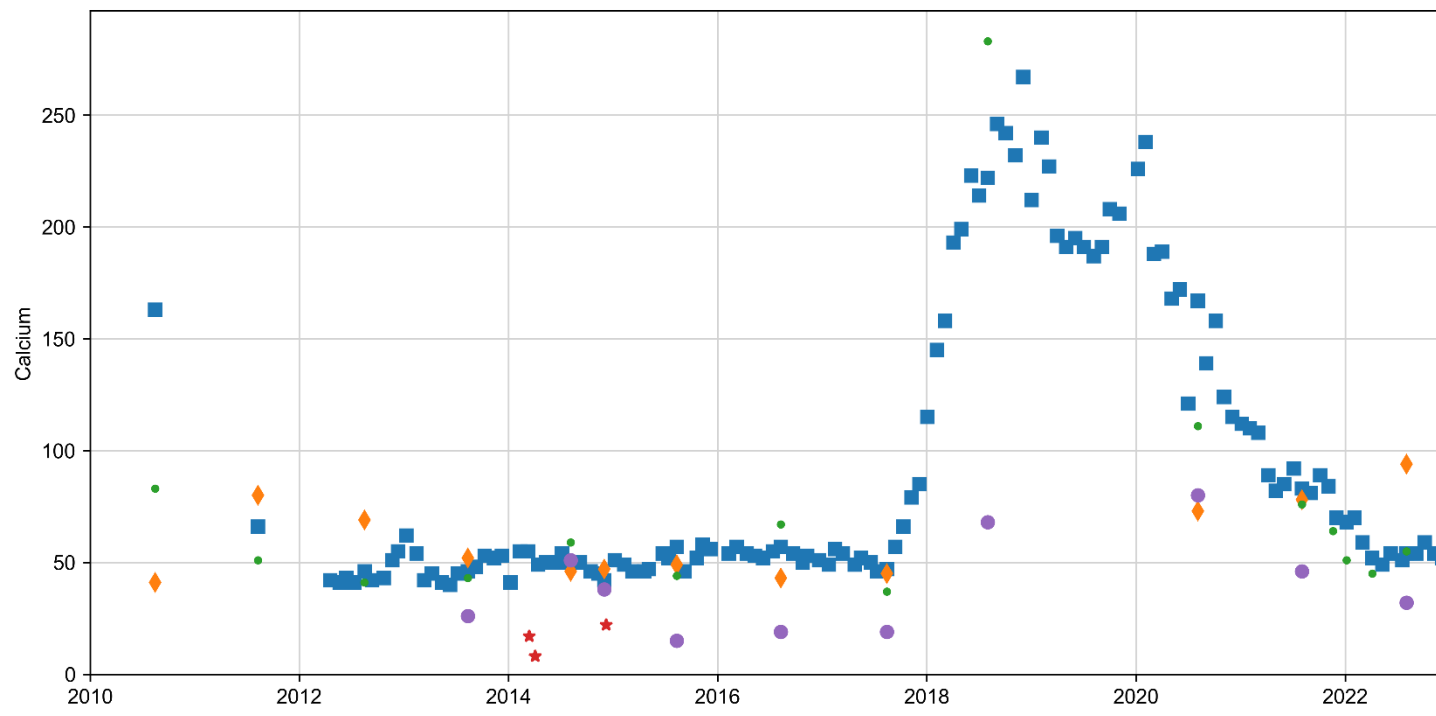


Major Ions

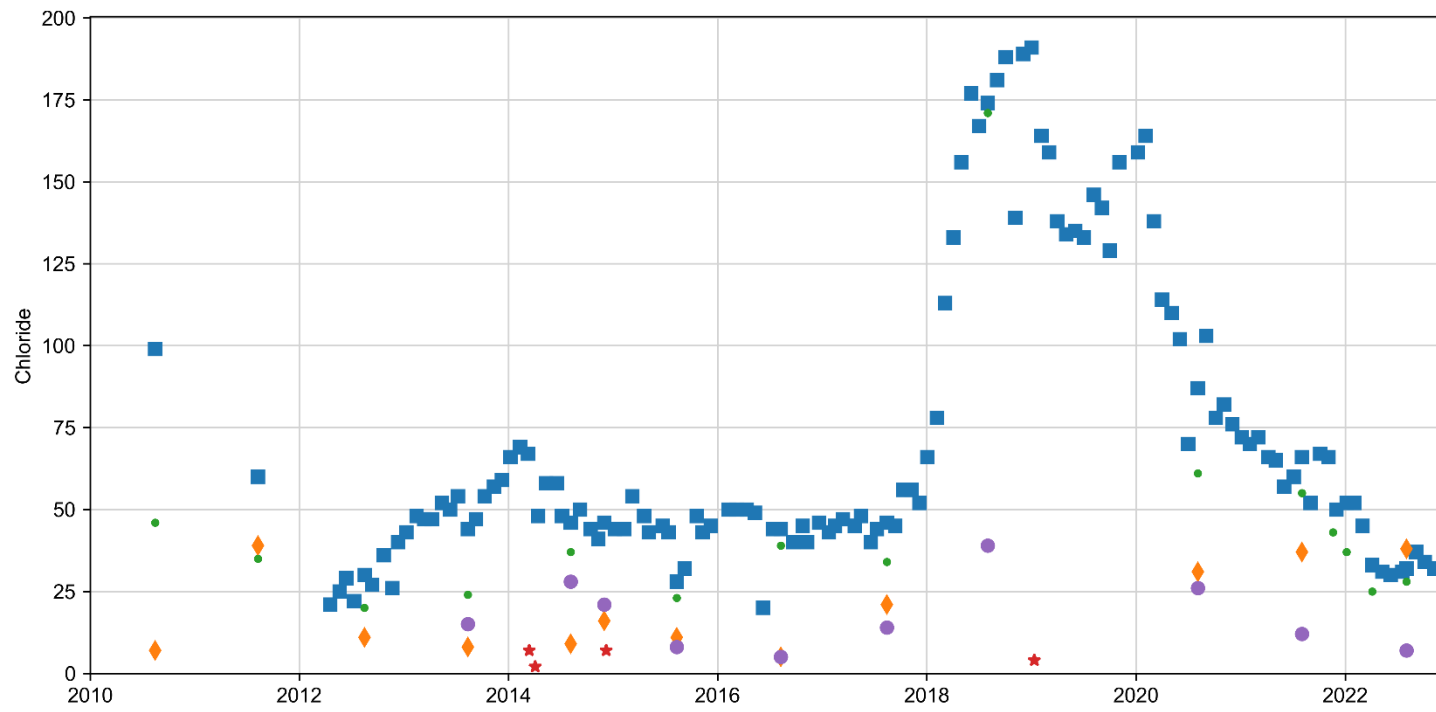




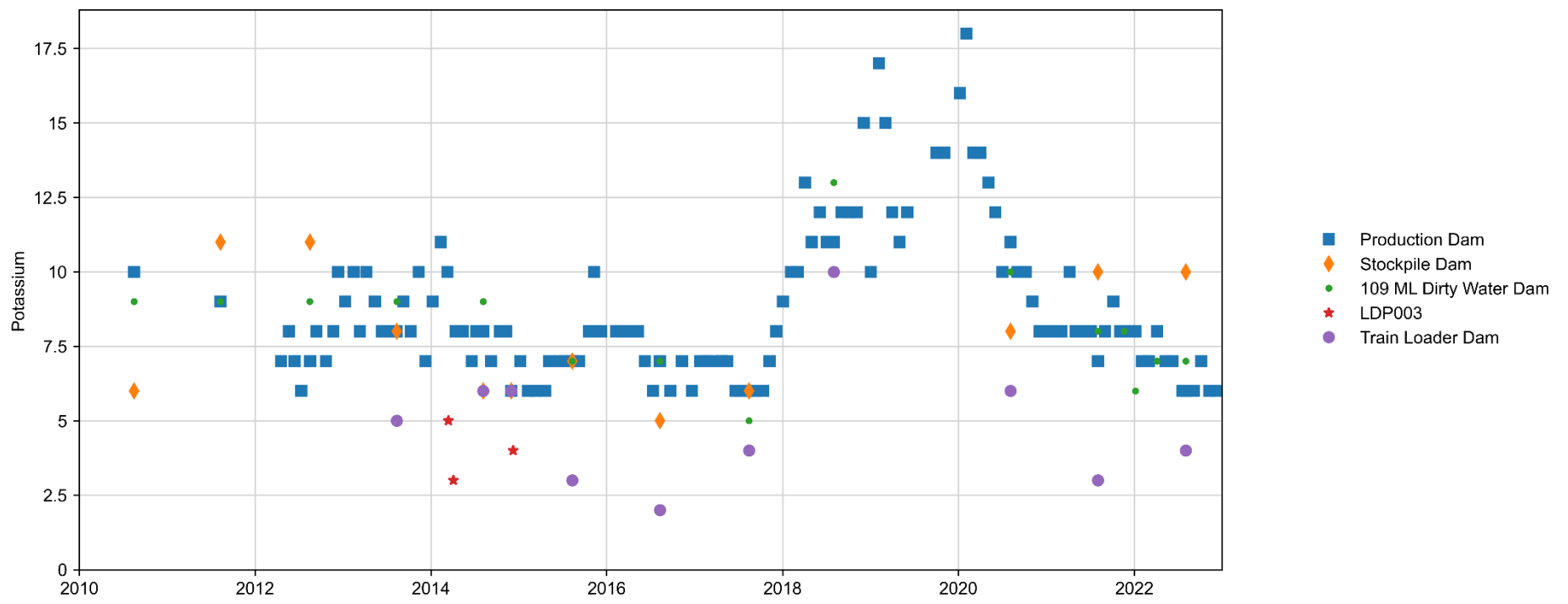
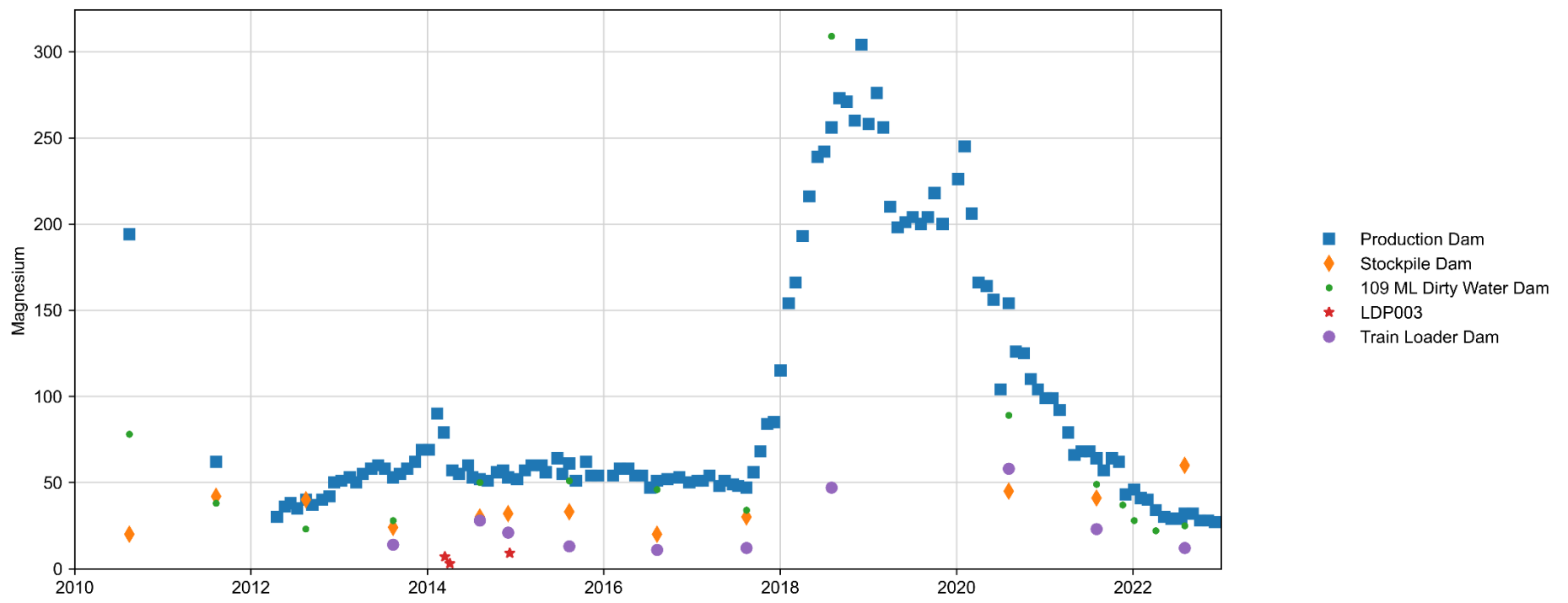
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- Stockpile Dam
- 109 ML Dirty Water Dam
- LDP003
- Train Loader Dam

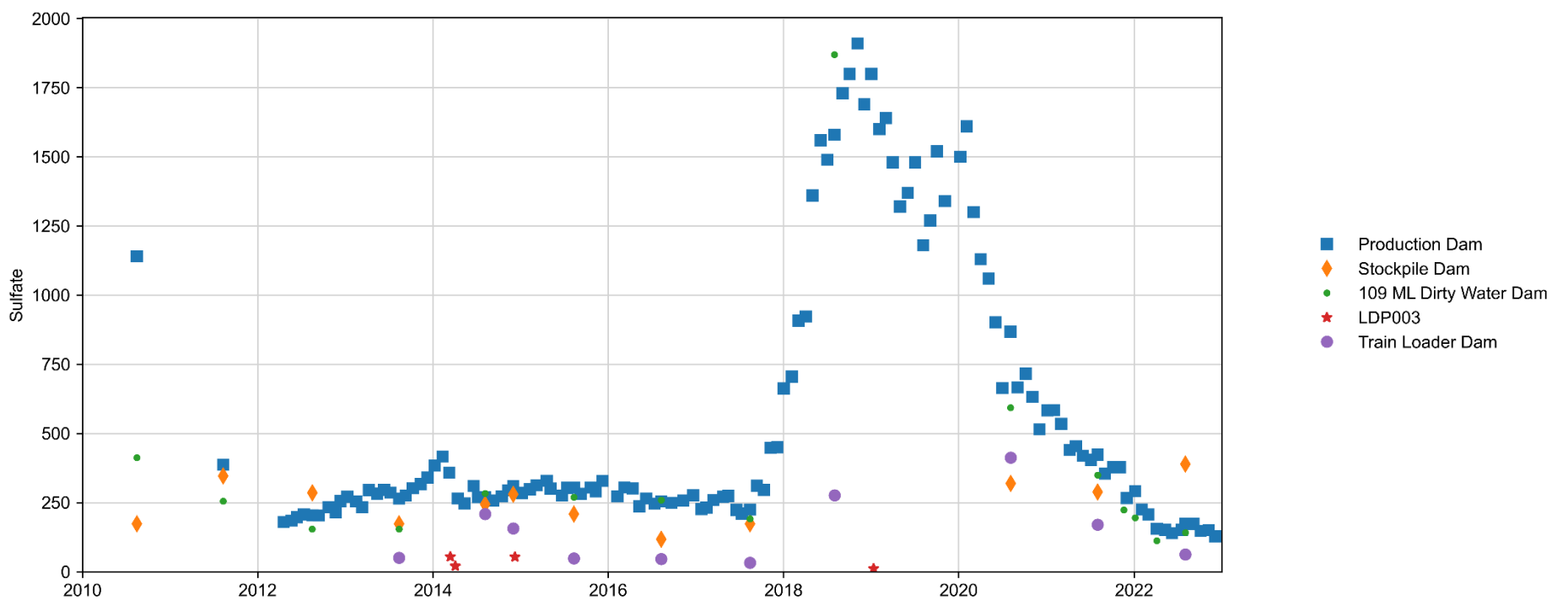
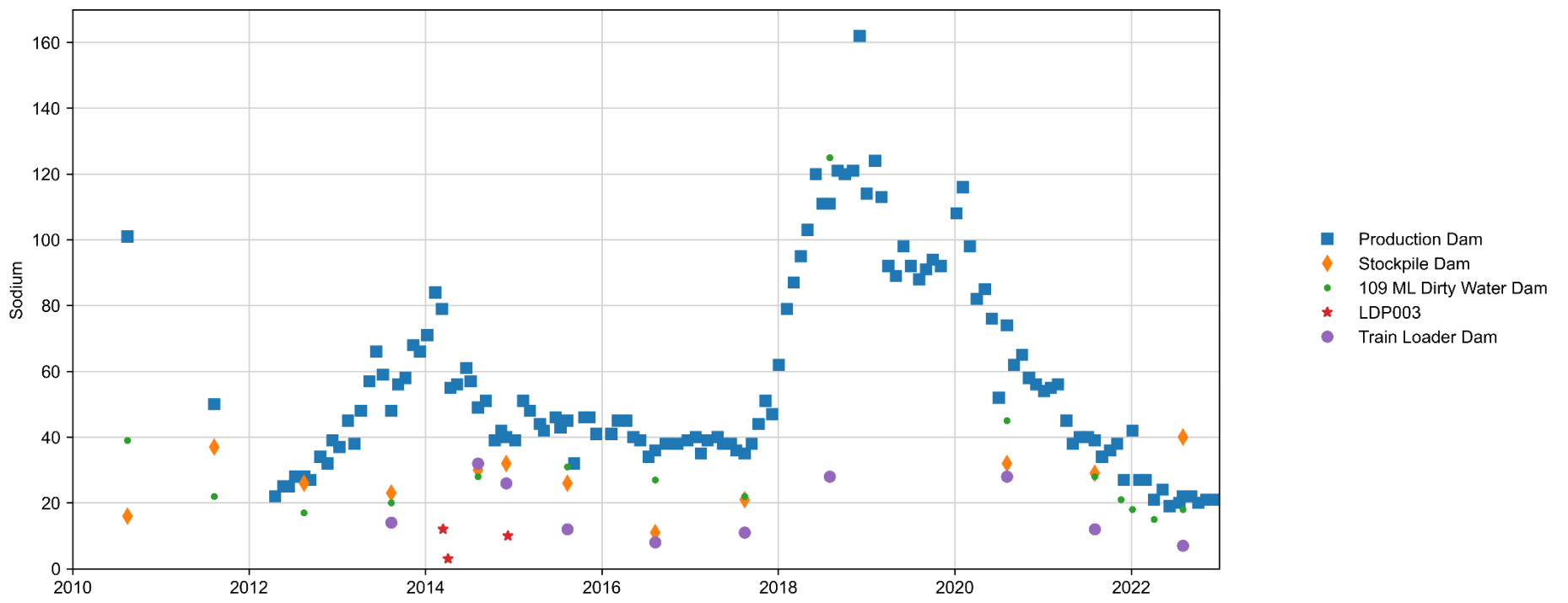


- Production Dam
- Stockpile Dam
- 109 ML Dirty Water Dam
- LDP003
- Train Loader Dam

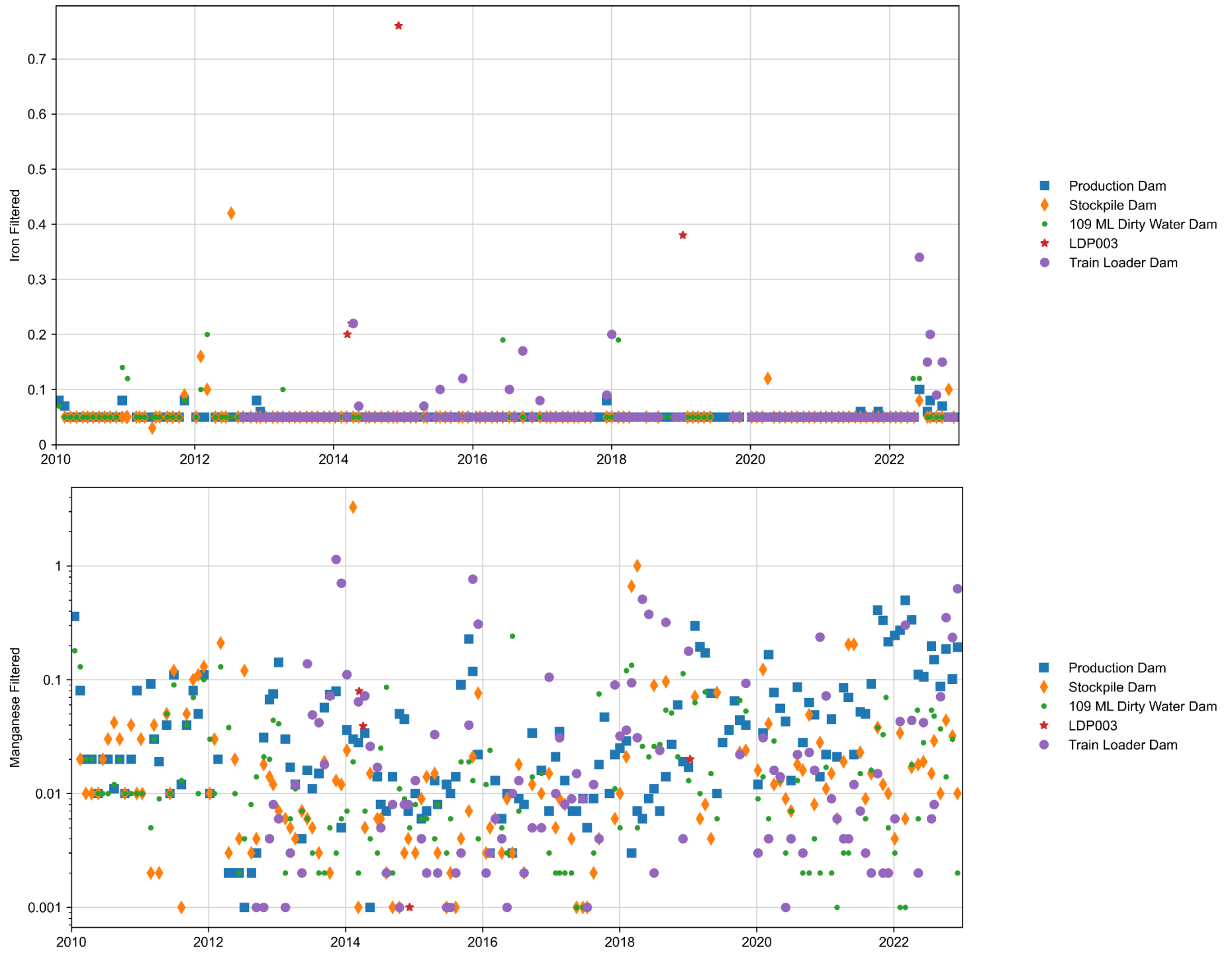


- Production Dam
- Stockpile Dam
- 109 ML Dirty Water Dam
- LDP003
- Train Loader Dam

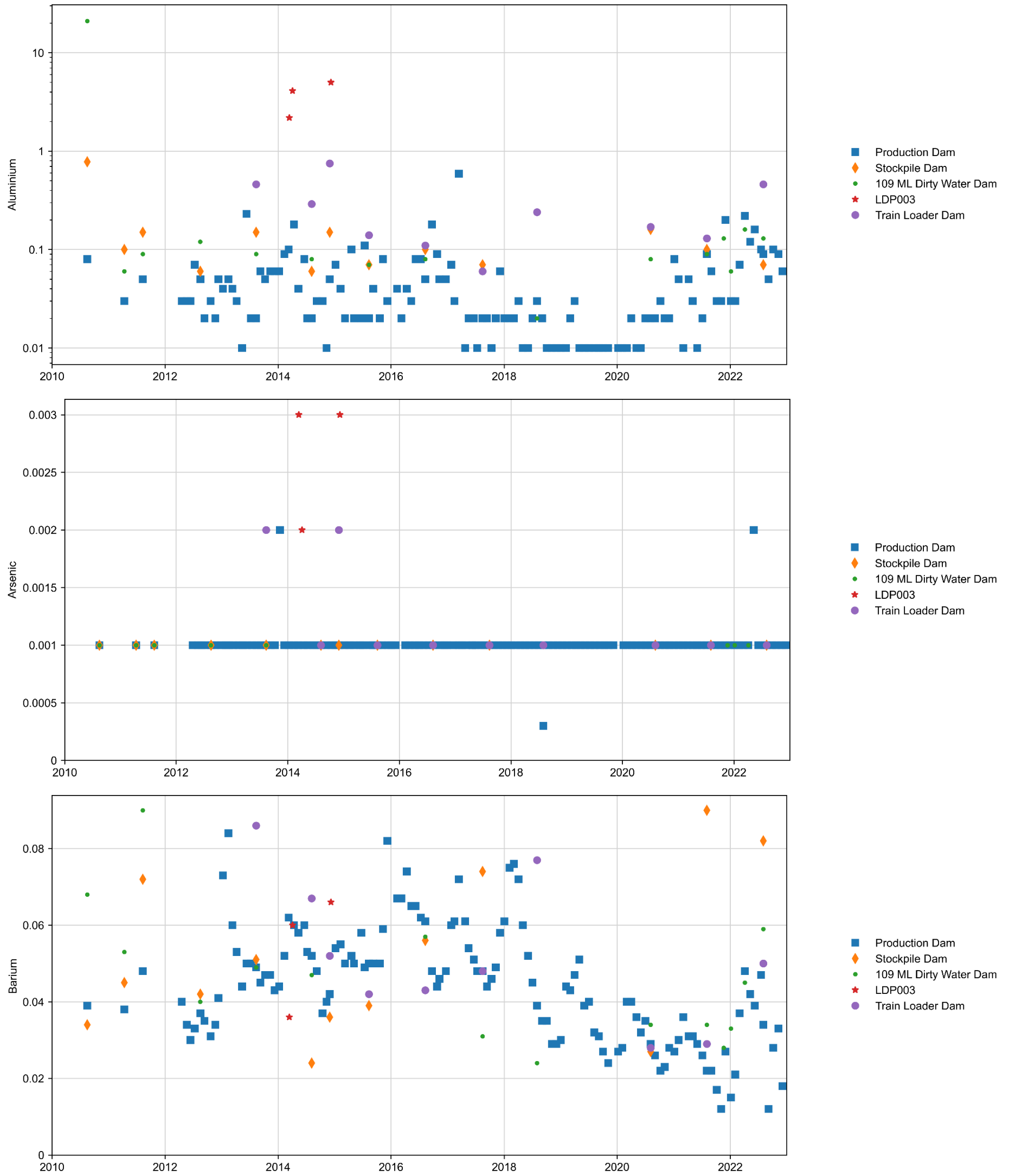


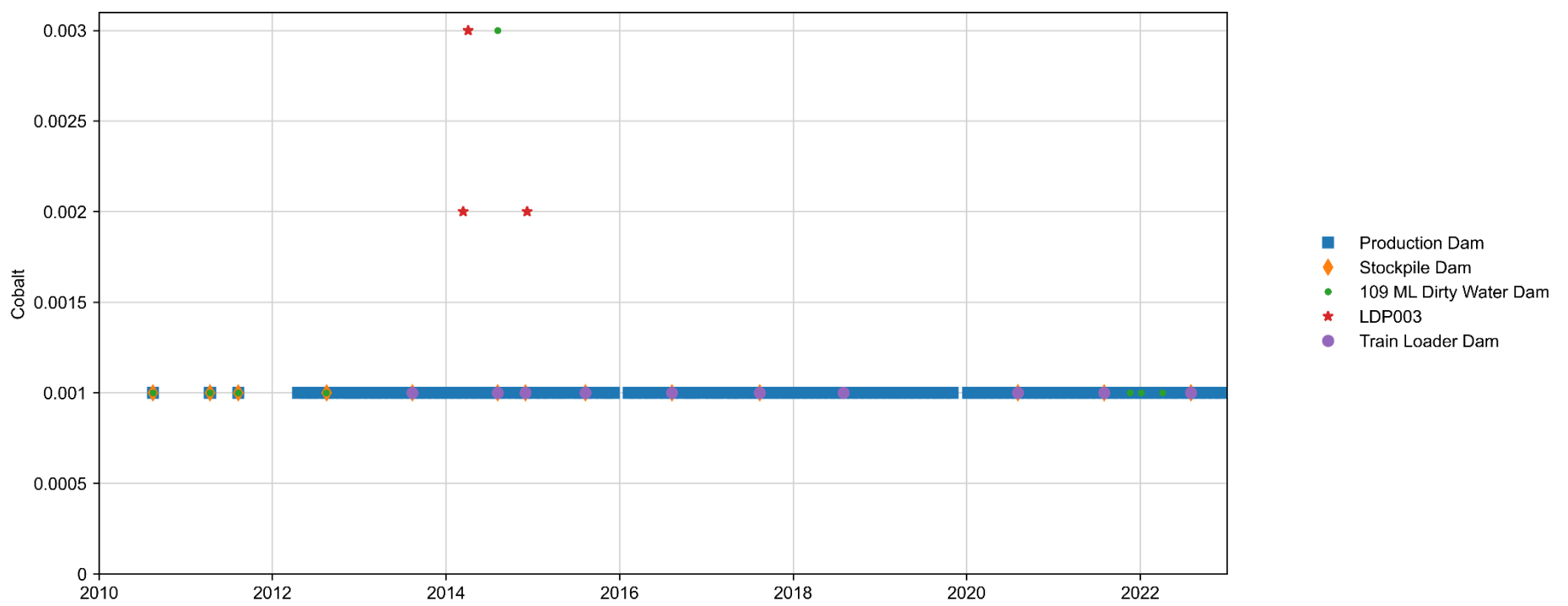
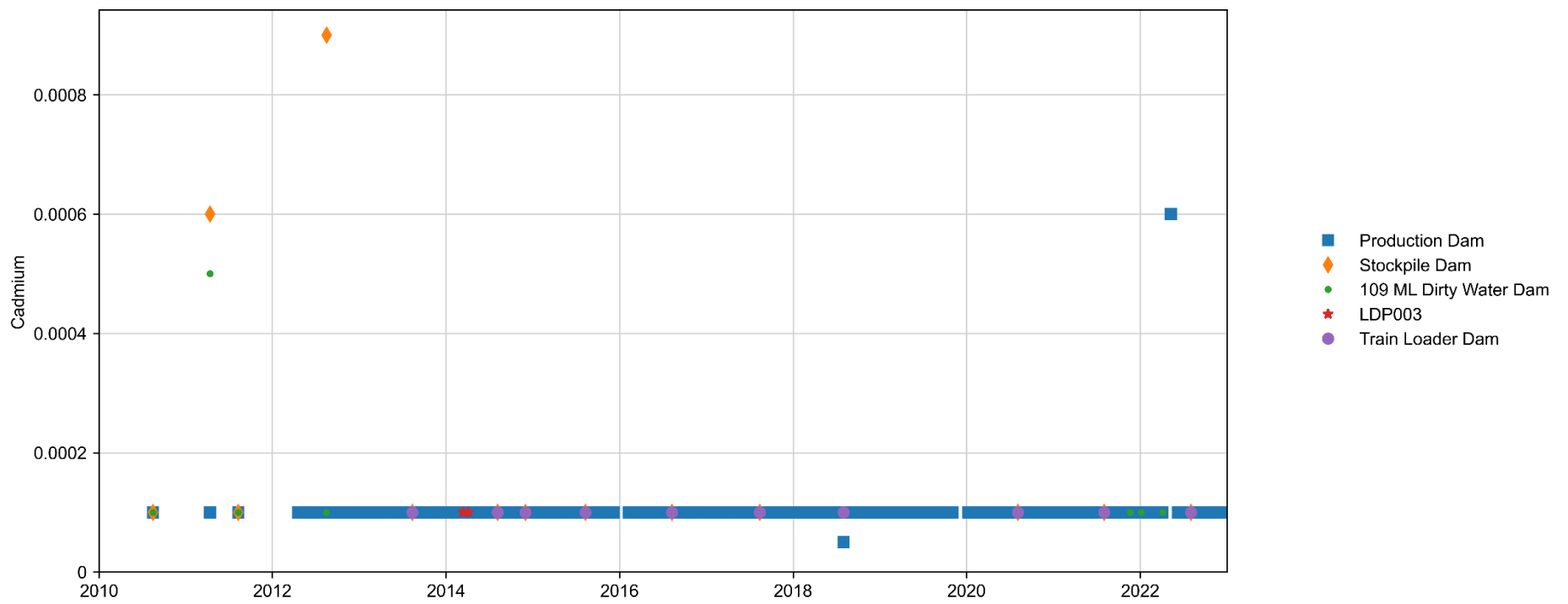
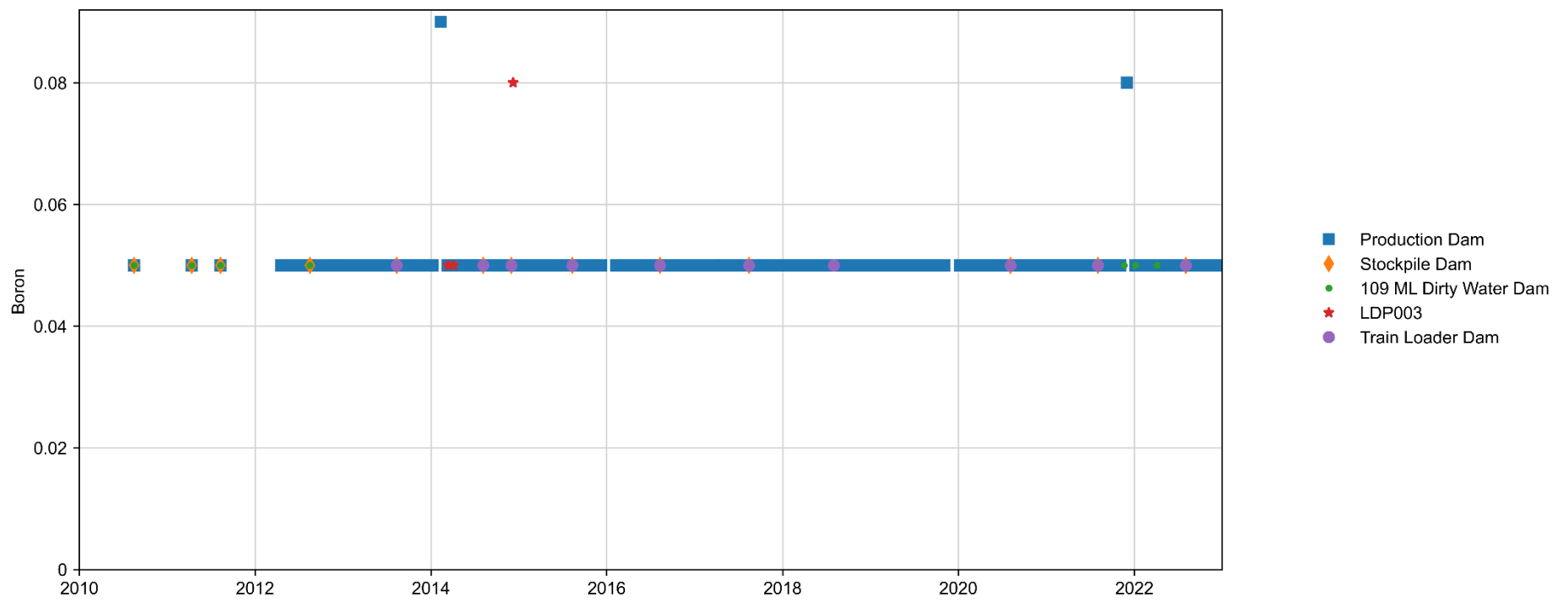


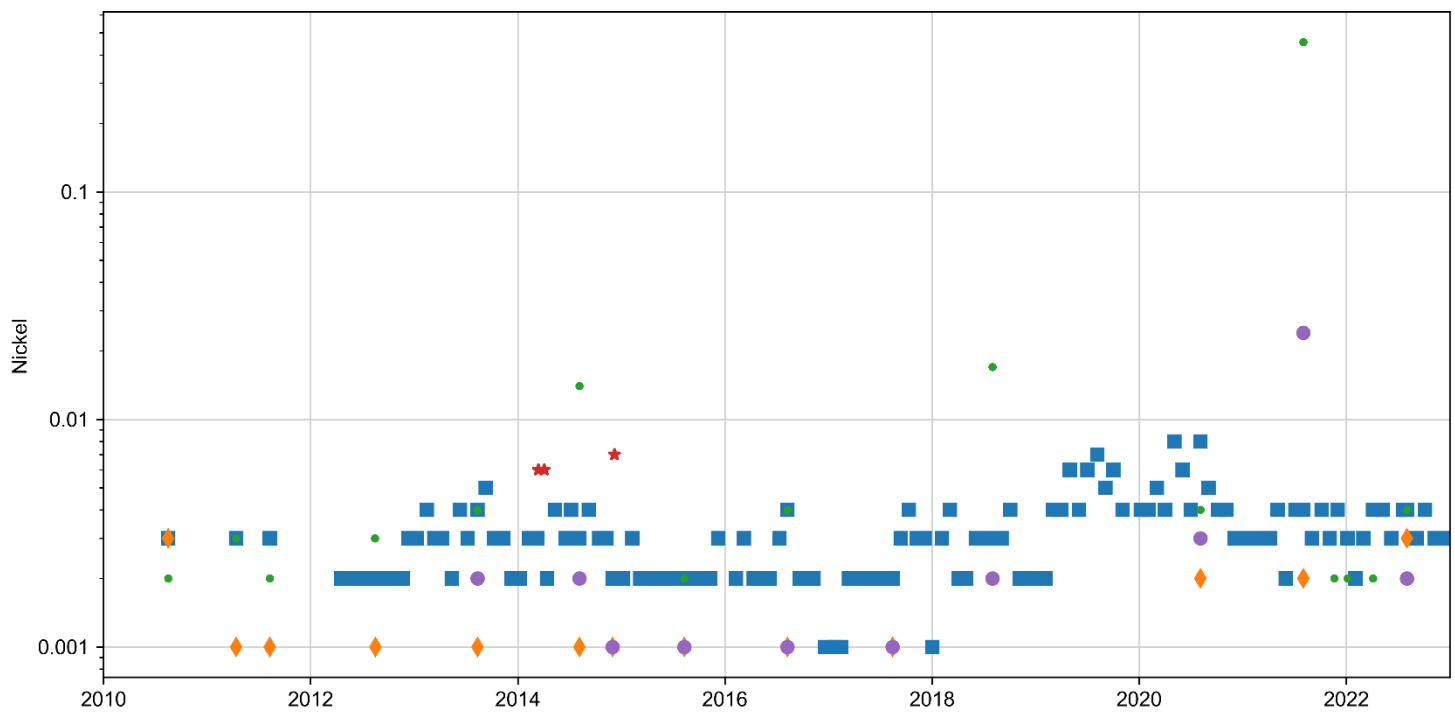
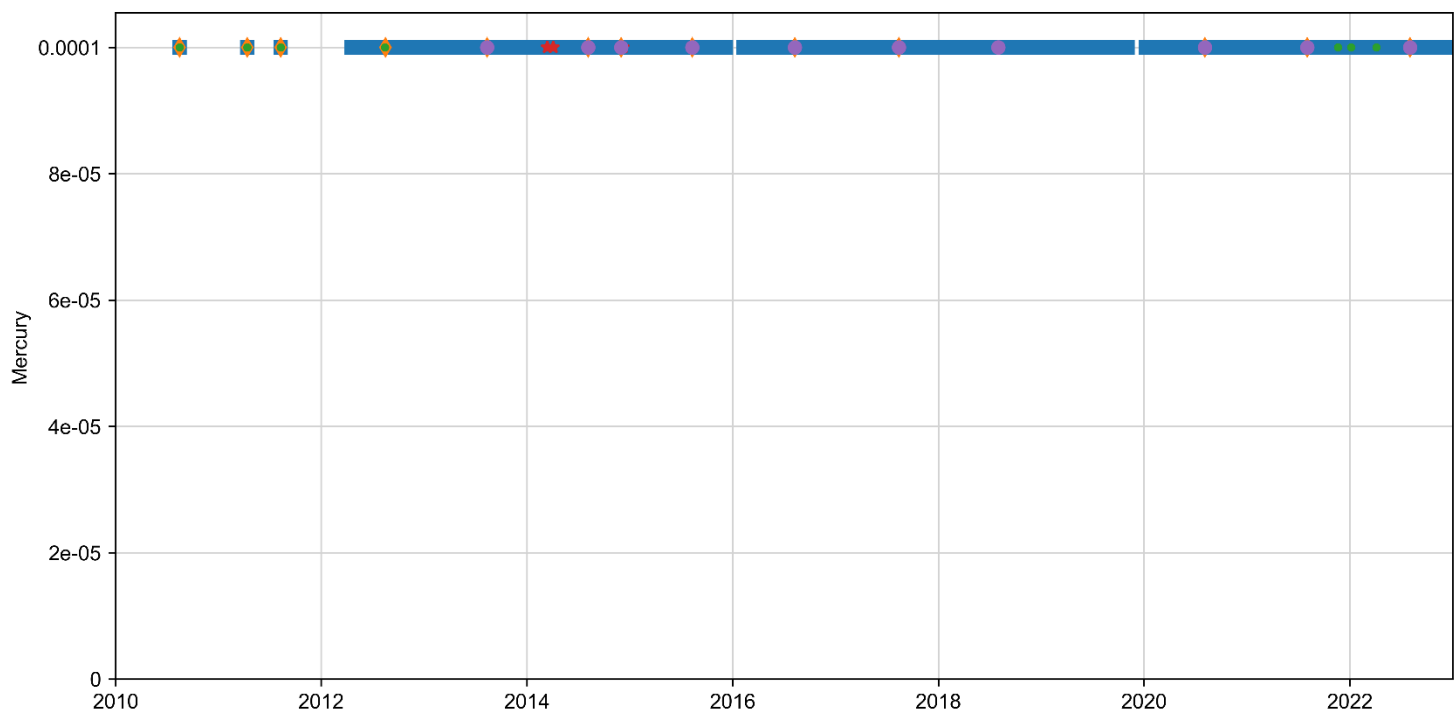
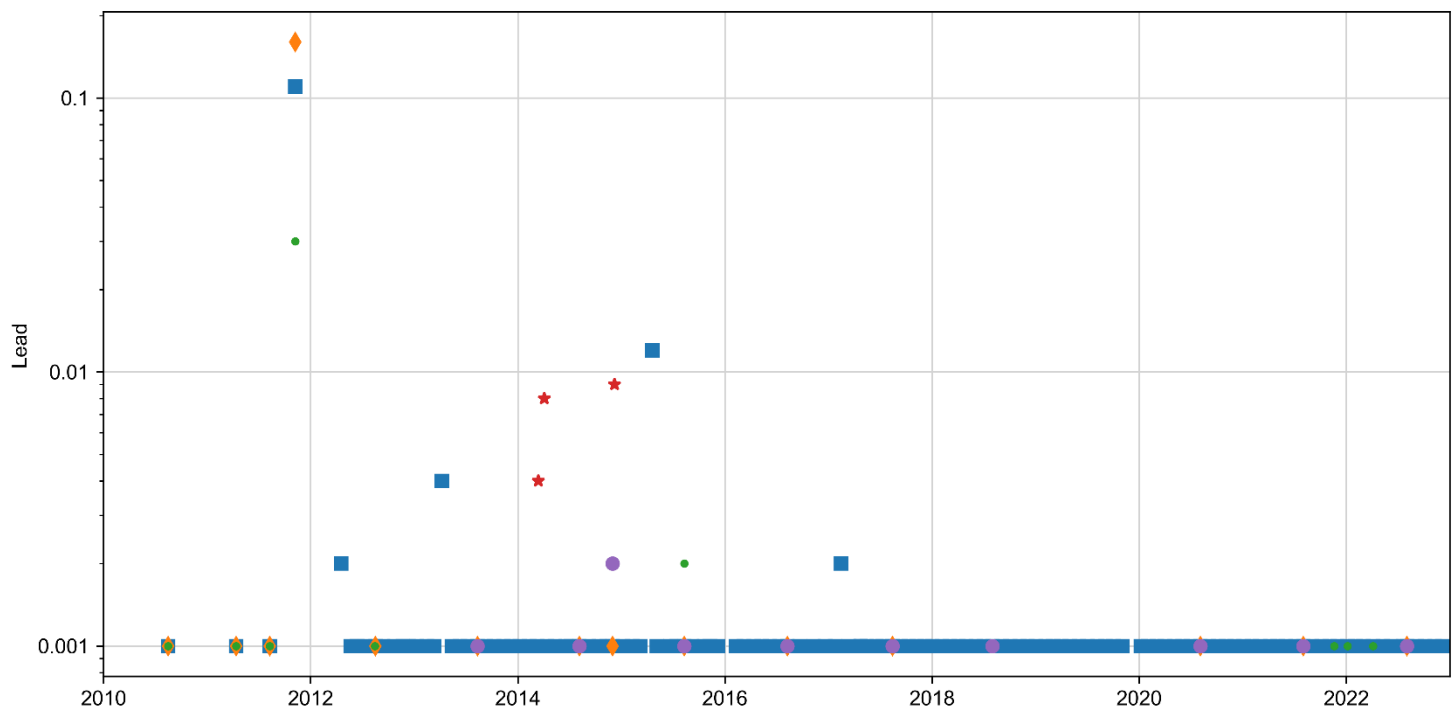
Dissolved metals

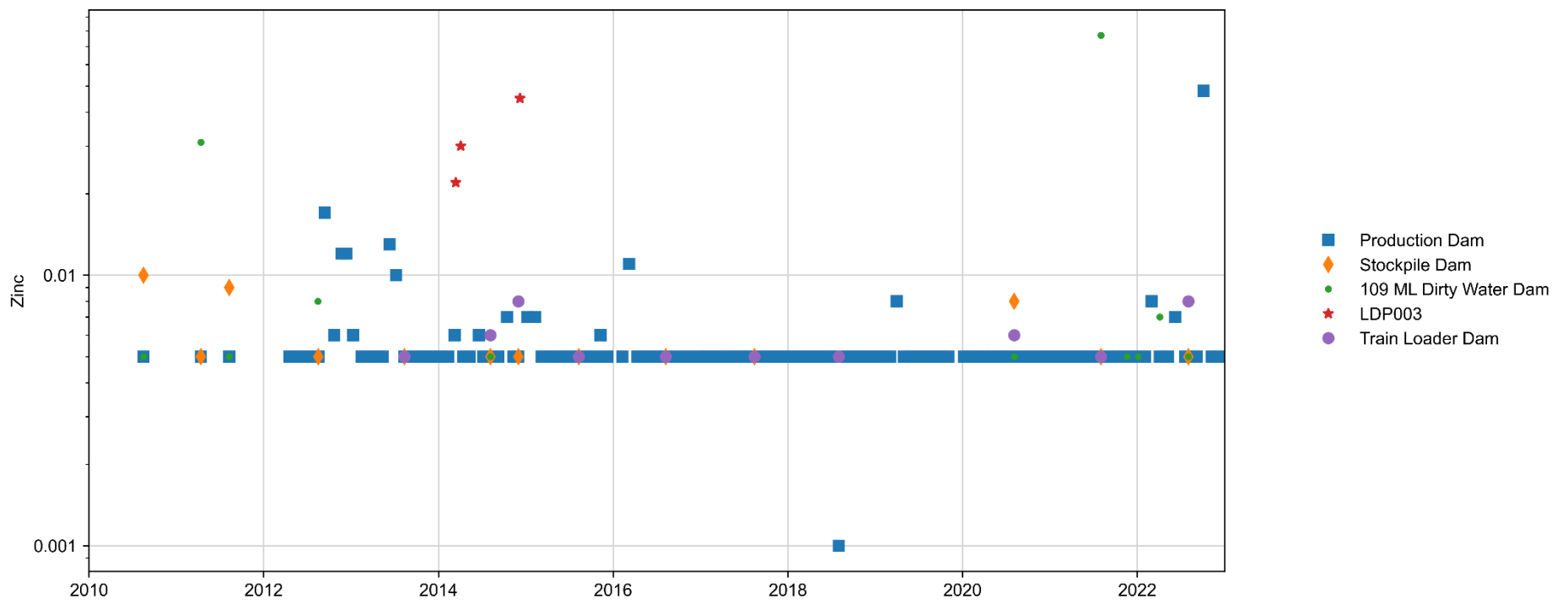
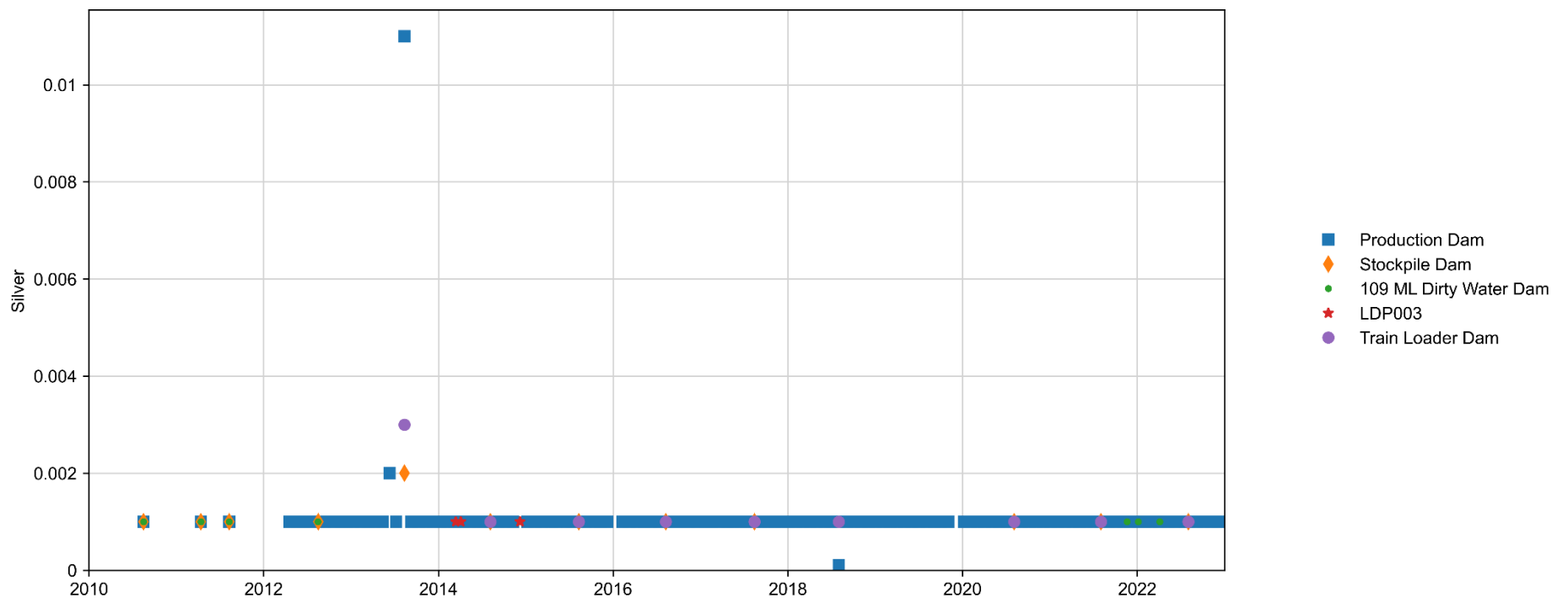


Total Metals

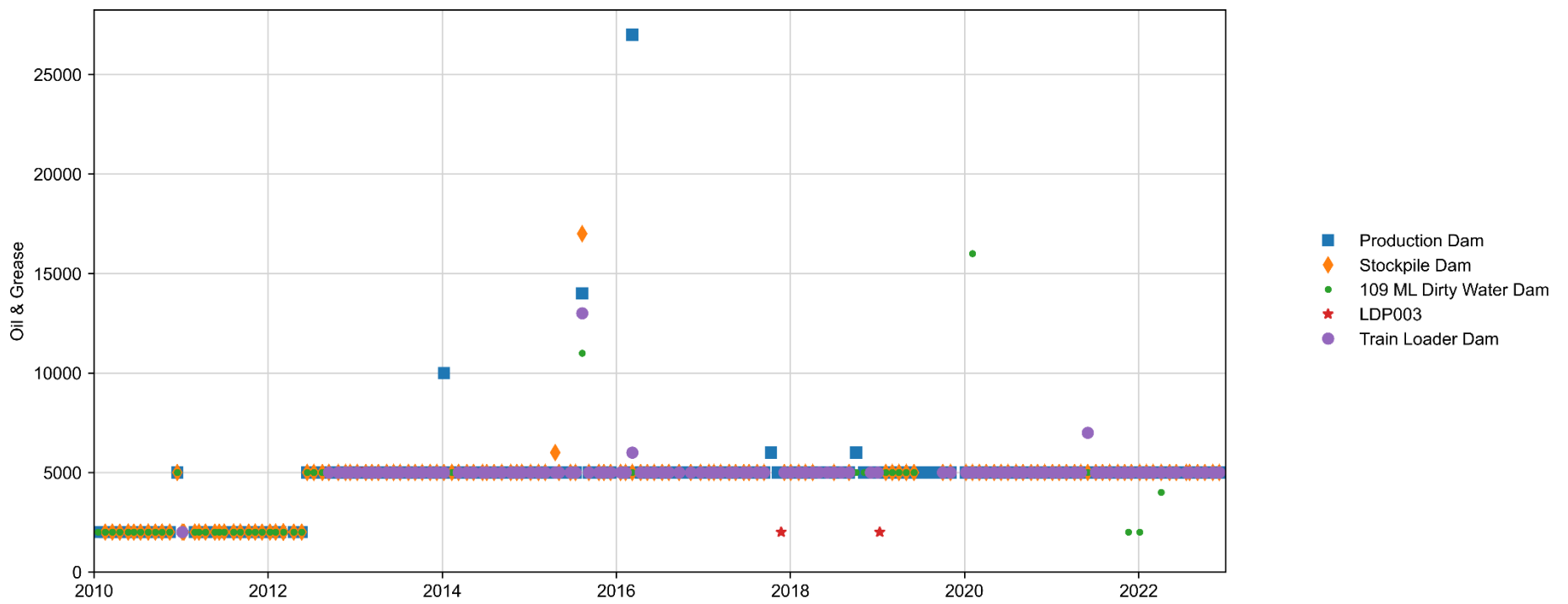


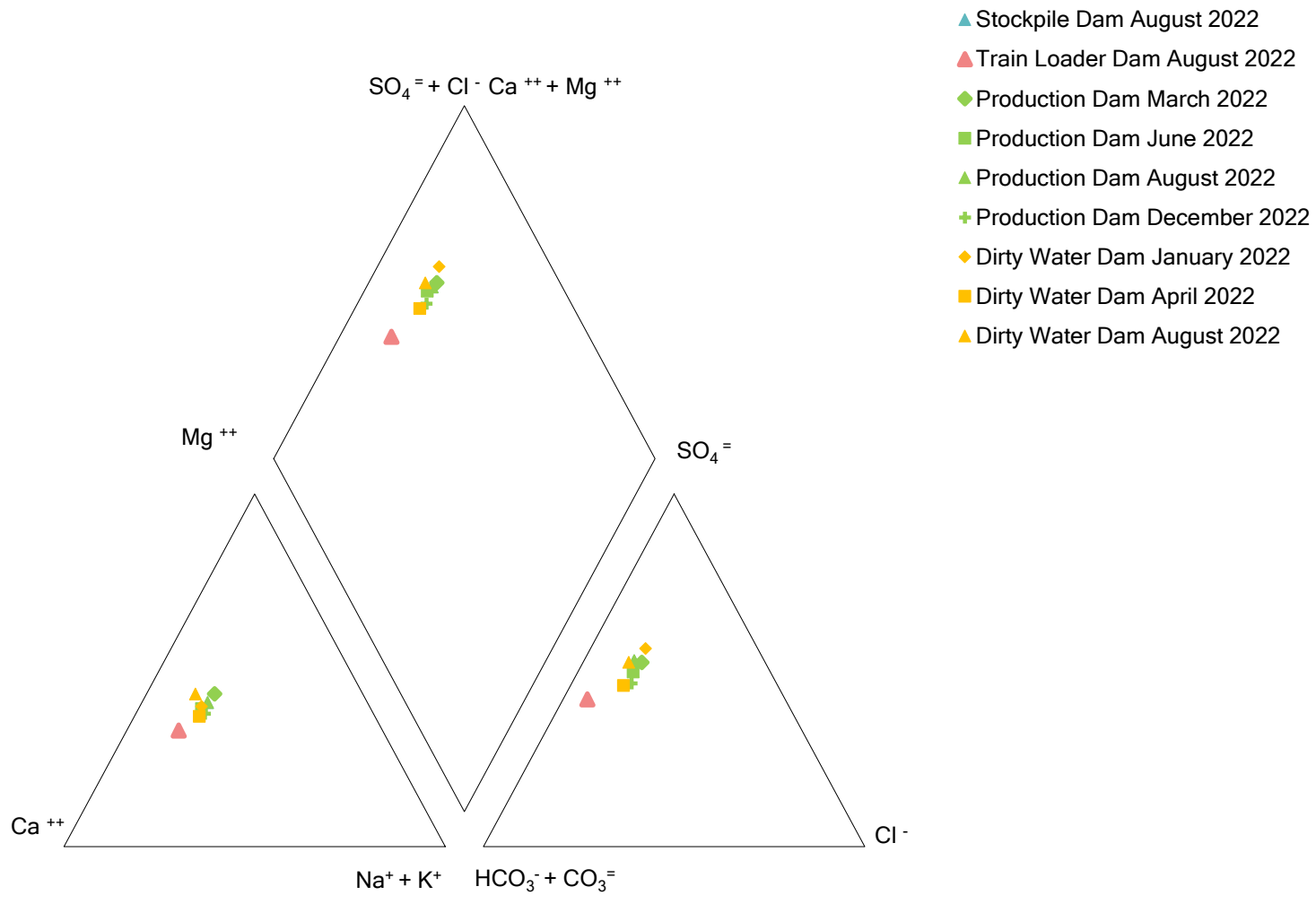






Other





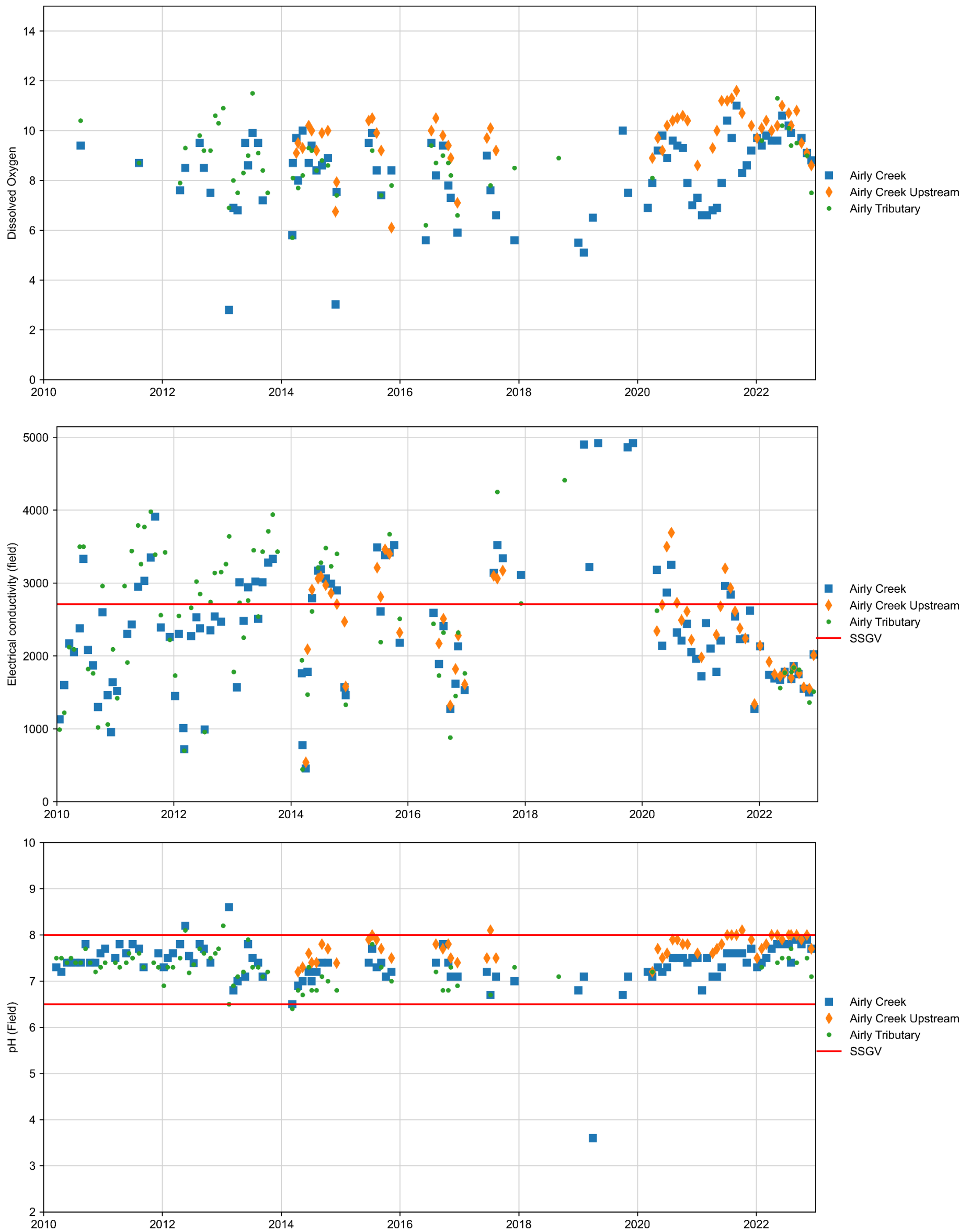
Appendix E – Surface Water - Catchments

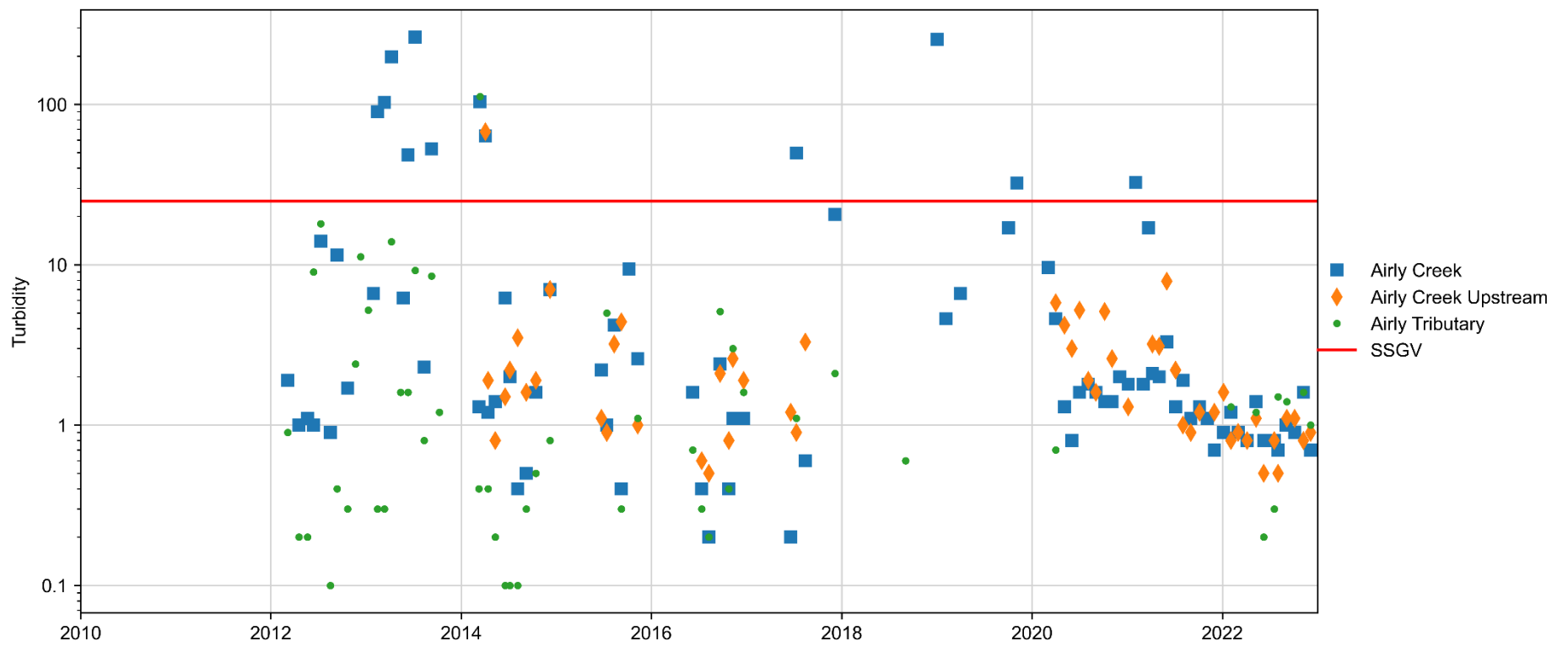
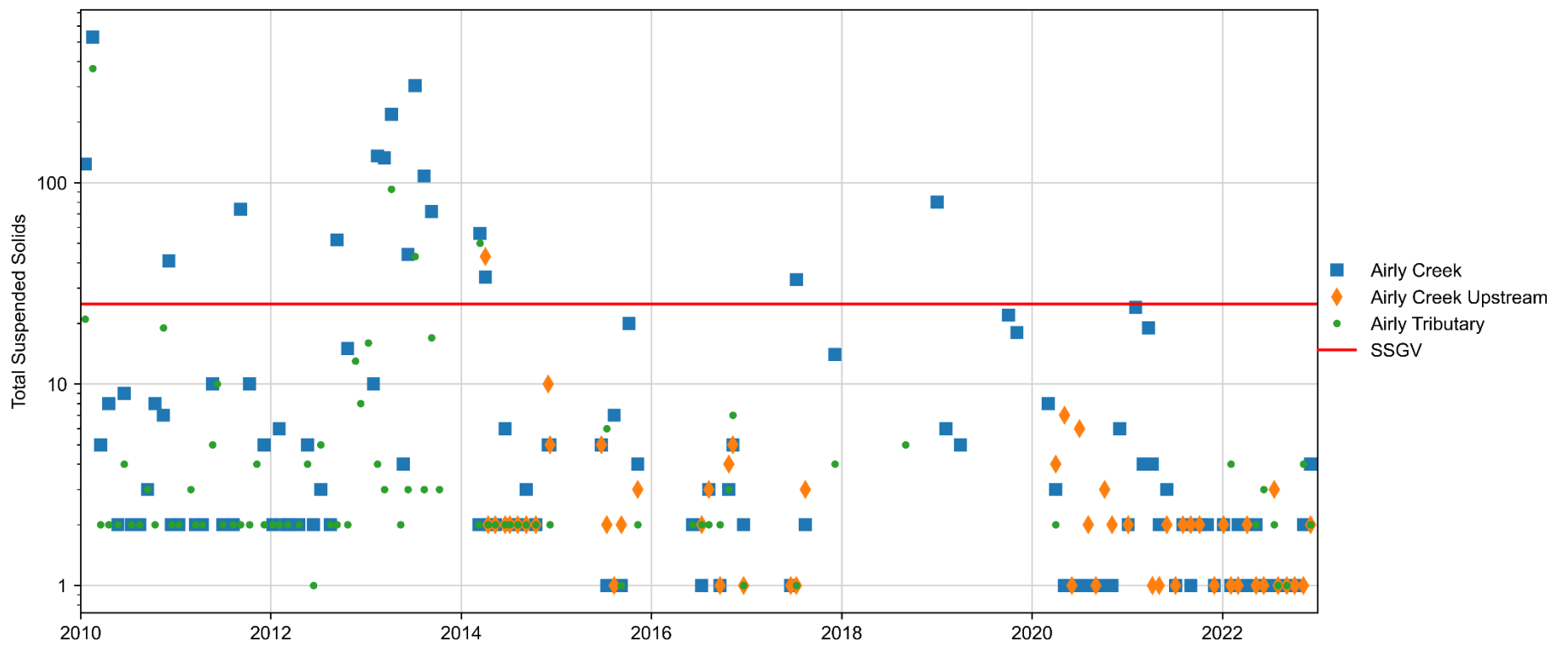
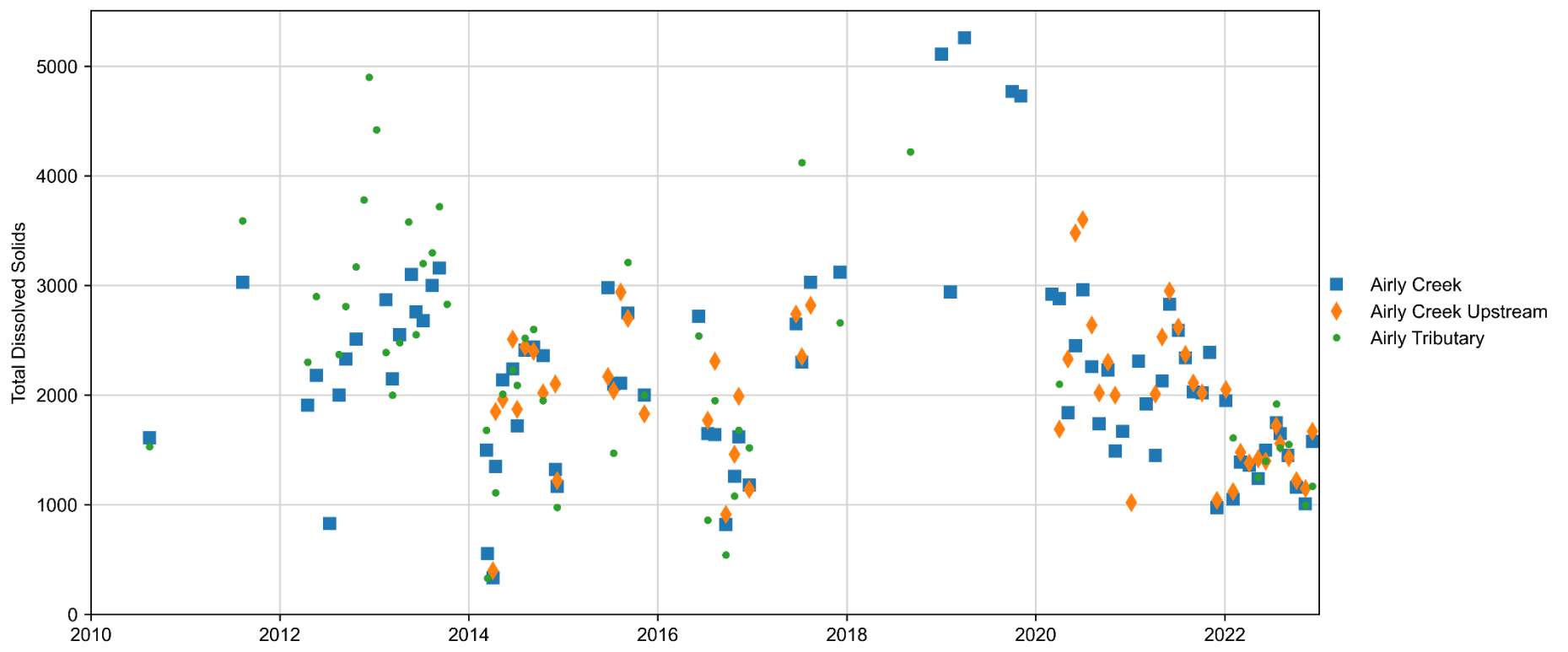
E.1 Airly Creek– statistical summary of water quality results

Parameters	Units	Airly Creek				Airly Creek Upstream				Airly Tributary			
		Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max
Physiochemical Parameters													
Dissolved Oxygen (Field)	mg/L	19	7.6	9.6	11	17	8.6	10.2	11.6	16	7.5	9.5	11.3
Electrical conductivity (field)	µS/cm	111	455	2320	4920	53	540	2340	3690	97	443	2470	4410
pH (Field)	pH units	103	3.6	7.4	8.6	51	7.2	7.8	8.1	93	6.4	7.3	8.2
Total Dissolved Solids	mg/L	85	334	2130	5260	54	399	2015	3600	71	332	2080	4900
Total Suspended Solids	mg/L	114	1	3	528	54	1	2	43	98	1	2	370
Turbidity	NTU	88	0.2	1.75	262	53	0.5	1.6	67.4	72	0.1	0.65	112
Nutrients													
Ammonia as N	mg/L	87	0.01	0.01	1.06	54	0.01	0.01	0.2	73	0.01	0.01	0.09
Nitrate as N	mg/L	87	0.01	0.01	1.87	54	0.01	0.01	0.31	73	0.01	0.01	0.52
Nitrite as N	mg/L	87	0.01	0.01	0.01	54	0.01	0.01	0.03	73	0.01	0.01	0.01
Nitrogen (Total oxidized as N)	mg/L	87	0.01	0.01	1.87	54	0.01	0.01	0.34	73	0.01	0.01	0.52
Nitrogen (Total)	mg/L	87	0.1	0.5	8.4	54	0.1	0.4	1.9	73	0.1	0.4	1.7
Kjeldahl Nitrogen Total	Mg/L	87	0.1	0.5	8.4	54	0.1	0.4	1.6	73	0.1	0.4	1.6
Phosphorus (Total)	mg/L	86	0.01	0.015	1.18	54	0.01	0.01	0.27	73	0.01	0.02	0.34
Major Ions													
Alkalinity (Carbonate as CaCO3)	mg/L	88	1	1	2	54	1	1	1	73	1	1	2
Alkalinity (Bicarbonate as CaCO3)	mg/L	88	1	143.5	422	54	14	155	260	73	10	98	291
Alkalinity (Hydroxide as CaCO3)	mg/L	88	1	1	2	54	1	1	1	73	1	1	2
Alkalinity (total as CaCO3)	mg/L	88	1	143.5	422	54	14	155	260	73	10	98	291
Calcium (Filtered)	mg/L	88	33	224	471	54	40	219.5	383	73	31	233	512
Magnesium (Filtered)	mg/L	88	29	209	478	54	34	191	328	73	27	196	504
Potassium (Filtered)	mg/L	88	2	5	16	54	2	5	11	73	1	6	17
Sodium (Filtered)	mg/L	88	13	75	247	54	15	65	109	73	14	86	243
Sulfate (Filtered)	mg/L	46	544	1180	3570	33	581	1110	2300	32	482	912.5	2850
Metals (Dissolved)													
Aluminium	mg/L	88	0.01	0.01	0.93	54	0.01	0.01	0.1	74	0.01	0.01	0.1
Arsenic	mg/L	50	0.0006	0.001	0.03	25	0.001	0.001	0.002	74	0.001	0.001	0.003
Cadmium	mg/L	86	0.00005	0.0001	0.0003	54	0.00005	0.00005	0.0001	74	0.0001	0.0001	0.0003
Cobalt	mg/L	88	0.001	0.001	0.265	54	0.001	0.001	0.004	74	0.001	0.001	0.007
Lead	mg/L	89	0.001	0.001	0.07	54	0.001	0.001	0.001	75	0.001	0.001	0.05
Mercury	mg/L	87	0.0001	0.0001	0.0001	53	0.0001	0.0001	0.0001	74	0.0001	0.0001	0.0001
Nickel	mg/L	88	0.002	0.0065	0.393	54	0.002	0.005	0.017	74	0.002	0.0085	0.043
Silver	mg/L	87	0.0001	0.001	0.007	53	0.0001	0.0001	0.001	74	0.001	0.001	0.006
Zinc	mg/L	63	0.001	0.006	1.32	30	0.001	0.005	0.02	74	0.005	0.008	0.052
Barium	mg/L	88	0.007	0.0155	0.192	54	0.01	0.014	0.052	74	0.002	0.011	0.051
Boron	mg/L	88	0.05	0.05	0.06	54	0.05	0.05	0.05	74	0.05	0.05	0.09

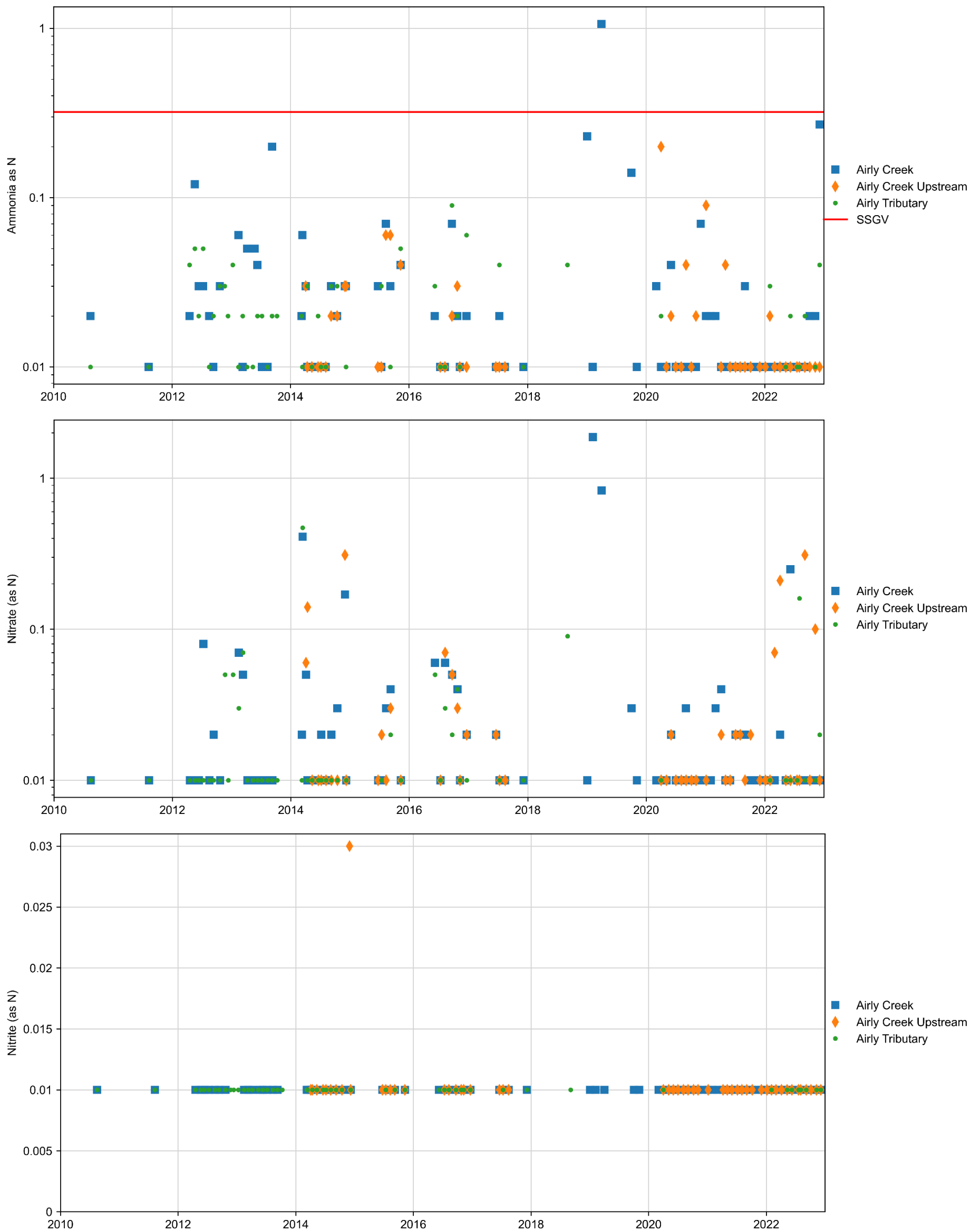
E.2 Chemical time series graphs- Airly Creek

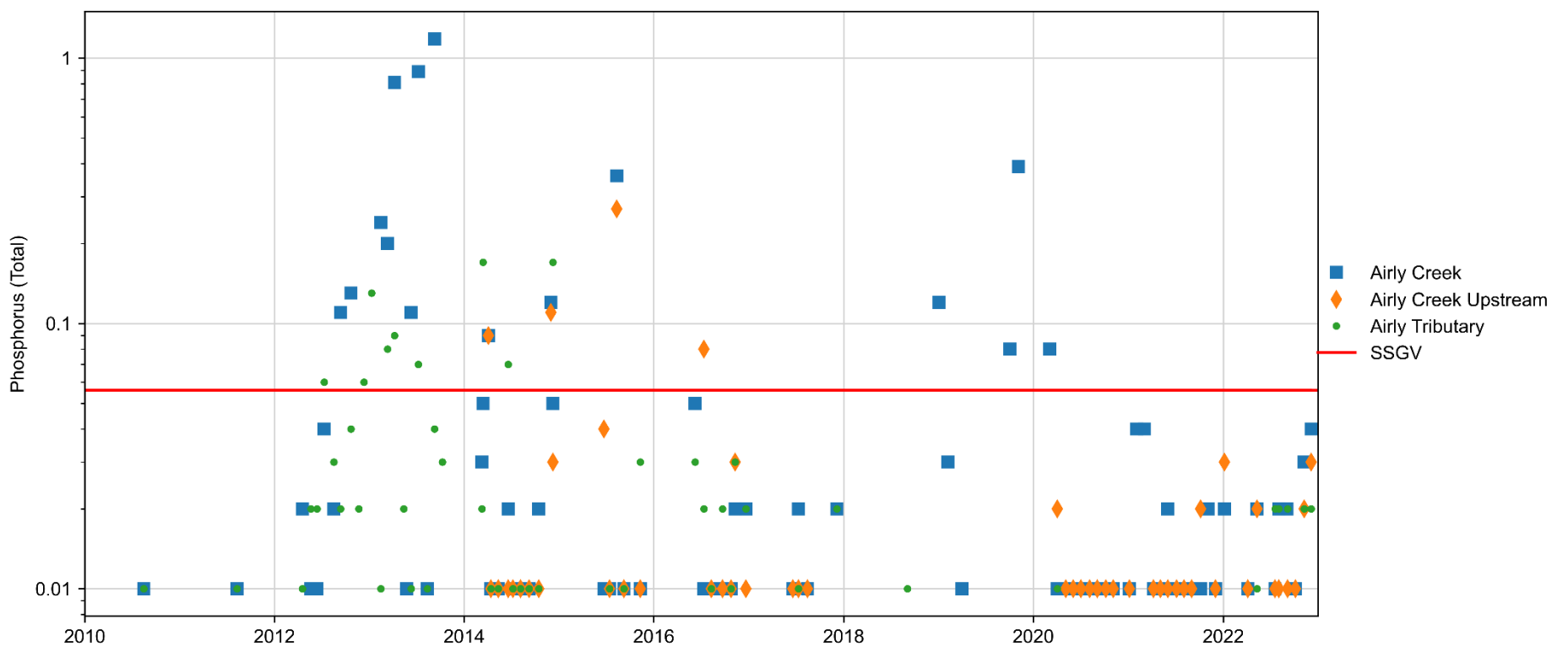
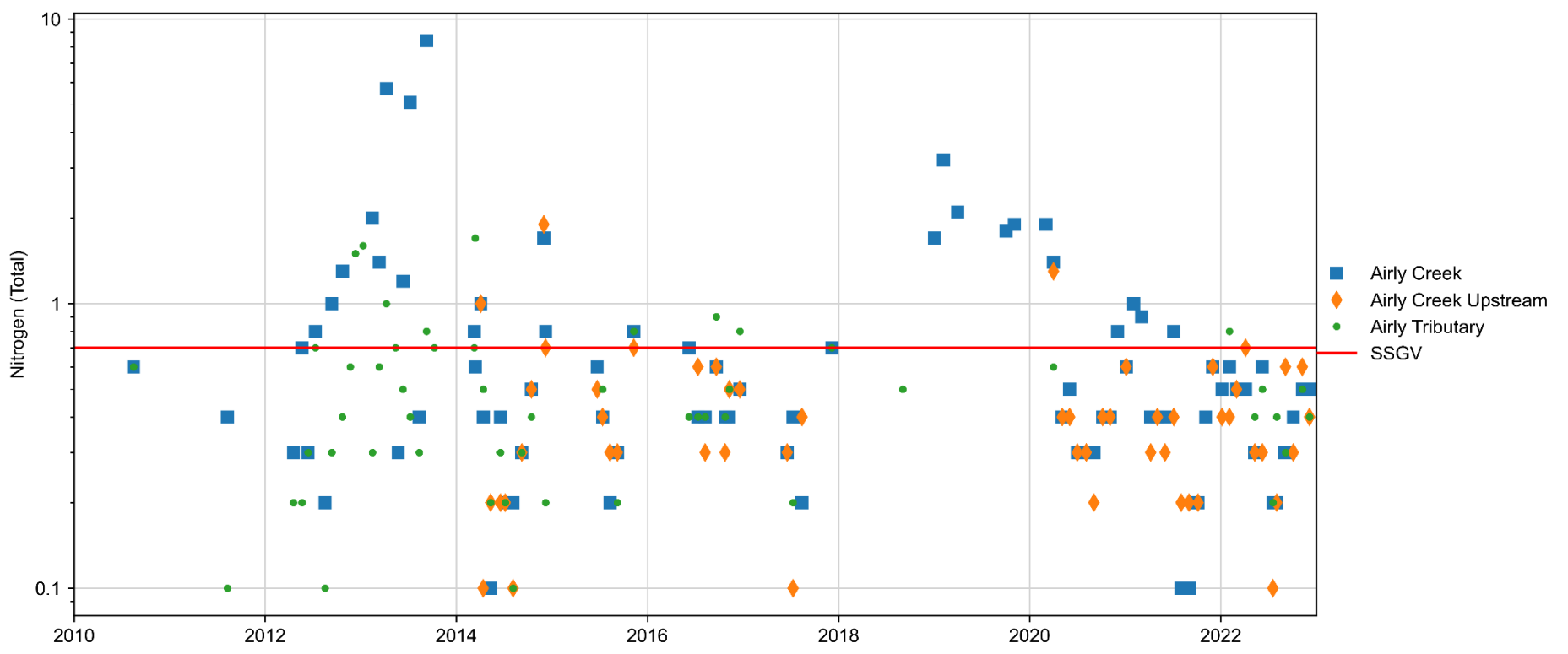
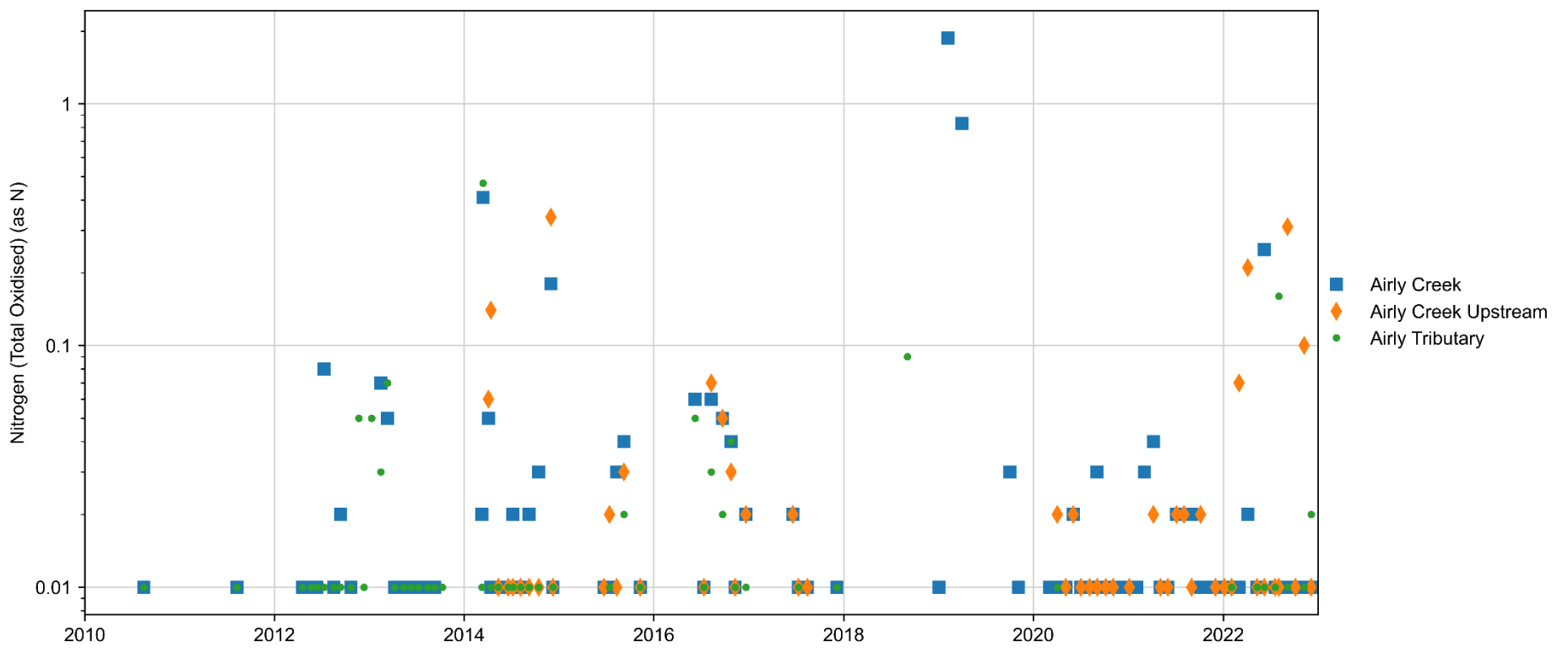
Physicochemical Parameters



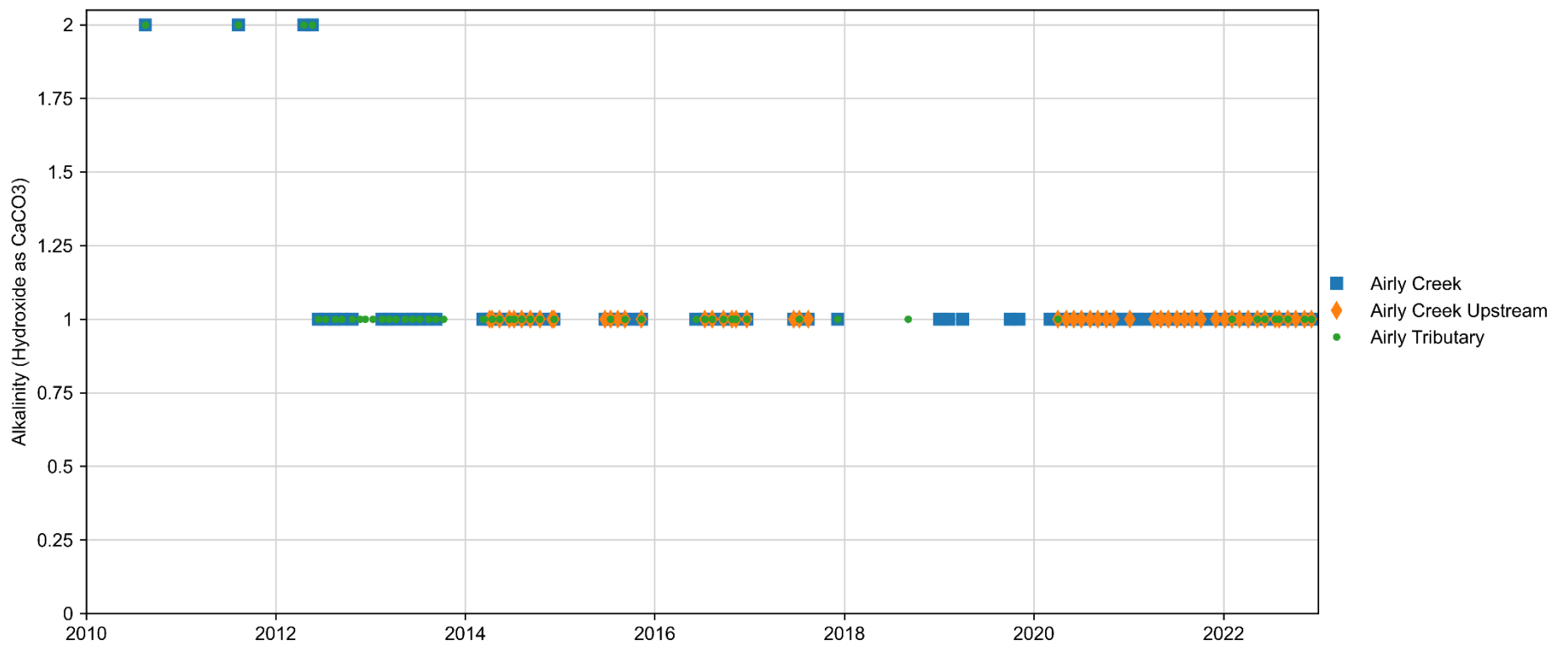
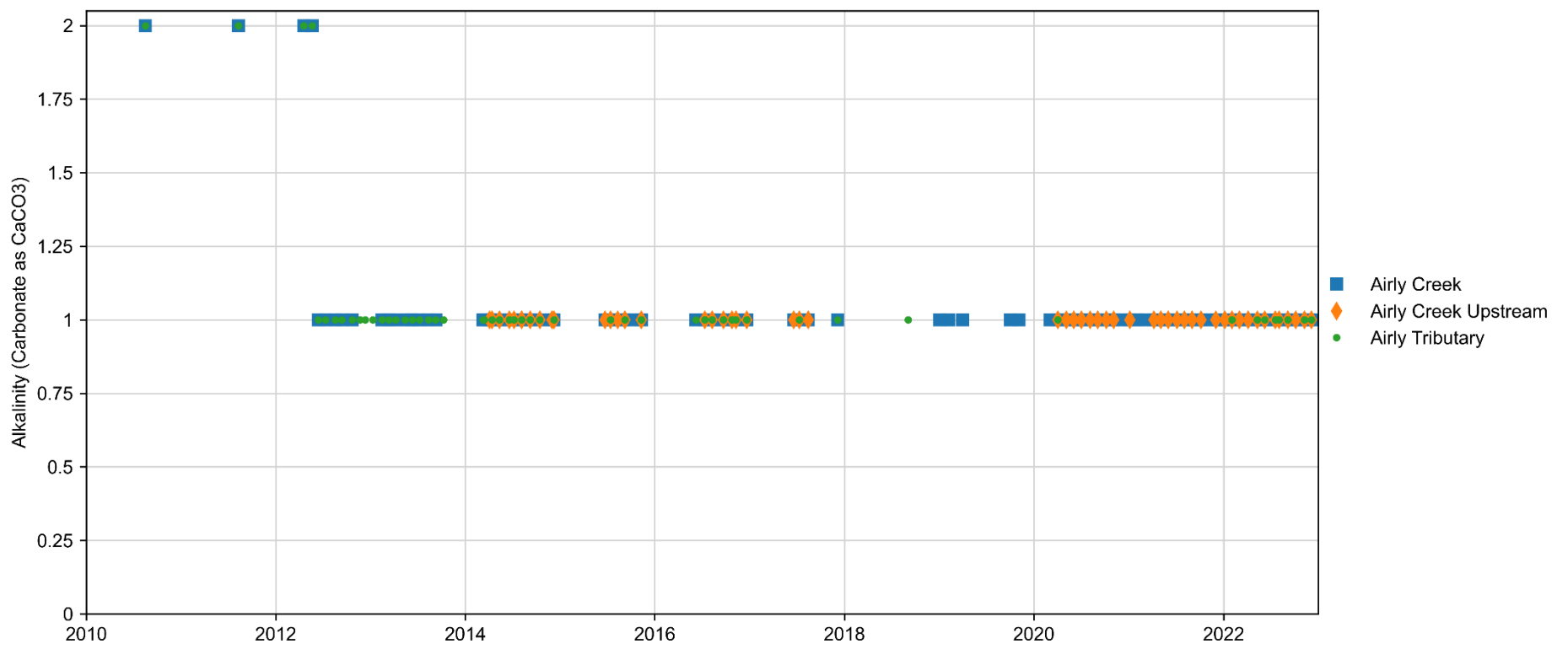
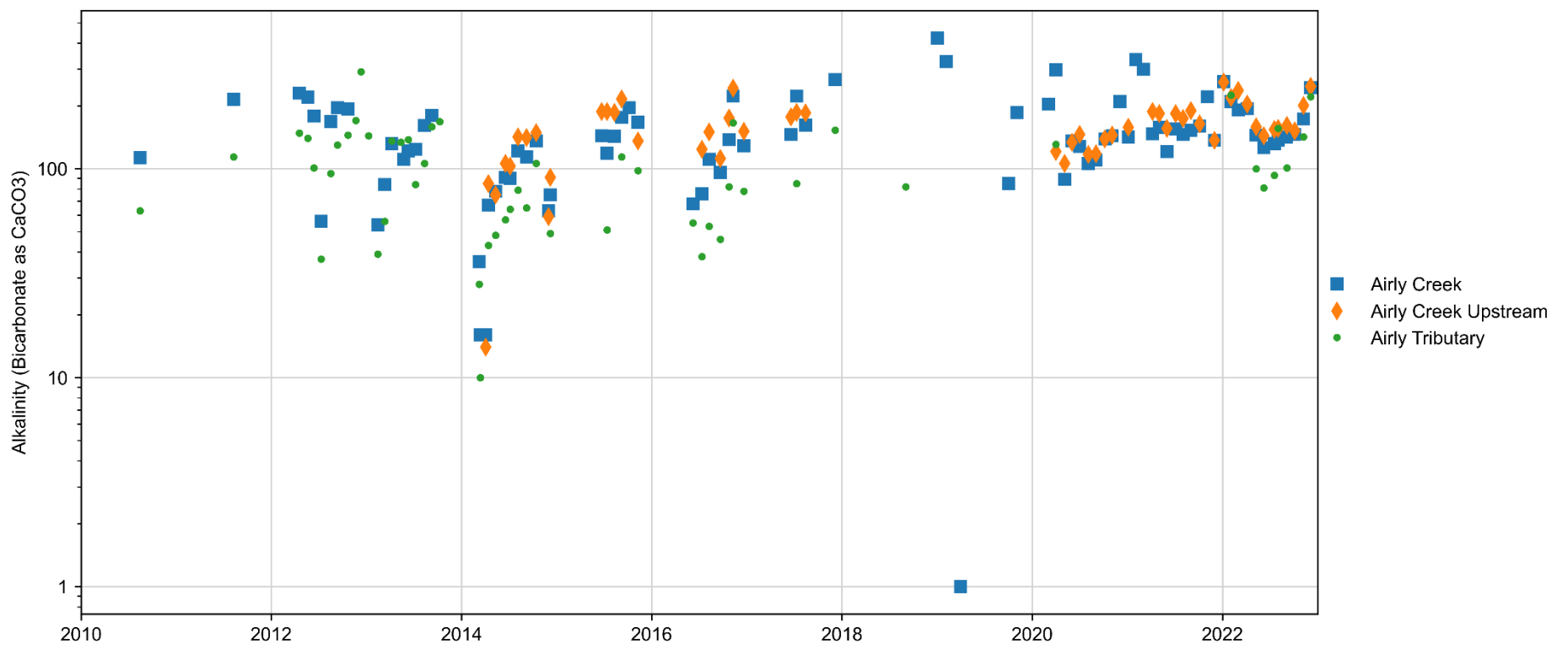


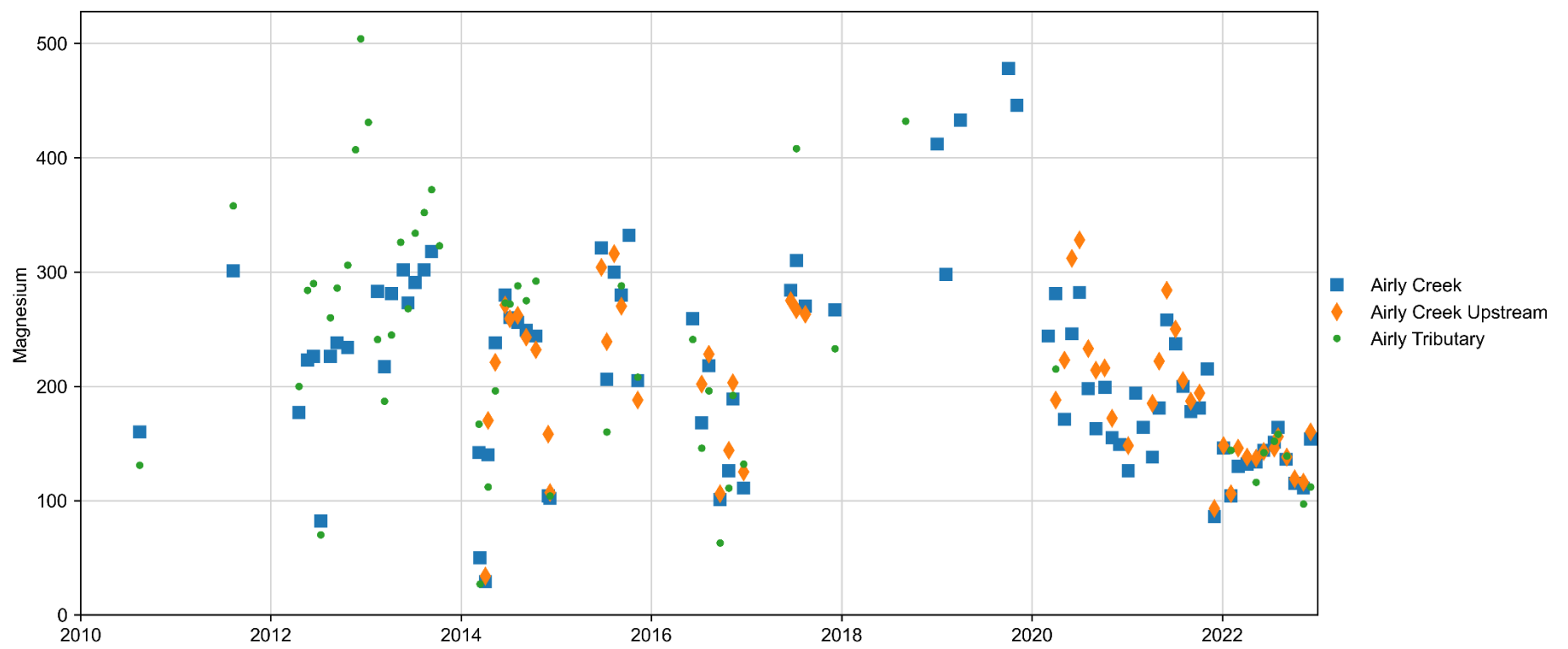
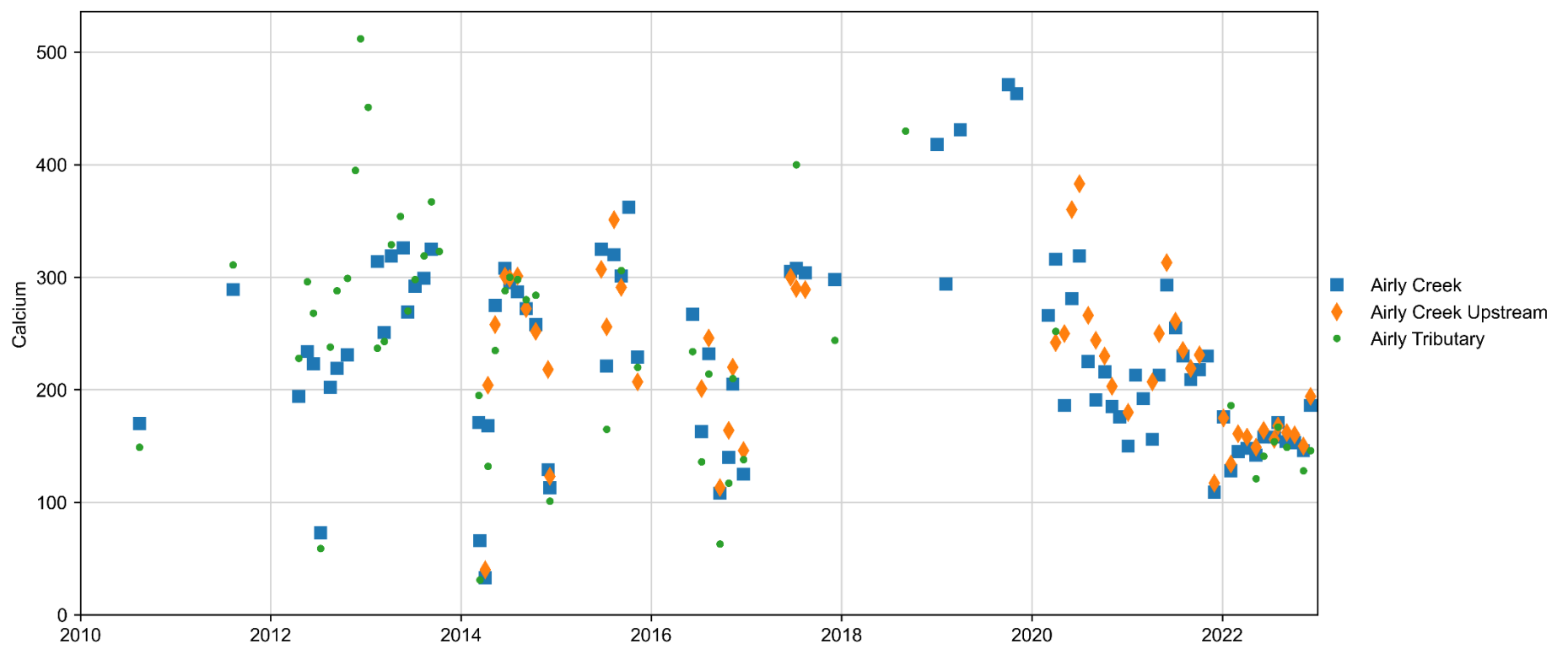
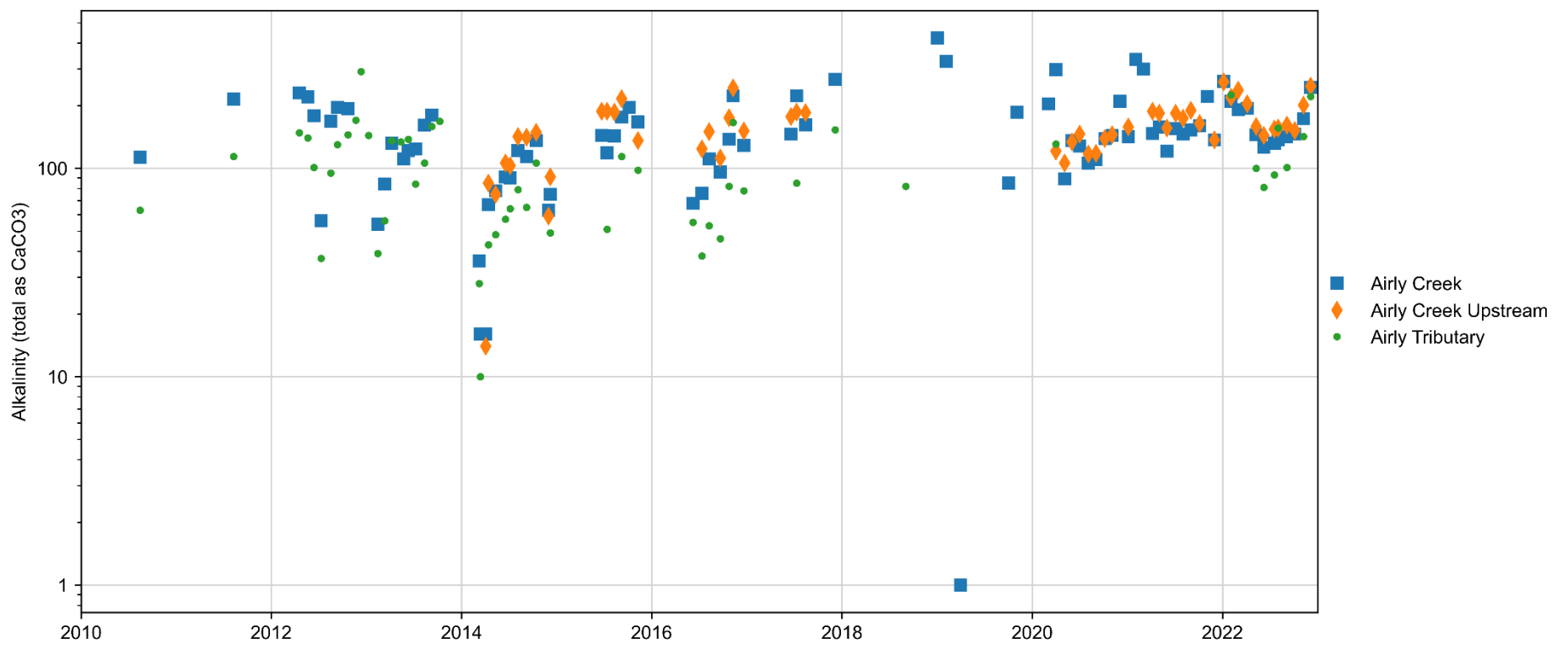
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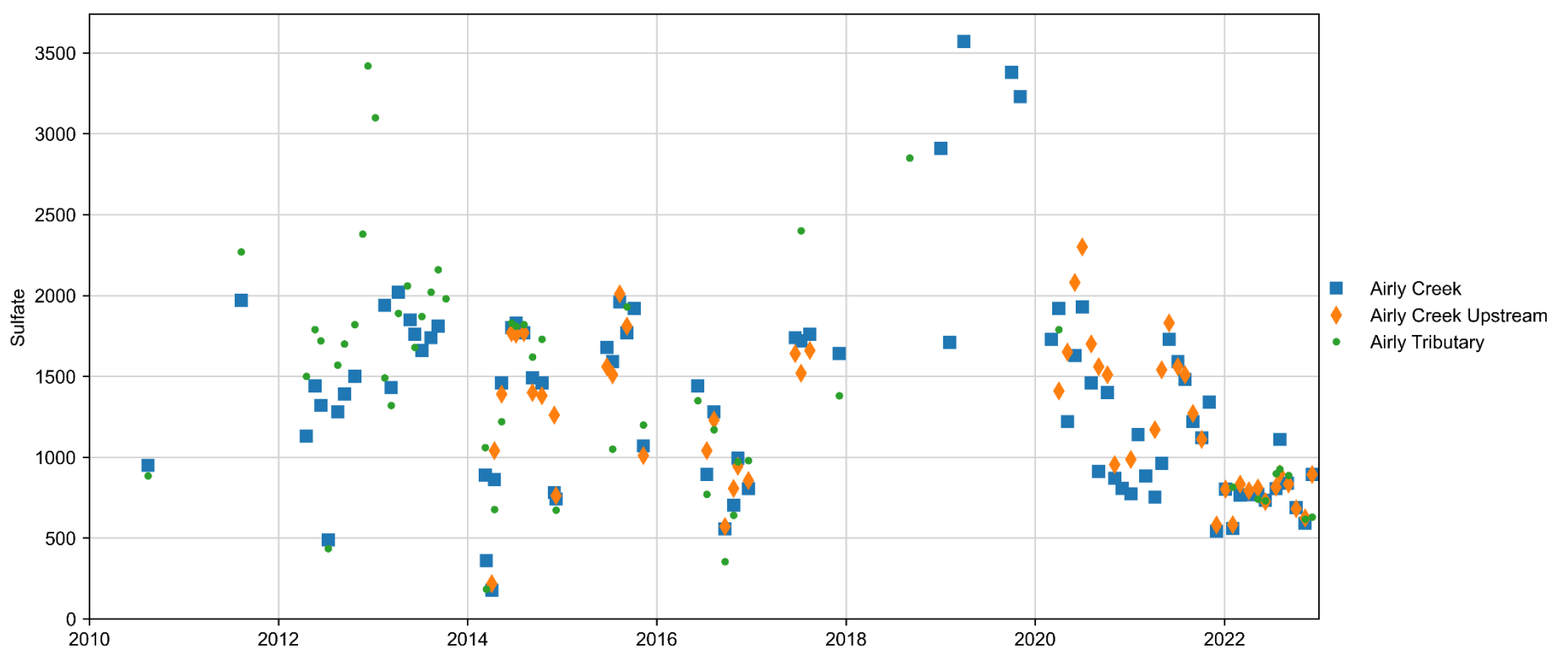
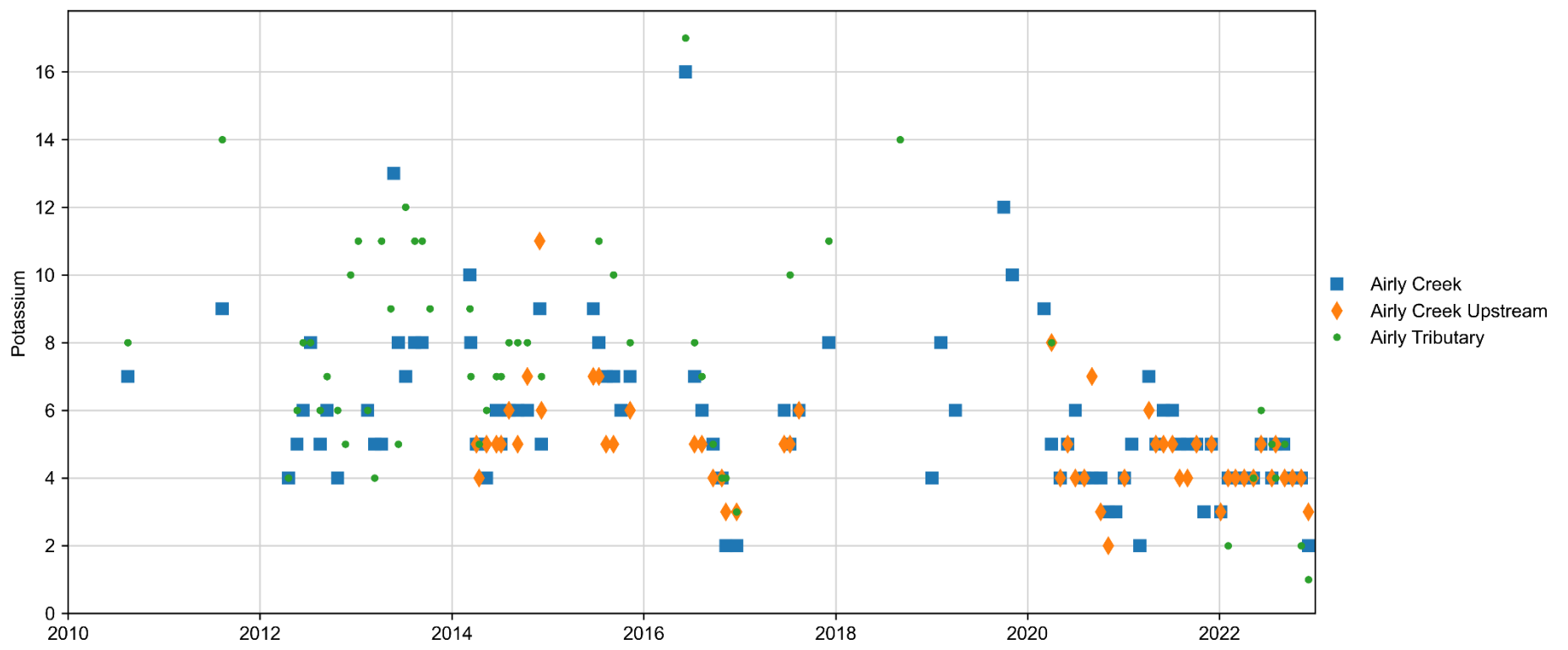




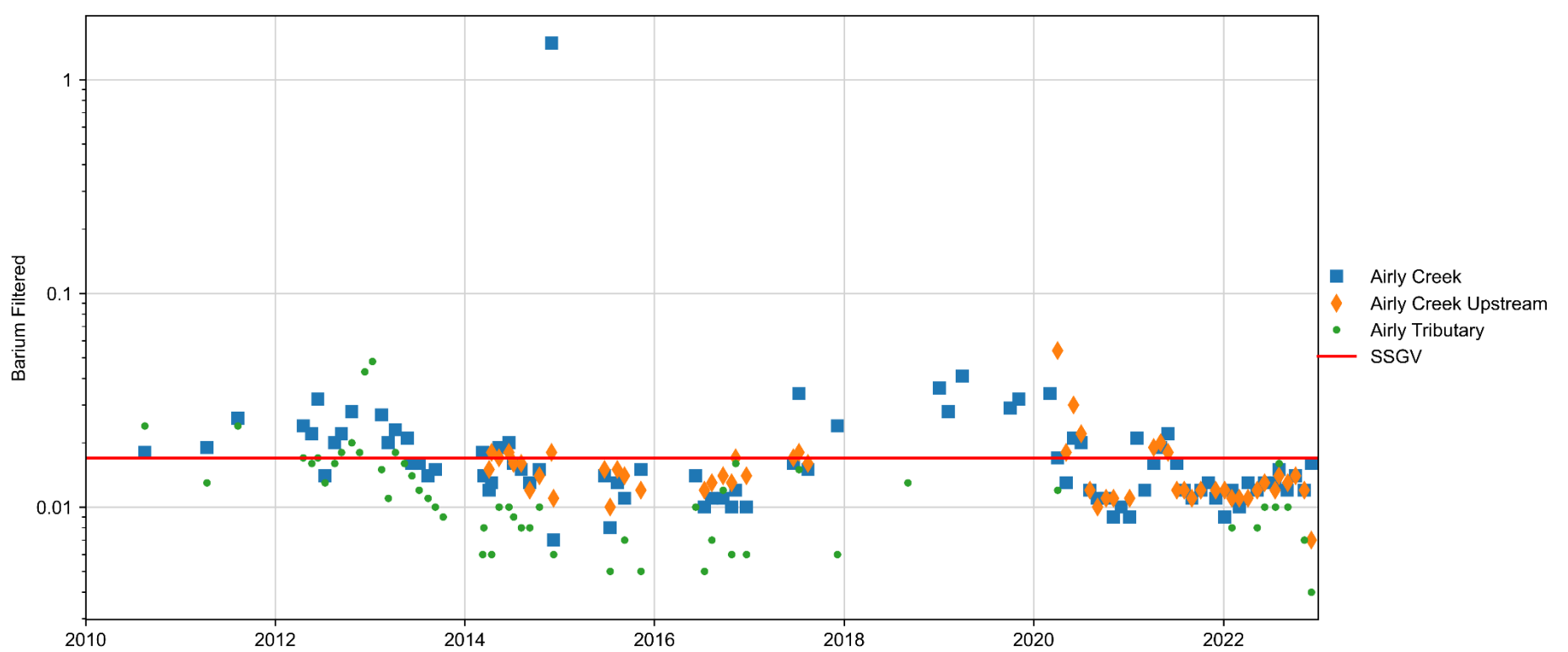
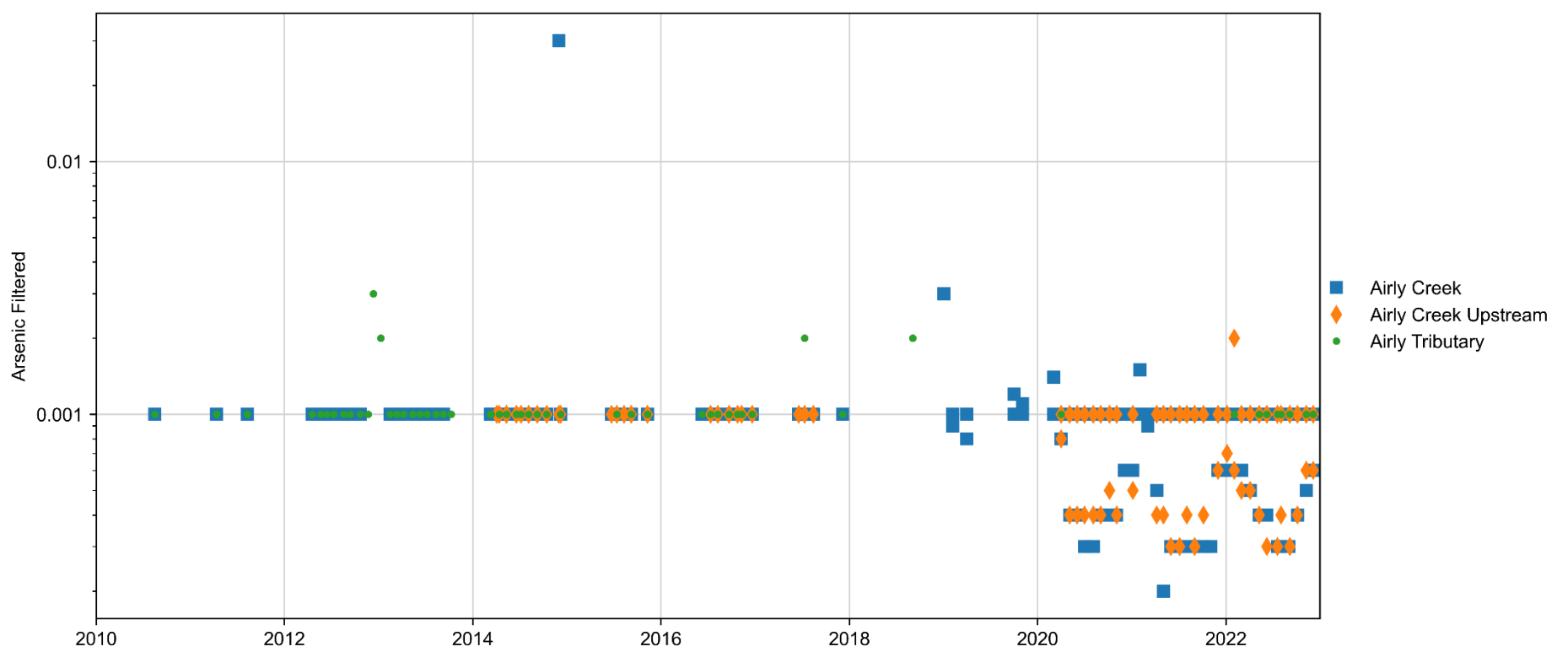
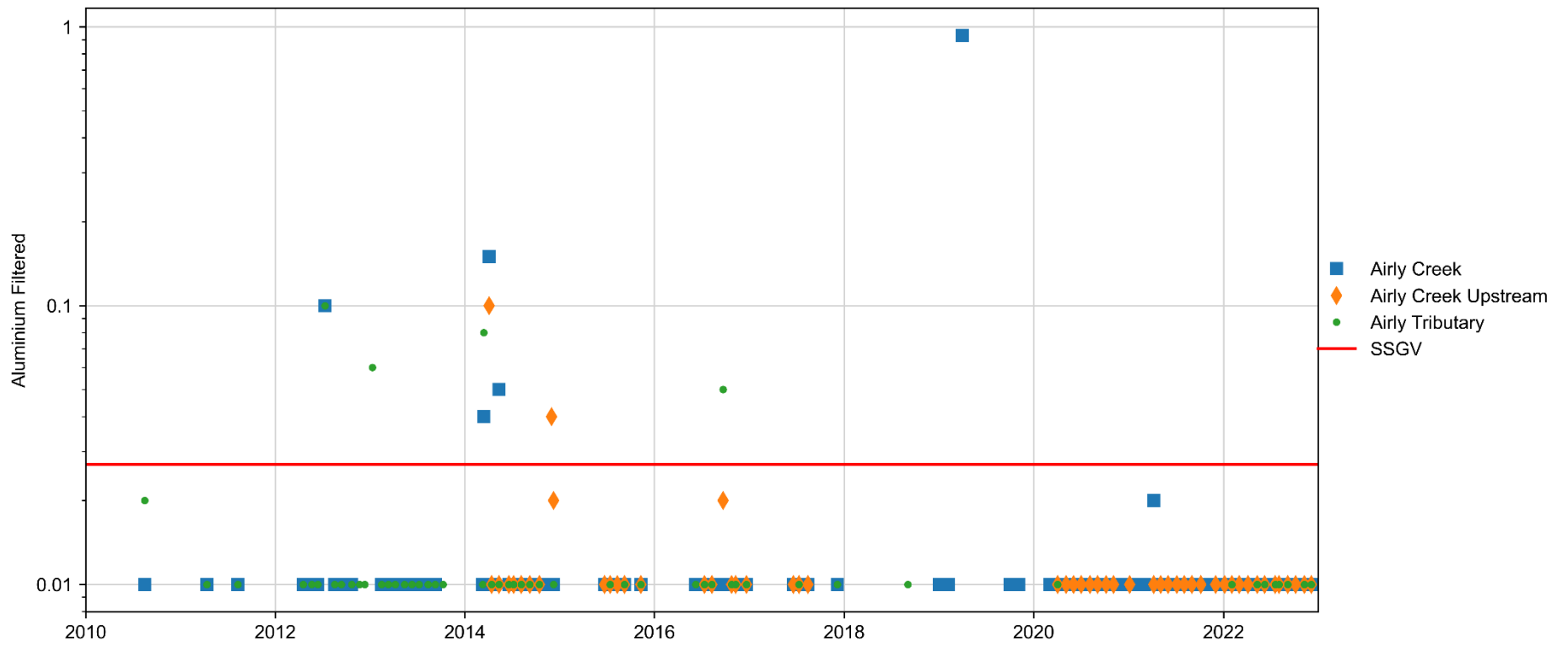
Major Ions

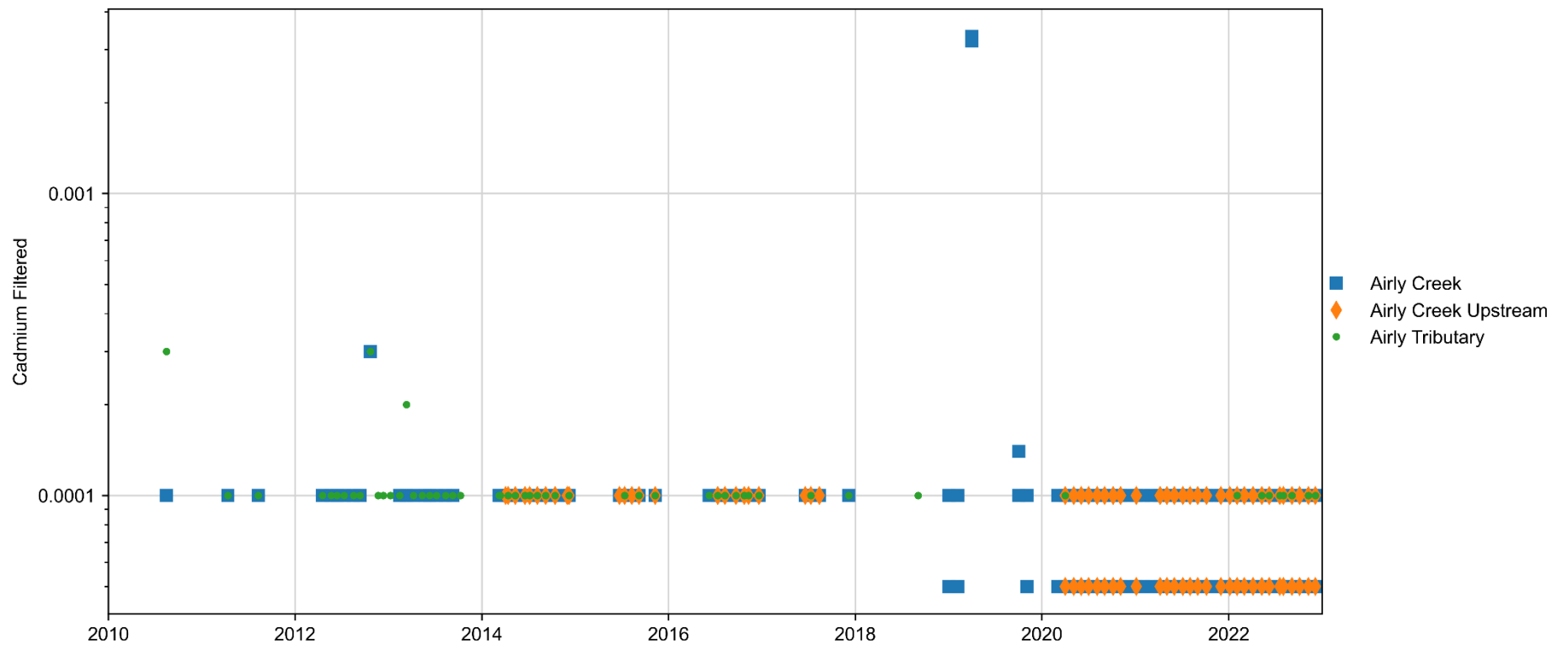
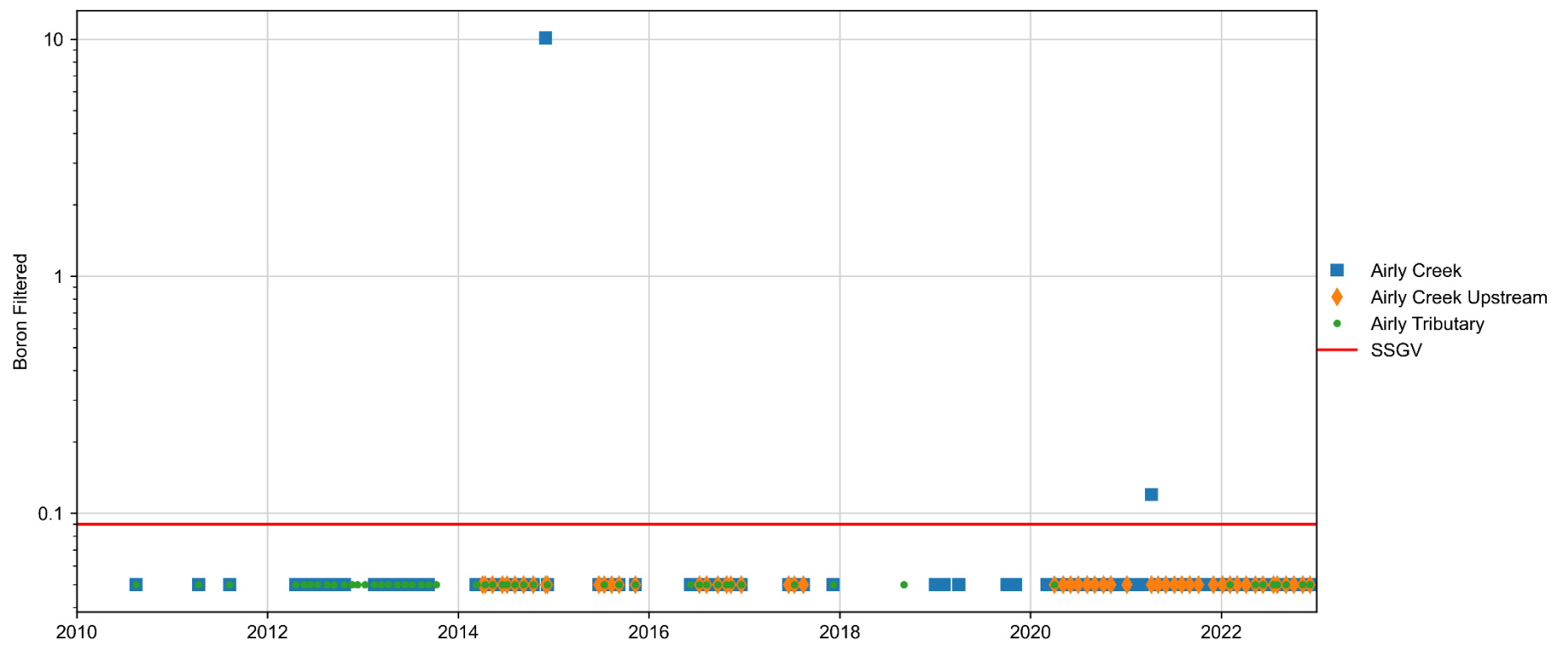


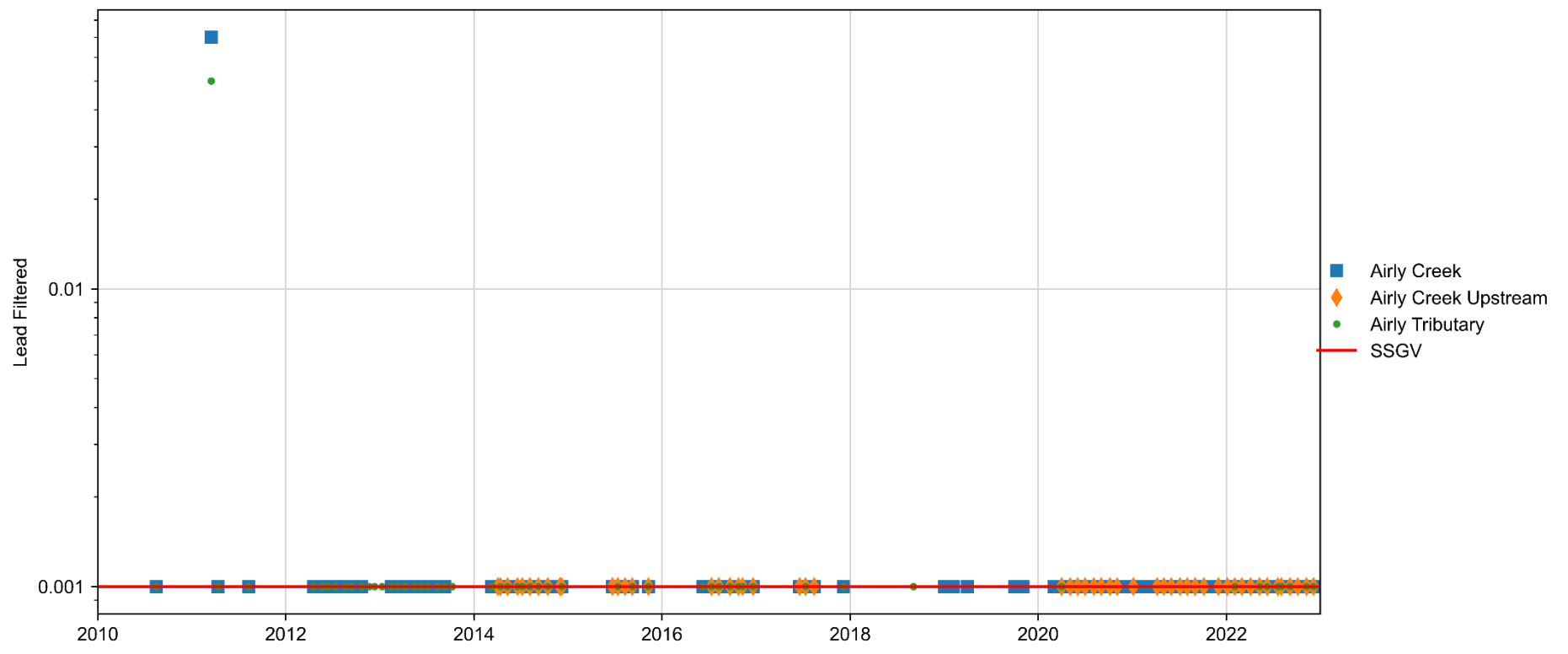
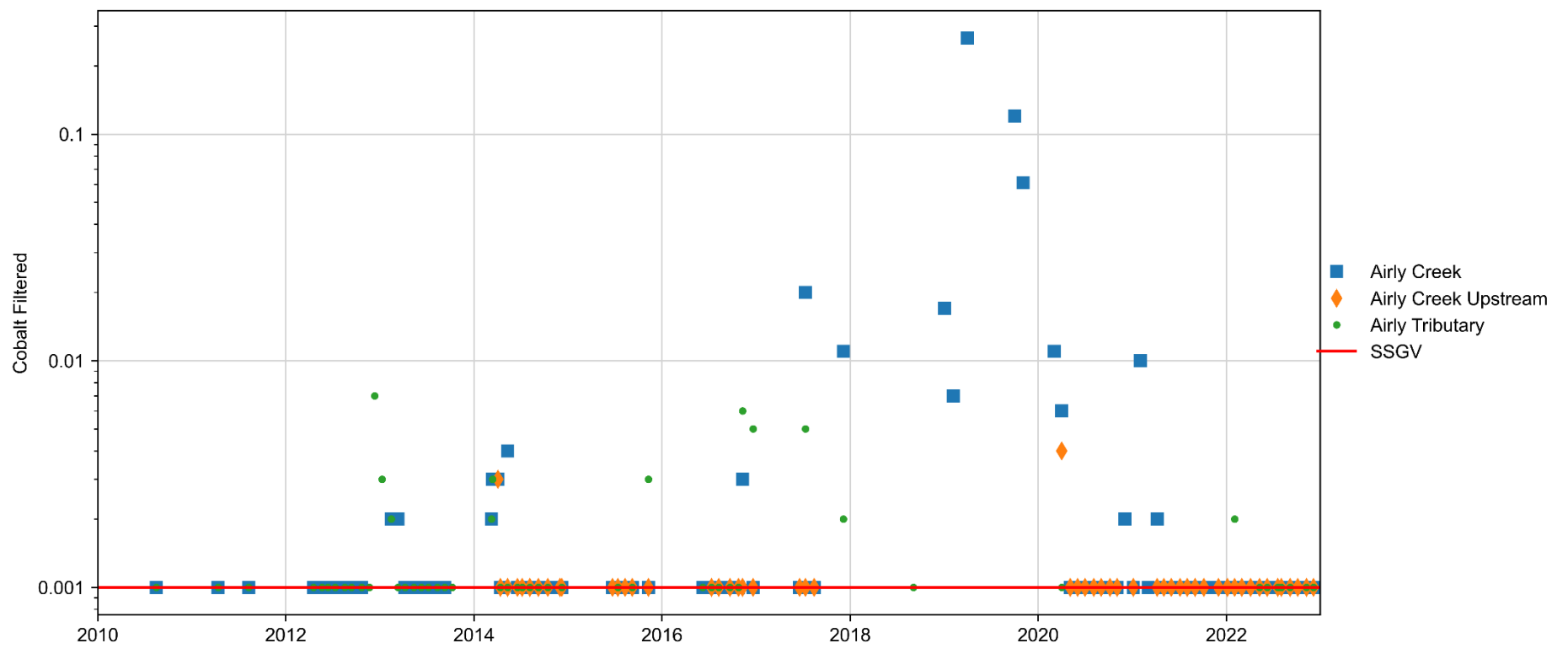


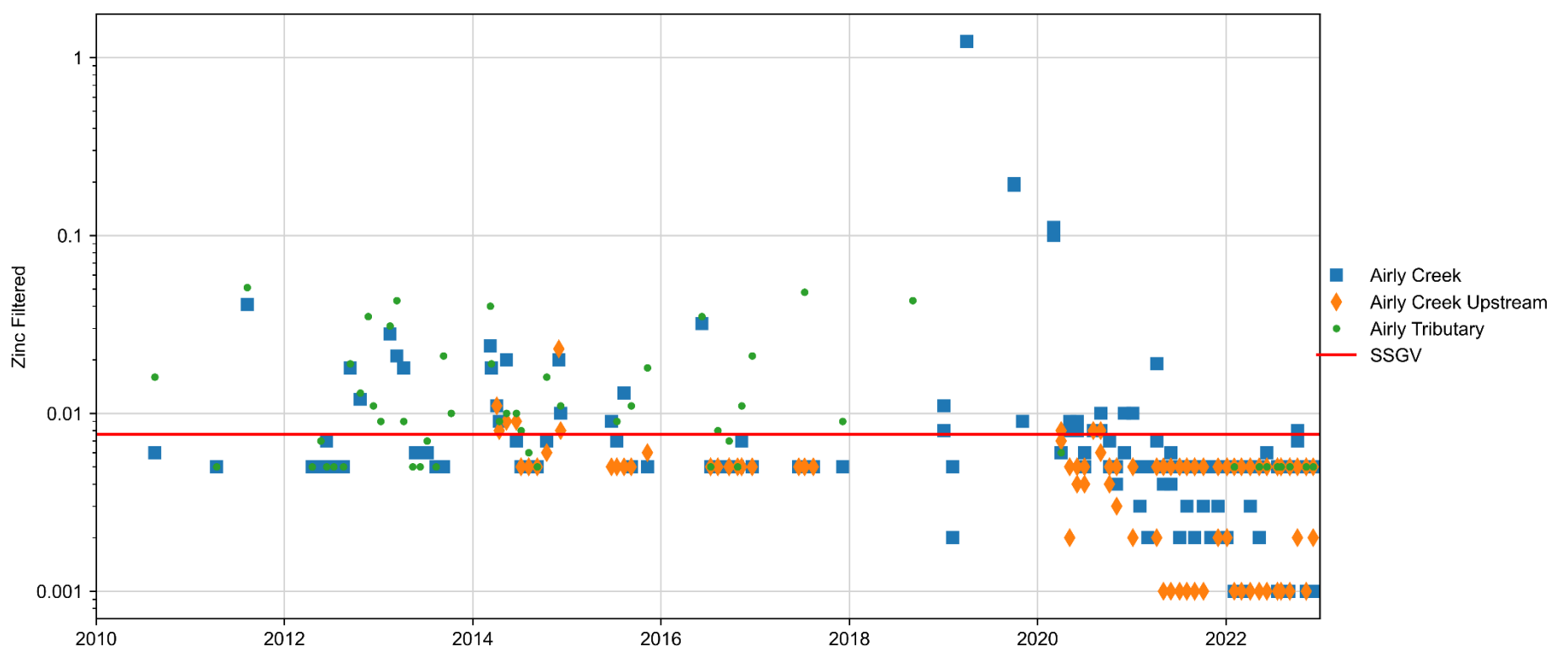
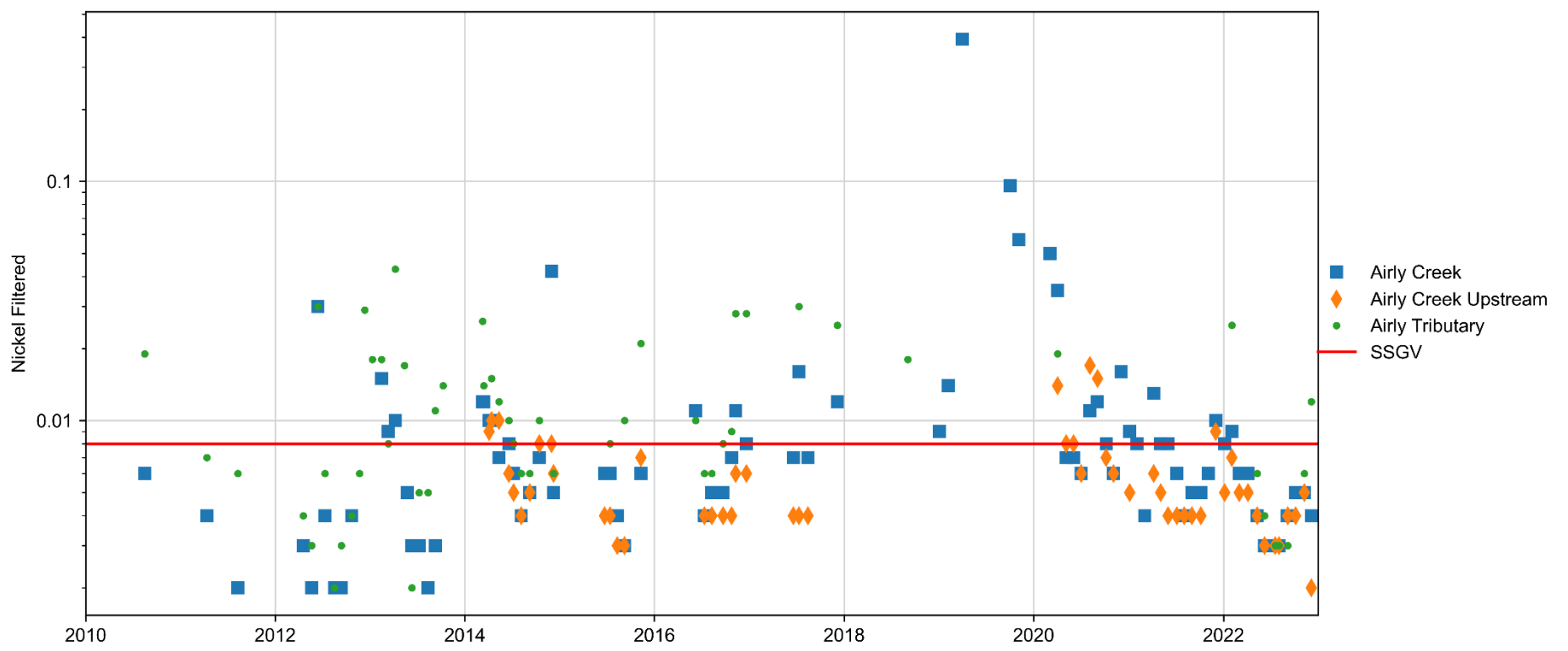
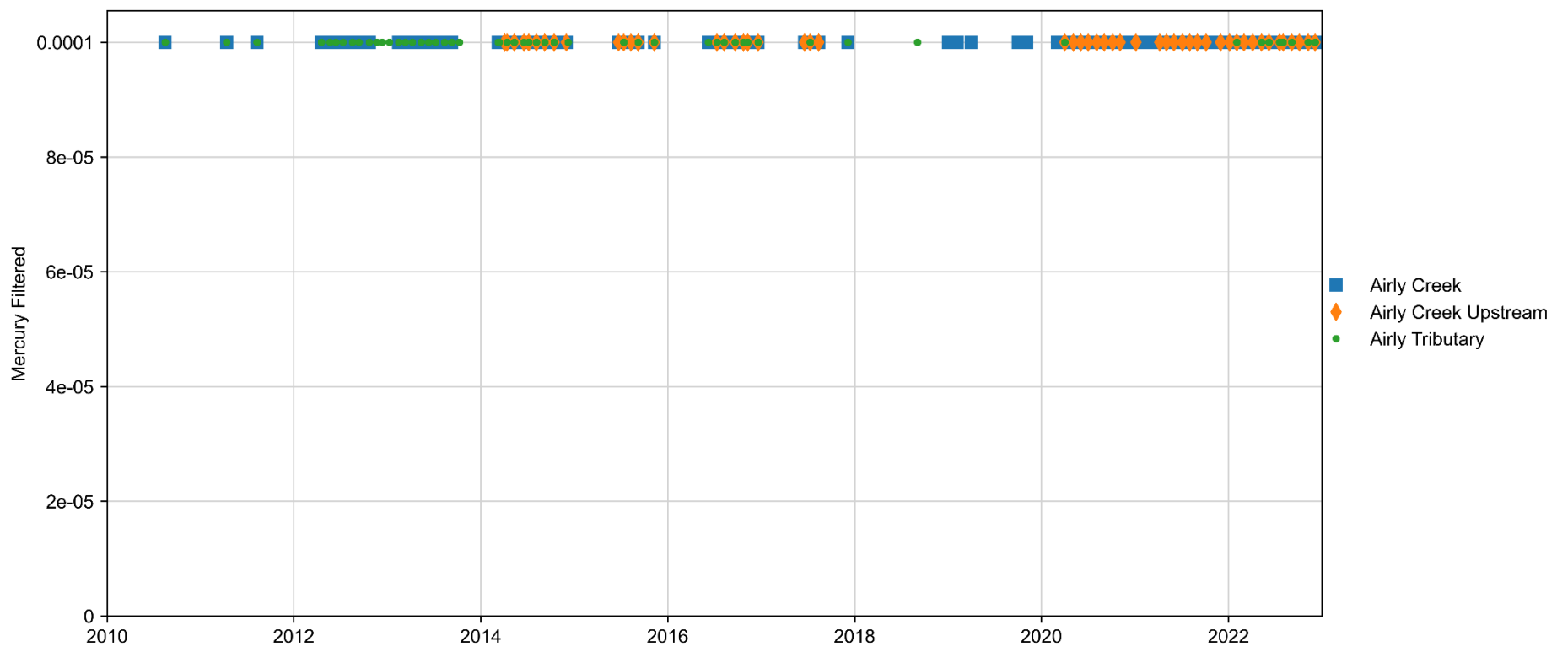


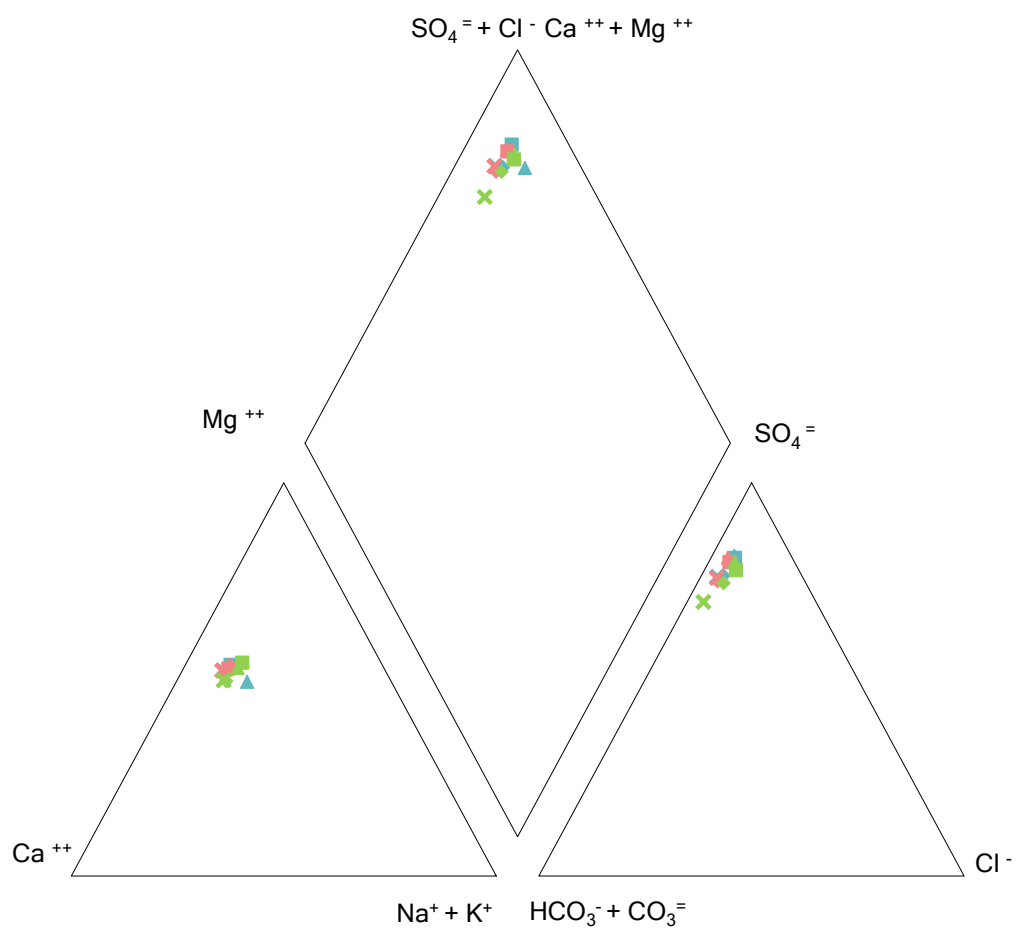
Metals (Dissolved)











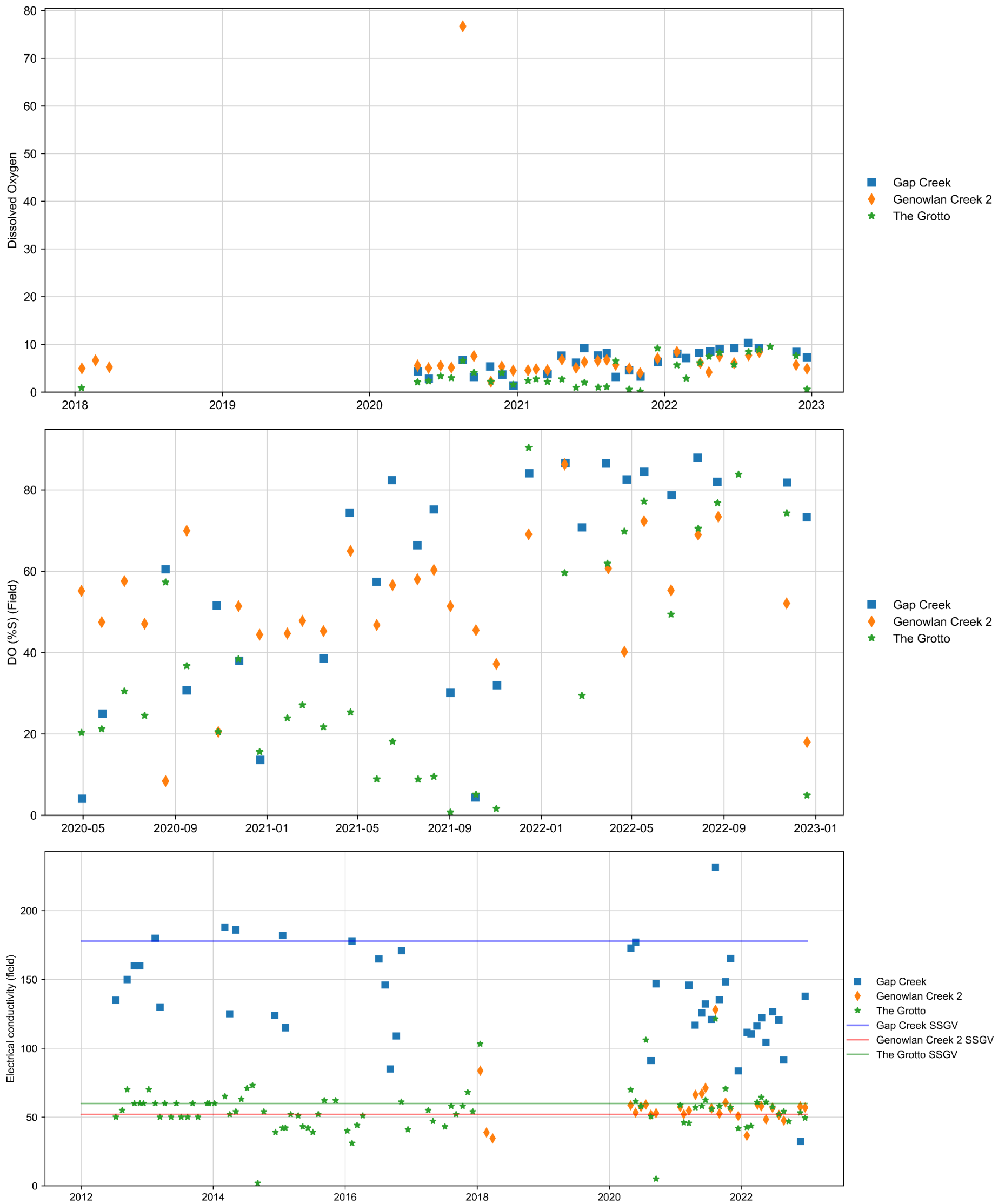
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- ▲ Airly Creek September 2022
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- ▲ Airly US September 2022
- × Airly US December 2022
- ◆ Airly Tributary February 2022
- Airly Tributary June 2022
- ▲ Airly Tributary September 2022
- × Airly Tributary December 2022

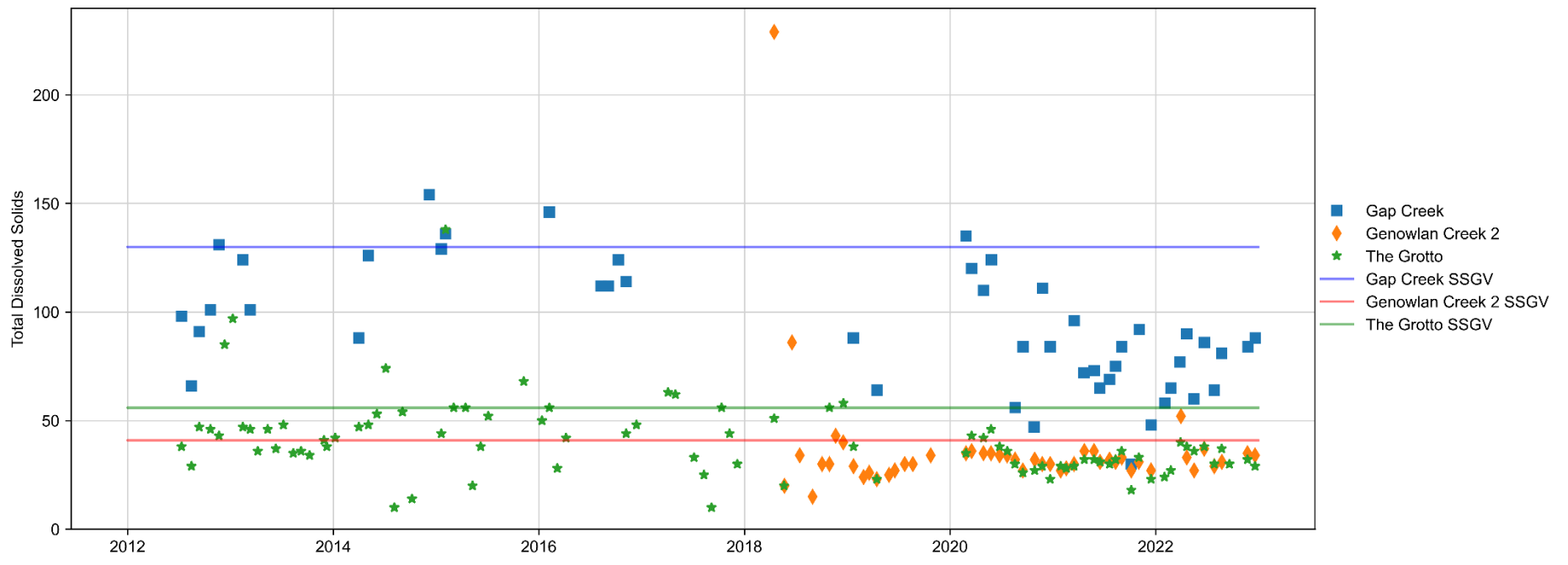
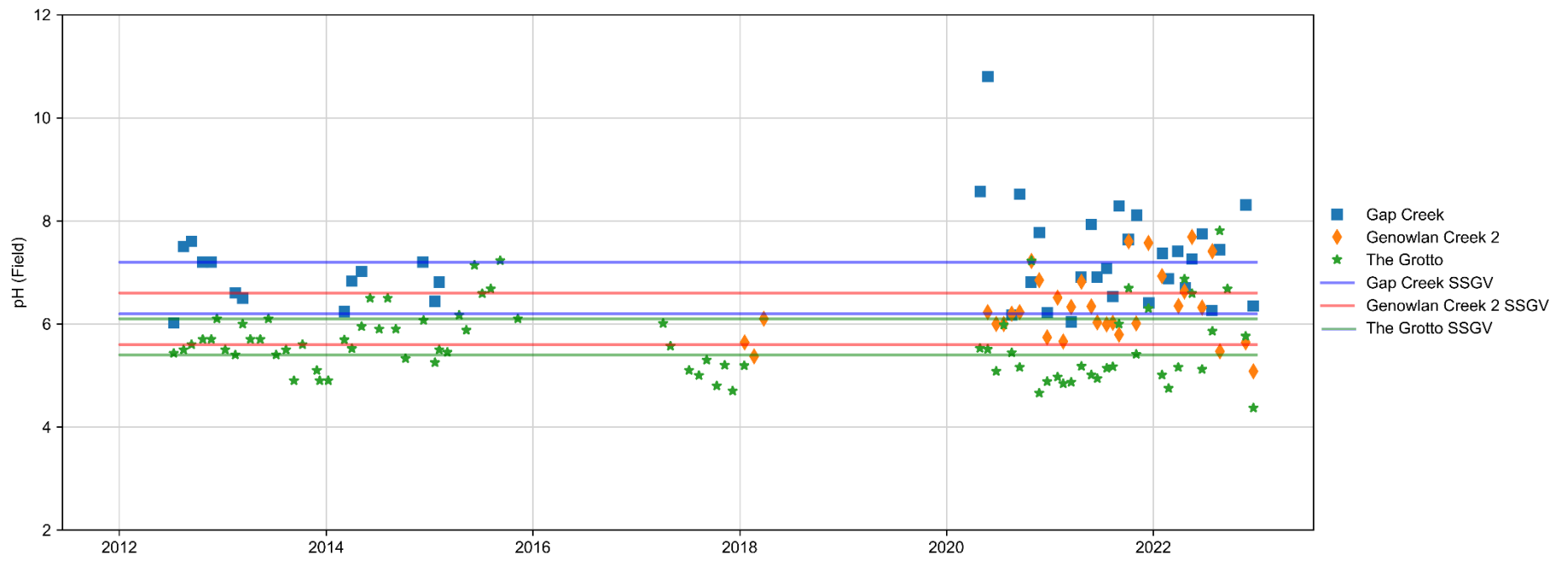
E.3 Genowlan Creek– statistical summary of water quality results

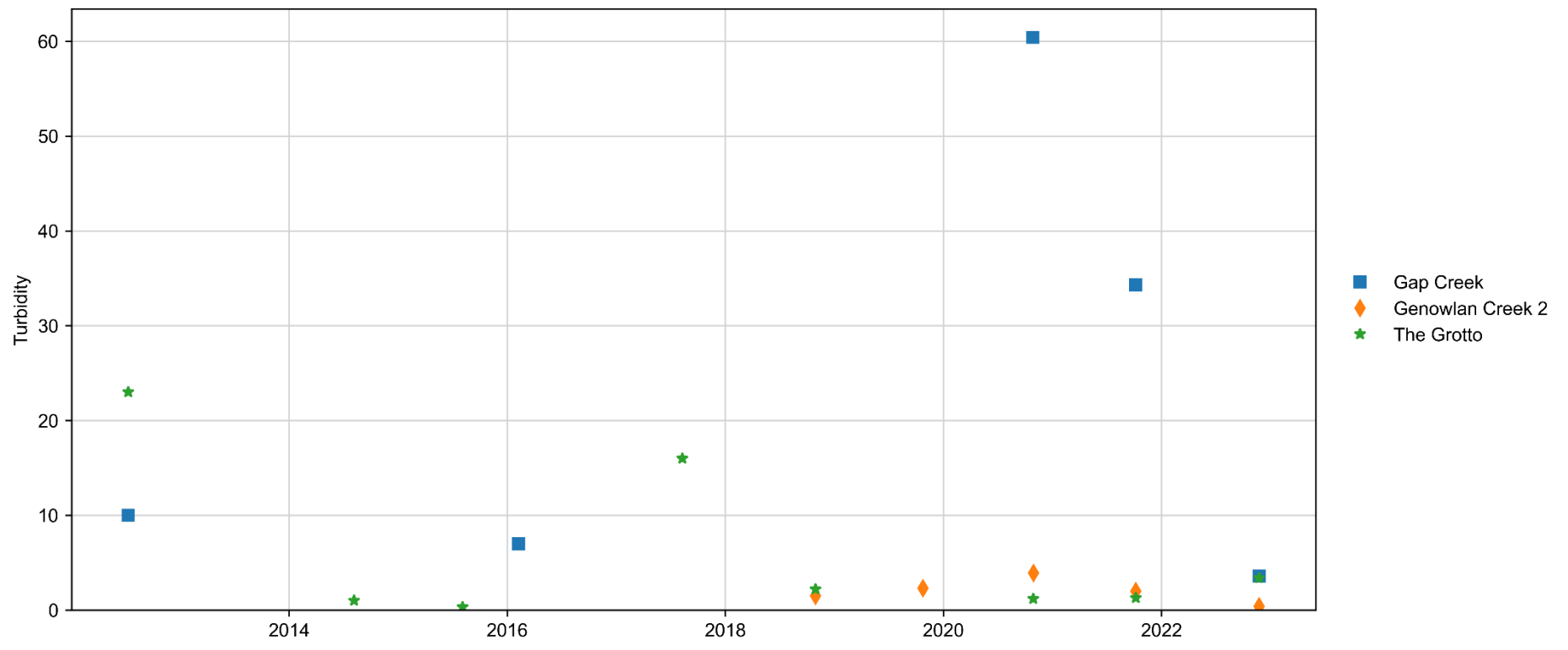
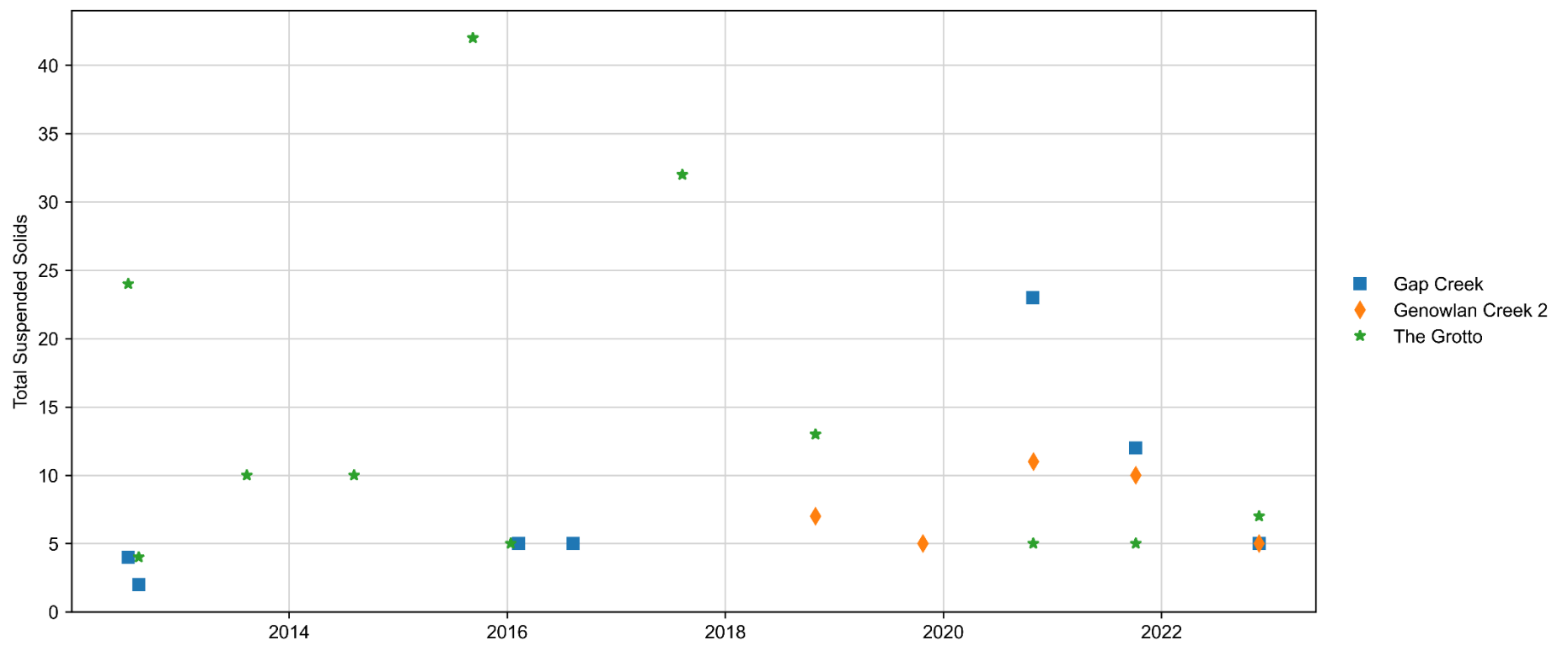
Parameters	Units	Gap Creek				Genowlan Creek 2				The Grotto			
		Count	Min	Median	Max	Count	Min	Median	Max	Count	Min	Median	Max
Physiochemical Parameters													
Dissolved Oxygen	mg/L	54	4.04	70.8	101.7	30	2.19	5.63	76.7	34	0.73	26.2	90.4
Electrical conductivity (field)	µS/cm	45	32.4	135.3	231.6	33	5.08	6.23	14.5	85	2	55	121.4
pH (Field)	pH units	43	6.02	7.08	10.8	32	5.08	6.215	7.69	82	4.37	5.5	7.81
Total Dissolved Solids	mg/L	44	30	88	154	41	15	32	229	83	10	38	138
Total Suspended Solids	mg/L	7	2	5	23	32	24	30	36	11	4	10	42
Turbidity	NTU	5	3.6	10	60.4	5	0.4	2	3.9	8	0.32	1.75	23
Major Ions													
Alkalinity (Carbonate as CaCO3)	mg/L	54	1	1	1	1	0.004	0.004	0.004	96	1	1	1
Alkalinity (Bicarbonate as CaCO3)	mg/L	54	11	29	61	56	1	1	1	96	1	6	16
Alkalinity (Hydroxide as CaCO3)	mg/L	54	1	1	1	56	1	5	10	96	1	1	1
Alkalinity (total as CaCO3)	mg/L	54	11	29	61	56	1	1	1	95	1	6	16
Calcium (Filtered)	mg/L	54	2	6	13	1	8	8	8	88	1	1	23
Magnesium (Filtered)	mg/L	54	2	5	8	56	1	1	2	88	1	1	18
Potassium (Filtered)	mg/L	54	2	3	6	56	1	1	1	88	1	1	2
Sodium (Filtered)	mg/L	54	5	11	17	56	1	1	4	88	4	6	35
Sulfate (Filtered)	mg/L	34	1	4	10	56	7	10	13	44	1	1	10
Metals (Dissolved)													
Arsenic	mg/L	54	0.001	0.001	0.002	7	0.001	0.001	0.001	96	0.001	0.001	0.004
Cadmium	mg/L	54	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001	96	0.0001	0.0001	0.0002
Chromium	mg/L	54	0.001	0.001	0.001	6	0.001	0.001	0.001	96	0.001	0.001	0.002
Copper	mg/L	54	0.001	0.001	0.008	6	0.001	0.001	0.002	96	0.001	0.001	0.009
Iron	mg/L	54	0.05	0.16	2.64	7	0.05	0.05	0.24	96	0.05	0.18	1.4
Lead	mg/L	54	0.001	0.001	0.001	7	0.001	0.001	0.001	96	0.001	0.001	0.002
Manganese	mg/L	53	0.001	0.014	0.412	7	0.005	0.007	0.058	95	0.001	0.008	0.028
Mercury	mg/L	53	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001	95	0.0001	0.0001	0.0001
Nickel	mg/L	54	0.001	0.001	0.012	7	0.001	0.001	0.001	96	0.001	0.001	0.021
Zinc	mg/L	54	0.005	0.005	0.065	7	0.005	0.007	0.014	96	0.004	0.005	0.078
Metals (Total)													
Aluminium	mg/L	6	0.04	0.7	2.68	5	0.05	0.05	0.05	9	0.13	0.23	0.48
Arsenic	mg/L	7	0.001	0.001	0.001	1	0.001	0.001	0.001	10	0.001	0.001	0.001
Cadmium	mg/L	7	0.0001	0.0001	0.0001	5	0.05	0.05	0.15	10	0.0001	0.0001	0.0001
Cobalt	mg/L	6	0.001	0.001	0.003	5	0.001	0.001	0.001	9	0.001	0.001	0.001
Iron	mg/L	7	0.11	0.85	1.42	1	0.001	0.001	0.001	10	0.11	0.33	2.04
Lead	mg/L	7	0.001	0.001	0.003	1	0.001	0.001	0.001	10	0.001	0.001	0.001
Manganese	mg/L	8	0.006	0.025	0.11	1	0.001	0.001	0.001	11	0.004	0.008	0.016
Mercury	mg/L	7	0.0001	0.0001	0.0001	56	0.001	0.007	0.168	10	0.0001	0.0001	0.0001
Nickel	mg/L	7	0.001	0.002	0.003	1	0.001	0.001	0.001	10	0.001	0.001	0.001
Silver	mg/L	5	0.001	0.001	0.001	1	0.005	0.005	0.005	7	0.001	0.001	0.001
zinc	mg/L	7	0.005	0.008	0.014	1	0.005	0.005	0.005	10	0.005	0.005	0.007

E.4 Chemical time series graphs- Genowlan Creek

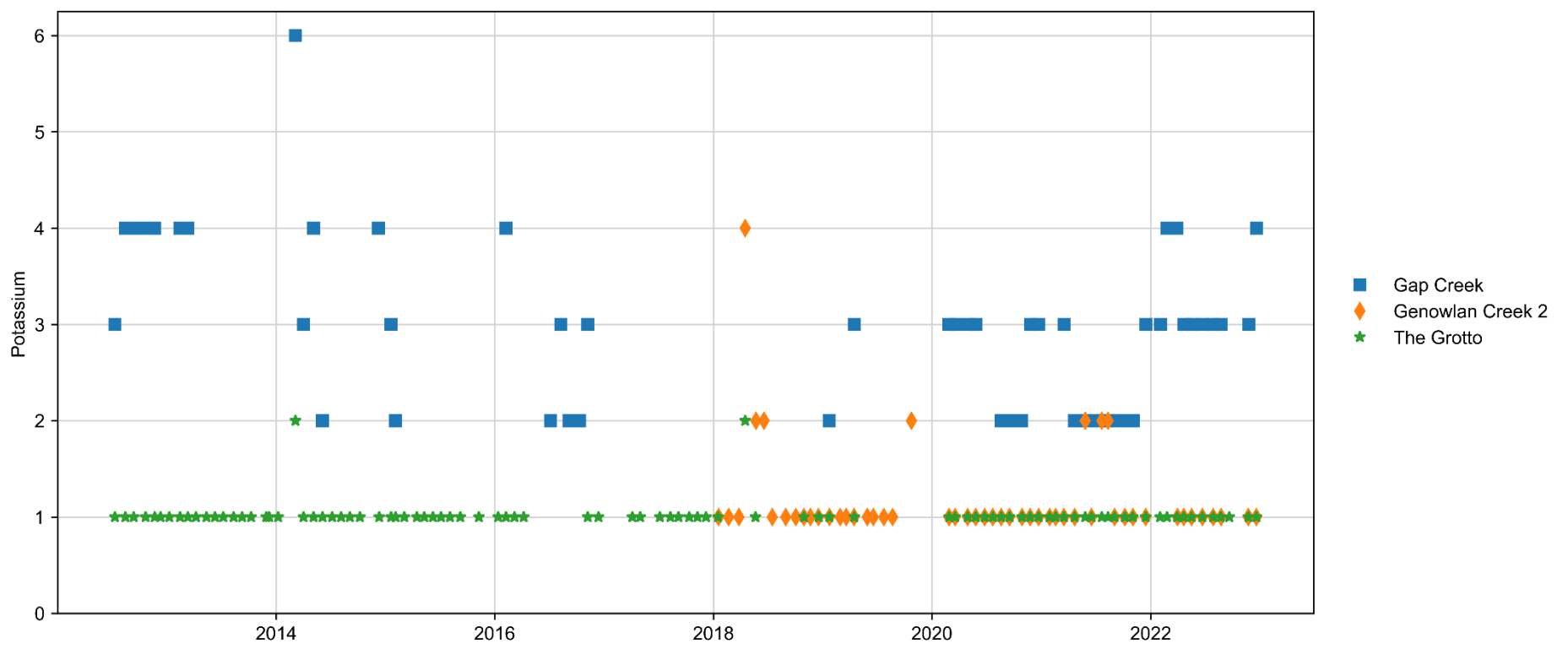
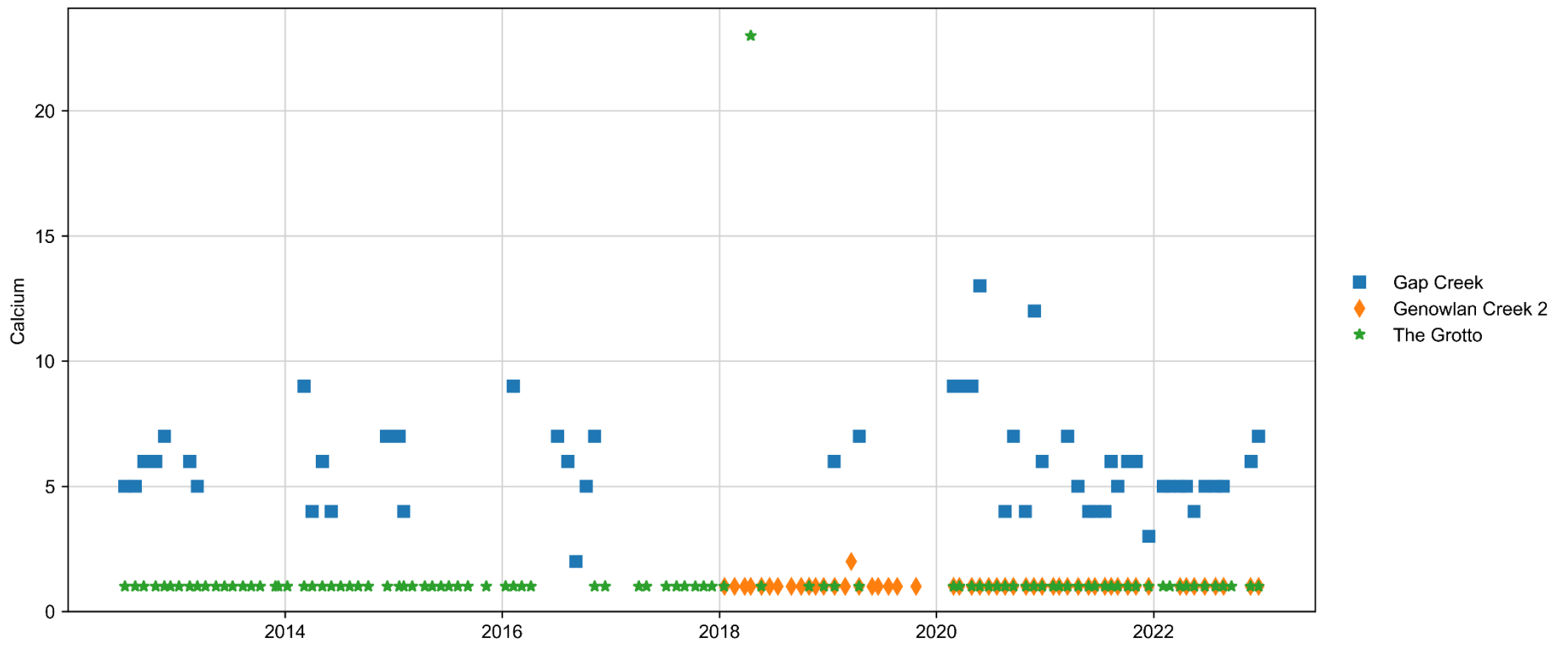
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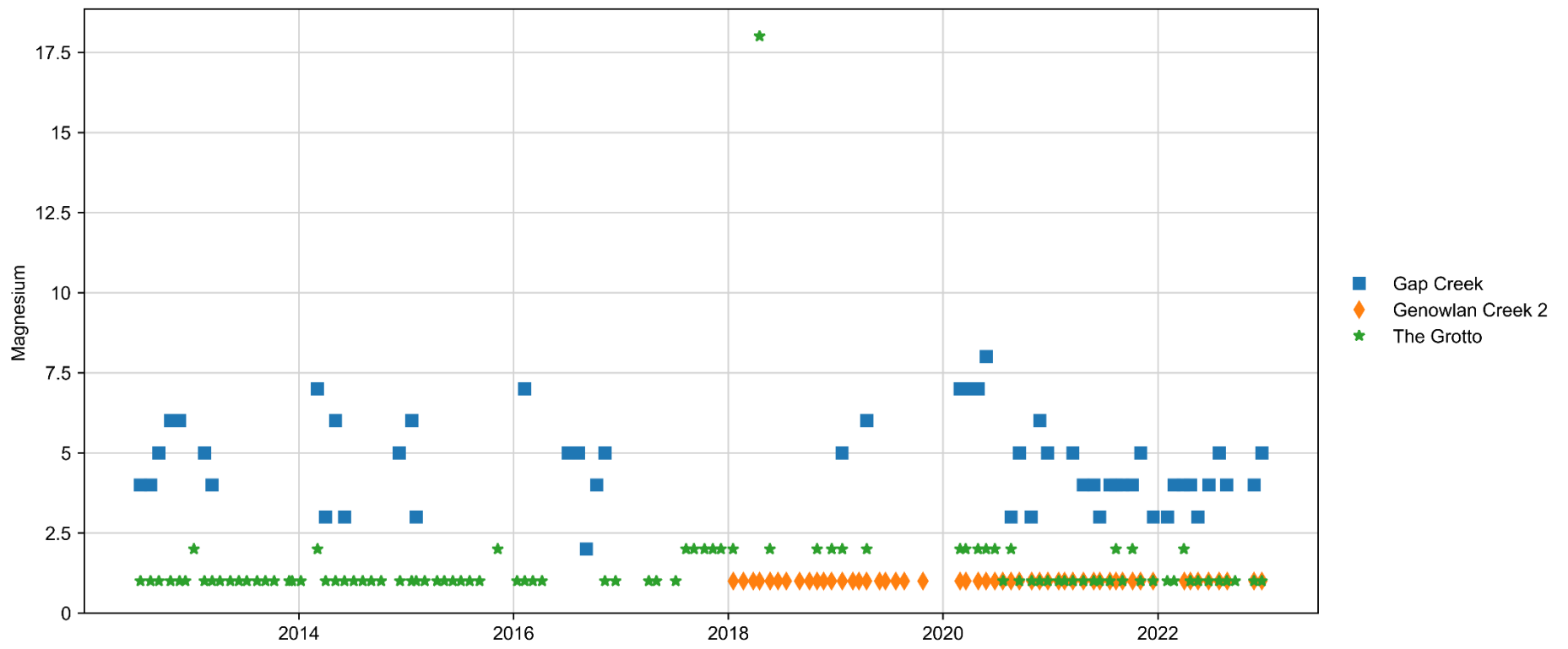
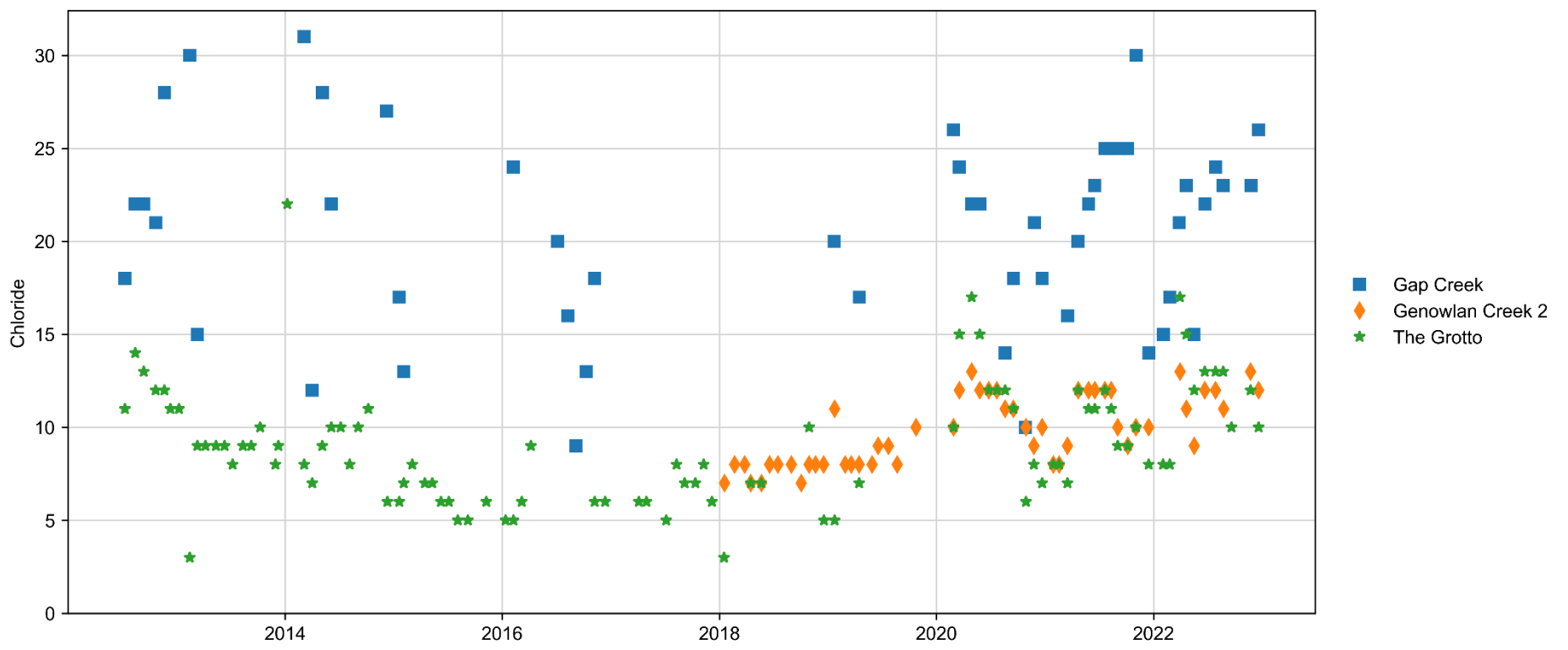






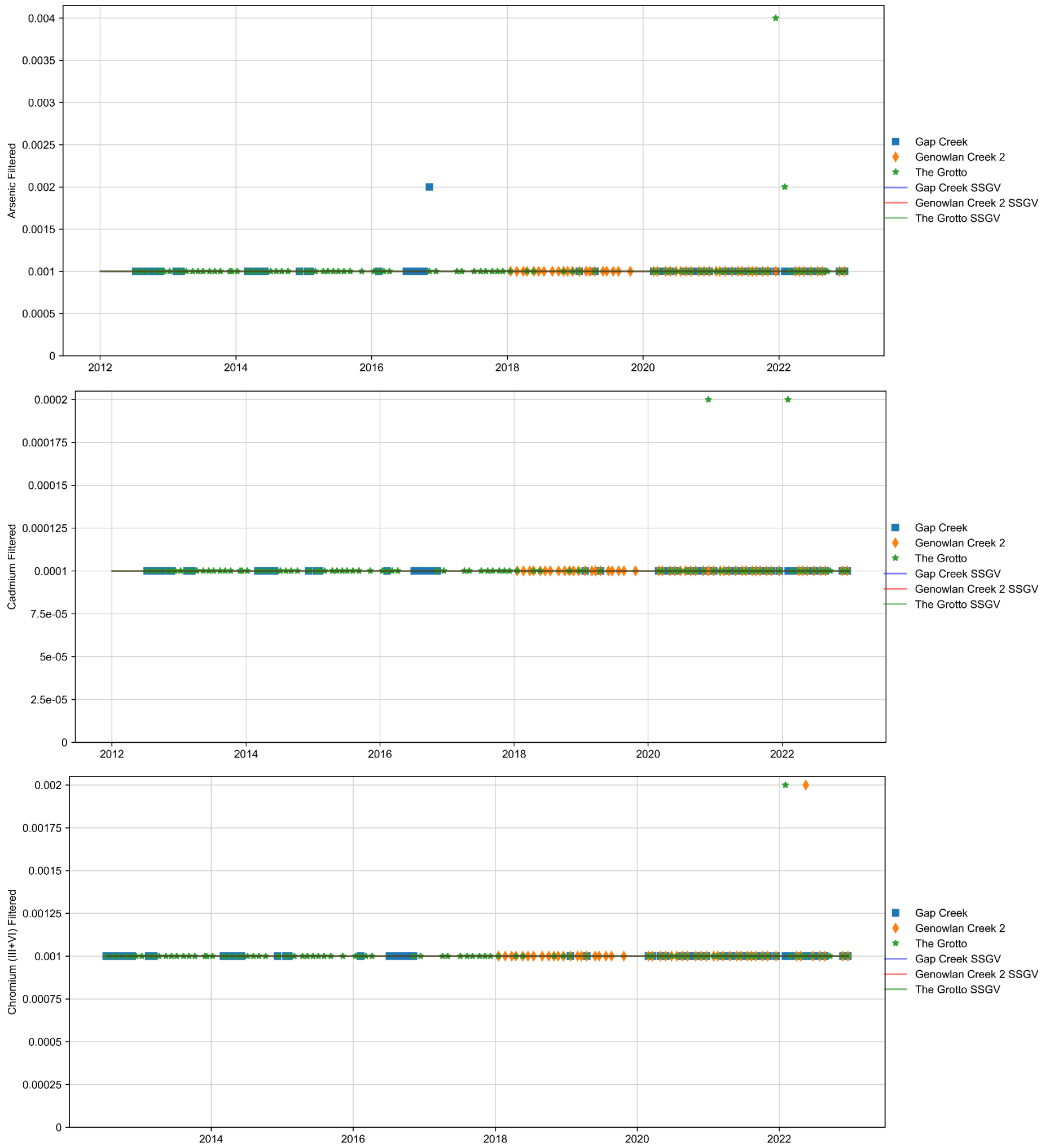
Major Ions

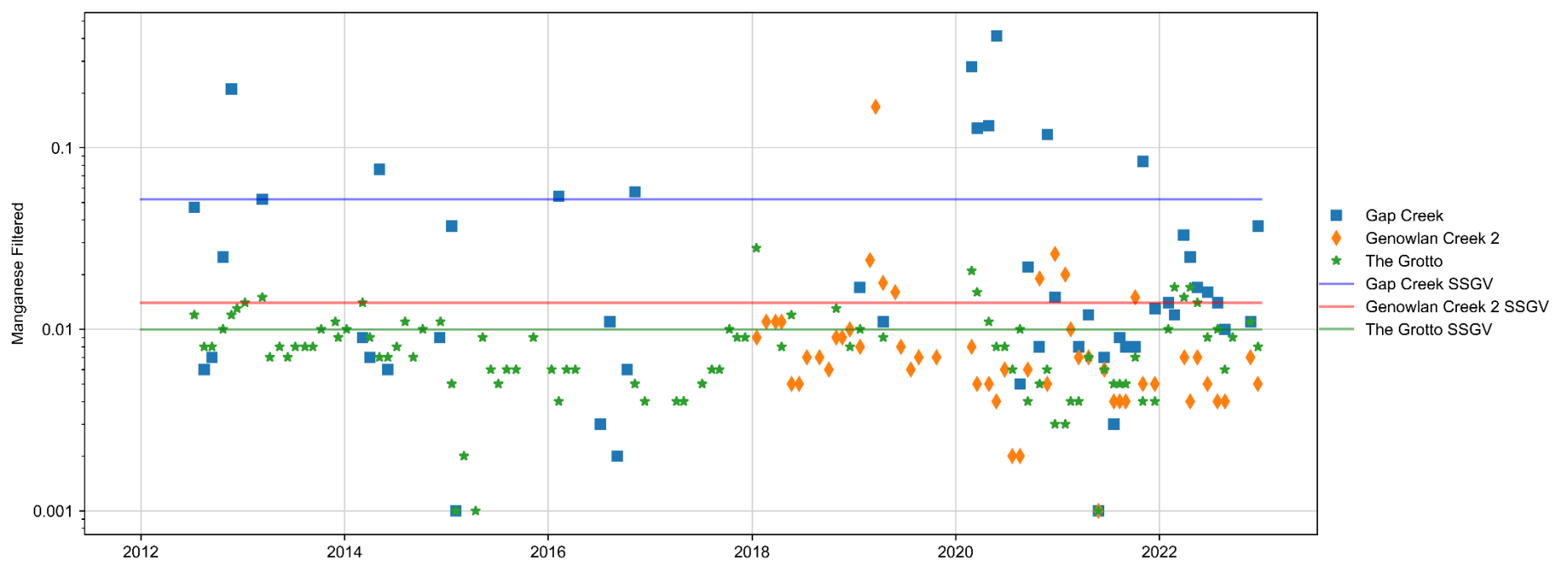
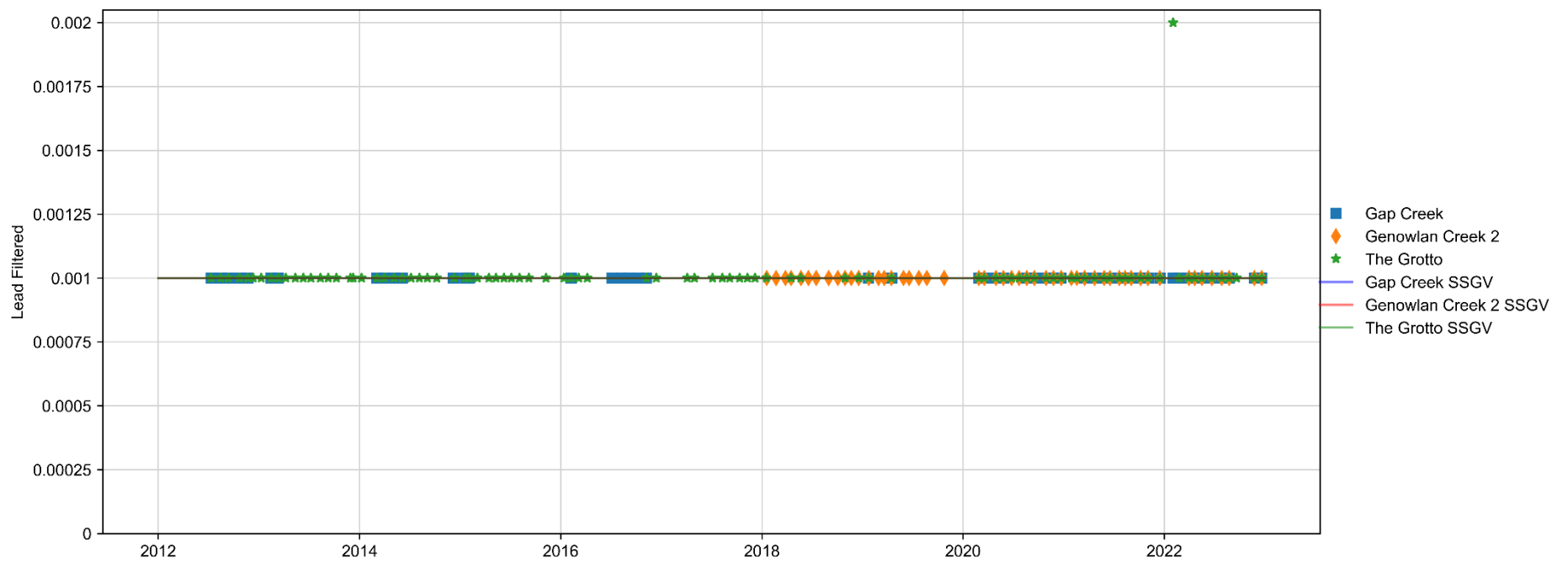
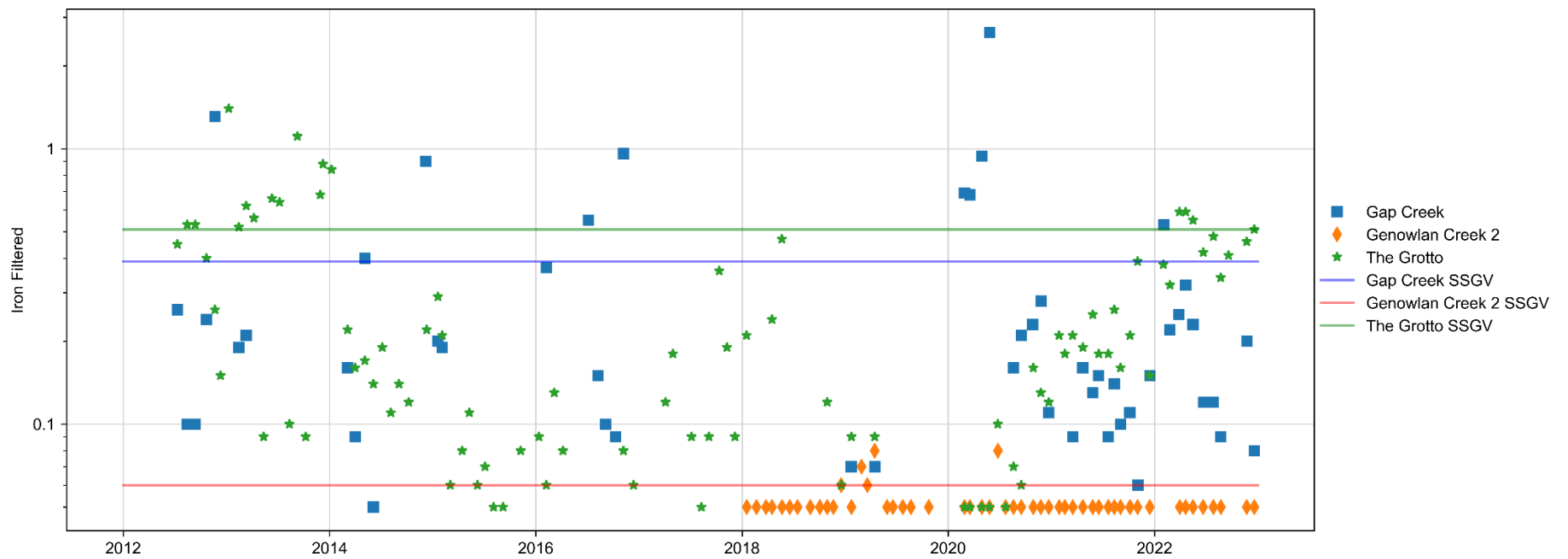
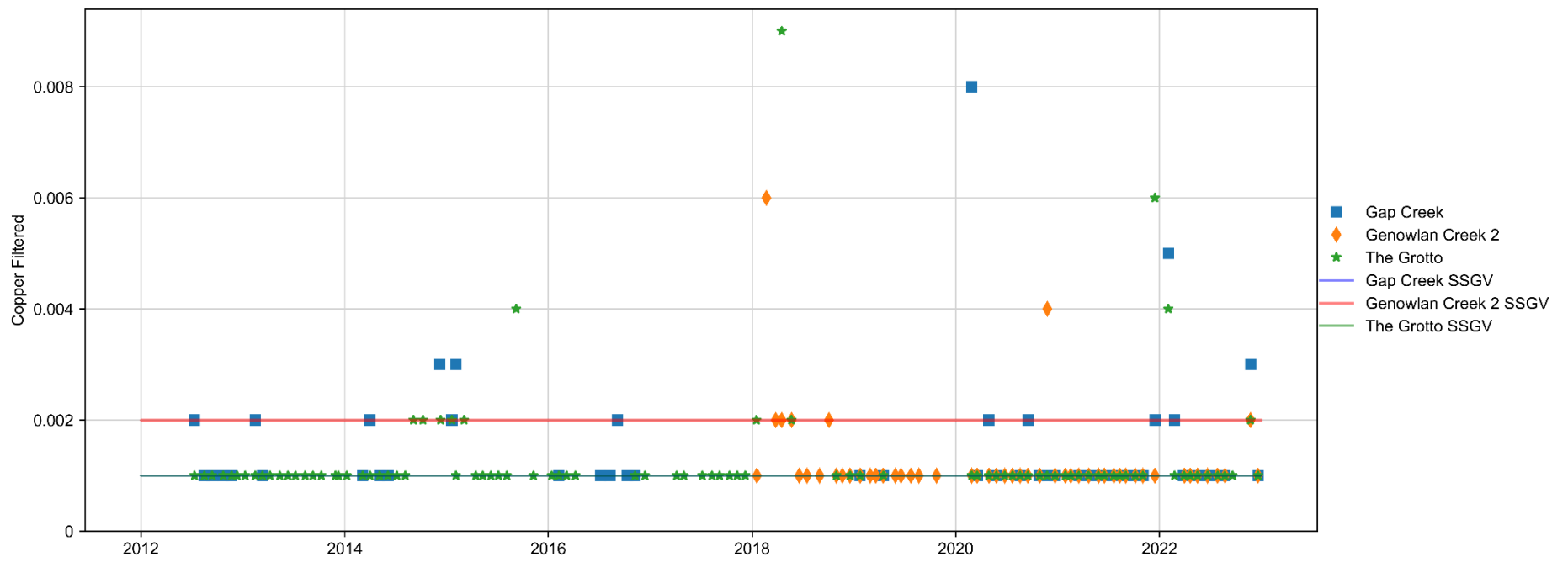


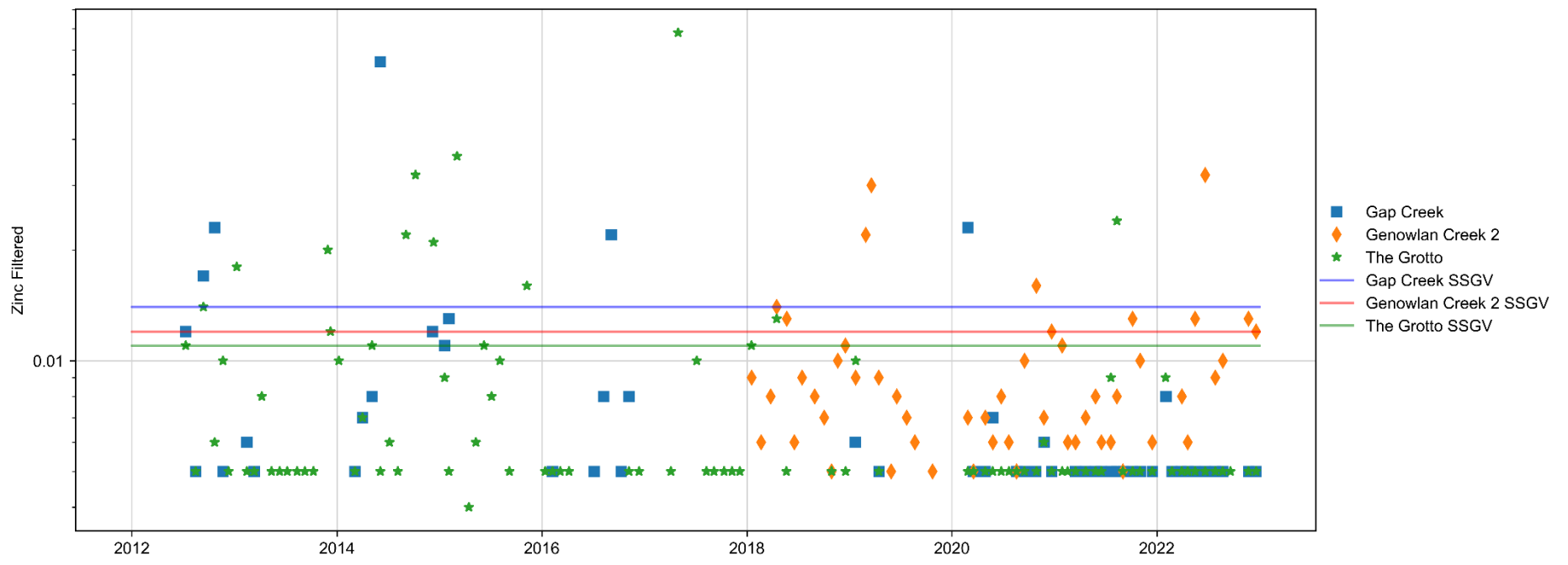
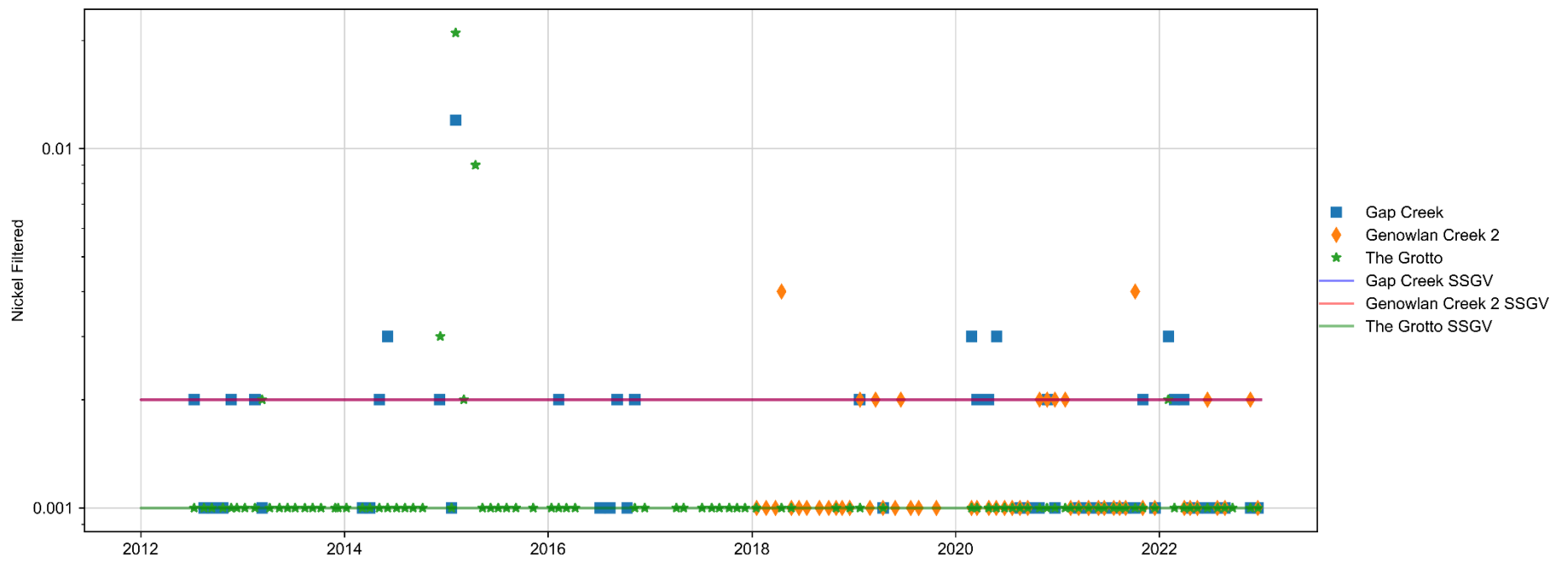
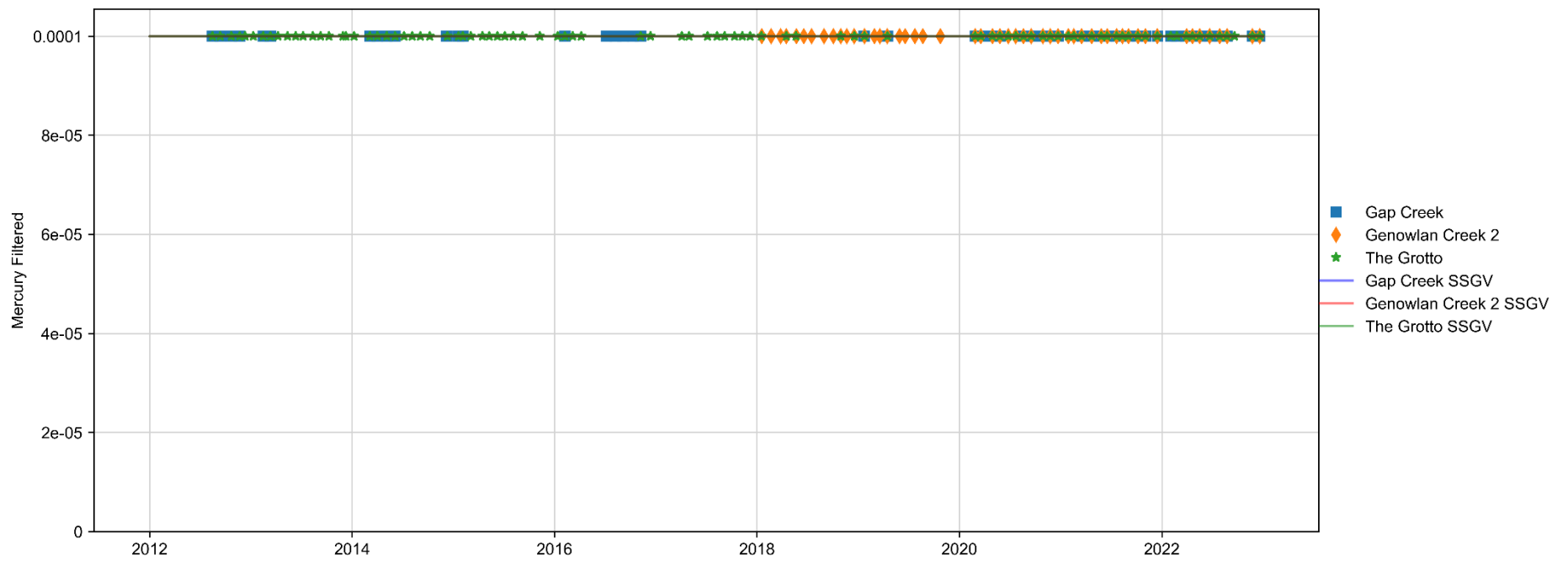


Metals (Dissolved)

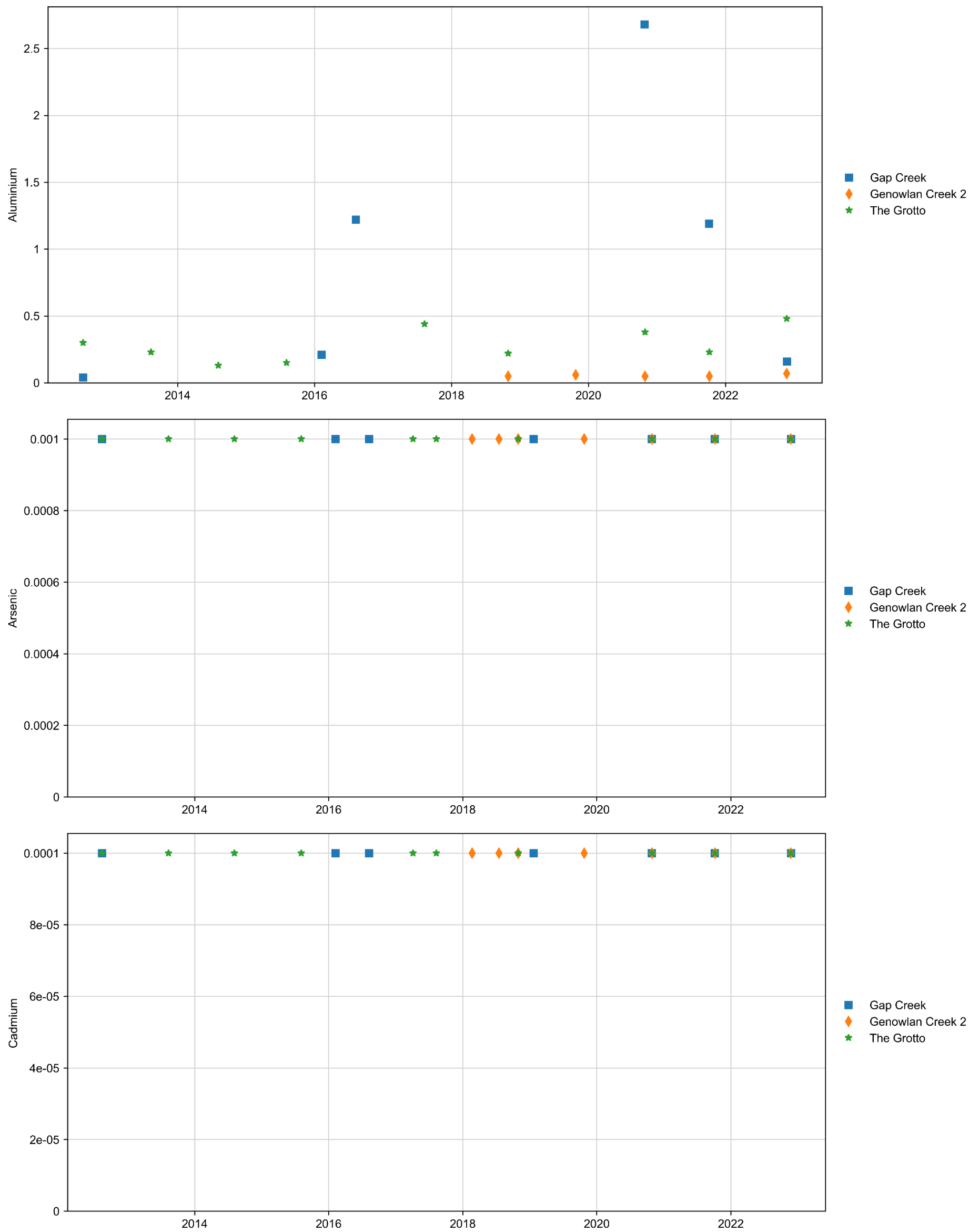
Note: dissolved metals Arsenic, cadmium, chromium, lead and mercury SSGV thresholds are equal to the LOR and identical at Gap Creek, Genowlan Creek 2 and The Grotto.

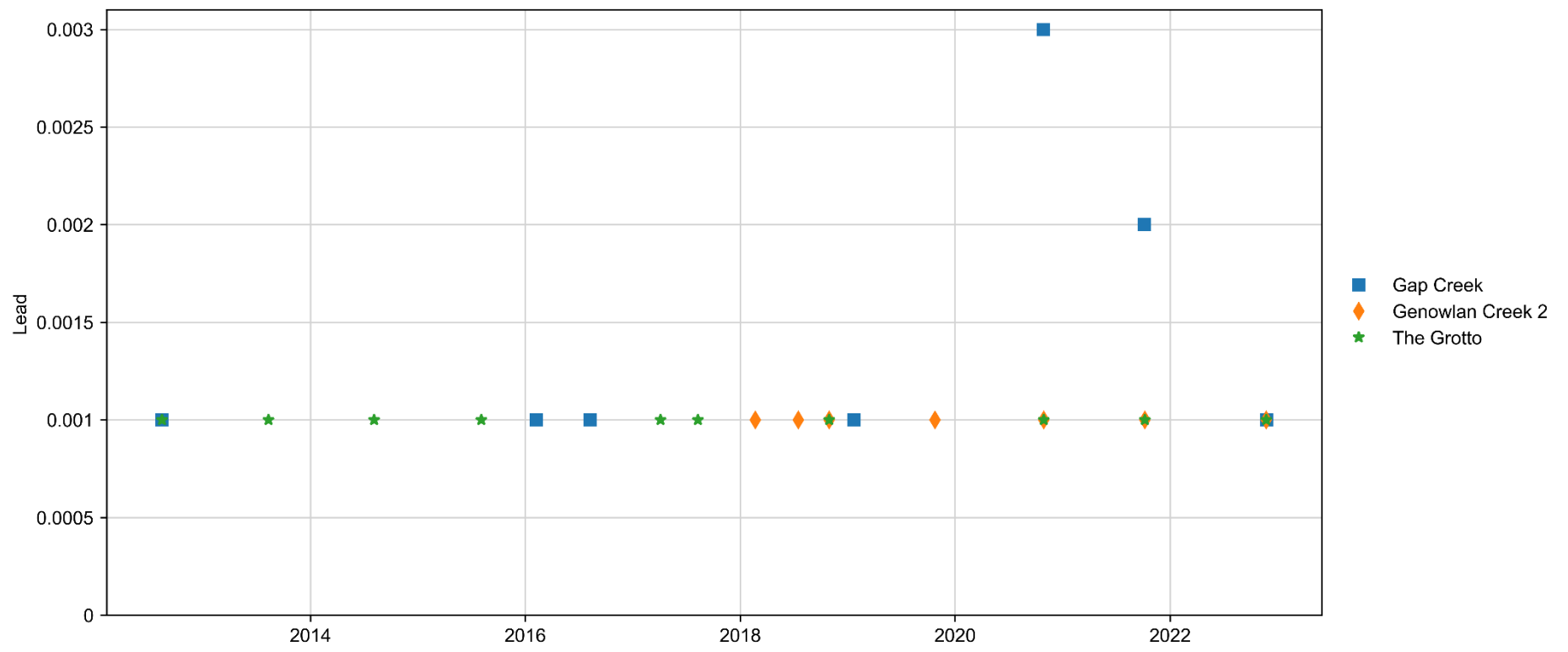
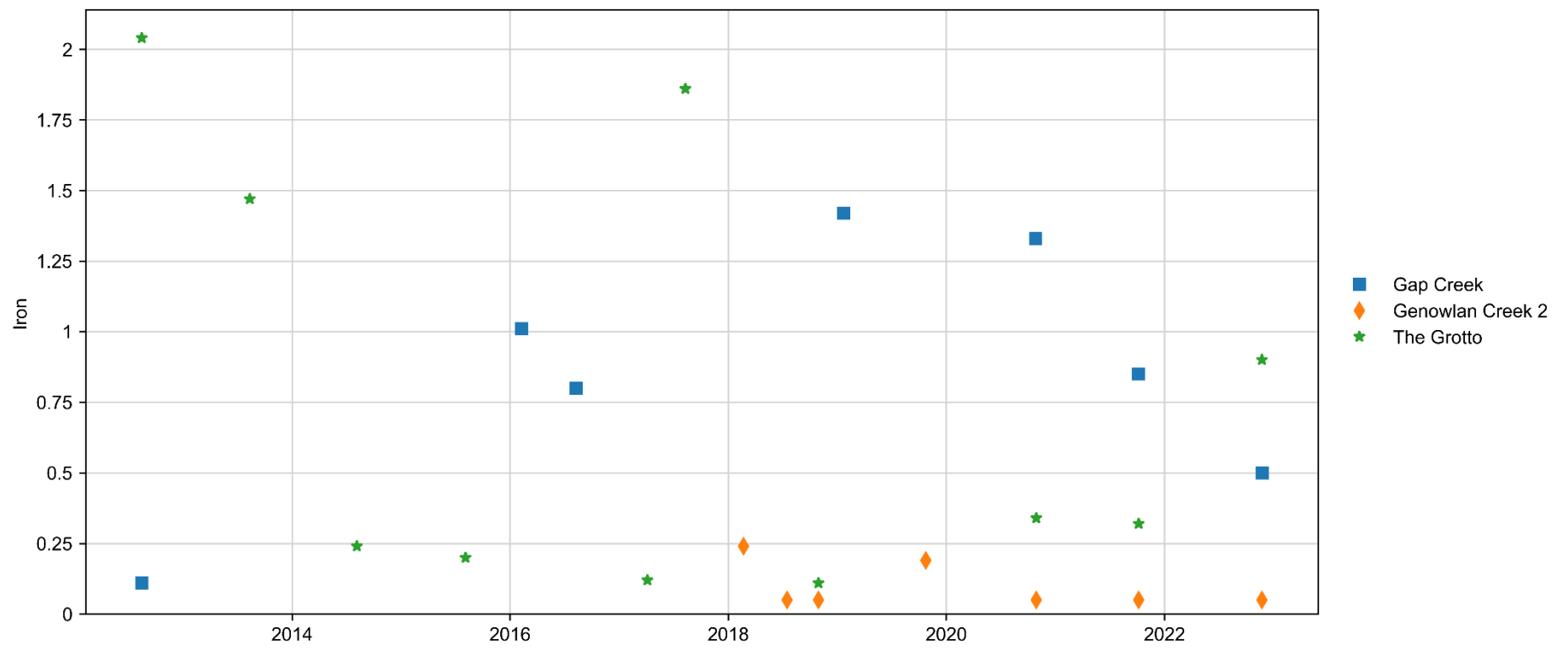
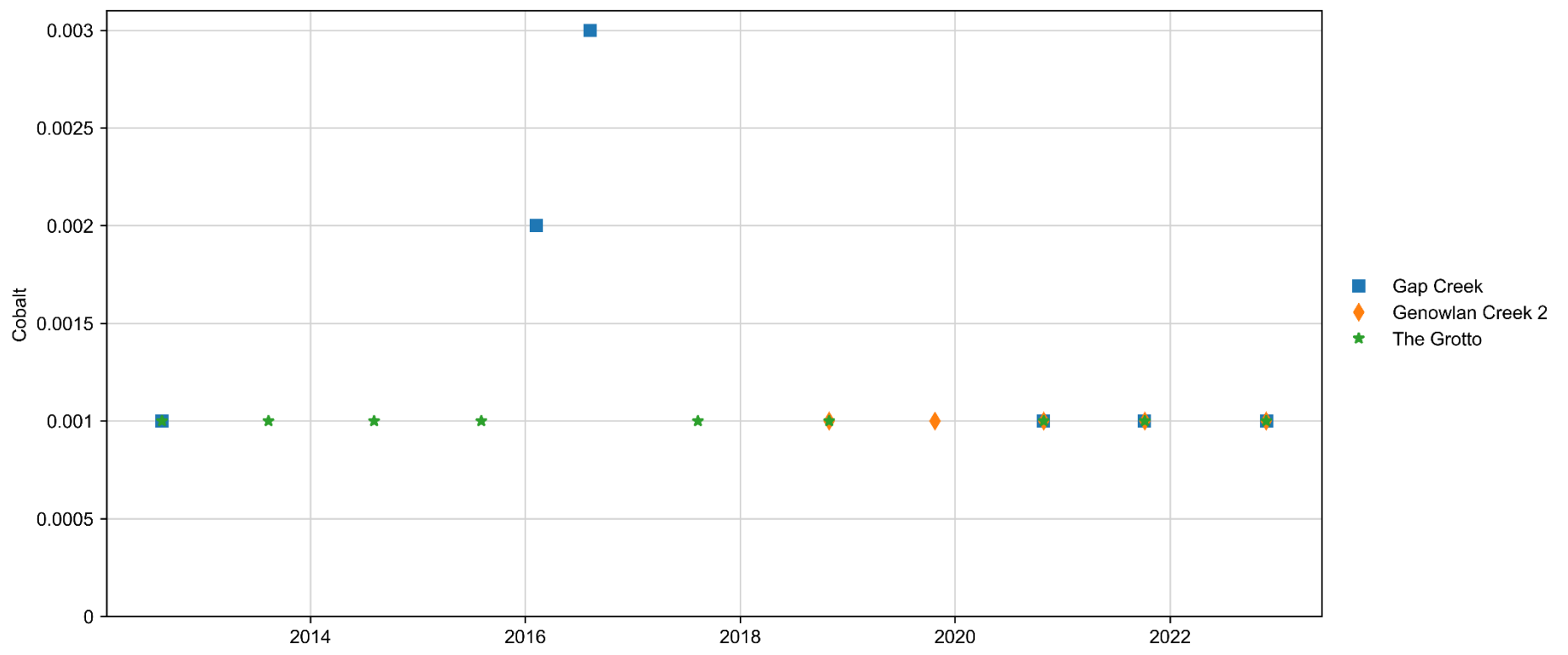


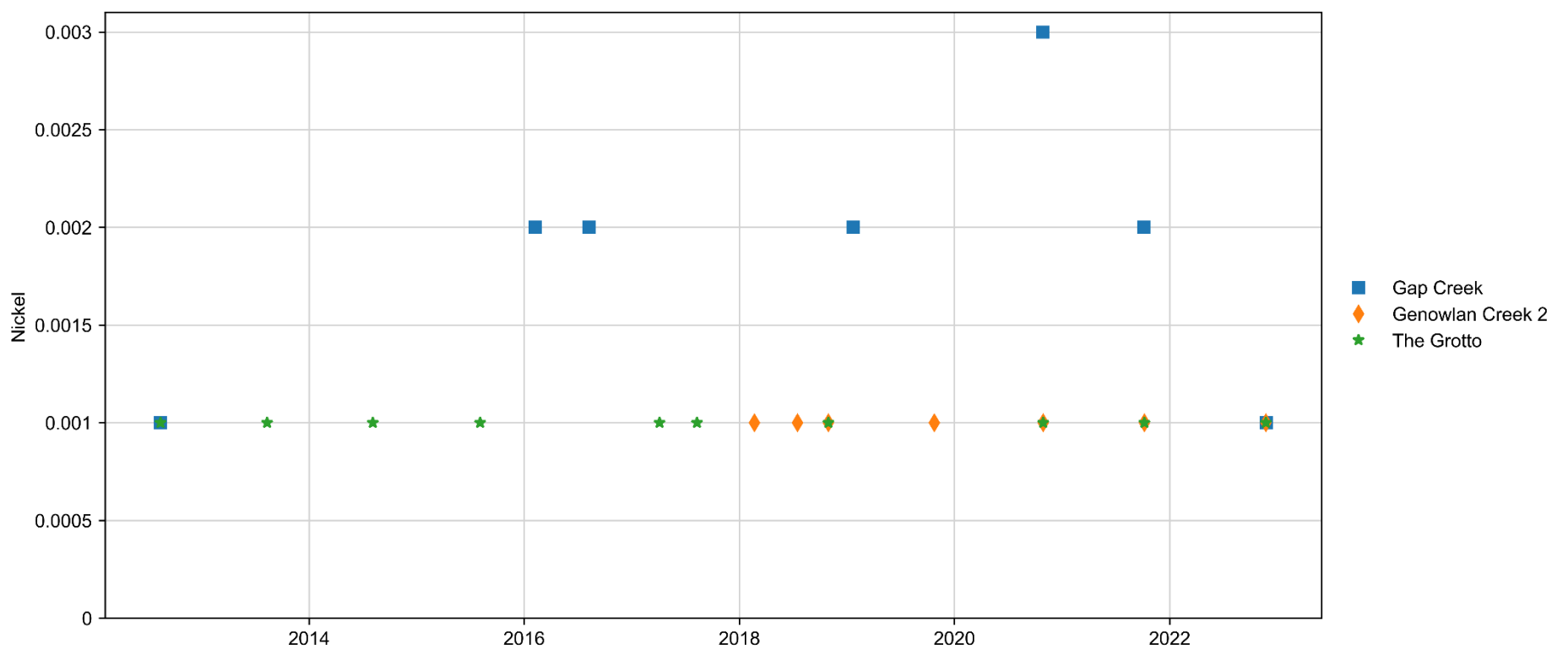
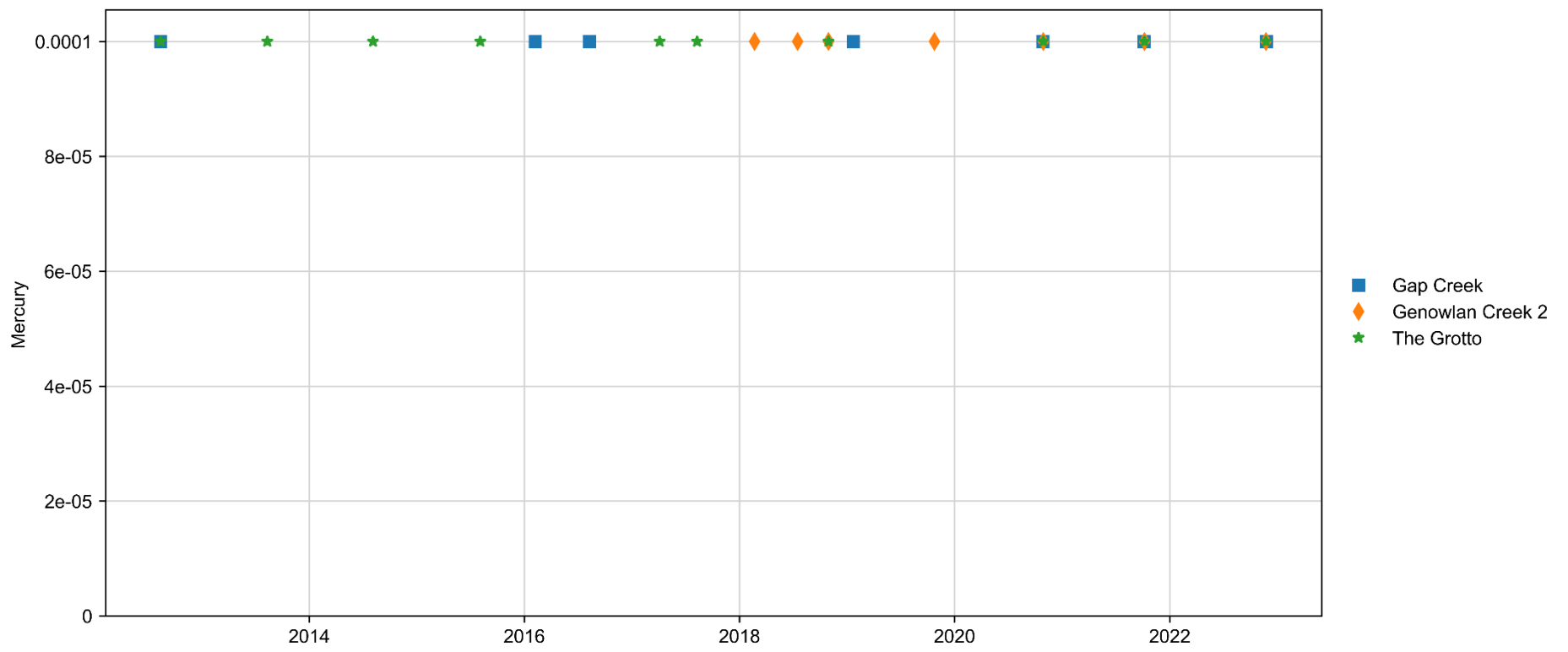
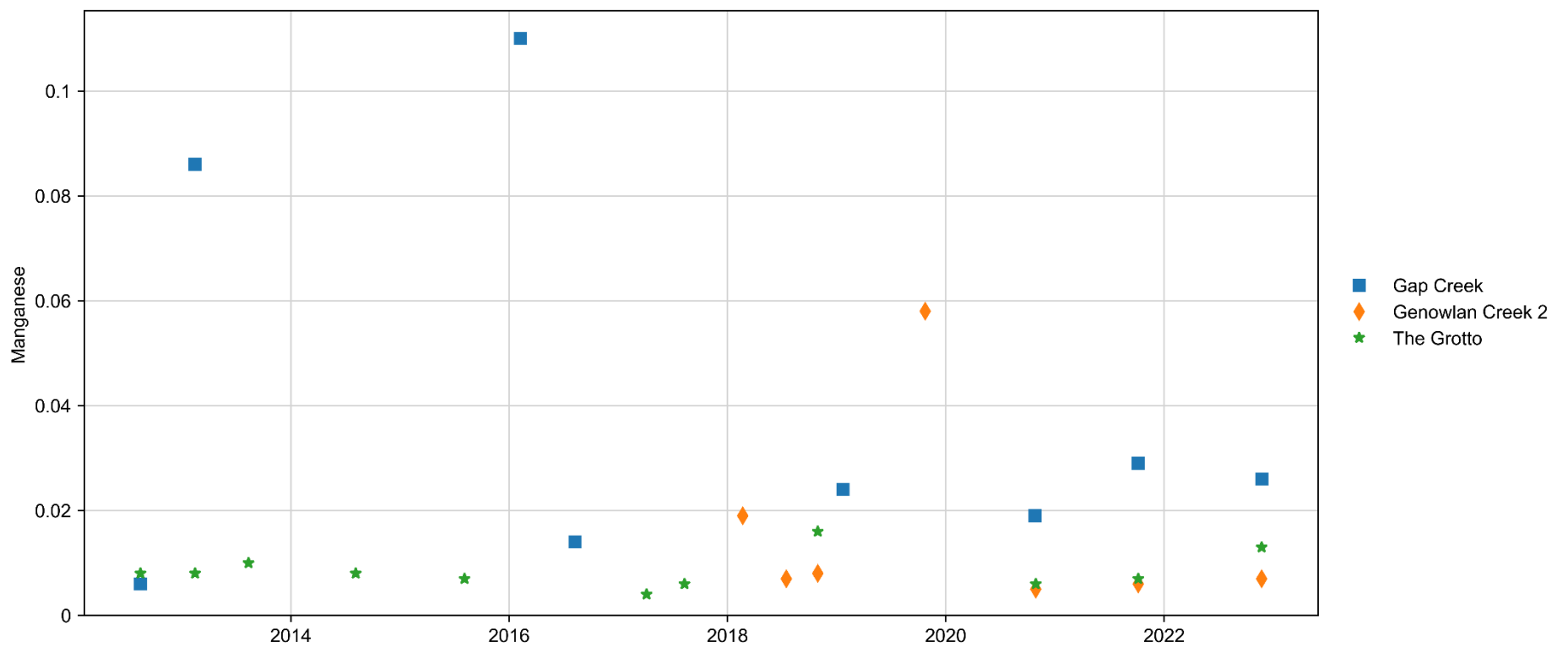


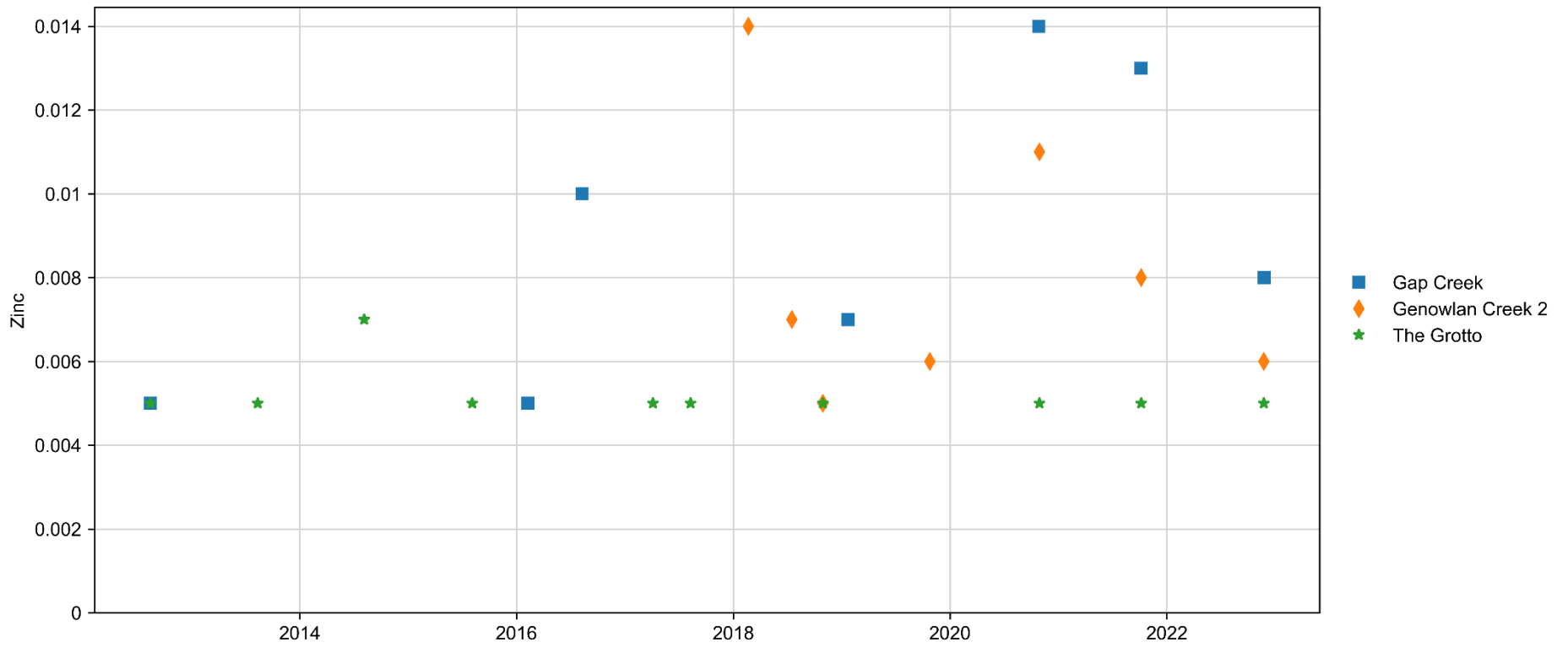
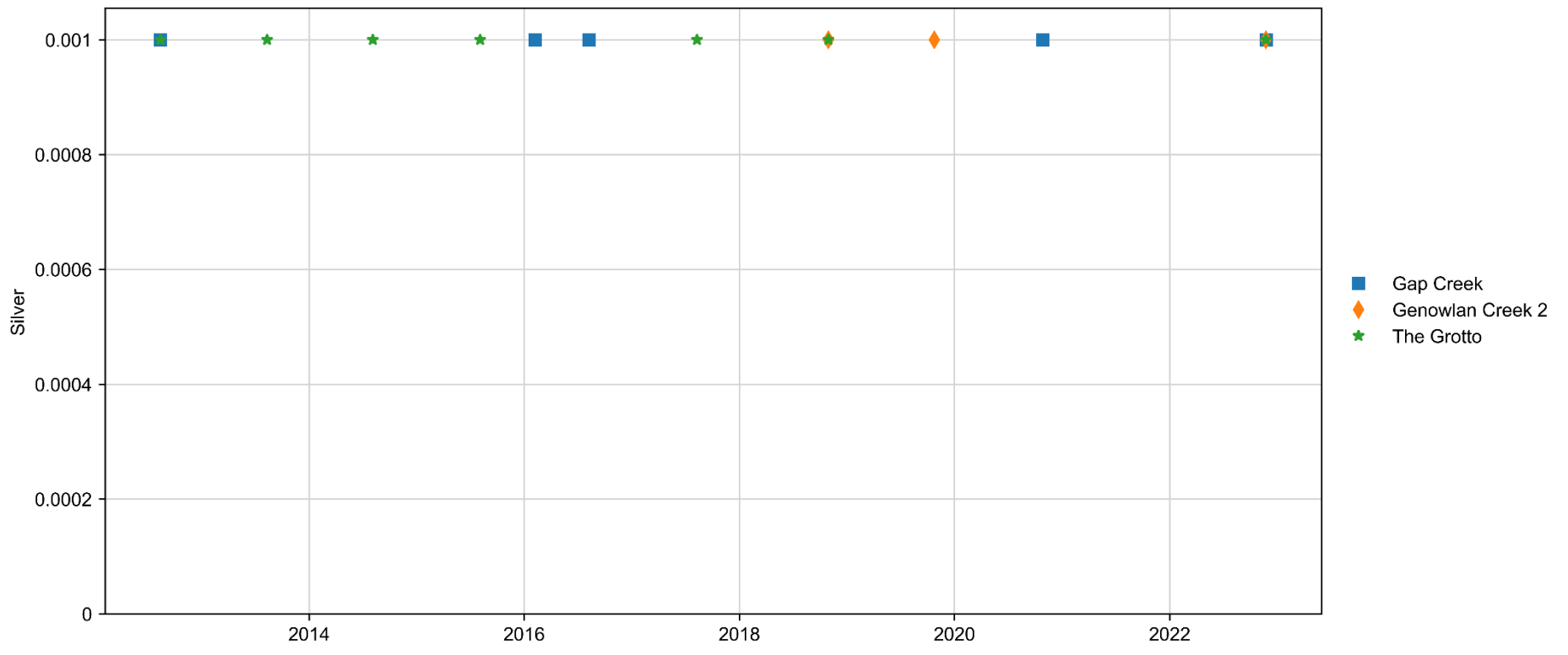


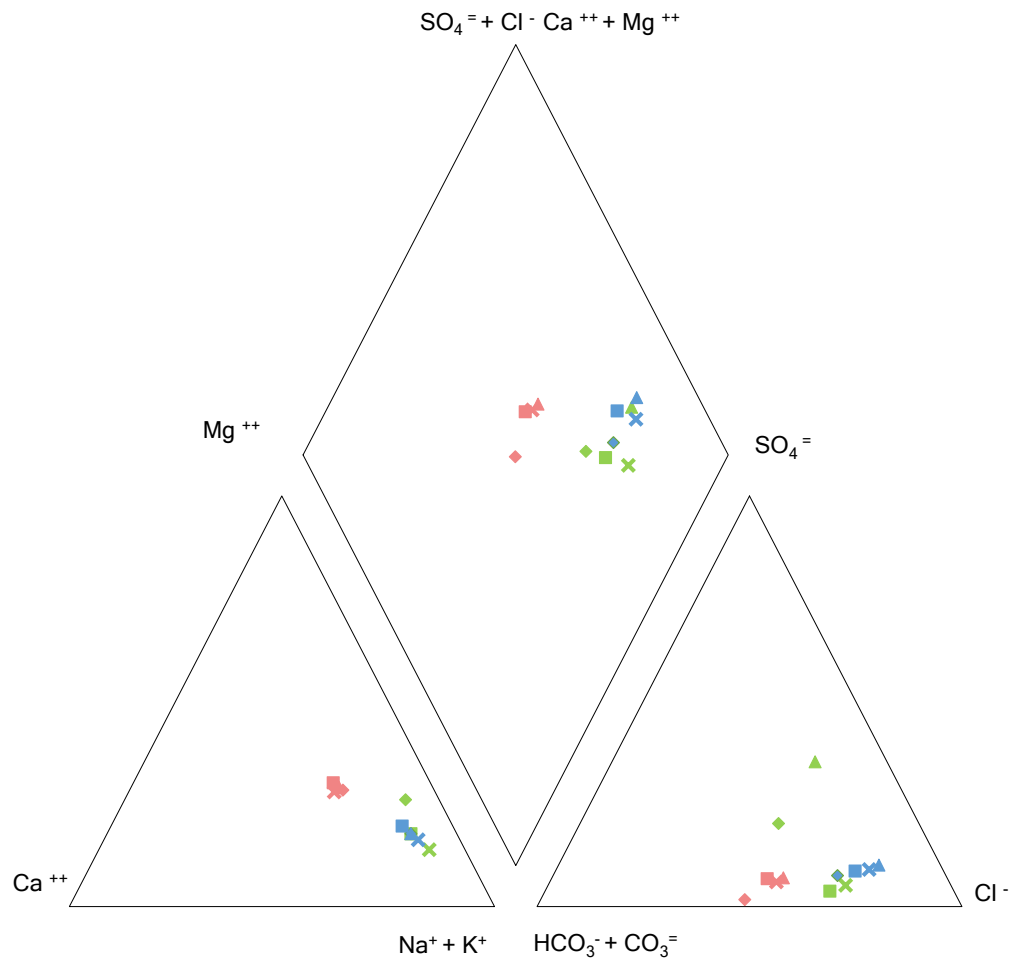
Metals (Total)





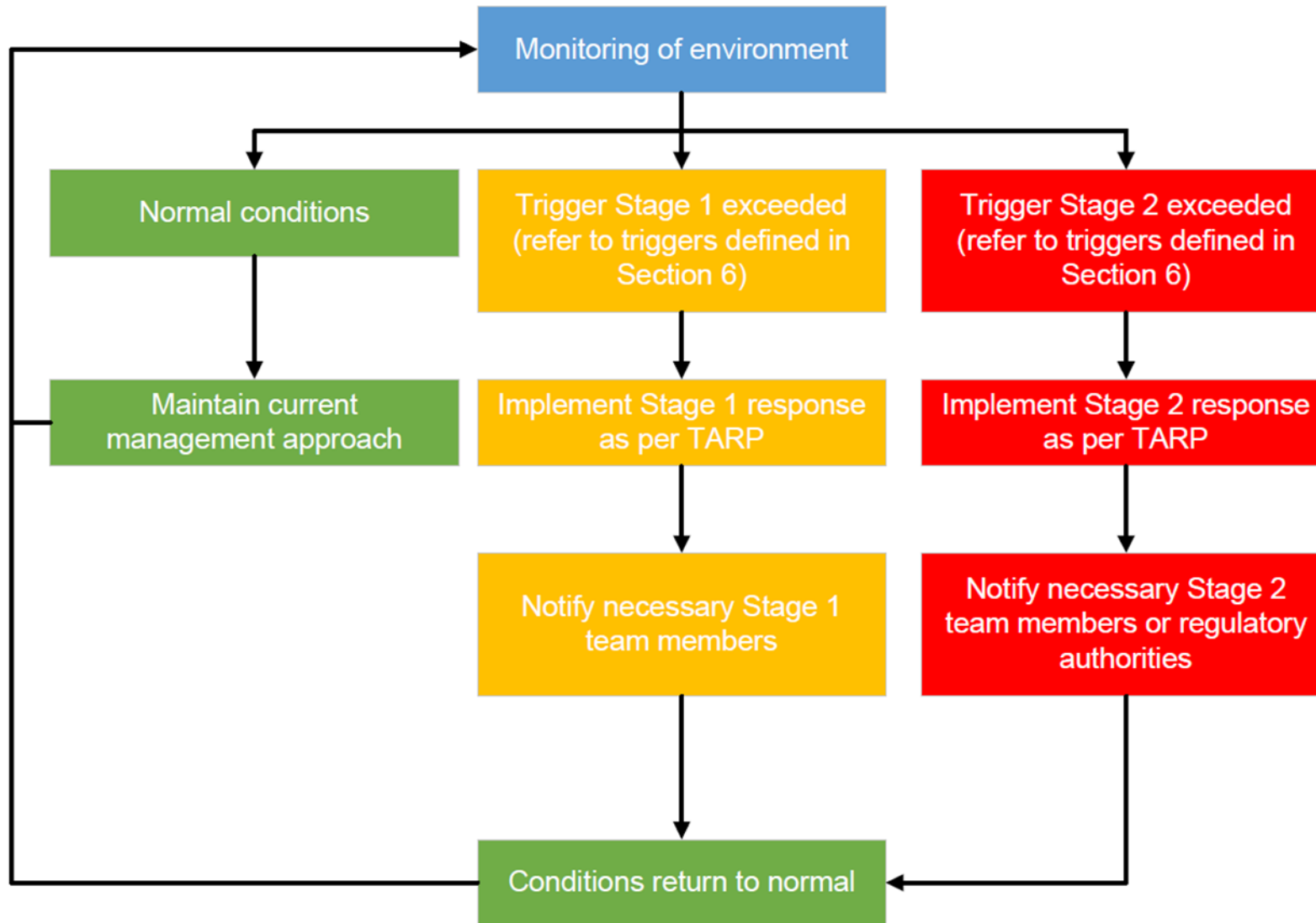






- ◆ The Grotto March 2022
- The Grotto June 2022
- ▲ The Grotto September 2022
- ✕ The Grotto December 2022
- ◆ Genowlan Creek 2 March 2022
- Genowlan Creek 2 June 2022
- ▲ Genowlan Creek 2 August 2022
- ✕ Genowlan Creek 2 December 2021
- ◆ Gap Creek March 2022
- Gap Creek June 2022
- ▲ Gap Creek August 2022
- ✕ Gap Creek December 2021

Appendix F – Trigger action response plans



F.1 Surface site operation

Aspect	Normal	Stage 1	Stage 2	Notifications
Surface water storage volume	Storages capture events up to and including the design criteria.	<p>Trigger: Storage is not dewatered appropriately following storm event in accordance with design criteria.</p> <p>Action: Investigate storage operation and dewatering operations.</p> <p>Undertake dewatering of relevant storages to Dirty Water Dam where capacity exists.</p> <p>Increase inspection frequency as required.</p> <p>Training for staff.</p>	<p>Trigger: Storage is discharging as a result of a storm event less than the design criteria.</p> <p>Action: Undertake dewatering of relevant storages to Dirty Water Dam where capacity exists. Prioritise dewatering of the Stockpile Dam and Train Loader Dam over the Production Dam.</p> <p>Investigate cause for discharge and if the appropriate procedures were followed.</p> <p>Undertake water quality sampling of discharge and add flocculant as necessary.</p> <p>Undertake water quality sampling of downstream locations on Airly Creek as appropriate to assess any potential impact.</p> <p>Review adequacy of storage design, dewatering procedure and inspection schedule.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with Pollution Incident Response Management Plan (PIRMP) requirements or if material harm has occurred.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Clean water diversions	Clean water diverted around dirty water areas.	<p>Trigger: Clean water bypass through dirty water areas.</p> <p>Action: Review catchment plan. Review design capacity of clean water system. Appropriately treat and manage dirty water. Facilitate works to resolve clean water flow diversion failure.</p>	<p>Trigger: Clean water creates flooding problems through site.</p> <p>Action: Evacuate site if danger exists. Establish temporary bunding around clean water source. Utilise earthworks machinery to cut appropriate channel to manage clean water. Protect equipment and infrastructure. Utilise portable pumps to dewater flooded areas into storages.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify Department of Planning, Industry and Environment (DPIE) if exceedance of limit occurs.</p>
Erosion and sediment control	<p>All controls are appropriately in place and well maintained.</p> <p>Site inspections do not identify any unstable disturbance areas or migration of sediment away from designated development areas.</p>	<p>Trigger: One or more areas of surface erosion in the form of rilling, bank erosion or other movement of sediment from an area of disturbance.</p> <p>Controls are not maintained or are inappropriately installed.</p> <p>Action: Seek to stabilise the area to stop the erosion process. This can include the use of groundcover or other temporary measures. Investigate works undertaken prior to the disturbance activities. Review adequacy of controls and inspection/maintenance schedule.</p>	<p>Trigger: Controls are not in place. Rainfall event has led to sediment migrating off site.</p> <p>Action: Isolate the area through diverting contributing surface flows to another appropriate control structure. Investigate works undertaken prior to the disturbance activities. Review adequacy of controls and inspection/maintenance schedule.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Hydrocarbon management	All hydrocarbon materials are stored appropriately.	<p>Trigger: Minor spill occurs on site with limited risk of off-site migration.</p> <p>Action: Implement procedures in the PIRMP. Utilise spill kit.</p>	<p>Trigger: Major spill occurs on site with risk of off-site migration.</p> <p>Action: Isolate area and divert contributing surface flows. Engage waste contractor to clean spill. Investigate potential for contamination of waterways.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.</p>

F.2 Watercourses

Aspect	Normal	Stage 1	Stage 2	Notifications
Water quality	Water quality at monitoring locations within or below the values specified in Table 6.1 (for Airly Creek) and Table 6.2 (for Gap Creek and Genowlan Creek).	<p>Trigger: Water quality is outside or above the values specified in Table 6.1 (for Airly Creek) and Table 6.2 (for Gap Creek and Genowlan Creek) for at least one parameter for two consecutive sampling events.</p> <p>Action: Review recent monitoring results for adjacent sites and any relevant operational data (e.g. mining activities, clearing activities, meteorological data) to identify any potentially contributing factors.</p> <p>Investigate the source of the exceedance and develop corrective/preventative actions based on outcomes of the investigation (refer Appendix H).</p>	<p>Trigger: Investigation into Stage 1 trigger identifies that trigger exceedance is due to a mining-related activity and outside predictions of EIS.</p> <p>Community complaint to Centennial Airly regarding surface water quality.</p> <p>Action: Determine if an incident has potentially occurred and investigate the source of the exceedance.</p> <p>Increase monitoring frequency and undertake additional monitoring (e.g. water quality, aquatic ecology) where relevant.</p> <p>Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring (refer Appendix H). Prioritise actions based on the risk to the environment and likelihood of further impact.</p> <p>Review the WMP and related procedures to prevent reoccurrence.</p> <p>Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial Airly.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE if Stage 2 exceedance is found to be mining-related.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Water flow	<p>Creek flow rates and rainfall-runoff response are consistent with the calibrated baseline model during the quarterly assessment demonstrated by either:</p> <ul style="list-style-type: none"> • Consistency between estimates in the calibrated model and observed flow (NSE > 0.5) • The recalibrated model parameters are within the bounds of the baseline assessment (NSE > 0.5) 	<p>Trigger: Changes in the rainfall-runoff response compared to the calibrated baseline model.</p> <p>Action:</p> <ul style="list-style-type: none"> • Complete detailed QA and QC on collected dataset. Consult with site staff as to potential orographic rainfall effects if individual events are poorly calibrated. Re-simulate if necessary. • Conduct a detailed review of the rainfall dataset to determine if conditions during the original calibration included sufficiently similar periods to those recently observed. • Conduct a walkover of the gauge locations to confirm whether any blocking or issues with data-logger may have contributed to poor quality calibration. Rectify if needed. • Conduct a walkover of the affected catchment(s) to identify if any physical changes to the catchment may have contributed to differences between estimates and observations. • Review recent monitoring results and any relevant operational data (e.g. mining activities, clearing activities, meteorological data) to identify any potentially contributing factors. <p>If necessary, investigate the source of the reduction in flow and develop corrective/preventative actions based on outcomes (refer Appendix H).</p>	<p>Trigger: Investigation in the changes to rainfall-runoff response is potentially due to a mining-related activity.</p> <p>Community complaint to Centennial Airly regarding surface water flow.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. mining activities, clearing activities, meteorological data) to identify any potentially contributing factors.</p> <p>Determine if an incident has potentially occurred and investigate the source of the loss of flow. A community complaint may be investigated using the baseline model detailed in Appendix J.</p> <p>Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation (refer Appendix H). Prioritise actions based on the risk to the environment and likelihood of further impact.</p> <p>Review the WMP and related procedures to prevent reoccurrence.</p> <p>Any measured or predicted loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial Airly.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE and Resource Regulator as soon as practicable if Stage 2 exceedance is found to be mining-related.</p>

Further details regarding the baseline model as related TARP F.2 are included in Appendix J.

F.3 Nissan Hut Dam water levels

Aspect	Normal	Stage 1	Stage 2	Notifications
Nissan Hut Dam water levels	Water level monitoring indicates sustained presence of water and is consistent with rainfall/evaporation.	<p>Trigger: Water level is below the base of the monitoring device and/or recorded water level at Nissan Hut Dam indicates a downward trend or drop in water level, beyond rainfall/evaporation correlation (including potential notification received from NPWS)</p> <p>Action: Review recent operational data (e.g. mining activities, clearing activities, meteorological data) to identify any potentially contributing factors. Further investigation (such as if the surface storage was used in firefighting activities) should be undertaken.</p> <p>Investigate the source of the exceedance and develop corrective/preventative actions based on outcomes of the investigation (refer Appendix H).</p>	<p>Trigger: Investigation into Stage 1 trigger identifies that trigger exceedance is due to a mining-related activity.</p> <p>Community complaint to Centennial Airly regarding surface water level.</p> <p>Action: Determine if an incident has potentially occurred and investigate the source of the exceedance.</p> <p>Undertake additional monitoring (e.g. subsidence monitoring) where relevant.</p> <p>Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring (refer Appendix H). Prioritise actions based on the risk to the environment and likelihood of further impact.</p> <p>Review the WMP and related procedures to prevent reoccurrence.</p> <p>Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial Airly.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE if Stage 2 exceedance is found to be mining-related.</p>

F.4 Discharge management

Aspect	Normal	Stage 1	Stage 2	Notifications
Discharge from LDP	No discharges as a result of events up to an including the design criteria.	<p>Trigger: Discharge occurs for no more than one day as a result of the storage capacity being exceeded.</p> <p>Action: Investigate storage operation and dewatering procedures.</p> <p>Undertake dewatering of relevant storages to areas where capacity exists.</p> <p>Increase inspection frequency as required.</p> <p>Training for staff.</p>	<p>Trigger: Discharge occurs for more than one day as a result of the storage capacity criteria being exceeded.</p> <p>Action: Investigate cause for discharge and if the appropriate procedures were followed.</p> <p>Undertake dewatering of relevant storages to areas where capacity exists.</p> <p>Review adequacy of storage design, dewatering procedure and inspection schedule.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE if exceedance of limit occurs.</p>
Discharge quality from LDP	Discharge quality is within or below EPL limits presented in Table 6.3.	<p>Trigger: Water quality parameters are outside or above EPL limits for one parameter.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Investigate cause for discharge and if the appropriate procedures were followed.</p> <p>Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact.</p>	<p>Trigger: Water quality parameters are outside or above EPL limits for more than one parameter.</p> <p>Action: Determine if an incident has potentially occurred.</p> <p>Increase monitoring frequency and undertake additional monitoring where relevant.</p> <p>Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring. Prioritise actions based on the risk to the environment and likelihood of further impact.</p> <p>Review the WMP and related procedures to prevent reoccurrence.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE if exceedance of limit occurs.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Emergency discharges	No discharges from emergency locations.	<p>Trigger: Discharge from a non-EPL defined, emergency discharge location.</p> <p>Action: Investigate cause for discharge and if the appropriate procedures were followed.</p> <p>Undertake dewatering of relevant storages to areas where capacity exists.</p> <p>Undertake water quality sampling of discharge and add flocculant as necessary.</p>	<p>Trigger: Continued discharge from a non-EPL defined, emergency discharge location.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Investigate cause for discharge and if the appropriate procedures were followed.</p> <p>Undertake water quality sampling of discharge and add flocculant as necessary.</p> <p>Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact.</p> <p>Review adequacy of storage design, dewatering procedure and inspection schedule.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE if exceedance of limit occurs.</p>

F.5 Groundwater environment

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater level	Monitored groundwater levels are greater than the groundwater level triggers specified in Table 6.4.	<p>Trigger: Monitored groundwater levels are consistently below the groundwater level triggers specified in Table 6.4. for more than three (3) consecutive months.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Undertake investigation to determine if the change in groundwater level is due to mining-related activities.</p>	<p>Trigger: Investigation into Stage 1 trigger identifies that trigger exceedance is due to mining-related activity and is outside predictions from the groundwater model and EIS.</p> <p>Community complaint to Centennial Airly regarding groundwater levels.</p> <p>Action: Verify whether monitoring results are consistent with hydrogeological model predictions and consider model recalibration.</p> <p>If impacts on any identified GDEs are unacceptable, then mitigation measures will be considered (refer Appendix H).</p> <p>Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial Airly.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE and any potentially affected landowners as soon as practicable if investigation triggered by Stage 2 identifies that the change in groundwater level is mining-related.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater quality	Groundwater quality within or below values specified in Table 6.5.	<p>Trigger: Groundwater quality is outside or above the values specified in Table 6.5 for at least one parameter for three consecutive sampling events.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Undertake investigation to determine if the change in groundwater quality is due to mining-related activities.</p>	<p>Trigger: Investigation into Stage 1 trigger identifies that trigger exceedance is due to mining-related activities and outside predictions of EIS.</p> <p>Community complaint to Centennial Airly regarding groundwater quality.</p> <p>Action: If environmental impacts are unacceptable and/or if the beneficial use of the groundwater changes, remediation options will be considered (refer Appendix H).</p> <p>Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial Airly.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE and any potentially affected landowners as soon as practicable if investigation triggered by Stage 2 identifies that the change in groundwater quality is mining-related.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater inflow	Groundwater inflow into the mine is consistent with hydrogeological model predictions and below licensed volumetric limit.	<p>Trigger: Groundwater inflows exceed predicted rates by more than 10% for three consecutive months.</p> <p>Action: Review monitoring and inflow estimation methodology and validate groundwater inflow volume data.</p> <p>Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Undertake investigation to determine cause of the change in groundwater inflow volume.</p>	<p>Trigger: Groundwater inflows exceed predicted rates by more than 20% for three consecutive months.</p> <p>Inflow volume likely to exceed licensed limit.</p> <p>Action: Review monitoring and inflow estimation methodology and validate groundwater inflow volume data.</p> <p>Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Undertake review of hydrogeological model predictions for groundwater inflows into the mine. Update and/or recalibrate the hydrogeological model and site water balance model as necessary.</p> <p>Modify site water management where possible to accommodate change in dewatering volume.</p> <p>Obtain additional groundwater licence allocations if necessary.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE if exceedance of limit occurs.</p>

F.6 Stream health

Aspect	Normal	Stage 1	Stage 2	Notifications
Watercourse instabilities (third order streams)	Watercourse monitoring indicates no areas of instabilities.	<p>Trigger: Visual inspection indicates one or more areas of minor instability.</p> <p>Action: Review historical monitoring records.</p> <p>Investigate the factors contributing to the instability, which may include advice from technical specialists.</p> <p>Implement corrective actions as required as soon as practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation (refer Appendix H).</p> <p>Increase monitoring frequency and undertake additional monitoring where relevant.</p>	<p>Trigger: Visual inspection indicates one or more areas of instabilities in watercourses causing sediment loads to migrate and/or impact riparian vegetation.</p> <p>Action: Immediately isolate areas of instability and implement remediation measures to stabilise surface and/or watercourse.</p> <p>Investigate the factors contributing to the instability, which may include advice from technical specialists.</p> <p>Implement corrective/preventative actions based on the outcomes of the investigation and/or additional monitoring (refer Appendix H). Prioritise actions based on the risk to the environment and likelihood of further impact.</p> <p>Increase monitoring frequency and undertake additional monitoring (e.g. watercourse stability, water quality, aquatic ecology) where relevant.</p> <p>Review WMP and related procedures to prevent reoccurrence.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
Watercourse instabilities (all other streams)	Subsidence levels are within predictions.	<p>Trigger: Subsidence levels 1.5 times greater than predicted values.</p> <p>Action: Undertake visual monitoring of watercourses to identify any instabilities that may have formed.</p>	<p>Trigger: Investigation into Stage 1 trigger indicates watercourse instabilities.</p> <p>Action: Review historical monitoring records.</p> <p>Investigate the factors contributing to the instability, which may include advice from technical specialists.</p> <p>Implement corrective actions as required as soon as practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation (refer Appendix H).</p> <p>Undertake additional monitoring (e.g. watercourse stability, water quality, aquatic ecology) where relevant.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.</p>
Instream vegetation	Extent and quality of instream vegetation is consistent with historical monitoring results.	<p>Trigger: Visual inspections show change in extent and density of instream vegetation not specific to season. Introduction or increase in number of exotic species.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Investigate cause for change in instream vegetation and if the appropriate procedures were followed.</p>	<p>Trigger: Visual inspections show significant change in extent and density of instream vegetation as a result of clearing or impact.</p> <p>Action: Increase monitoring frequency and undertake additional monitoring (e.g. watercourse stability, water quality, aquatic ecology) where relevant.</p> <p>Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact.</p> <p>Stabilise watercourse banks as necessary.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.</p>

Aspect	Normal	Stage 1	Stage 2	Notifications
In situ water quality	In situ water quality is consistent with historical monitoring results.	<p>Trigger: Water quality is not consistent with historical monitoring results.</p> <p>Action: Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) to identify any potentially contributing factors.</p> <p>Investigate the source of the variability and develop corrective/preventative actions based on the outcomes of the investigation (refer Appendix H).</p> <p>Increase monitoring frequency and undertake additional monitoring where relevant.</p>	<p>Trigger: Water quality continues to not be consistent with historical monitoring results after Stage 1 actions are implemented.</p> <p>Action: Determine if an incident has potentially occurred.</p> <p>Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring (refer Appendix H). Prioritise actions based on the risk to the environment and likelihood of further impact.</p> <p>Review the WMP and related procedures to prevent reoccurrence.</p>	<p>Stage 1: Notify Environment and Community Coordinator/Mine Manager as soon as practicable.</p> <p>Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.</p> <p>Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.</p>

Appendix G – Independent review of groundwater management plan

Comment	Response
Review groundwater triggers to ensure that none are based on unsaturated values from the VWPs.	Table 6.4 has been updated to remove triggers that are based on unsaturated pressures.
Update the VWP hydrographs in Appendix C and remove any unsaturated pressures.	Hydrographs have been updated. A note has been added to denote where pressures are unsaturated.
Revise analytical suite for both surface water and groundwater samples.	The analytical suite for surface water and groundwater samples outlined in Table 4.1 and Table 4.4 has been updated. Generally parameters that have consistently been below LOR have been removed from the analytical suite.

Appendix H – Surface and groundwater remediation measures

H.1 Background

Surface water and groundwater remediation strategies can take one of two forms:

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

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

Potential engineering solutions may include but are not limited to those outlined below. These engineering solutions are not provided with significant detail as they only provide an indication of possible solutions as a last measure. As technology and research improves, alternative and better engineering solutions may be developed. This is why a detailed assessment and investigation needs to be instigated prior to the implementation of any engineering solutions. This should be followed by a detailed review by relevant government departments and specialist consultants.

The measures outlined below would need careful consideration and investigation by appropriate experts before they are adopted, to prevent any unintended adverse effects.

H.2 Surface water drainage to mitigate ponding

Where subsidence has resulted in a significant increase in remnant ponding, surface or subsurface water drains can be constructed to improve water carriage. These drains need to be designed to have sufficient capacity to drain areas affected by ponding. These drains are typically of a shallow design depending on existing surface gradients and direct surface water to establish drainage lines.

H.3 Infilling of surface cracks to prevent surface water loss

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

H.4 Creek realignment measures to improve flows

If sections of creek bed become hydrologically isolated or have significant areas of additional pooling caused by changes in bed gradients, then these bed sections may need to be realigned to improve flows. Realignment needs to be designed based on surveyed long sections to best suit existing creek grades. This remediation measure typically involves excavating to regrade a creek bed section or removing elevated sections causing a constriction to flow. Upstream water would need to be contained to allow excavation and following realignment similar soil material would be reinstalled to stabilise the creek bed. Permits to work within a waterway would need to be obtained from relevant government authorities prior to commencing works.

H.5 Creek bed stabilisation measures to reduce erosion

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

H.6 Measures to control out-of-channel erosion

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

H.7 Diversion of water into creek

When considering this action, it is important to take secondary impacts into account. These may include erosion, water quality and impacts on the vegetation and fauna.

Water can be diverted into creeks from new or existing pipelines. Depending on where the water is required, energy dissipaters can be constructed to reduce the erosivity of the water. This can be implemented by constructing stepped ponding or broad/level stilling ponds. Detailed survey will be required to design these facilities to ensure they feed water to the relevant areas. Inspections of the subject area will be carried out to monitor further erosion. It may be necessary to vary the rate at which water is released or install natural snags to dissipate energy further or further stabilise banks.

H.8 Sub-surface drains

If different areas become hydrogeologically isolated due to excessive ground movements, one method of restoring the pre-mining groundwater table would be to install subsurface drains to equalise the groundwater in each area. Care would be required in locating the drains to ensure that the desired results are achieved. This would also necessitate detailed survey and subsurface investigation.

H.9 Grouting of rock bars

Cracking of rock bars may lead to drainage of groundwater and surface water. Where possible, grouting of these rock bars may be effective in reducing water loss. Based on the outcomes of the ongoing monitoring program and any remedial measures undertaken, an assessment should be made of the potential for similar anomalous conditions to arise in subsequent areas to be undermined. Recommendations should be made for control measures that may mitigate any such impact.

H.10 Grouting of aquifer cracks

Where cracks are identified in the near-surface aquifers that are causing loss of piezometric head, grouting may be used to fill the crack followed by re-injection of suitable water as required.

Appendix I – Typical erosion and sediment controls

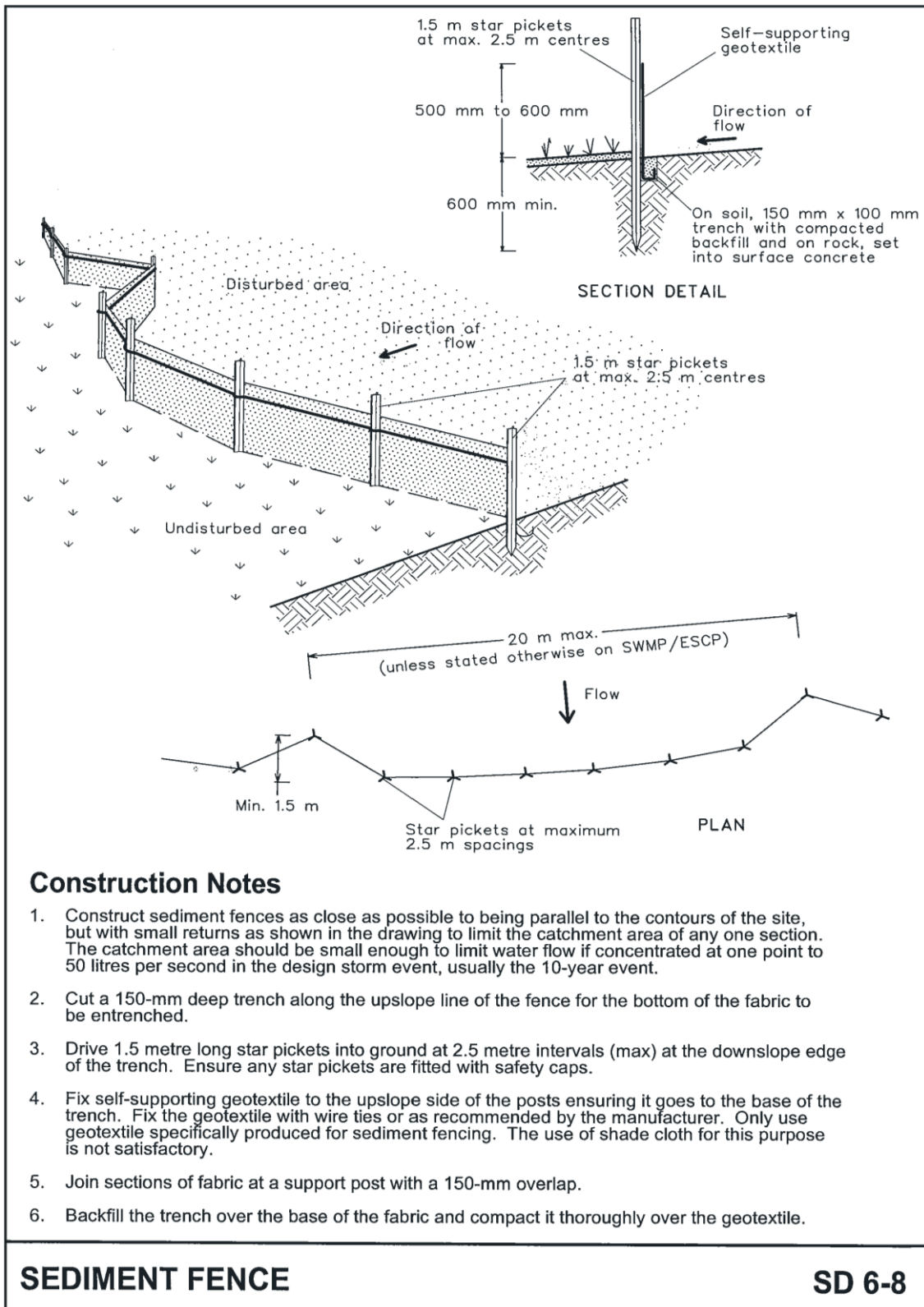


Figure I.1 Typical sediment fence (Landcom, 2008)

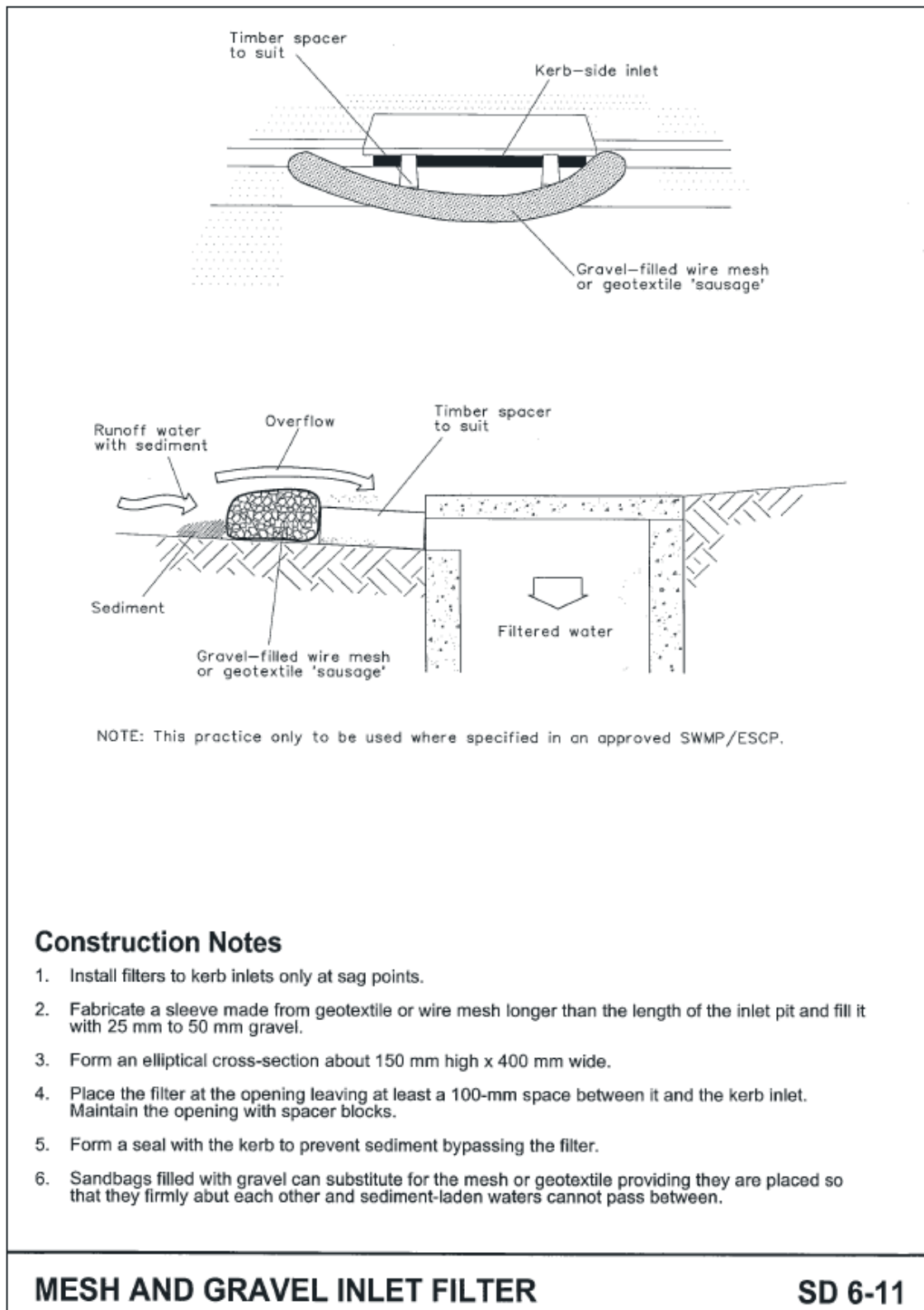


Figure I.2 Typical inlet protection measure (Landcom, 2008)

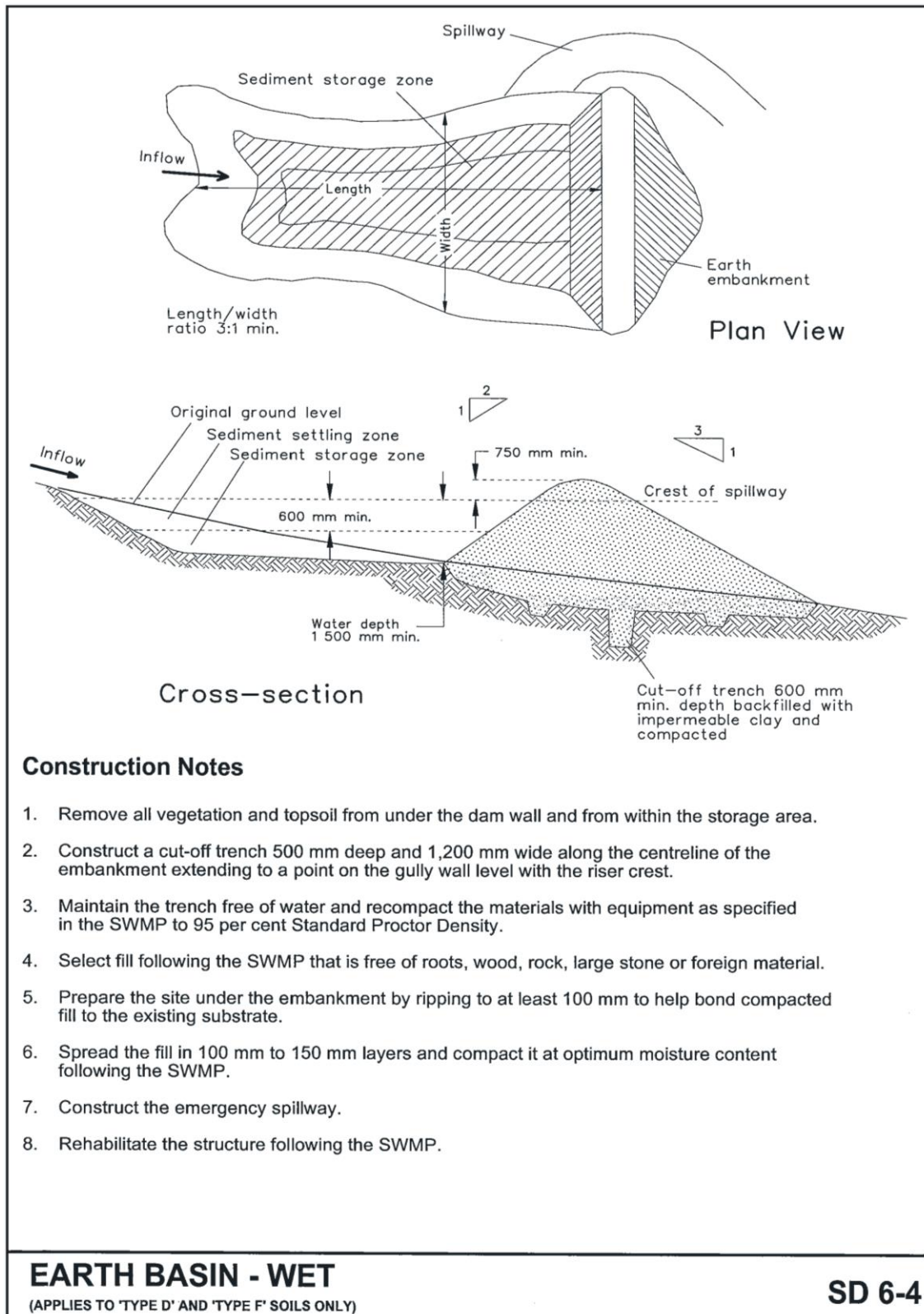


Figure I.3 Typical sediment basin (Landcom, 2008)

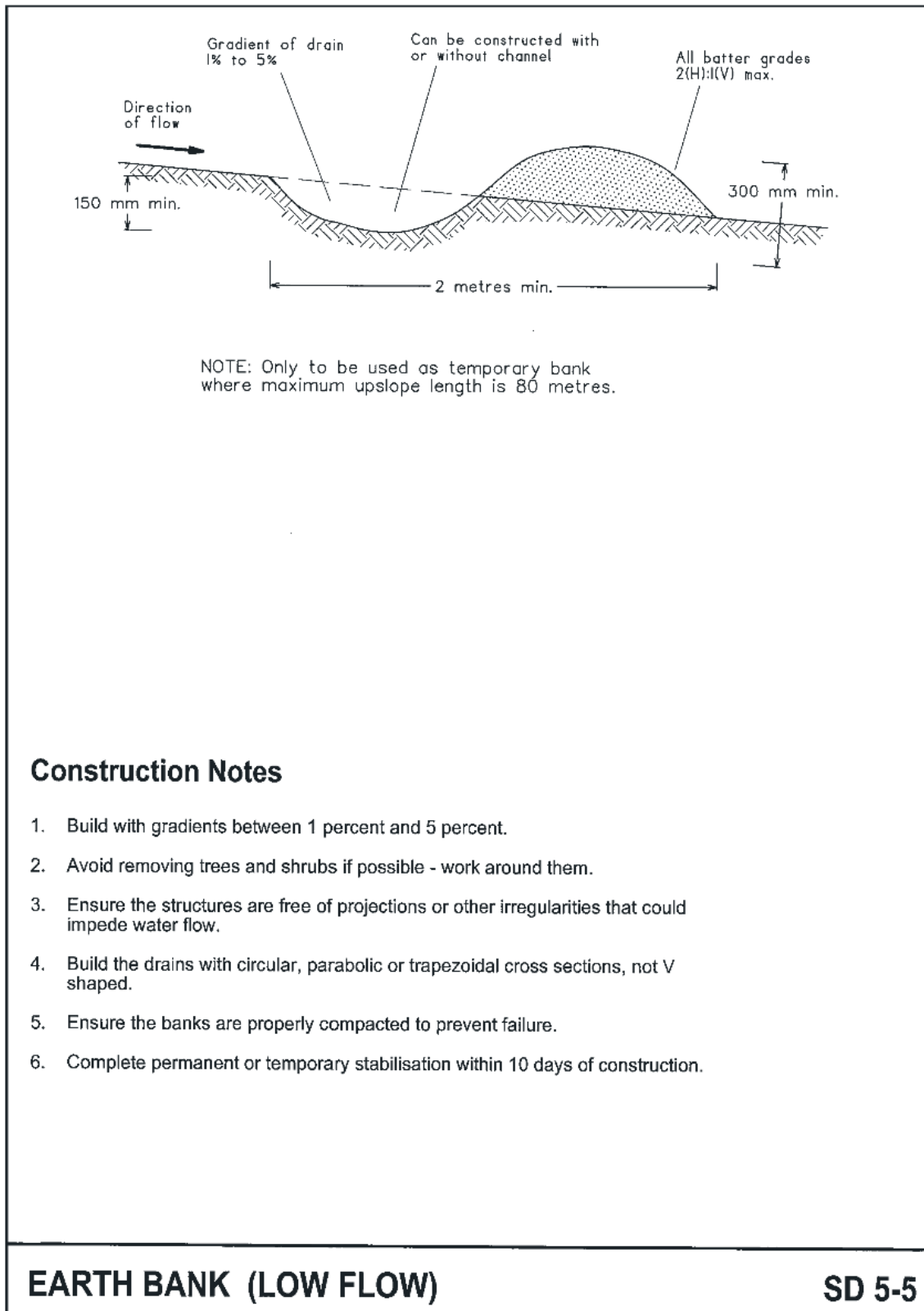


Figure I.4 Typical diversion channel (Landcom, 2008)

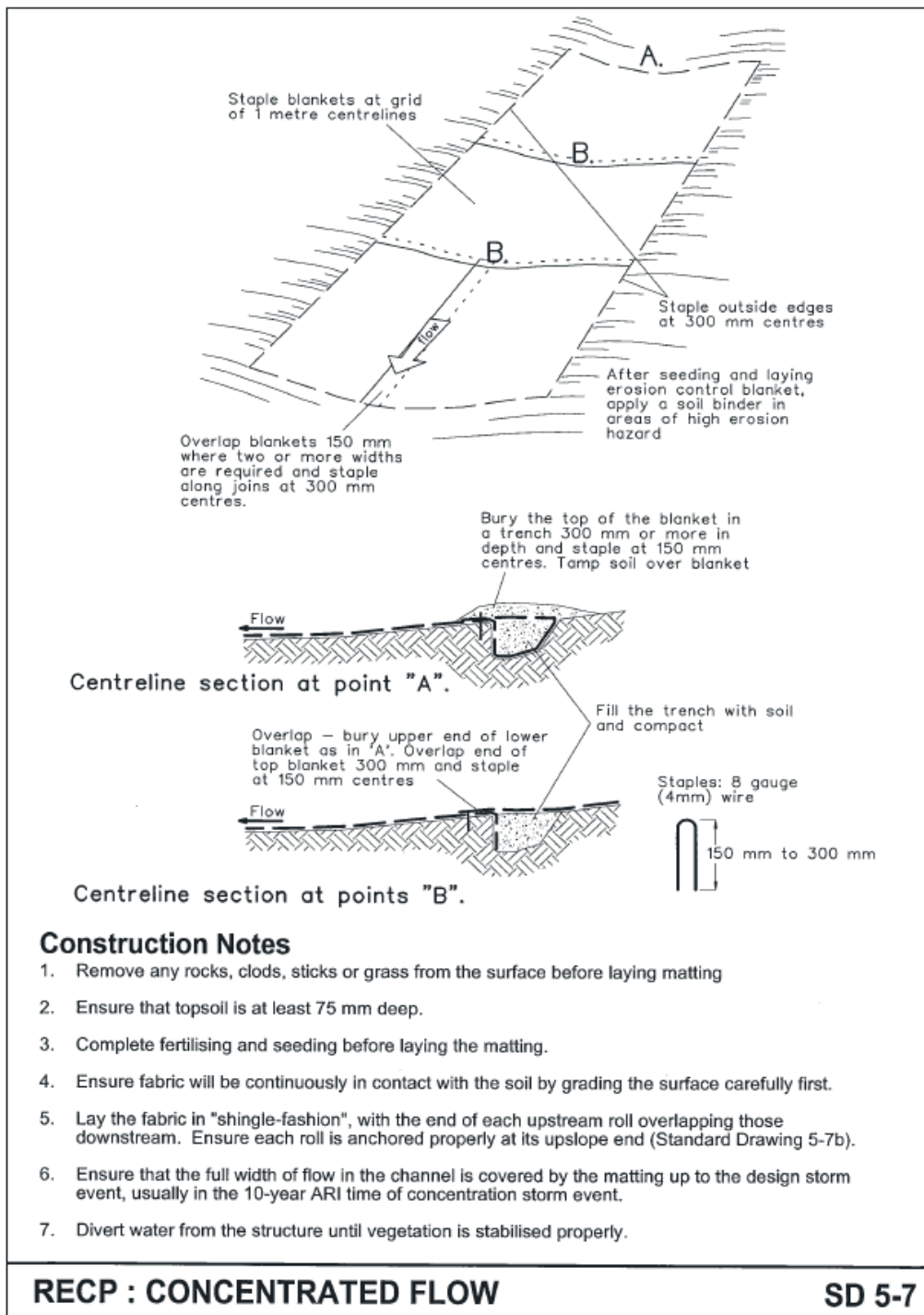


Figure I.5 Typical application of rolled erosion control products in channels

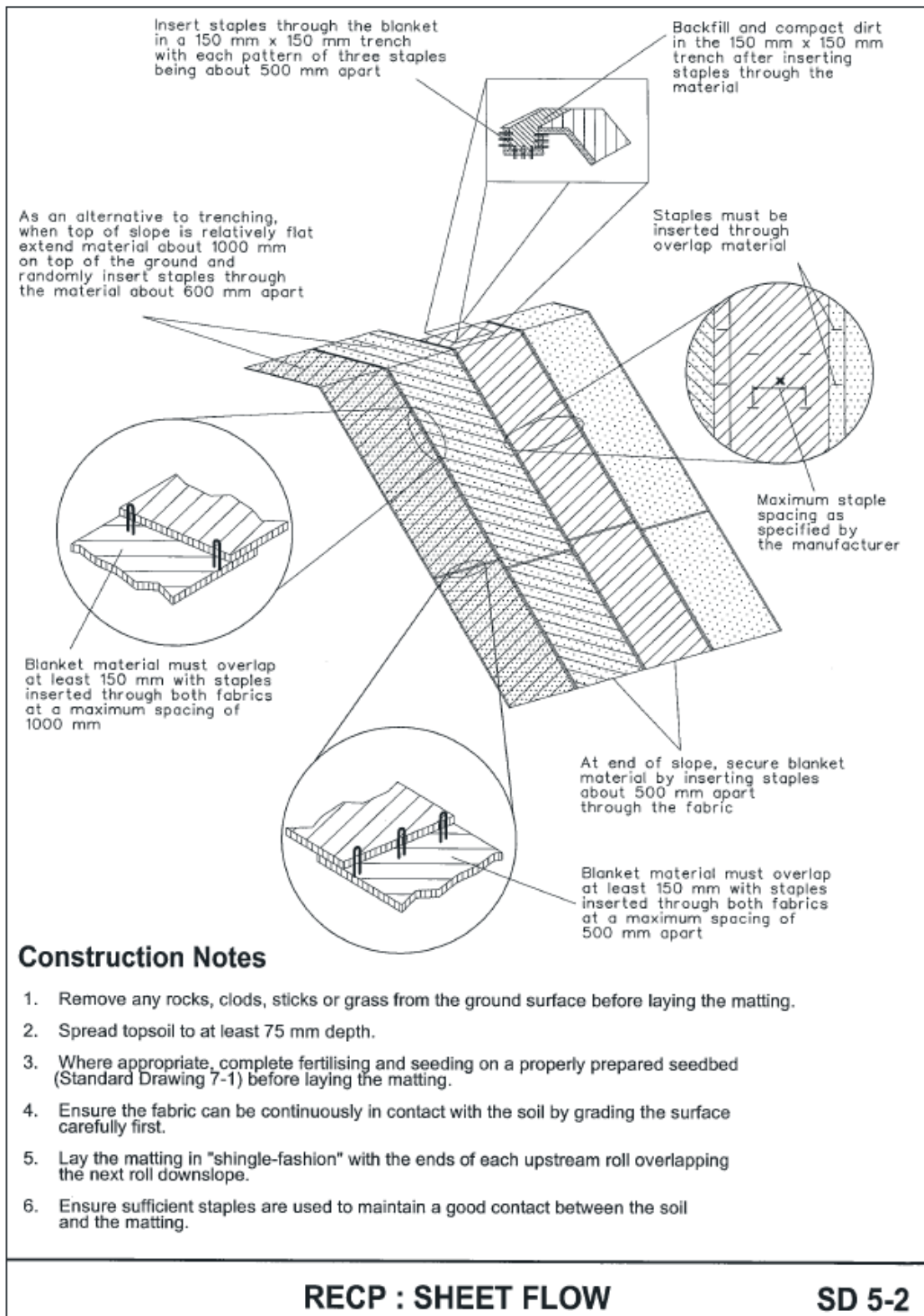


Figure I.6 Typical application of rolled erosion control products on disturbed areas

Appendix J – Surface Water Balance Modelling for TARP F2 Development



Report

16 April 2024

To	Sam Price	Contact No.	02 6359 2108
Copy to	Centennial Coal	Email	Sam.Price@centennialcoal.com.au
From	Tom Darley, Alyssa Barron	Project No.	12633022
Project Name	Centennial Airly Water Monitoring 2024		
Subject	Surface Water Balance Modelling and Proposed changes to Trigger Action Response Plans		

Dear Sam

1. Introduction

GHD Pty Ltd (GHD) was engaged by Centennial Airly Pty Ltd (Centennial) to address comments Centennial received from the NSW Department of Planning and Environment (DPIE) in response to their submission of revision 8 of the Airly Mine Water Management Plan (DPIE reference SSD-5581-PA-65). DPIE comments pertain to the development of trigger action response plans (TARPs) for surface water flow and groundwater levels. Specifically, the incorporation of measurable triggers for surface water flow and temporal scales for both surface water flow and groundwater levels.

1.1 Purpose of this report

The purpose of this report is to present a basis for the amendment of the current TARPs for surface water (F2) in line with DPIE recommendations incorporating measurable triggers for changes in surface water flow that would require further action.

1.2 Background

GHD reviewed feedback from DPE regarding the TARPs which were originally intended for a surface water specialist to make judgement on any potential changes in the rainfall-runoff response at the site based on observed flow data, meteorological conditions, and qualitative observations onsite. Given the nature of runoff at the site, the request to develop relatively simple percentage reductions triggers for F2 was considered potentially impractical on the following basis:

- A review of rainfall at the site identified that it is highly variable and produces a non-linear runoff response on an event-by-event basis (runoff not linearly proportional to rainfall). Providing a linear (e.g., a percentage reduction) representation over a short time-period would result in potentially substantially erroneous outcomes.
- To establish a linear rainfall-runoff metric, the data would need to be aggregated over a very large temporal scale (i.e. annual), and as a result, any changes in annual flow would be potentially dominated by the volumetrically larger flow events that may mask changes to smaller, day-to-day rainfall-runoff events.
- As each rainfall and runoff event is unique, it is unlikely the assessment would have an effective control or baseline to make conclusions.

2. Scope and limitations

2.1 Scope of work

Given the above, GHD proposed an alternate method utilising a water balance model and existing stream gauges. GHD developed a water balance model based on the historical flow data recorded to date, which was calibrated to measured flows. The set of calibrated model parameters (representing a catchment in a particular physical state and configuration) would be selected to represent 'baseline' conditions at the time of this report. By using the model calibrated to conditions at the time of this report, the model can be simulated with future rainfall to identify whether a potential change to the catchment's physical behaviour may have occurred.

Development of the F2 TARP would then consider the calibrated model and parameters to be a 'baseline' as of the time of this report. Changes to the rainfall-runoff response of the catchment would be assessed by simulating the model calibrated to conditions at the time of this report using future rainfall at each gauge to determine if either:

- The estimated future streamflow is similar to observed streamflow (based on a statistical metric) which suggests that catchment conditions are similar to those when the model was calibrated, OR
- The estimated future streamflow is not similar to observed stream flow (based on a statistical metric), but could otherwise be explained why the estimates were not similar to observations. This may occur, for example, because a magnitude storm, or rainfall pattern, that was not yet previously seen during the calibration period may be poorly estimated by the calibrated model for future conditions, OR
- If non-similar results were observed, this may warrant further actions – e.g., catchment review, QA/QC of streamflow for any erroneous data, recalibration of streamflow instrumentation. If non-similar results could not be explained, this may suggest a change in catchment conditions from when the model was calibrated.

To complete this scope of work, the following processes were undertaken which are detailed in following sections:

- Develop a site-specific surface water balance model using the Australian Water Balance Model (AWBM – per Boughton et. al, 2003).
- Calibrate of the model using observed datasets from the three flow gauges (one in Gap Creek and two in Genowlan Creek).
- Develop an uncertainty analysis to identify the 'baseline' range of model parameters reflective of the catchment and its physical condition.
- Develop a procedure for model predictions and revise surface water flow TARP (F2) to quantify the trigger for the Water Management Plan

2.2 Limitations

This report: has been prepared by GHD for Centennial Airly Pty Ltd and may only be used and relied on by Centennial Airly Pty Ltd for the purpose agreed between GHD and Centennial Airly Pty Ltd as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Centennial Airly Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

GHD has prepared this report on the basis of information provided by Centennial Airly Pty Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the Water Balance Model (“Model”) for, and for the benefit and sole use of, Centennial Airly Pty Ltd to support investigations of rainfall-runoff processes at the site and must not be used for any other purpose or by any other person. The Model is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD’s scope. The information, data and assumptions (“Inputs”) used as inputs into the Model are from publicly available sources or provided by or on behalf of the Centennial Airly Pty Ltd, (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD’s scope of work does not include review or update of the Model as further Inputs becomes available. The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed. The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Model including any outputs.

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

3. Development of a surface water balance model

3.1 Catchment properties

To establish a baseline catchment condition to assess future changes to streamflow behaviour (if any), a water balance model was developed for three gauged surface-water flow sites at the Airly mine. Publicly available LiDAR information was sourced to determine the catchment areas that drain through these three gauges. Catchment delineation is shown in Figure 2 with key properties shown in Table 1.

Table 1 Catchment properties

Parameter	Genowlan Creek #1	Genowlan Creek #2	Gap Creek
Total catchment area	82.39 ha	201.76 ha	320.1 ha
Flows to	Genowlan Creek #2	Offsite	Offsite
Average slope	11.11%	7.89%	15.63%
Main stream length	0.84 km	1.25 km	3.01 km
Main stream slope	7.41%	8.98%	9.14%

Prior to developing a water balance model, the catchment properties were reviewed alongside recent observations within the catchments to determine the potential runoff-response for future investigation:

- Vegetative cover and shading of flow pathways are likely to result in reduced actual evapo-transpiration compared to potential evapo-transpiration from the catchment.
- The presence of rocky-outcrops coupled with steep catchment slopes and stream-slopes, is likely to result in a rapid runoff response, particularly in the relatively steeper Gap Creek catchment. Given the size of the upstream catchment of Genowlan Creek #2 and its relatively flatter hill slope and stream slope, there is potential for small quantities of base-flow, although could be dry during extended dry periods. Genowlan Creek #1 would be expected to be similar to Gap Creek, with peaky runoff in response to rainfall events.

- Storages within the catchments would be expected to be variable and generally controlled by pools with varying depths and level of shading. Given the proximity within the regional catchment, it is likely that a large portion of water infiltrates and is potentially expresses at lower elevations

3.2 Model selection

Given the variability of pools and flow conditions within each catchment, the Australian Water Balance Model (AWBM) runoff representation was utilised. The AWBM is a catchment water balance model that relates rainfall and evapotranspiration to runoff, and calculates losses from rainfall for flow modelling. The model contains five stores; three surface stores to simulate partial areas of runoff, a base flow store and a surface runoff routing store as shown in Figure 3. The model was simulated on a daily time-step to reduce computational time, and as additional benefits from a sub-daily time-step were not anticipated.

3.3 Meteorological data

Meteorological data was collected from the site rainfall gauge (reference: Airly Mine AWS01, which is located on Genowlan Mountain) as well as from the SILO Long-paddock tool, centred on the site (<https://www.longpaddock.qld.gov.au/> extracted coordinates -33.10, 150.05 from 01/01/2000 until 06/03/2024). SILO aggregates publicly available meteorological data from a range of weather stations in Australia and interpolates weather observations to create a spatially and temporally continuous dataset across Australia. Data analysed for modelling included point-potential-evapotranspiration as well as rainfall data. Rainfall data from the site rainfall gauge was utilised over the SILO rainfall data where available which was generally available from 2018 onwards.

A comparison of rainfall recorded at the Site gauge and from SILO was undertaken from 2/3/2018 until 05/03/2024 to identify any differences in rainfall behaviour. As SILO relies on interpolation of publicly available data, there is the potential for deviations from site rainfall as a result of:

- Small (in spatial extent) storms over the site that were not observed at all nearby gauges
- Orographic effects as the catchments of interest have an elevation ranging from approximately 670 mAHD to 1040 mAHD, and while two nearby gauges are at similar elevations, rainfall interpolation may be skewed by observations at Glen Alice which has approximately 350 m less elevation than the site as shown below:
 - 63012 Running Stream (Brooklyn): 1070 mAHD
 - 61334 Glen Alice: 320 mAHD
 - 63132 Lidsdale (Maddox Lane): 890 mAHD

Cumulative rainfall depths were compared, as shown in Figure 1, that indicate that:

- Generally, the site receives less rainfall than the SILO point interpolation, approximately 8% less over 6 years, or roughly 1.3% less per year.
- Rainfall at the site appears to peak higher for select storm events, for example March 2020 and March 2021
- As some storm events have higher rainfall peaks than those estimated in the SILO dataset, and as the site generally receives less annual rainfall than in the SILO dataset, this would potentially suggest that day-to-day rainfall and small storm events at the site are lesser than those observed in nearby gauges. Accordingly, calibrating the model using SILO rainfall data may lead to over-estimates of baseflow conditions and under-estimates of peaks as a result of the differing rainfall behaviour.

On this basis, it was selected that calibration would be undertaken only using site rainfall data from the period of 2/3/2018 until 05/03/2024, with simulation of earlier data potentially useful as a pseudo-validation.

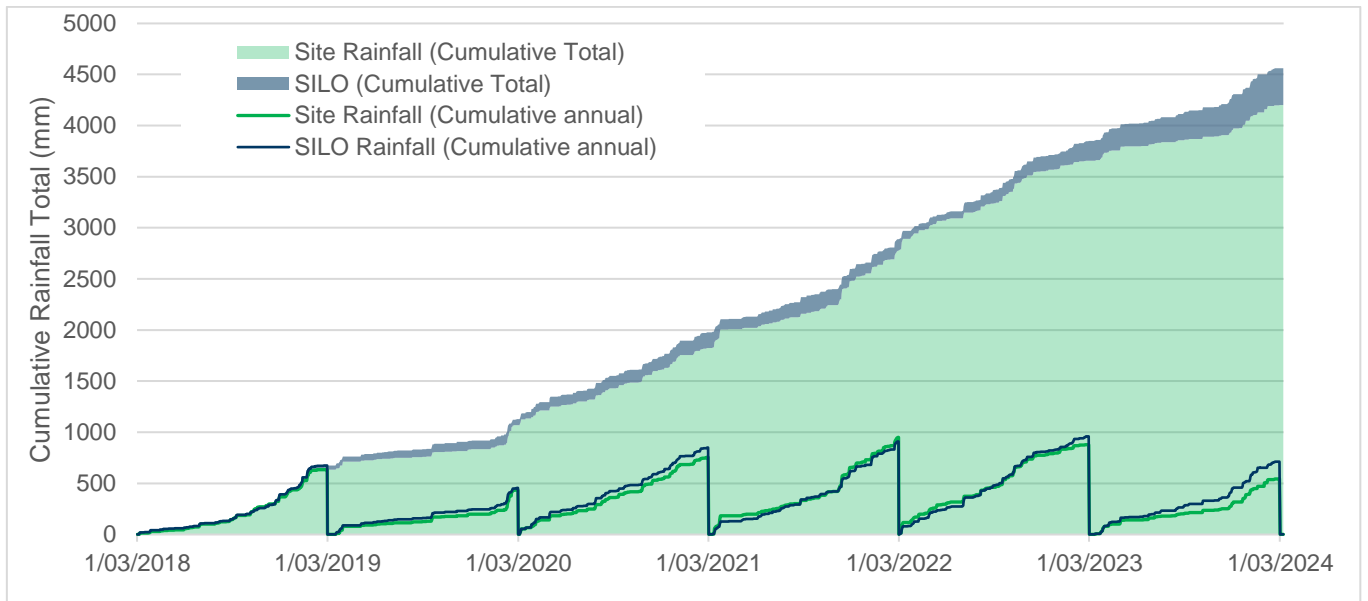


Figure 1 Comparison of cumulative rainfall at the site gauge and using SILOs point interpolation data

3.4 Flow data

Flow data is collected at three gauges. The raw data was provided by Centennial and utilised for the modelling calibration. Where data was not available, the flow value for the purpose of calibration was linearly interpolated.



Figure 2 Catchment Delineation for Gauge Locations of Interest

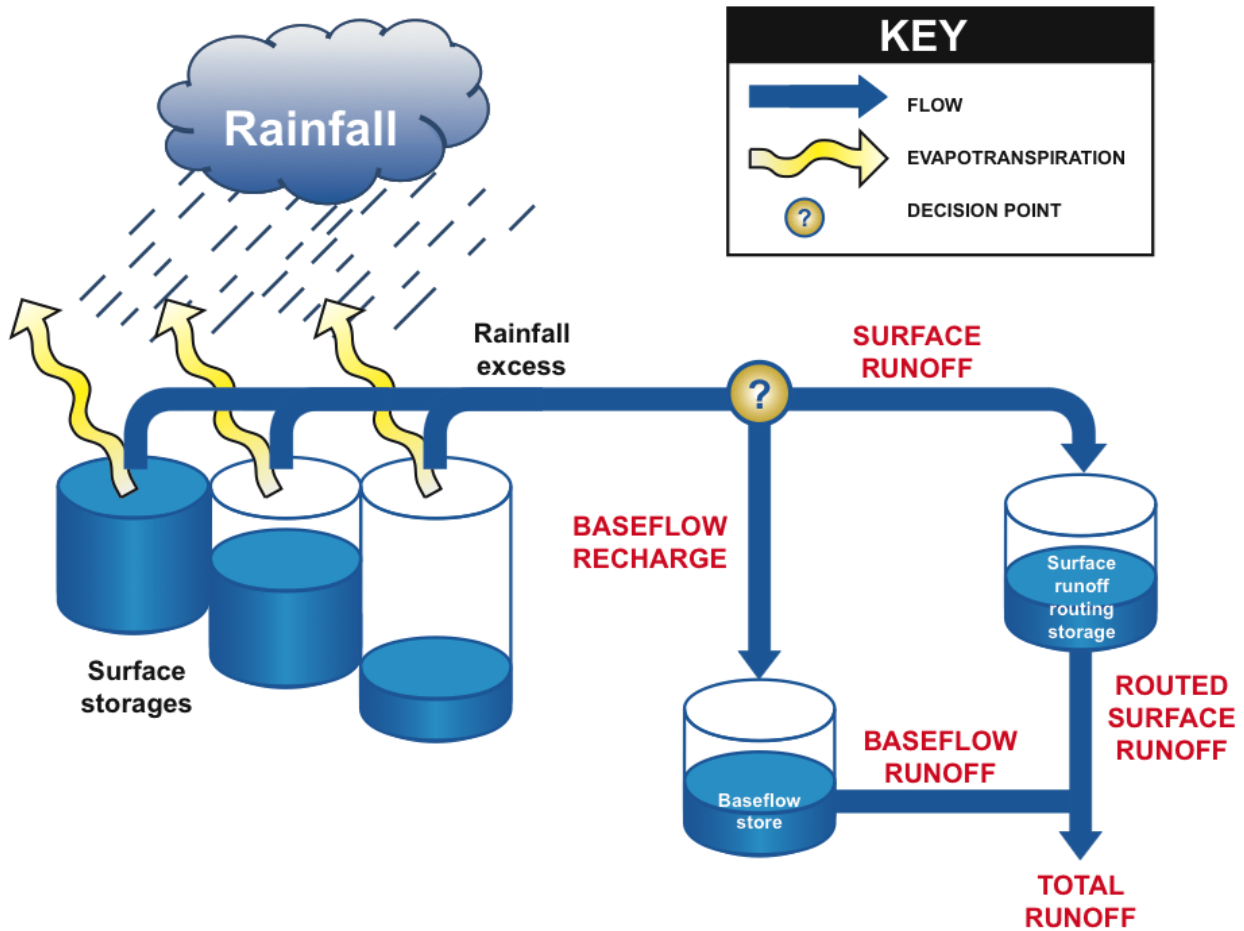


Figure 3 Structure of the Australian Water Balance Model Results (reproduced eWater, 2024)

4. Calibration results

While data availability for Genowlan Creek #1 gauge was only available until 21-February-2024, calibration was undertaken as a comparison point for Genowlan Creek #2 gauge given the longer temporal-scale. Future studies should consider Genowlan Creek #2 to reflect the Genowlan Creek catchment.

Calibration of model parameters was undertaken using the Nash-Sutcliffe model efficiency coefficient (NSE) which is a commonly used metric to assess the predictive skills of hydrological models. It is calculated as one minus the error variance of the model divided by the variance of the observed and ranges from 1 (a perfect fit) to 0 (the model is as accurate as assuming the average observed flow). Negative values indicate that the model is less accurate than assuming the average observed flow.

$$NSE = 1 - \frac{\sum_{t=1}^T (Q_o^t - Q_m^t)^2}{\sum_{t=1}^T (Q_o^t - \bar{Q}_o)^2}$$

Where the model is simulated for some time (T) and at each timestep (t) the variance is calculated using the observed flow (Q_o^t), the modelled flow (Q_m^t) and the average observed flow (\bar{Q}_o).

As per Moriasi et al., (2015), a NSE result lesser than 0.5 is considered unsatisfactory, a value between 0.5 and 0.7 is considered satisfactory, a value between 0.7 and 0.8 is considered good, and a result greater than 0.8 is considered very good. As shown in Table 2, model calibration was good for all. In addition to a good statistical calibration, visual consideration of runoff behaviour was also undertaken, with calibrated model results shown in Figure 4, Figure 5, and Figure 6. These results suggest that:

- The fit at Genowlan Creek #1 gauge is generally satisfactory, with runoff peaks represented, matching the observed timing, and generally appear suitable.
- Calibration at Genowlan Creek #2 gauge was good, with general agreeance between observed and model behaviour with regards to flow peaks, timing, decay and baseflow.
- Calibration at Gap Creek was good and since 2019 rainfall-runoff behaviour particularly well matches between modelled and observed.
- Calibration overall was a success at all three gauges.

Table 2 Calibration model statistical results

Model Results	Genowlan Creek #1	Genowlan Creek #2	Gap Creek
Calibration NSE	0.709	0.739	0.744
Period of calibration	02-03-2018 to 21-02-2024	04-05-2019 to 05-03-2024	02-03-2018 to -05-03-2024

The calibrated datasets for the three gauges are tabulated in Table 3.

Table 3 Calibrated Model Parameters

Parameter	Definition	Genowlan Creek #1	Genowlan Creek #2	Gap Creek
Kb	Speed of baseflow discharge (1 is slow, 0 is fast)	0.969	0.977	1.000
Ks	Speed of surface runoff discharge (1 is slow, 0 is fast)	0.738	0.900	0.908
BFI	Proportion of rainfall excess which flows to baseflow	0.450	0.740	0.729
A1	The proportion of catchment area of the first surface store.	28.2%	14.3%	3.9%
A2	The proportion of catchment area of the second surface store.	39.2%	27.5%	17.7%
A3	The proportion of catchment area of the third surface store.	32.6%	58.2%	78.9%
C1	The average depth of the first storage store	38.7 mm	6.3 mm	11.9 mm
C2	The average depth of the second storage store	127.2 mm	142.9 mm	151.2 mm
C3	The average depth of the third storage store	492.1 mm	497.0 mm	424.6 mm
PET Factor	A factor on potential evapo-transpiration (PET) to account for differences between potential and actual PET (e.g., from shading).	67.57%	67.50%	51.28%

Pseudo-validation of model results prior to March 2018 were undertaken for Gap Creek and Genowlan Creek. As previously discussed regarding meteorological data, this results in an under-estimate of peaks and an over-estimate of baseflow which resulted in unsatisfactory statistical outcomes. This suggests that publicly available SILO data should not be utilised with the developed water balance model.

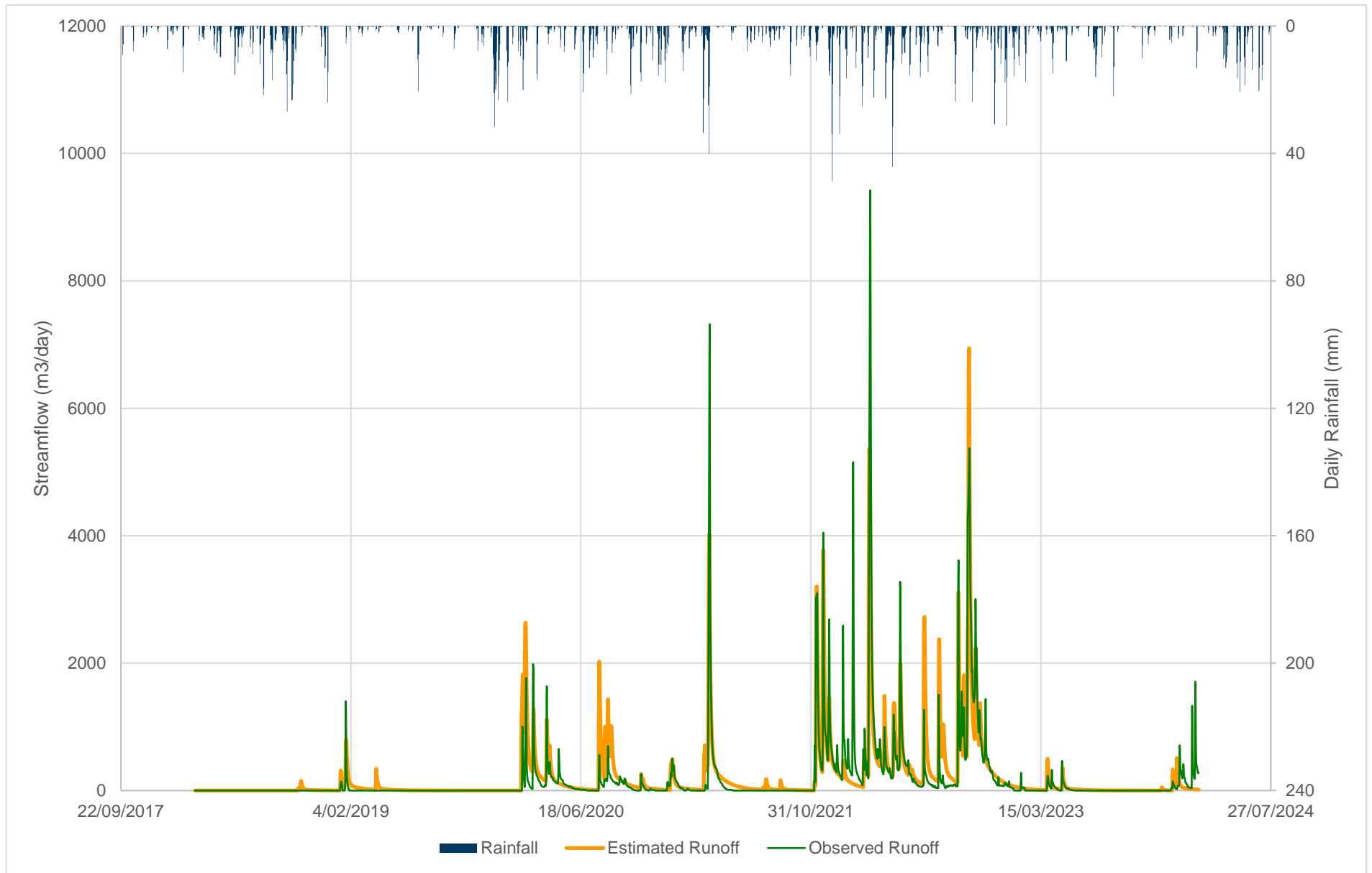


Figure 4 Model Calibration at Genowlan Creek #1 Gauge

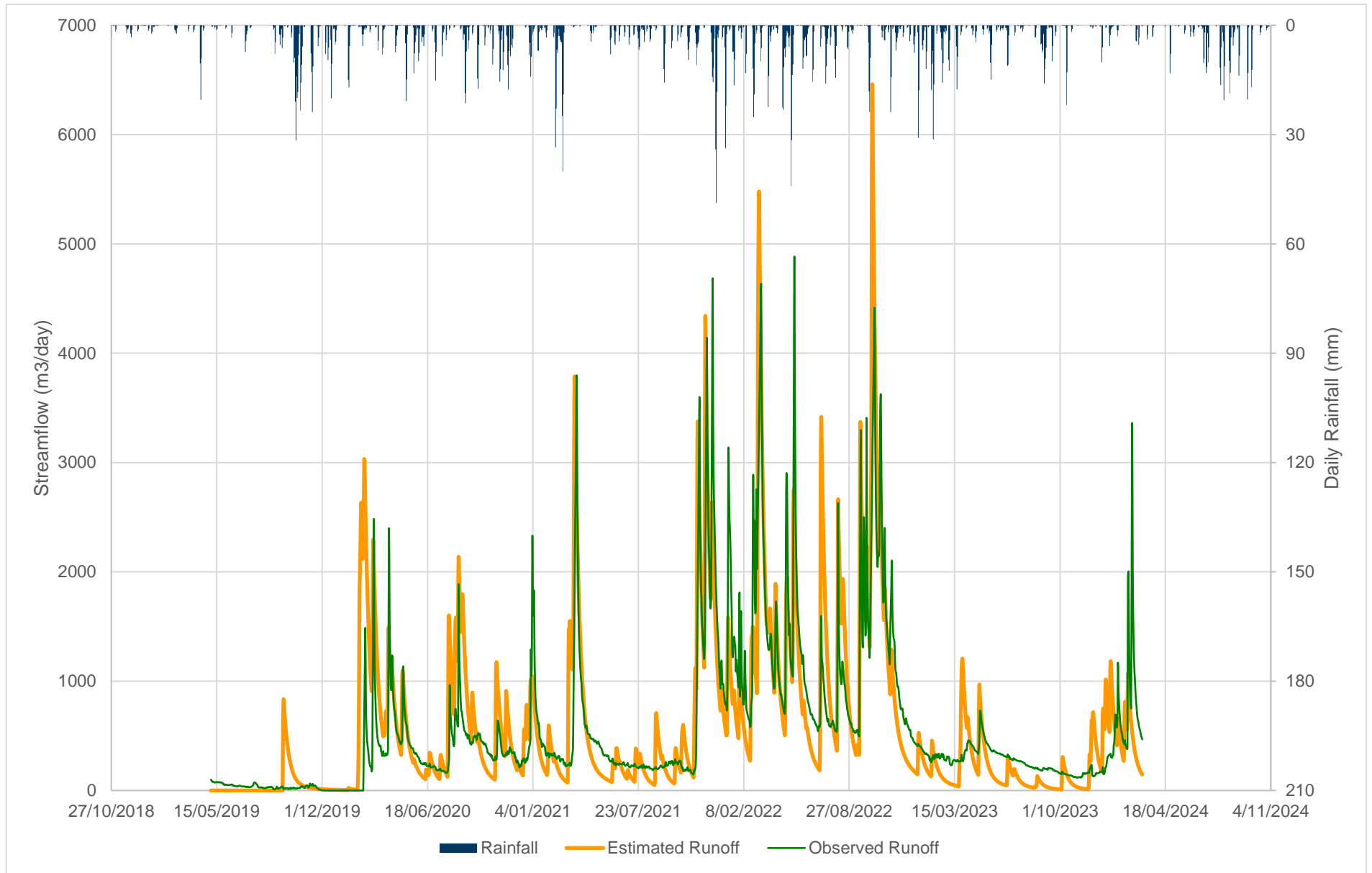


Figure 5 Model Calibration at Genowlan Creek #2 Gauge

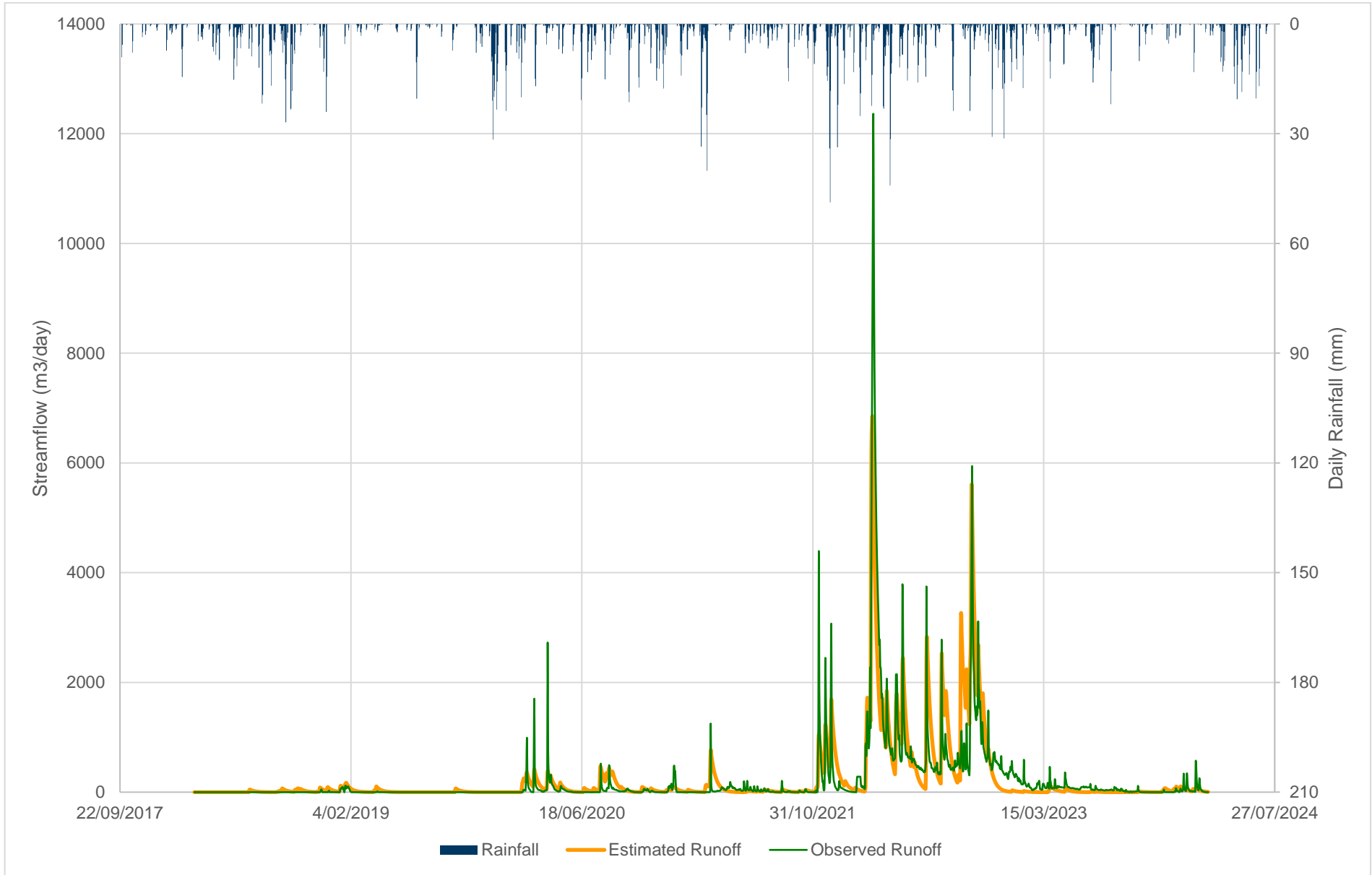


Figure 6 Model Calibration at Gap Creek Gauge

5. Uncertainty analysis

An uncertainty analysis was undertaken by individual model parameters and determining the range for each parameter at which model calibration would be unsatisfactory (NSE < 0.5), satisfactory (NSE > 0.5), acceptable (NSE > 0.6), or good (NSE > 0.7) for the Gap Creek Gauge as well as Genowlan #2 Gauge. Results are tabulated below.

Table 4 *Uncertainty analysis at Gap Creek Gauge based on NSE outcomes*

Parameter	Unacceptable NSE	Satisfactory NSE	Acceptable NSE	Good NSE
Kb	Kb ≠ 1	Kb ≠ 1	Kb ≠ 1	Kb ≠ 1
Ks	< 0.81 or > 0.97	0.81 – 0.97	0.83 – 0.96	0.89 – 0.94
BFI	< 0.60 or > 0.87	0.60 – 0.87	0.62 – 0.84	0.68 – 0.79
A1	> 33%	0% - 33%	0% - 27%	0% - 16%
A2	No Limit	0% - 100%	0% - 81%	0% - 53%
A3	This parameter is calculated as 100% – A1 – A2 and was not assessed			
C1	No Limit	No Limit	No Limit	No Limit
C2	No Limit	No Limit	No Limit	18.5 mm – 200 mm
C3	< 130 mm	130 mm – 500 mm	268.6 mm – 500 mm	363.9 mm – 480 mm
PET Factor	< 46.0% or > 54.3%	46.0% to 54.3%	47.1% to 54.3%	50.2% to 53.3%

Table 5 *Uncertainty analysis at Genowlan Creek #2 Gauge based on NSE outcomes*

Parameter	Unacceptable NSE	Satisfactory NSE	Acceptable NSE	Good NSE
Kb	< 0.94	0.94 – 1.00	0.96 – 1.00	0.98 – 0.99
Ks	< 0.57	0.57 – 1.00	0.66 – 1.00	0.79 – 0.98
BFI	< 0.14	0.14 – 1.00	0.27 – 1.00	0.47 – 0.97
A1	< 5% or > 23%	5% - 23%	7% - 21%	16% - 18%
A2	< 1% or > 54%	1% - 54%	7% - 48%	16% - 39%
A3	This parameter is calculated as 100% – A1 – A2 and was not assessed			
C1	No Limit	No Limit	0 mm – 36.6 mm	0 mm – 17 mm
C2	< 61.2 mm	61.2 mm – 200 mm	78.7 mm – 200 mm	105.0 mm – 200 mm
C3	< 385.4 mm	385.4 mm – 500 mm	405.7 mm – 500 mm	426 mm – 500 mm
PET Factor	< 62%	62% - 100%	62% - 88.1%	63.4% - 76.1%

Outcomes of the uncertainty analysis considered the following:

- The baseflow recession constant (Kb) is a key parameter and generally high results between 0.94 and 1.00 are necessary to provide a satisfactory model. This indicates a large portion of rainfall flows to subsurface flow that bypasses the gauge.
- The surface recession constant (Ks) is less sensitive than baseflow recession with an acceptable range of 0.94 to 0.97 for both sites. Both models would provide good outcomes for Ks between 0.89 and 0.94.
- The baseflow index (BFI) varies between sites but satisfactory outcomes for both gauges occur between 0.64 and 0.87. Both models report good outcomes for BFIs between 0.68 and 0.79.
- There are wider margins on the surface stores in terms of depth and areas. Generally:
 - Best estimate is that between 16% of the catchment potentially has around 17-18 mm of storage. Potentially around 5% to 23% of the catchment has storage up to 50 mm.

- Another portion of the catchment making up approximately 16% to 39% of the catchment with depths between 105 mm and 200 mm. Potentially this portion of the catchment is between 1% and 54% with between 61 mm and 200 mm of catchment.
 - The remainder of the catchment has larger quantities of storage with a best estimate range of 426 mm to 480 mm. Potentially the storage is between 385 mm and 500 mm.
- PET factors between the two gauges vary and would be expected to be between 46.0% and 54.3% at Gap Creek. This parameter is less sensitive at Genowlan Creek with the likely range between 62% to 100% with a best estimate of 63.4% to 76.1%.

6. Updated Trigger Action Response Plan

An update to the Trigger Action Response Plan (TARP) is proposed to reflect this study. This study found that a water balance model could be calibrated to observed streamflow with good calibration results. Accordingly, the water balance model would be expected to be able to suitably predict future streamflow for the style of events the gauge was calibrated to. During quarterly investigations of surface water flow at the site, the calibrated model should be used to estimate runoff using observed rainfall for the previous six-month period for comparison to observed flows at the gauges. The following TARP is proposed as shown in Figure 7.

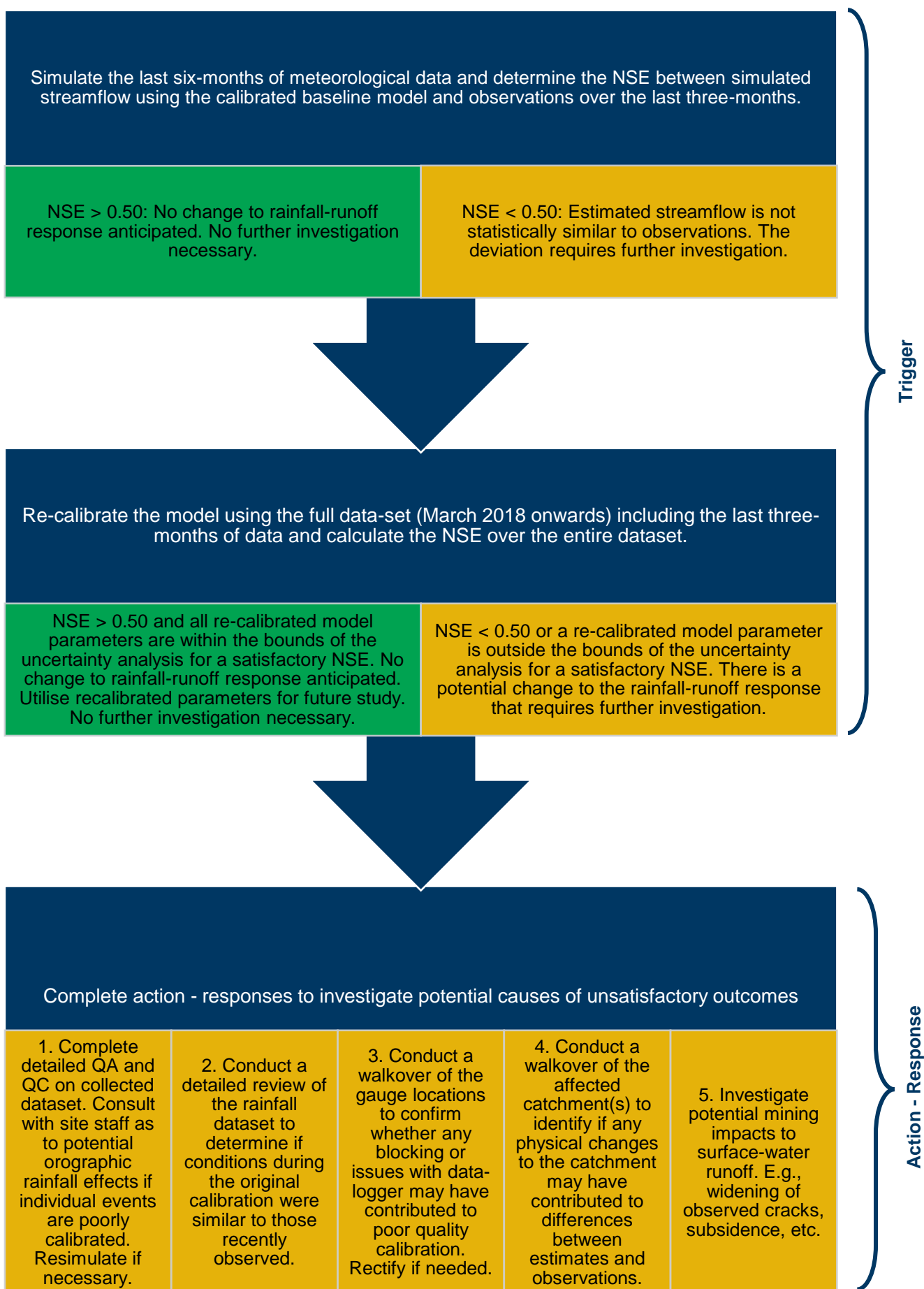




Figure 7 Proposed Trigger Action Response Plan

7. Conclusion

A water balance model was established to estimate streamflow at the Airly Mine. This model was established for the purpose of assessing changes to rainfall-runoff response at the site, specifically with respect to the Trigger Action Response Plan (TARP) item F2, in response to comments provided from DPE. The model was developed and calibrated to conditions occurring at the time of this report using historical observations. The calibrated model established a baseline set of model parameters for the Australian Water Balance Model (AWBM) which reflects the current catchment properties and the current rainfall-runoff response. Statistics associated with the AWBM calibration had good outcomes, indicating the model was able to recreate observations at three stream gauges within the expected parameter bounds.

During future quarterly monitoring at the site, the baseline model could be run with recent meteorological data using the calibrated baseline model parameters; and the outputs from this model could be compared to observed streamflow to determine the level of similarity between the two datasets. Datasets which are in good agreement would suggest no notable changes to catchment characteristics or the rainfall-runoff response, whereas deviation between the two datasets may warrant further investigation of the catchment behaviour.

A proposed process for TARP F2 was established and will be reflected in the Water Management Plan.

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GHD Pty Ltd | ABN 39 008 488 373

Contact: Tom Darley, Senior Water Resource Engineer | GHD

133 Castlereagh Street, Level 15

Sydney, New South Wales 2000, Australia

T +61 2 9239 7100 | F +61 2 9239 7199 | E sydmail@ghd.com | ghd.com

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