

Ref no. TCTA 08-032 -A02

21st July 2020

**RFT FOR THE OPERATION AND MAINTENANCE OF THE AMD TREATMENT PLANT AT
EASTERN BASIN**

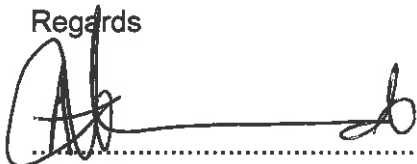
ADDENDUM NO 2-ANNEXURE G

Herewith please find Addendum No 2 which forms an integral part of the above-mentioned contract.

PLEASE ACKNOWLEDGE RECEIPT OF THIS ADDENDUM AS FOLLOWS:

1. Complete the section below and **without delay** email a copy of this page to TCTA, email address tenders01@tcta.co.za; for the attention of The Receiving Officer to confirm that you have received this addendum.

Regards



Azwi Nelwamondo
Senior Manager: Procurement

I/We herewith acknowledge receipt of ADDENDUM NO 2 for CONTRACT NO. TCTA-08-032

SIGNATURE: DATE:

ON BEHALF OF:

ADDENDUM NO 2-ANNEXURE G

1. ANNEXURE G: SURFACE AND GROUNDWATER MONITORING TOR

The Surface and Groundwater Monitoring Reports are hereby added to this RFT. These reports are attached.



East Rand Basin

AMD Deep Mine Sludge Disposal Evaluation Report

February 2020

A grayscale image of a globe with a dynamic splash of water over it, positioned in the center of the page. A large, faint, light-gray Exigo logo is overlaid on the left side of the globe.

**Innovation in
Sustainability**

Technical Report: E-R-2020-03-12

Prepared for: TCTA

Prepared by: Exigo Sustainability (Pty) Ltd

East Rand Basin AMD Deep Mine Sludge Disposal Evaluation Report

February 2020

TECHNICAL REPORT

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Notations and terms

Cone of depression is a depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a borehole from which water is being withdrawn. It defines the area of influence of a borehole.

A *confined aquifer* is a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.

Drawdown is the distance between the static water level and the surface of the cone of depression.

Groundwater table is the surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

A *fault* is a fracture or a zone of fractures along which there has been displacement.

Observation borehole is a borehole drilled in a selected location for the purpose of observing parameters such as water levels.

Pumping tests are conducted to determine aquifer or borehole characteristics.

Recharge is the addition of water to the zone of saturation; also, the amount of water added.

Static water level is the level of water in a borehole that is not being affected by withdrawal of groundwater.

Total dissolved solids (TDS) is a term that expresses the quantity of dissolved material in a sample of water.

Organoleptic Determinants that affects the smell, taste and appearance of water

LIST OF ABBREVIATIONS

Abbreviation	Description
AMD	Acid Mine Drainage
cfu	Colony Forming Units
COD	Chemical Oxidation Demand
CRB	Central Rand Basin
DH	Department of Health
DO	Dissolved Oxygen
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
ECL	Environmental Critical Level
ERB	East Rand Basin
HDS	High Density Sludge
IWUL	Integrated Water Use Licence
mbch	Meter Below Casing Height (i.e. depth to water level as measured from top of casing)
MAMSL	Meter Above Mean Sea Level
MAP	Mean Annual Precipitation
ML	Mega Litre = 1 000 000 Litre or 1 000 m ³
ND	Not Detected
N.T.U.	Nephelometric Turbidity Units
SANS	South African National Standard
SOG	Soap Oil, and Grease
TCTA	Trans Caledon Tunnel Authority
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
T.U.	Tritium units (where 1 is 1 tritium atom per 10 ¹⁸ hydrogen atoms)
TWQR	Target Water Quality Range
WRC	Water Research Commission
WTO/TBT	World Trade Organisation / Technical Barriers to Trade
WUL	Water Use License

Executive Summary

Exigo Sustainability (Pty) Ltd (Exigo) was appointed by PROXA on behalf of the Trans Caledon Tunnel Authority (TCTA) to implement a monitoring programme to determine the continued feasibility of underground disposal of sludge in the vicinity of the Grootvlei #3 Shaft. The sludge is generated during the treatment of Acid Mine Drainage (AMD) water abstracted at the ERB AMD Treatment Plant. The monitoring is a requirement as per Directive (Ref: 16/2/7/C231/C068) granted by the Department of Water and Sanitation (DWS). Following monitoring from June 2016 to February 2020 the following findings were made:

1. **Shallow groundwater:** The regional shallow (<100 m depth) groundwater resource represented by the near-surface dolomite aquifer was not negatively impacted as the ECL of the mine void water at 100 m depth was not breached. Furthermore, regional shallow groundwater monitoring conducted within the greater East Rand Basin (ERB) and shallow groundwater monitoring conducted at the ERB AMD Treatment Plant specific monitoring boreholes did not show any negative impacts as a result of the AMD sludge disposal into the Shaft (Report no. E-R-2020-01-20).
2. **Disposal Options**
 - **Intermediate sludge disposal in Shaft (760 m):** The disposal of sludge into the Shaft was considered as a short term solution (1 year to 18 months). The associated increased suspended solids in the AMD feed to the plant during Q4 2017 and later during September 2019 resulted in operational issues.
 - **Intermediate (±680 m) & deep (±1 148 m) void sludge disposal via sludge disposal boreholes:** Disposal to boreholes targeting mining voids at a depth of ±680 m and ±1 148 m commenced during December 2018. This pilot study has proven to be a viable alternative to disposal directly in the shaft. From 20 January 2018 to 19 September 2018 sludge was solely disposed at borehole BH8, with the exception of 3 days. During January 2019 to February 2020, disposal was to BH8, except for 29 days to BH1 and limited disposal to the shaft during September 2019.

According to Exigo (2018) the total ERB basin volume was calculated at ±250 mil m³ which would be able to sustain sludge disposal for 860 years (compaction excluded) or at least 400 years if ± 50% filling is assumed. The initial mass balance modelling and risk assessment indicated that sludge disposal is a long-term option that is expected to improve the basin water quality over time.

Elevated turbidity and TSS have at times influenced plant operations for a limited period of a few days. These events were linked to sludge disposal to the shaft itself. Currently there is only one alternative disposal location, namely deep borehole BH8. According to plant management, some problems have been experienced with the capacity of this borehole and an alternative disposal route to the mining void is being investigated.

3. **Impacts of sludge disposal on water quality:** No significant adverse impact on the shaft water (raw AMD) was observed as a result of AMD sludge disposal within the deep void borehole. The AMD sludge disposal was also not observed to be compromising any element of the ERB plant performance and efficiency. This was confirmed by the following:
 - Shaft profiling results
 - Shaft hydrochemical data
 - Operational data from ERB AMD plant operations
4. **Sludge build-up in Shaft:** Based on the total suspended solids sampled up to February 2020, sludge disposal in the deep void borehole BH8 at a depth of 684 m did not have a noticeable effect on shaft water quality.
5. **Isotope results:** The isotopes results indicated that the component of water in the shaft that originates from surface water varies from $\pm 40\%$ during the dry season to $\pm 80\%$ during the wet season. The results were similar to a simulated ingress study (Vivier 2018) that indicated that ± 50 ML/d (65%) ingress originates from the Blesbokspruit and ± 25 ML/d (35%) from the Dolomite Aquifer. The surface water flow in the Blesbokspruit is sustained by sewage works discharges of <100 ML/d on the ERB catchment area. If these discharges could be downstream from the basin, it could potentially significantly reduce the ingress/treatment problem.
6. **Shaft water quality results**
 - Hydrochemistry – When comparing the baseline results from June 2016 with results obtained during July 2019 and February 2020, some improvement over time can be observed. TDS decreased by 21% on average from June 2016 to July 2019 and February 2020 at depths of 200 m and deeper. At the 125 m level, with TDS decreased by 4% from June 2016 to February 2020.
 - Metals – February 2020 results for iron concentrations at 125 m, 200 m and 400 m were below 0.02 mg/L. Historically, Fe was detected in approximately half of the samples taken at 200 m, 500 m and 700 m. When detected, values were varied, with a highest value of 99 mg/L at 700 m during June 2019. Manganese has been detected in all samples taken from the shaft except one sample. Average concentrations to date

were observed to increase from 1.3 mg/L at 125 m to 3.3 mg/L at 200 m and then to 4.6 mg/L at 700 m. Uranium was not measured in concentrations above the detection limit of 0.015 mg/L in surface water and shallow surface groundwater in the vicinity of the ERB treatment plant or in treated effluent discharged into the Blesbokspruit.

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1 INTRODUCTION

Exigo Sustainability (Pty) Ltd (Exigo) was appointed by PROXA on behalf of the Trans Caledon Tunnel Authority (TCTA) to implement a monitoring programme to determine possible impacts of sludge disposal to deep compartments of mine voids near the Grootvlei #3 Shaft. The monitoring is a requirement as per Directive (Ref: 16/2/7/C231/C068) issued by the Department of Water and Sanitation (DWS) during December 2018 and valid for eighteen months. The sludge is produced at the Eastern Rand Basin (ERB) Acid Mine Drainage (AMD) Treatment Plant. Reference is made to Exigo report "East Rand Basin AMD Deep Mine Sludge Disposal Evaluation Report June 2019", where comprehensive reporting on monitoring dating back to 2016 was done. Related information, including a conceptual model of the east rand basin, was also included in the report mentioned. The focus of this report is primarily the results from the latest monitoring conducted by Exigo during February 2020. The main objective of this report is reporting on the period since the previous comprehensive monitoring by Exigo during June 2019 as well as comparisons to baseline data obtained prior to plant operations in June 2016. Historical perspectives are however also included where appropriate.

2 PROJECT LOCATION

The ERB AMD Treatment Plant site and Grootvlei #3 Shaft are located in the ERB mine lease area to the east of the town of Springs, approximately 70 km east from Johannesburg, in the Gauteng Province. See Figure 7-1 and Figure 8-1.

3 BACKGROUND

The ERB AMD Treatment Plant was constructed and became operational during 2016. Authorisation in terms of the National Environmental Management Act, 1998 (Act 107 of 1998) and National Environmental Management Waste Act (Act 59 of 2008) was obtained to dispose of sludge on the Grootvlei Sludge Dam for the Eastern Basin treatment Plant. This disposal was however not possible due to the management of the dam by the mine.

On the 20th of June 2016 the DWS granted approval (Ref: 16/2/7/C231/C068) to the TCTA to proceed with a field study to determine the feasibility of underground sludge disposal. Sludge from the ERB AMD plant at Springs were to be disposed of into the Grootvlei #3 Shaft and/or suitably-constructed deep boreholes intersecting the ERB mine void (Kimberley and/ or Main Reefs). The initial directive was for a period of 12 months. Conceptually the method of sludge disposal into mining voids has several advantages including cost efficiency and the reduction of surface waste facilities. This was considered to be a potential sustainable solution.

4 GROOTVLEI #3 SHAFT

The Grootvlei #3 Shaft (hereafter also referred to as Shaft) was constructed with a main Shaft superstructure and overhead superstructure crane. See Figure 4-1. The shaft top opening measures 3.3 m x 13 m and is completely covered with a concrete cap.

The shaft comprises of six compartments numbered 1 to 6 from west to east. Compartments 1 and 6 are closed off. Compartments 2, 3 and 4 are each equipped with an AMD abstraction pump installed at depths from 160 m to 180 m below the concrete cap collar. Compartment 5 is utilised for shaft water sampling and monitoring activities. A high-density polyethylene (HDPE) sludge disposal pipe is also installed in this compartment and feeds into an existing pipe on the southern side of the compartment, to a depth of 760 m.

The Grootvlei #3 Shaft was developed to a depth of 1 271 m below surface, but the shaft was plugged at 775 m and at two further levels below that. AMD flow into the shaft is expected to mainly occur at the Kimberley Station Rail level at 694 m, approximately 80 m above the shaft plug at 775 m. Initially, sludge was disposed of into the shaft at a depth of 760 m, into a submerged dewatering pump station. See Figure 4-2. Since December 2017, most of the disposal was into the deep void borehole BH8. See Figure 4-2 and Figure 12-19.



Figure 4-1 Photo: Grootvlei #3 Shaft with Main Shaft Superstructure

Schematic of Grootvlei #3 Shaft – Sampling Locations & Probable AMD Inflows to Shaft

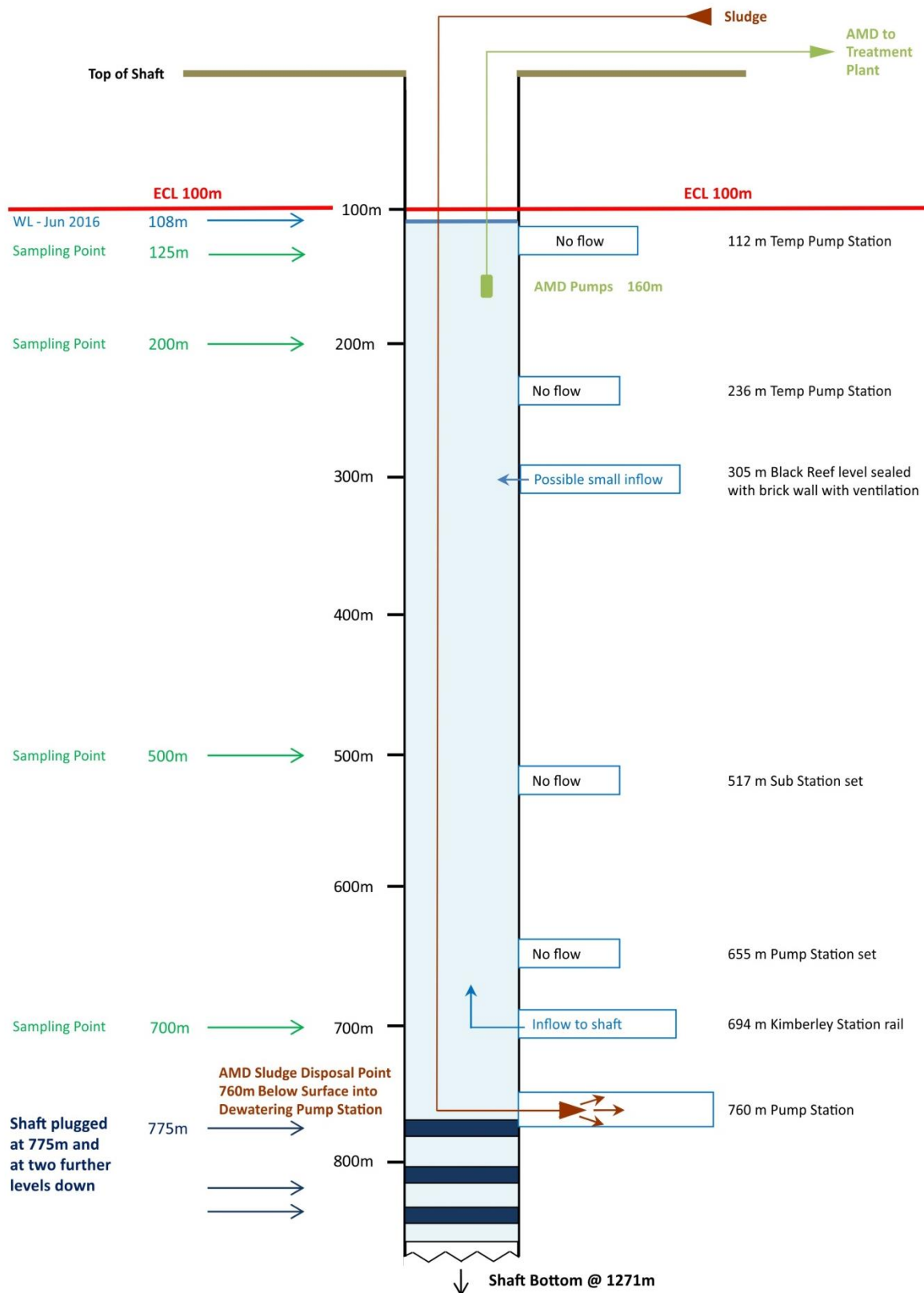


Figure 4-2 Schematic of Grootvlei #3 Shaft

5 DWS DIRECTIVE REQUIREMENTS

An initial directive by the DWS, Ref: 16/2/7/C231/C068, was issued on 20 June 2016 and approved the disposal of sludge into the shaft or suitably-constructed deep boreholes for a period of 12 months. The latest directive, with the same reference, was issued on 20 December 2018 and approved the same disposal of sludge for a period of 18 months.

The following was also required in terms of the latest directive:

- Continuation of a geo-hydrological and geo-chemical monitoring programme to evaluate any potential impact of the disposal on the regional groundwater resource;
- The representative surface and groundwater resources that may be impacted by the sludge disposal must be assessed on a monthly basis for the parameters pH, conductivity, total suspended solids, sulphate, iron, manganese and uranium.
- Reports must be submitted to the Department on a monthly basis from commencement of activity.
- Sludge disposal should be terminated immediately if there is any indication that sludge disposal is adversely impacting on mine void water (raw AMD) and/ or compromising any element of the ERB plant performance and efficiency.

6 OBJECTIVES

The principle objectives of this study were to:

- Implement a geo-hydrological and geo-chemical monitoring programme to evaluate any potential impact on the regional groundwater resource, represented by the significant near-surface dolomite aquifer, which is considered a potential long-term water supply source;
- Determine if sludge disposal is adversely impacting on mine void water (raw AMD) and/ or compromising any element of the ERB plant performance and efficiency;

7 SCOPE OF WORK

A monitoring programme was implemented to evaluate the feasibility of continued underground AMD sludge disposal in the vicinity of the Grootvlei #3 Shaft as per DWS Directive (Ref: 16/2/7/C231/C068). The respective monitoring runs, each with corresponding monitoring locations and analyses types, are detailed in Table 7-1.



Figure 7-1 Regional Map: ERB AMD Treatment Plant Location

Table 7-1 AMD Sludge Disposal Monitoring Programme

Category	Monitoring Location	Analyses Type	Date																																		
			2016/06/28	2016/12/14	2017/01/26	2017/02/27	2017/03/30	2017/04/24	2017/05/24	2017/06/28	2017/07/28	2017/08/28	2017/09/28	2017/10/23	2017/11/10	2017/12/28	2018/01/10	2018/02/26	2018/04/30	2018/05/31	2018/06/29	2018/08/02	2018/08/29	2018/10/01	2018/10/30	2018/11/28	2018/12/12	2019/01/30	2019/02/27	2019/03/25	2019/04/26	2019/05/27	2019/06/26	2019/07/30	2019/08/27	2020/02/26	
Shaft Water Column - @ Depth Sampling	125m	Hydrochemical	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Microbiological							•						•	•																					
		Isotopes *	•	•					•						•	•					•																
		TerrAttest **	•																																		
		Shaft Profiling ***	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
	200m	Hydrochemical	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Microbiological							•																												
		Isotopes *	•	•					•						•	•					•														•		
		TerrAttest **	•																																		
		Shaft Profiling ***	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	400 m	Hydrochemical																																			
		Isotopes *																																			
		Shaft Profiling ***																																			
	500m	Hydrochemical	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Microbiological							•																												
		Isotopes *	•	•					•						•	•					•														•		
		TerrAttest **	•																																		
		Shaft Profiling ***	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	700m	Hydrochemical	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Microbiological							•																												
Isotopes *		•	•					•						•	•					•														•			
TerrAttest **		•																																			
Shaft Profiling ***		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Shaft: AMD	Pump	Hydrochemical																																•			
		Isotopes *	•																															•	•		
ERB Void Boreholes	BH6N	Hydrochemical									•																										
	BH1N	Hydrochemical													•																						
		Microbiological														•																					
		TerrAttest **														•																					
		Isotopes *														•																					
	BH8	Hydrochemical																																			
Isotopes *																																					

* Stable Environmental Isotopes

** TerrAttest Scan for 230 Compounds

*** Profiling of Shaft Water Column for pH, EC & Temperature

Category	Monitoring Location	Analyses Type	Date																																		
			2016/06/28	2016/12/14	2017/01/26	2017/02/27	2017/03/30	2017/04/24	2017/05/24	2017/06/28	2017/07/28	2017/08/28	2017/09/28	2017/10/23	2017/11/10	2017/12/28	2018/01/10	2018/02/26	2018/04/30	2018/05/31	2018/06/29	2018/08/02	2018/08/29	2018/10/01	2018/10/30	2018/11/28	2018/12/12	2019/01/30	2019/02/27	2019/03/25	2019/04/26	2019/05/27	2019/06/26	2019/07/30	2019/08/27	2020/02/26	
Surface Water - Blesbokspruit	ESW-01	Hydrochemical	•					•					•	•							•						•	•									•
		Microbiological						•																													
		Isotopes *	•					•						•	•						•						•	•	•	•	•	•	•	•	•	•	•
	ESW-03	Hydrochemical	•																																		
		Isotopes *	•																																		
		ESW-05	Hydrochemical						•						•	•						•						•									
Microbiological							•																														
Isotopes *							•					•	•	•						•						•	•	•	•	•	•	•	•	•	•	•	
Surface Water - Water Body	Alexander Dam	Hydrochemical	•					•					•	•							•						•										•
		Isotopes *	•					•					•	•	•						•						•	•	•	•	•	•	•	•	•	•	
	Cowles Dam	Hydrochemical	•					•					•	•	•						•						•										•
		Isotopes *	•					•					•	•	•						•						•	•	•	•	•	•	•	•	•	•	•
	Aston Lake	Hydrochemical	•					•					•	•	•						•						•										•
		Isotopes *	•					•					•	•	•						•						•										•
Shallow Groundwater - Boreholes	AECBH01	Hydrochemical	•					•					•	•							•						•										•
		Isotopes *	•					•						•	•						•						•										•
	AECBH13	Hydrochemical	•					•						•	•						•						•										•
		Isotopes *	•					•						•	•						•						•										•
	CEN371 (A)	Hydrochemical	•					•						•	•						•						•										•
		Isotopes *	•					•						•	•						•						•										•
Municipal Water	Rand Water	Hydrochemical						•					•	•							•						•										•
		Isotopes *						•						•	•						•						•	•	•	•	•	•	•	•	•	•	•
ERWAT Treatment Plant	Sewage Effluent	Hydrochemical						•					•	•							•						•										•
		Microbiological						•						•	•																						
		Isotopes *						•						•	•						•						•	•	•	•	•	•	•	•	•	•	•

- * Stable Environmental Isotopes
 ** TerrAttest Scan for 230 Compounds
 *** Profiling of Shaft Water Column for pH, EC & Temperature

8 MONITORING LOCATIONS

The various monitoring locations are detailed in Table 8-1 and illustrated in Figure 8-1.

Shallow groundwater monitoring of the Dolomite Aquifer consists of three boreholes that were identified during a hydrocensus conducted specifically for the purpose prior to commencement of baseline monitoring in June 2016.

Surface water monitoring consists of five monitoring locations. ESW-01 and ESW-05 (monitored since Apr 2017) are monitoring locations on the Blesbokspuit. Both are located upstream from the ERB AMD Treatment Plant point. The Alexander Dam and Cowles Dam are located on a tributary joining the Blesbokspuit from the west. This tributary joins the Blesbokspuit upstream of the shaft. Ashton Lake is located on a tributary joining the Blesbokspuit from the east, with the tributary joining the Blesbokspuit downstream of the shaft.

Sewage Effluent from the ERWAT Welgedacht Waste Water Treatment Works (WWTW) was included as a monitoring location as >100 megalitre per day of treated effluent from the ERWAT Welgedacht and Ancor WWTW's is discharged into the Blesbokspuit. Discharge of treated sewage water from the two ERWAT WWTW's is upstream of the ERB AMD plant and important contributions to the flow in the Blesbokspuit. According to Vivier (2017) simulated ingress of water into the ERB basin (void) indicated that approximately 65% originates from the Blesbokspuit and approximately 35% from the shallow Dolomite Aquifer. Sewage Effluent discharged into the Blesbokspuit therefore constitutes a significant portion of ERB void water abstracted at the Grootvlei #3 Shaft.

Rand Water (Municipal water) as sampled at a tap at the ERB AMD Plant was also included as a monitoring location. According to Vivier (2017) isotope tracer analysis indicated that there may be municipal pipeline leaks which contribute to the ingress of water into the ERB basin. The actual contribution from municipal water to water abstracted at the Grootvlei #3 Shaft is currently an unknown.

Three deep void sludge disposal boreholes namely BH6N, BH1N and BH8 were drilled into the ERB void during July 2017, August 2017 and November 2017 respectively. The boreholes were sampled after being drilled in order to obtain baseline data.

Table 8-1 Monitoring Locations

Category	Location	Latitude	Longitude	Description
Shaft	Grootvlei No. 3	-26.25152	28.48876	Mine shaft plugged at 760 m below top of shaft. Sampling of water in the shaft was primarily conducted at four depths. AMD feed to plant also sampled.
ERB Void Borehole	BH6N	-26.25294	28.49109	Sludge disposal BH located approx. 220 m south east of AMD ERB Plant perimeter. Intersected Main Reef Void at 1 148 m on 24 Jul 2018. Sampling run on 27 Oct 2017 failed as bailer could not be lowered past 460 m.
	BH1N	-26.25036	28.48964	Sludge disposal BH located on north east perimeter of the AMD ERB Plant area. Intersected "Ghost" Kimberley Reef Void at 669 m on 30 Aug 2017. A pressure blowout occurred on 5 Jan 2018. No sludge disposal at the borehole was done since.
	BH8	-26.25001	28.4872	Sludge disposal BH located on north west perimeter of the AMD ERB Plant area. Intersected Kimberley Reef Void at 684 m on 7 Nov 2017.
Surface Water - Blesbokspruit	ESW01	-26.21449	28.47996	Located approx. 4 km upstream from the AMD ERB Plant, in the Blesbokspruit
	ESW03	-26.25551	28.49827	Located downstream from the AMD ERB Plant, in the Blesbokspruit. Sampled during baseline monitoring run in June 2016.
	ESW05	-26.25018	28.49762	Located upstream of the effluent discharge point, and approx. 600 m upstream from ESW-03. Replaced ESW-03 as monitoring location as ESW-03 is affected by plant waste water discharge.
Surface Water - Water Body	Alexander Dam	-26.21257	28.41473	Dam northwest of the shaft, in a tributary to the Blesbokspruit joining from the west. Upstream from Cowles Dam.
	Cowles Dam	-26.20693	28.46102	Dam northwest of the shaft, in a tributary to the Blesbokspruit flowing from the west. Downstream of Alexander Dam.
	Aston Lake	-26.2536	28.52746	Dam east of the shaft, in a tributary to the Blesbokspruit joining from the east.
Shallow Groundwater - Boreholes	AECBH01	-26.24118	28.4622	Borehole located approx. 2.8 km north west of the AMD ERB Plant.
	AECBH13 (A)	-26.24034	28.5107	Replacement borehole for AECBH13 since April 2017. Located 2.3 km northeast of AMD ERB Plant
	CEN371 (A)	-26.22321	28.4285	Borehole located approx. 7 km north west of the AMD ERB Plant.
Municipal Water	Rand Water	-26.2502	28.48869	Samples at tap at ERB AMD Plant.
ERWAT Treatment Plant	Sewage Effluent	-26.19315	28.4765	The Welgedacht WWTW located upstream from the AMD ERB Plant, discharging treated effluent into the Blesbokspruit.

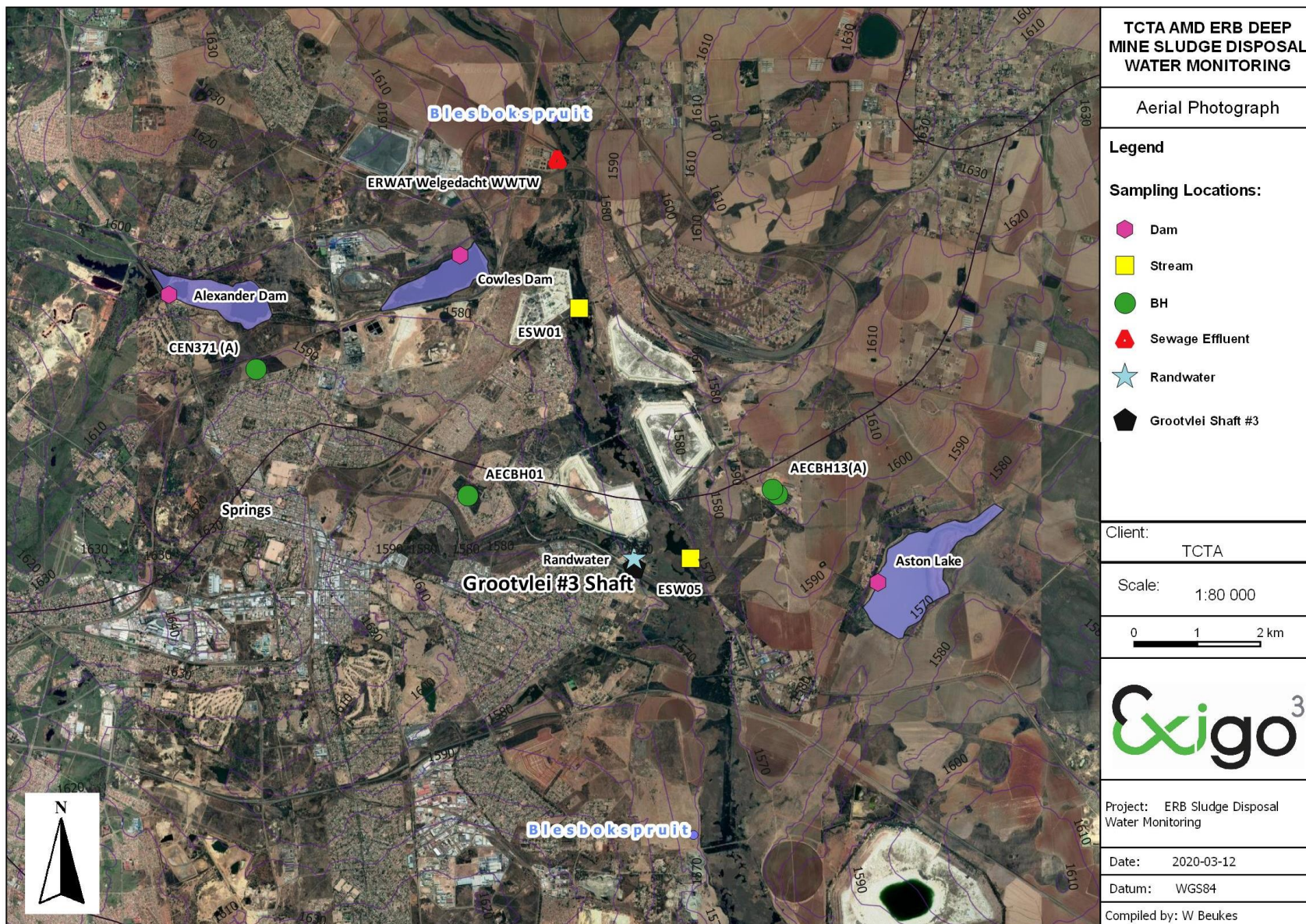


Figure 8-1 Map: Sampling Locations - Regional

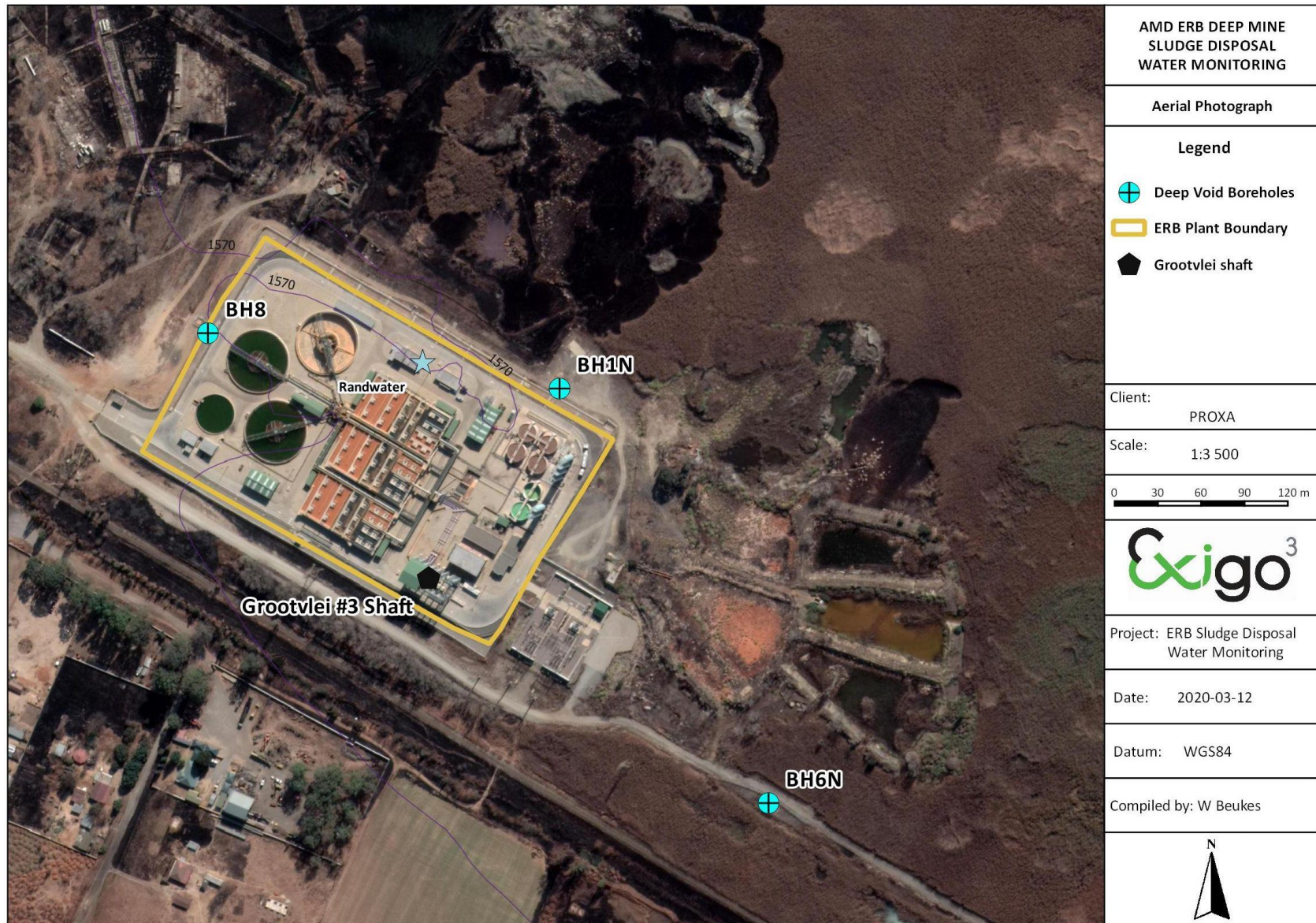


Figure 8-2 Map: ERB AMD Treatment Plant Sampling Locations

9 WATER QUALITY STANDARD USED

It is important to note that where results were evaluated for compliance to guidelines or standards, only specifications relating to the parameters tested were evaluated. Compliance may not necessarily imply compliance to the guideline or standard as a whole. The specific water quality criteria evaluated and accompanying test results are included in table form at the end of the report.

The following standard was used for interpretation:

- SANS 241:2011, Drinking Water – Edition 2

SANS 241 (2015) is a South African standard approved by the National Committee SABS TC 147 on Water, in accordance with procedures of SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement. This drinking water standard was used in the report as a general guideline to evaluate the chemical water quality. Evaluation is therefore an indication of quality and does not necessarily relate to a suggestion for use.

For Exigo reporting purposes, in instances where SANS 241 specifies different limits for different risk factors (aesthetic, operational, chronic health), the chronic health limit was used for iron and manganese, the operational limit for turbidity and the acute limit for sulphate.

9.1 SANS 241:2015 – Drinking Water

SANS 241 consists of the following parts, under the general title Drinking water:

- Part 1: Microbiological, physical, aesthetic and chemical determinants
- Part 2: Application of SANS 241-1

9.1.1 Part 1: Microbiological, physical, aesthetic and chemical determinants

According to SANS 241:2015, the scope of Part 1 is as follows:

- This part of SANS 241 specifies the quality of acceptable drinking water, defined in terms of microbiological, physical, aesthetic and chemical determinants, at the point of delivery.
- Water that complies with this part of SANS 241 is deemed to present an acceptable health risk for lifetime consumption (this implies an average consumption of 2 L of water per day for 70 years by a person that weighs 60 kg).
- Water services institutions and water services intermediaries ensure that water provided by them complies with the numerical limits given in this part of SANS 241.
- Water services institutions and water services intermediaries monitor and maintain monitoring programmes informed by the routine monitoring programme and risk assessment processes described in SANS 241-2.

10 WATER LEVELS

The potential impact of sludge disposal into the ERB void on the shallow groundwater of the Dolomite Aquifer was evaluated in terms of groundwater levels as well as water quality. For this purpose, three boreholes located within 7 km of the shaft have been monitored, namely boreholes AECBH01, AECBH13 and CEN371(A). The locations are mapped in Figure 7-1 and Figure 8-1.

Shallow groundwater levels recorded at the three boreholes were measured as depth to water level in m, as measured from top of the borehole casing (mbch). Water levels as measured since June 2016 are detailed in Table 10-1 and illustrated in Figure 10-1. An average shallow groundwater level of 19.45 mbch was recorded during February 2020. Borehole AECBH13 (A) replaced AECBH13 during 2017. Water level has not been measured at AECBH13 (A) due to obstruction.

The ERB mine void water level has been below the ECL (Environmental Critical Level) of 100 m since monitoring by Exigo commenced in 2016. See Figure 10-1. The ECL was previously determined in order to protect the dolomitic aquifer, which is considered a regional groundwater resource and a potential long-term water supply source. As the mine void water (raw AMD) was not in contact with the dolomitic aquifer situated above the ECL, it is inferred that the dolomitic aquifer was not negatively impacted upon as a result of AMD sludge disposal within the shaft or deep mining voids via deep boreholes.

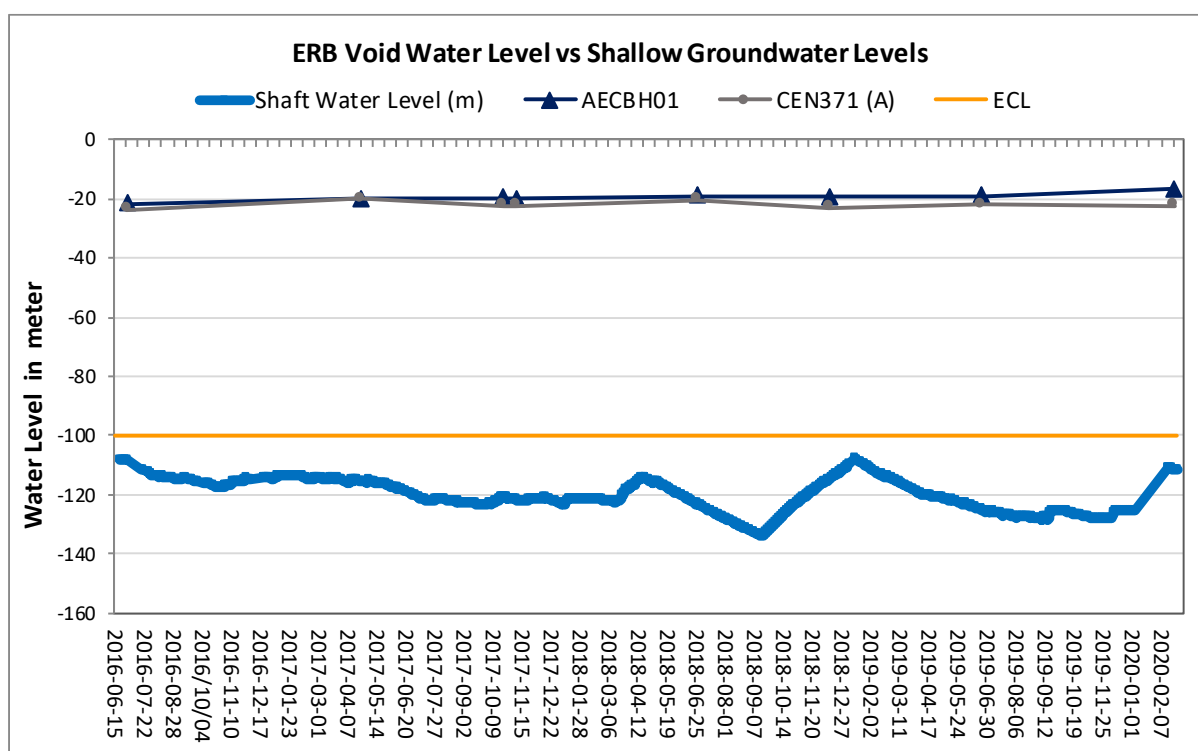


Figure 10-1 ERB Void Water Level vs Shallow Groundwater Levels

Table 10-1 Shallow Groundwater Levels

DATE	Water Level, mbch		
	AECBH01	AECBH13	CEN371 (A)
2016-06-30	21.65	34.10	23.51
2017-04-24	20.09	-	19.93
2017-10-23	19.79	-	22.22
2017-11-09	19.97	-	22.41
2018-06-28	19.00	-	20.25
2018-12-13	19.20	-	23.04
2019-06-26	19.00	-	22.00
2020-02-26	16.63	-	22.26

11 WATER QUALITY MONITORING

Various quality control measures relating to water quality monitoring by Exigo are detailed in APPENDIX C: QUALITY CONTROL.

11.1 Baseline Water Quality

Baseline monitoring was conducted during June 2016, prior to the commencement of sludge disposal at the Grootvlei #3 Shaft. Baseline monitoring locations included surface water, shallow groundwater and ERB void water represented by samples taken within the shaft at various depths. The baseline monitoring data serves as reference for all subsequent monitoring conducted and was addressed throughout the report where applicable. ESW-05, Rand water (municipal water supply) and effluent from the Erwat Welgedacht sewage treatment facility were sampled for the first time during April 2017. These results are included in the illustration of the major chemical composition of baseline samples, Figure 11-1. Following the disposal of sludge at the shaft, monthly water monitoring commenced during December 2016. Results for the major chemical composition of samples taken during the latest sampling run, February 2020, are illustrated in Figure 11-2.

In comparing the latest results for major components with baseline results, the following was noted:

- Sulphate concentrations in the shaft at 200 m and deeper varied from 1 395 mg/L to 1 438 mg/L during June 2016. The February 2020 concentrations at 200 m and 400 m of respectively 1 052 mg/L and 976 mg/L were on average 30% lower. The latest concentrations were similar to lower concentrations observed since December 2016, when 80% of values were below 1 300 mg/L
- Sulphate concentration at ESW-05 of 100 mg/L during February 2020 was 50% of the baseline value of 199 mg/L. However, historical values have been varied (94 mg/L to 468 mg/L), although only two values from the six samples taken since April 2017 have exceeded the baseline value.
- Changes in TDS varied from a decrease of 54% at borehole CEN371(A) to an increase of 43% at AECBH01. TDS of Rand water increased by 90%, from 102 mg/L to 194 mg/L. None of these changes are seen as significant.

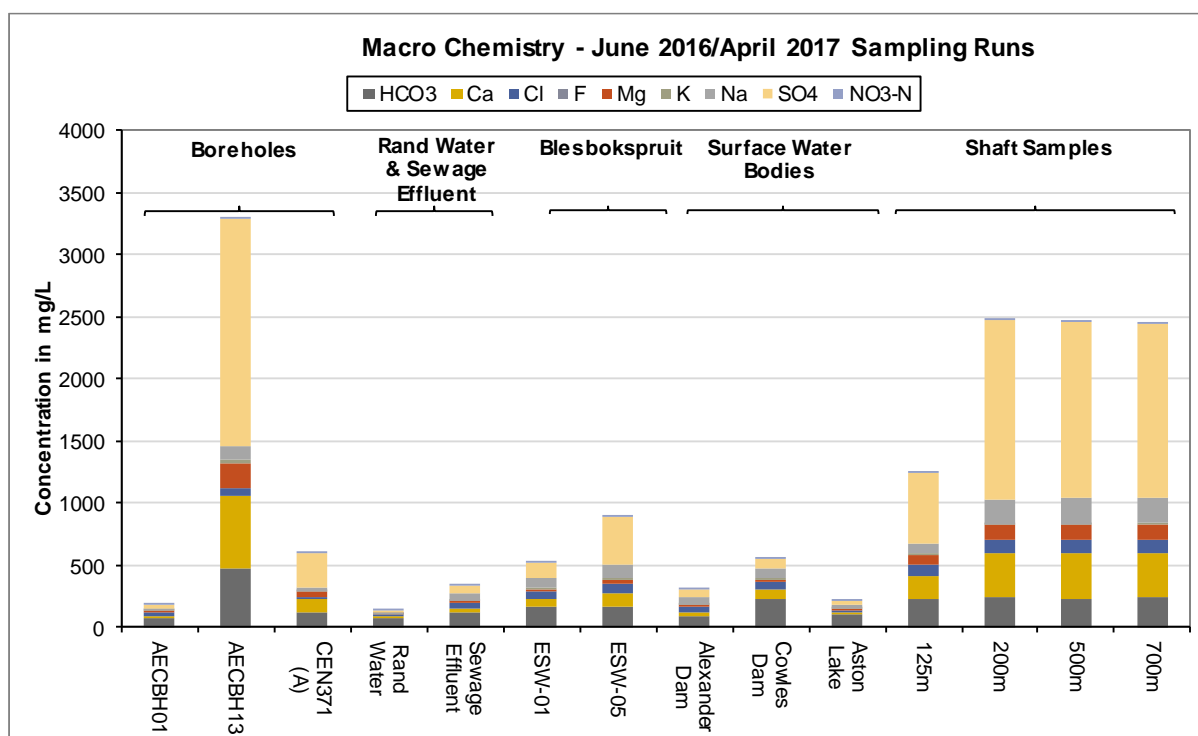


Figure 11-1 Comparative Chemical Composition, Baseline Sampling

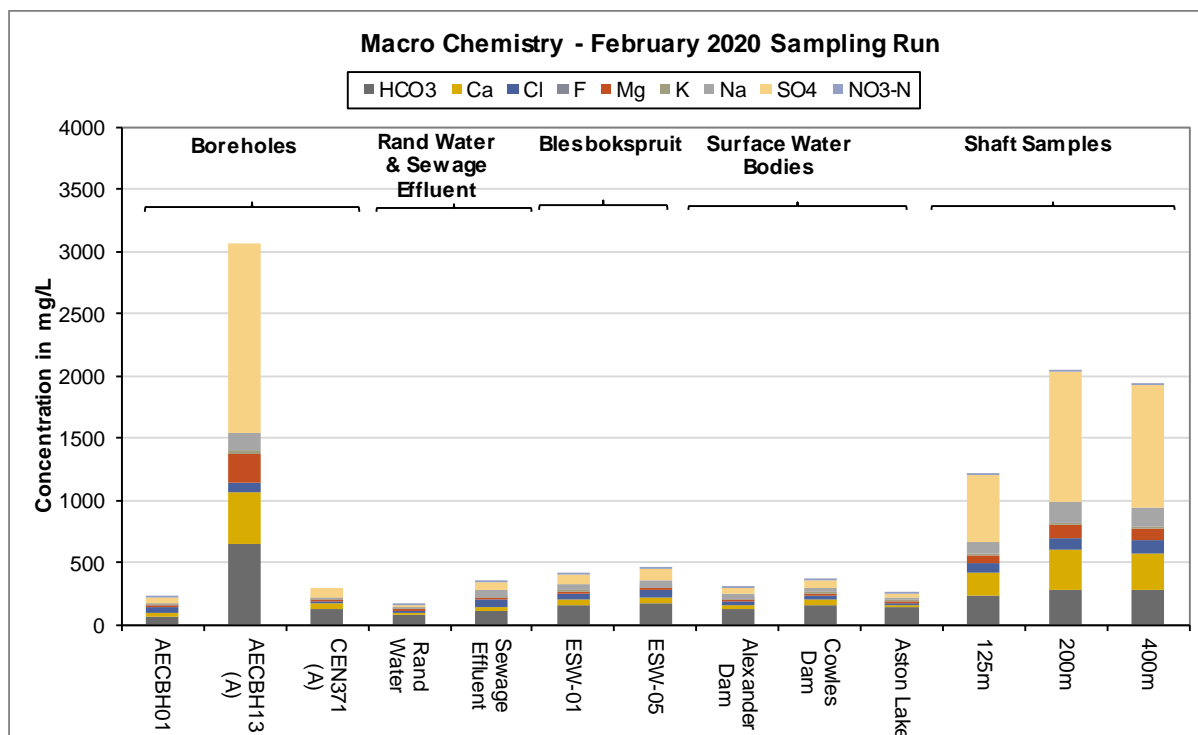


Figure 11-2 Comparative Chemical Composition, February 2020

11.2 Shallow Groundwater Quality

Water quality results obtained for boreholes AECBH01, AECBH13 and CEN371(A) are illustrated in Figure 11-3 to Figure 11-10 and detailed in Table 17-1. As the ERB mine void water level was for the duration of the study period below that of the ECL of 100 m, it is inferred that there was no impact on the shallow groundwater quality as a result of sludge disposal. This was however verified by comparing the water quality of the sample obtained at 125 m deep in the Grootvlei #3 Shaft with that of the three boreholes. Water quality results from the 125 m sampling depth were used as it is the uppermost sample of the ERB void water taken within the shaft and thus located closest to the shallow Dolomite Aquifer.

The June 2016 baseline water quality and February 2020 water quality results were plotted on piper diagrams in order to determine the water type and the major chemical characteristics. See Figure 11-3 and Figure 11-4. The stagnant characteristics and calcium magnesium sulphate nature of boreholes AECBH13(A) and CEN371(A) were very similar to that of 125 m during baseline determination. Water character for borehole AECBH01 was slightly different at the time, due to a more mixed anion nature. The February 2020 character for CEN371(A) was different from baseline due to a lower sulphate concentration recently. Sulphate concentration decreased from 239 mg/L during June 2019 to 77 mg/L during February 2020. No other change in water character since baseline determination was observed.

The June 2016 baseline results were compared with the February 2020 overall water quality of the shallow groundwater. See Figure 11-5. The overall water quality of borehole CEN371(A) showed significant improvement from baseline. This was due to improvement from June 2019 to February 2020, when TDS decreased from 450 mg/L to 250 mg/L. The decrease was related to decreased sulphate and total hardness values. See Figure 11-8. Overall water quality of borehole AECBH01 deteriorated when compared to baseline values. See Figure 11-6. However, TDS has remained below 280 mg/L throughout monitoring, well below the values observed at the other two boreholes. Parameter values that exceeded baseline values are indicated in Table 17-1. Due to normal variations, it is expected that baseline values will be exceeded in 50% of samples when water quality remains effectively unchanged.

Borehole AECBH13, sampled during June 2016, was found obstructed during April 2017 and the replacement borehole AECBH13 (A) was sampled. AECBH13 (A) is located approximately 100 m northwest of AECBH13 and was drilled to a depth of 95 m. The boreholes are located 2.3 km northeast of AMD ERB Plant, at a brick making facility. They are on the eastern side of the Blesbokspruit, as opposed to the shaft, CEN371(A) and AECBH01, that are west of the spruit. A TDS value of 2 988 mg/L at AECBH13 during June 2016 decreased to 1 234 mg/L at AECBH13(A) during April 2017. The lower TDS still significantly exceeded the TDS values observed at CEN371(A) (538 mg/L) and AECBH01 (182 mg/L) at the time. TDS gradually increased at AECBH13(A) to 2 556 mg/L during June 2019, followed by a slight decrease to 2 550 mg/L during February 2020. Deteriorating water quality was due to increasing sulphate and total hardness. See Figure 11-7. The February 2020 TDS and sulphate at AECBH13(A) remains below the values observed at AECBH13 during June 2016.

Iron and manganese concentrations were observed to be elevated in the ERB void water. A maximum iron concentration of 109 mg/L was detected at 200 m in February 2017 while a maximum manganese concentration of 14 mg/L was detected at 700 m in January 2018. When looking at results for 125 m, located closest to the shallow Dolomite Aquifer, a maximum iron concentration of 30.3 mg/L (Aug 2017) and manganese concentration of 5.2 mg/L (Nov 2017) was observed. Iron has not been detected at 125 m above 0.004 mg/L since 2017 and all but two manganese concentrations were below 1 mg/L during this period. Iron concentration at the three boreholes have been below the detection limit of 0.004 mg/L throughout monitoring. The maximum groundwater manganese concentration that have been detected was 0.887 mg/L at borehole AECBH13(A) during February 2020. See Figure 11-9 to Figure 11-10.

No impact as a result of sludge disposal into the ERB void was therefore observed on the shallow groundwater quality as monitored at boreholes AECBH01, AECBH13(A) and CEN371(A).

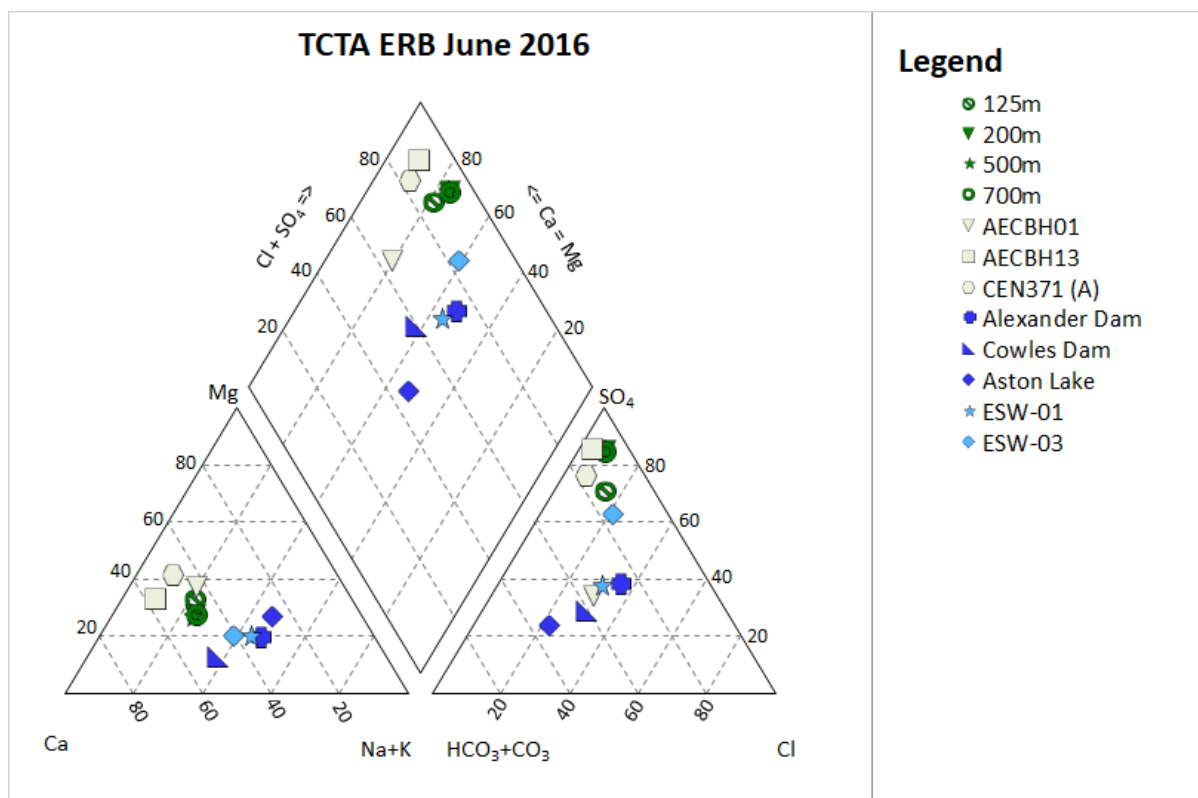


Figure 11-3 Piper Diagram – Shaft, Shallow Groundwater and Surface Water – June 2016

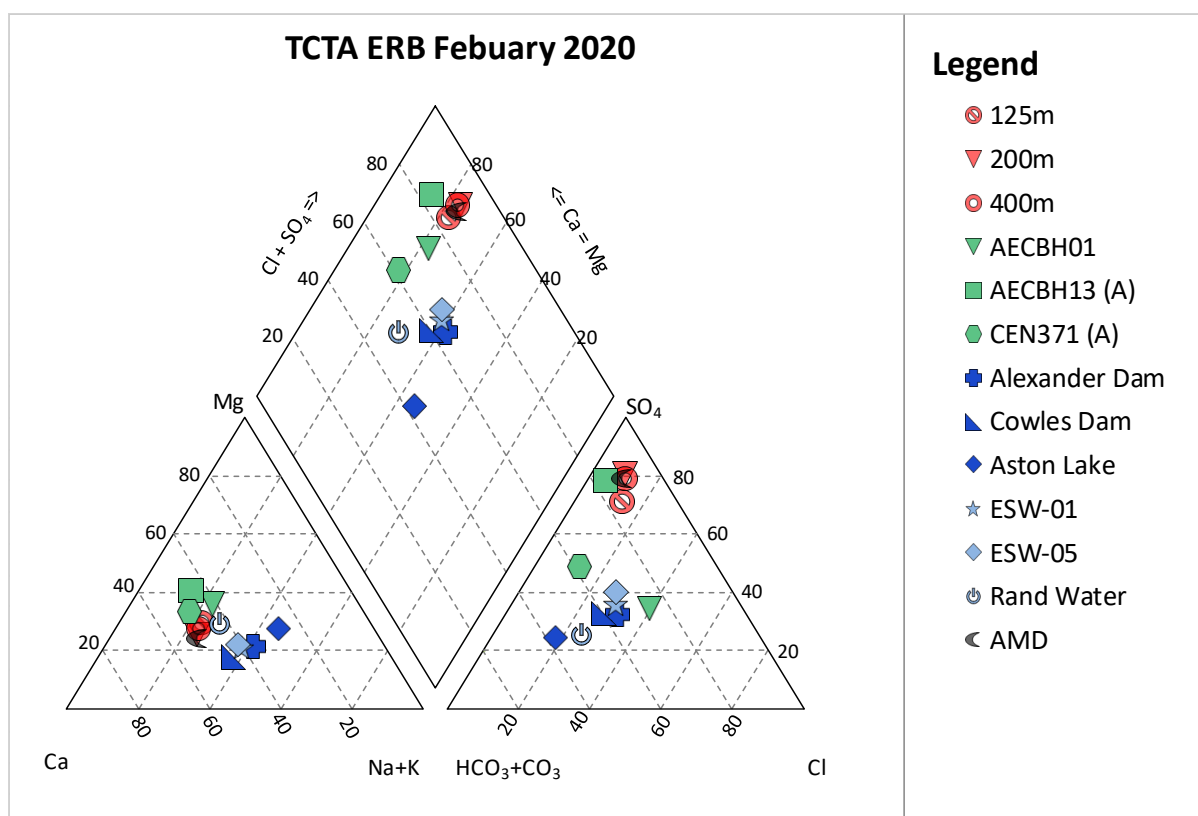


Figure 11-4 Piper Diagram: Shaft, Shallow Groundwater and Surface Water – Feb 2020

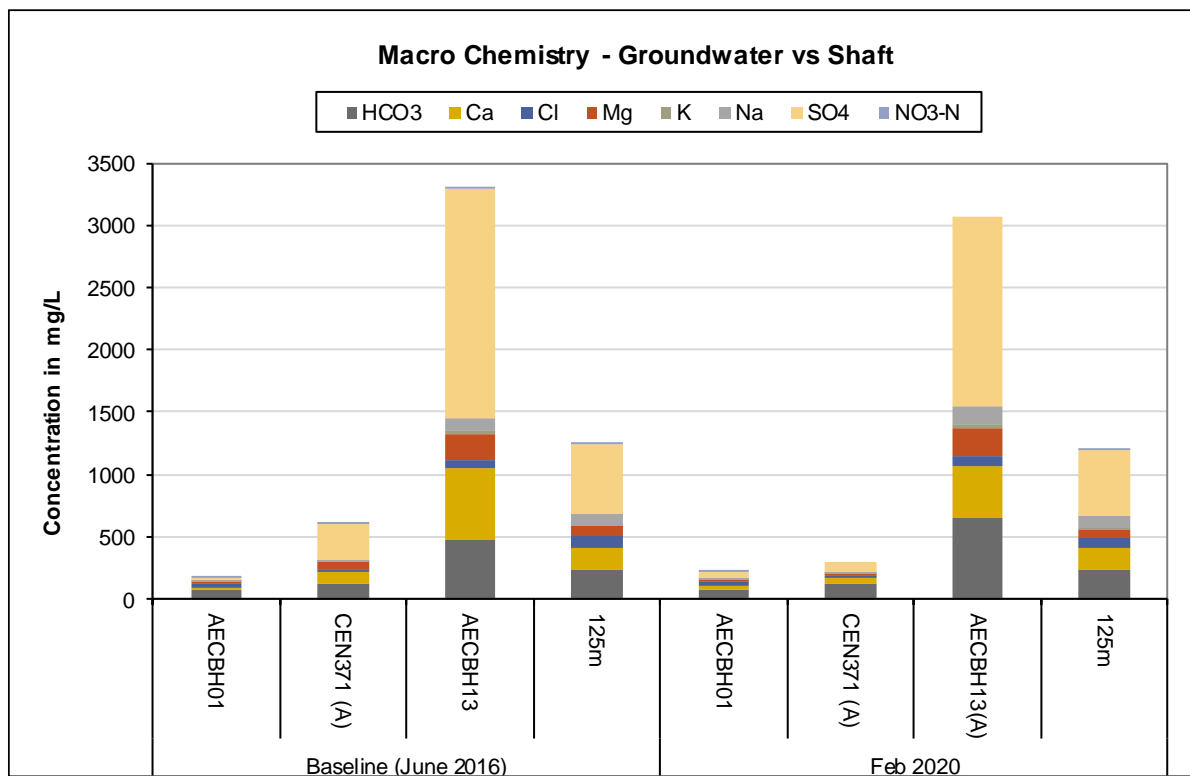


Figure 11-5 Comparative Chemical Composition – Shallow Groundwater & 125 m Shaft

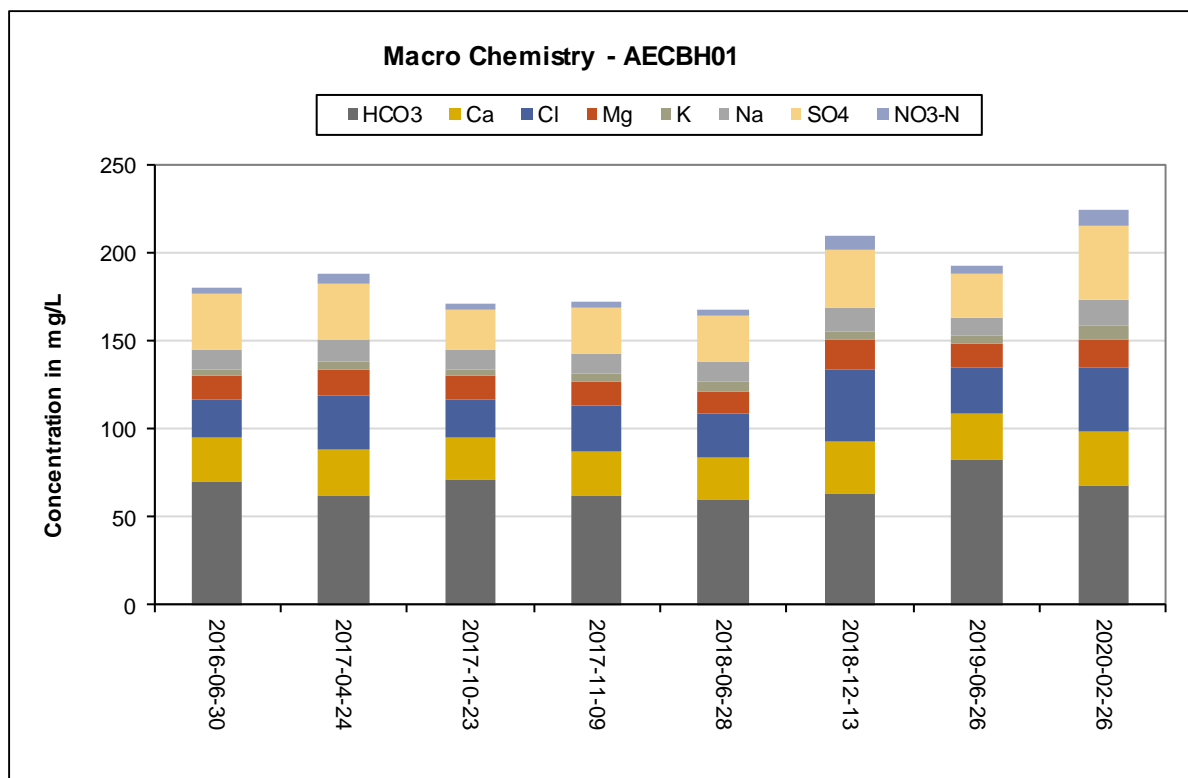


Figure 11-6 Comparative Chemical Composition -AECBH01

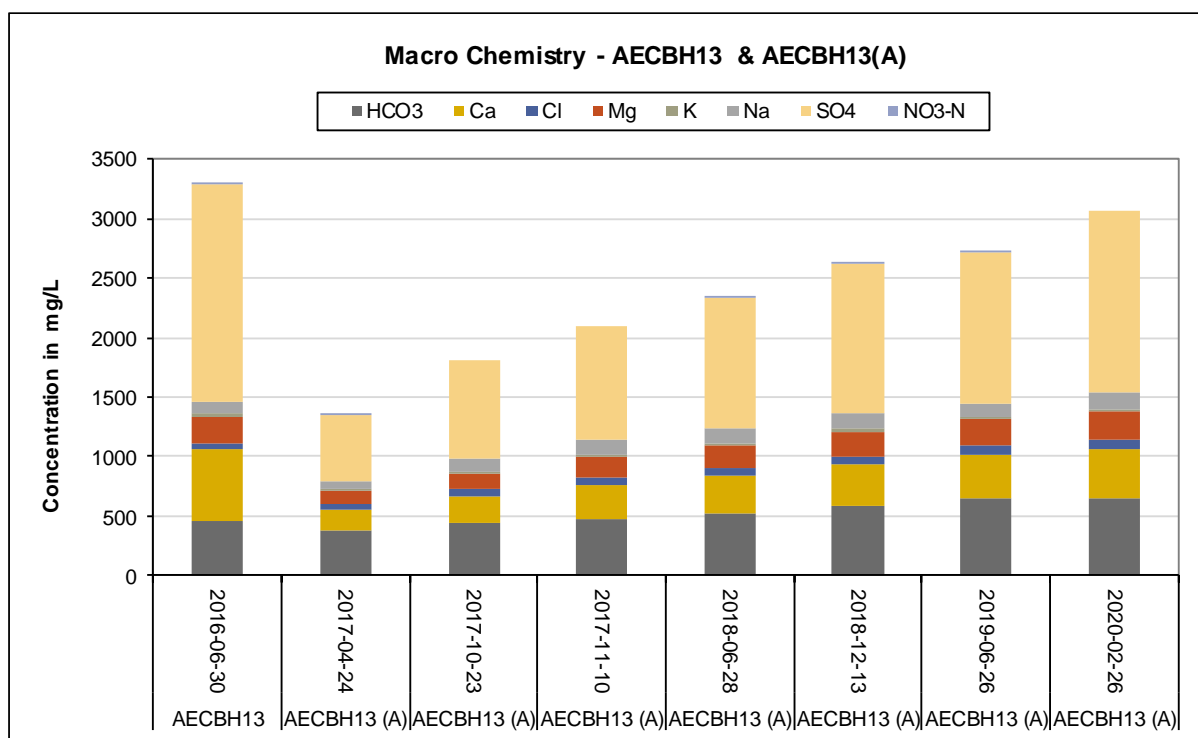


Figure 11-7 Comparative Chemical Composition -AECBH13

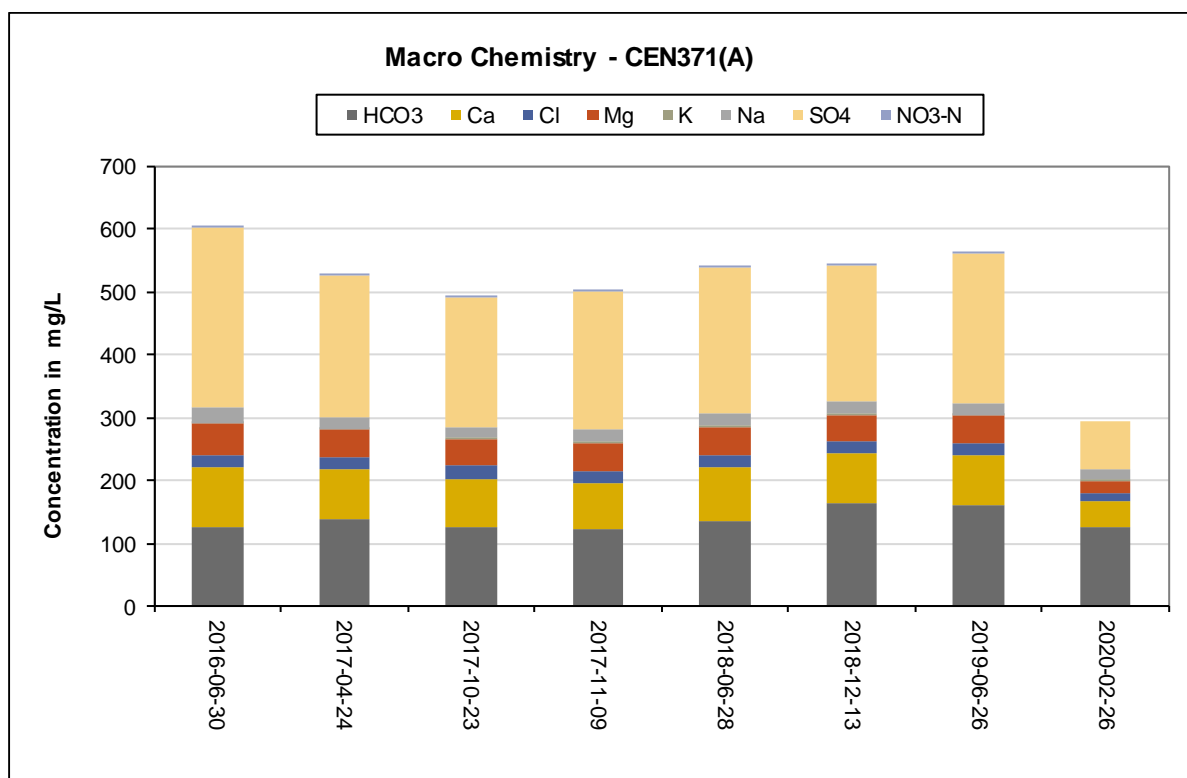


Figure 11-8 Comparative Chemical Composition -CEN371(A)

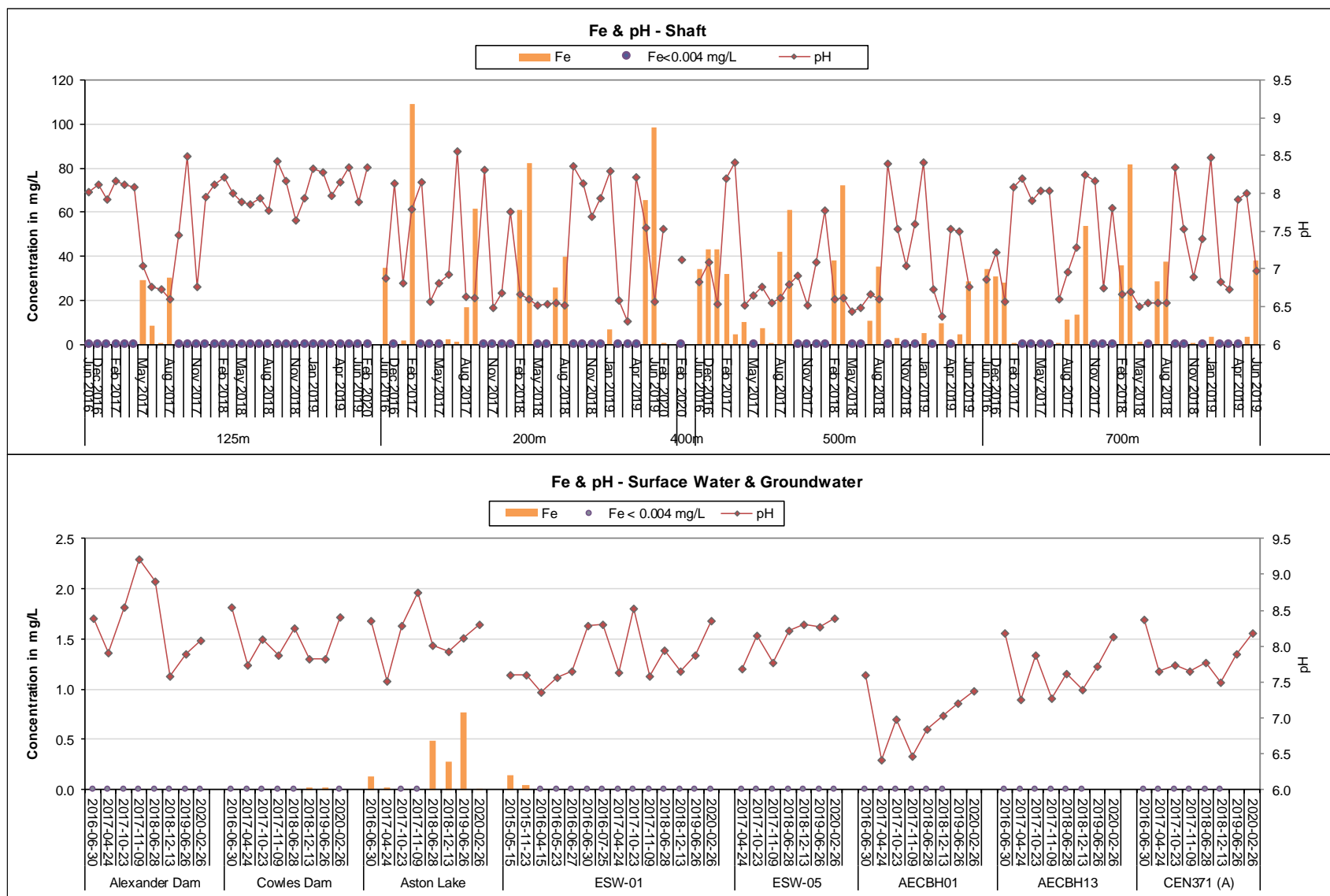


Figure 11-9 Iron & pH Levels – Shaft, Surface Water & Shallow Groundwater

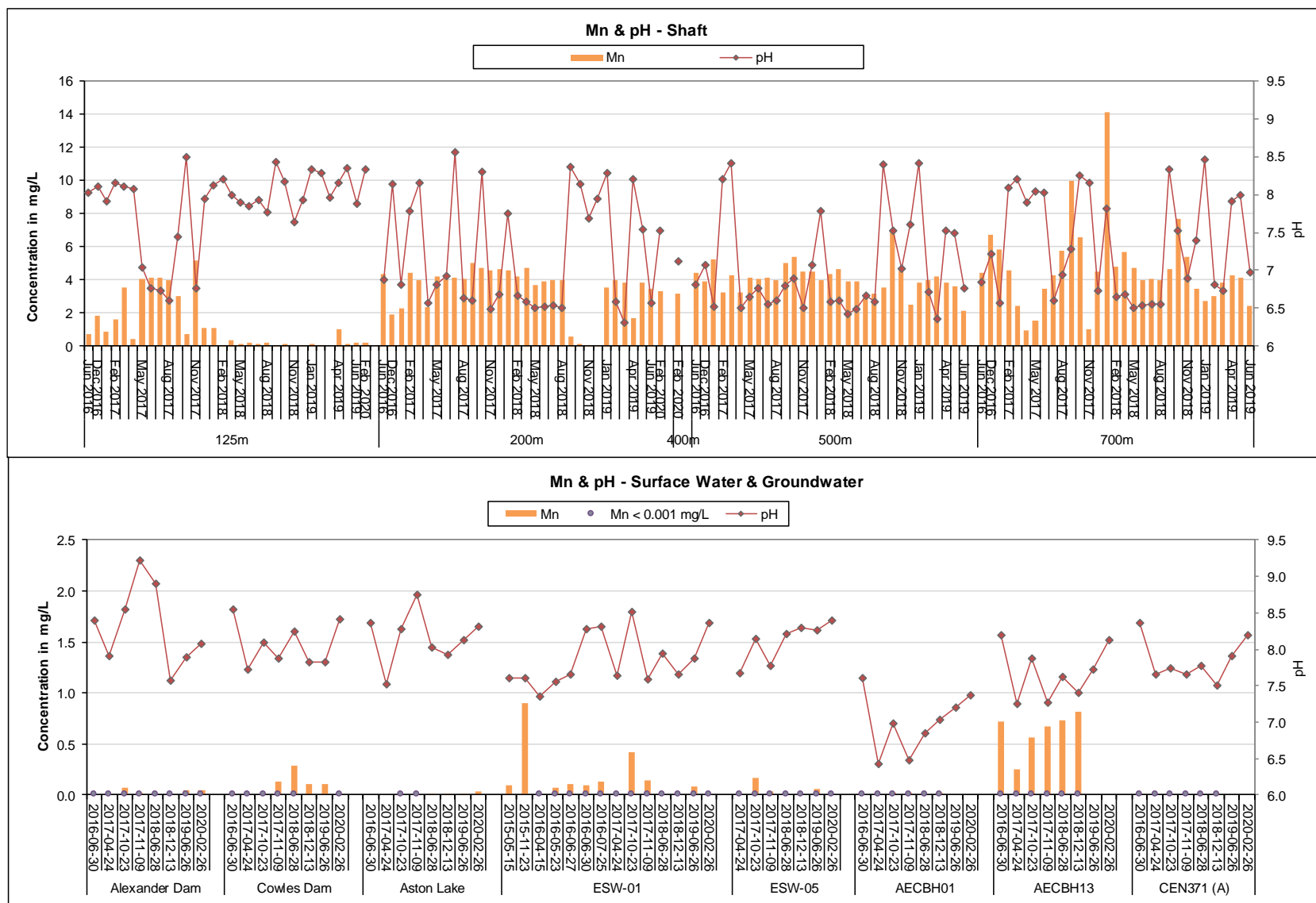


Figure 11-10 Manganese & pH Levels – Shaft, Surface Water & Shallow Groundwater

11.3 Surface Water Quality Monitoring

Water quality results obtained for the respective surface water monitoring locations are illustrated in Figure 11-1 to Figure 11-4 and Figure 11-9 and Figure 11-10 and detailed in Table 17-2 to Table 17-8. The monitoring locations are mapped in Figure 8-1.

The water quality of the respective surface water monitoring locations were analysed in order to better understand the contribution (ingress) and impact of the Blesbokspruit (ESW-01 and ESW-05) and the respective surface water bodies (Alexander Dam, Cowles Dam and Ashton Lake) on the water quality of the ERB basin (void). As mentioned before, the ERB mine void water level was for the duration of the study period below that of the ECL of 100 m. See Figure 10-1. The mine void water was therefore not in contact with the respective surface water bodies and could therefore not have had a negative impact on them.

From the Piper diagram (Figure 11-4) it can be observed that water from the respective shaft sampling depths (125 m, 200 m & 400 m) during February 2020 was of a more stagnant character and calcium sulphate nature compared to the more mixed character of the respective surface water monitoring locations.

Surface water iron and manganese concentrations were compared to the elevated levels observed for ERB void water. For the five respective surface water locations a maximum iron concentration of 0.765 mg/L was detected at Ashton Lake in June 2019 while a maximum manganese concentration of 0.423 mg/L was detected at ESW-01 in October 2017. This was in contrast to results for 125 m, located closest to the shallow Dolomite Aquifer, where a maximum iron concentration of 30.3 mg/L (Aug 2017) and manganese concentration of 5.2 mg/L (Nov 2017) was observed. See Figure 11-9 to Figure 11-10.

As expected no impact as a result of sludge disposal into the ERB void was therefore observed on the surface water quality as monitored at the respective five surface water monitoring locations.

12 GROOTVLEI # 3 SHAFT

12.1 Shaft Profiling Results

Profiling of the shaft water column in terms of water temperature, electrical conductivity (EC) and pH was conducted during June 2016 (baseline) and then monthly from December 2016 to July 2019 and then during February 2020. Profiling was not done during March 2018. All the profiling was conducted by SM Enviro Pty (Ltd).

The objectives of the shaft profiling were as follow:

- Identify changes in water quality within the shaft water column, associated with inflow of AMD water from the ERB void at certain depths. The main inflow of AMD water into the shaft is expected to be at 694 m where the Kimberley Reef was mined, with a possible small inflow expected at 305 m at the Black Reef. See Figure 4-2;
- Monitor the extent of possible AMD sludge build-up in shaft water column over time.

Initial profiling was done at approximately 1 m intervals, starting at the ERB void water level, down to 700+ m below top of shaft. The measurement intervals were changed to 5 m from the May 2017 profiling onwards. Temperature was only measured during the first six efforts. The results of EC and pH profiling to date is illustrated in Figure 12-1 to Figure 12-3.

Baseline profiling during June 2016 indicated a definite interface, between 140 m and 150 m, where temperature and EC increased and pH decreased when moving down in the shaft. During most shaft depth profiling efforts since this interface was observed and its depth has varied between 130 m to 160 m over time. See Figure 12-2. The interface depth was likely influenced by factors such as operational conditions, seasonal rainfall and the ERB mine void water level. Monitoring and flow conditions within the shaft water column were not consistent on a month to month basis when monitoring was conducted. It is important to note that the shaft water column represents a dynamic zone where flow is taking place. The flow dynamics and therefore monitoring conditions within the shaft is significantly influenced by the number of AMD abstraction pumps in operation and daily hours of operation.

The void water above the interface, with lower temperature and EC but higher pH, is inferred to represent void water of which the quality is impacted upon by water originating from the shallow dolomite aquifer and ingress from a variety of surface water sources, e.g. the Blesbokspruit. The void water below the interface is characteristic of what can be expected of AMD water, with higher EC but lower pH.

The mentioned interface was notably absent during October 2018 and three subsequent profiling efforts. See Table 12-1. These four profiling efforts were conducted during the period that the plant was not operational. All EC values during this period were below 170 mS/m, compared to values as high as 300 mS/m during other months. During April 2018 to June 2018 the interface was also less defined. EC values obtained during the profiling efforts are summarised in Table 12-1.

Shaft profiling results: February 2020

February 2020 profiling was only conducted down to 450 m, as entanglement of equipment was a significant problem during the July 2019 profiling at deeper depths.

The latest profiling results were significantly different from previous results. Similar to previous profiling, the mentioned interface was again observed between 150 and 165 m. See Figure 12-2. The extent to which EC values increased below the interface was however much larger. EC values during previous profiling have not exceeded 330 mS/m, while during February 2020, 50% of values taken deeper than 180 m exceeded 400 mS/m. A highest value of 469 mS/m was observed at 210 m. Between 415 m and 435 m, EC values dropped to below 200 mS/m. The resulting variation in values of 281 mS/m was the largest observed to date. Figure 12-1.

pH values during the February 2020 profiling were lower than during previous months and averaged 5.92 at depths below 180 m. Similar values were last observed during February 2017. See Table 12-2 and Figure 12-3.

The plant was only operational again for eight day before the latest profiling was conducted on 26 February 2020. Abstraction averaged 52 207 m³ during this eight days. The plant did not operate between 6 January 2020 and 18 February 2020 as maintenance was done on a thickener unit. The difference of the latest profiling results with previous results likely relates to the timing of the profiling in this regard.

Table 12-1 Shaft Profiling – EC Summary

Profiling Month and Date	EC at top of Shaft water column, mS/m	Depth 180 m to 650 m				Average EC, all depths, mS/m
		Minimum EC, mS/m	Maximum EC, mS/m	EC Variance, mS/m	Average EC mS/m	
Jun 2016/06/27	153	225	225	0	225	219
Dec 2016/12/14	215	318	326	8	321	316
Jan 2017/01/27	229	319	323	4	320	315
Feb 2017/02/27	188	316	319	3	318	313
Mar 2017/03/30	214	317	320	3	318	314
Apr 2017/04/24	114	314	318	4	316	309
May 2017/05/24	287	300	317	17	313	286
Jun 2017/06/21	261	288	299	11	291	290
Jul 2017/07/31	310	299	311	12	304	305
Aug 2017/08/30	286	259	307	48	287	290
Sep 2017/09/30	226	260	310	50	287	287
Oct 2017/10/23	195	230	298	68	257	254
Nov 2017/11/10	178	194	235	41	207	205
Dec 2017/12/13	167	226	311	85	268	270
Jan 2018/01/10	143	110	236	126	188	191
Feb 2018/02/26	124	170	239	69	190	188
Apr 2018/04/30	121	138	193	55	152	155
May 2018/05/31	99	119	159	40	131	132
Jun 2018/06/29	112	131	174	43	145	146
Jul 2018/08/02	114	155	203	48	196	190
Aug 2018/08/29	128	135	261	126	196	196
Sep 2018/10/01	113	118	154	36	129	130
Oct 2018/10/30	123	113	153	39	127	130
Nov 2018/11/28	115	114	169	55	134	133
Dec 2018/12/12	118	107	138	31	121	122
Jan 2019/01/30	162	249	295	46	276	268
Feb 2019/02/27	228	238	290	52	275	272
Mar 2019/03/25	124	189	283	94	264	258
Apr 2019/04/26	135	189	265	76	245	236
May 2019/05/27	131	206	267	61	247	239
Jun 2019/06/26	135	183	236	53	212	207
Feb 2020/02/26	131	188	469	281	389	361

Table 12-2 Shaft Profiling – pH Summary

Profiling Month and Date	pH at top of Shaft water column	Depth 180 m to 650 m				Average pH, all depths
		Minimum pH	Maximum pH	pH Variance	Average pH	
Jun 2016/06/27	7.28	6.12	6.15	0.03	6.13	6.20
Dec 2016/12/14	7.17	6.22	6.32	0.10	6.25	6.42
Jan 2017/01/27	6.94	6.11	6.73	0.62	6.17	6.24
Feb 2017/02/27	7.30	5.90	6.70	0.80	6.02	6.12
Mar 2017/03/30	7.18	5.75	6.85	1.10	6.22	6.37
Apr 2017/04/24	7.51	6.00	6.80	0.81	6.20	6.39
May 2017/05/24	6.52	N/A	N/A	N/A	N/A	N/A
Jun 2017/06/21	6.77	6.07	6.54	0.47	6.40	6.49
Jul 2017/07/31	6.35	6.32	6.42	0.10	6.35	6.37
Aug 2017/08/30	6.43	6.39	6.64	0.25	6.48	6.48
Sep 2017/09/30	7.10	6.43	6.76	0.33	6.52	6.54
Oct 2017/10/23	7.19	5.78	6.93	1.15	6.63	6.67
Nov 2017/11/10	6.70	6.06	7.08	1.02	6.77	6.81
Dec 2017/12/13	7.58	7.29	7.74	0.45	7.40	7.40
Jan 2018/01/10	7.20	6.86	7.63	0.77	7.04	7.05
Feb 2018/02/26	7.25	6.35	6.72	0.37	6.48	6.53
Apr 2018/04/30	7.24	6.27	6.67	0.40	6.37	6.42
May 2018/05/31	7.68	4.21	6.57	2.36	6.26	6.32
Jun 2018/06/29	7.52	6.58	7.26	0.68	6.88	6.92
Jul 2018/08/02	7.59	5.95	6.51	0.56	6.15	6.23
Aug 2018/08/29	7.53	6.27	6.84	0.57	6.41	6.46
Sep 2018/10/01	7.97	6.89	7.63	0.74	7.05	7.11
Oct 2018/10/30	7.40	6.96	7.79	0.83	7.27	7.30
Nov 2018/11/28	7.57	6.75	7.66	0.91	7.23	7.25
Dec 2018/12/12	7.61	6.83	7.72	0.89	7.26	7.28
Jan 2019/01/30	7.59	6.08	6.78	0.70	6.28	6.36
Feb 2019/02/27	7.90	6.70	7.31	0.61	6.93	6.99
Mar 2019/03/25	7.55	5.91	6.56	0.65	6.16	6.24
Apr 2019/04/26	6.96	6.09	6.58	0.49	6.35	6.36
May 2019/05/27	7.78	6.76	7.38	0.62	6.89	6.97
Jun 2019/06/26	8.14	5.89	6.59	0.70	6.15	6.25
Feb 2020/02/26	7.19	5.76	6.22	0.46	5.92	6.08

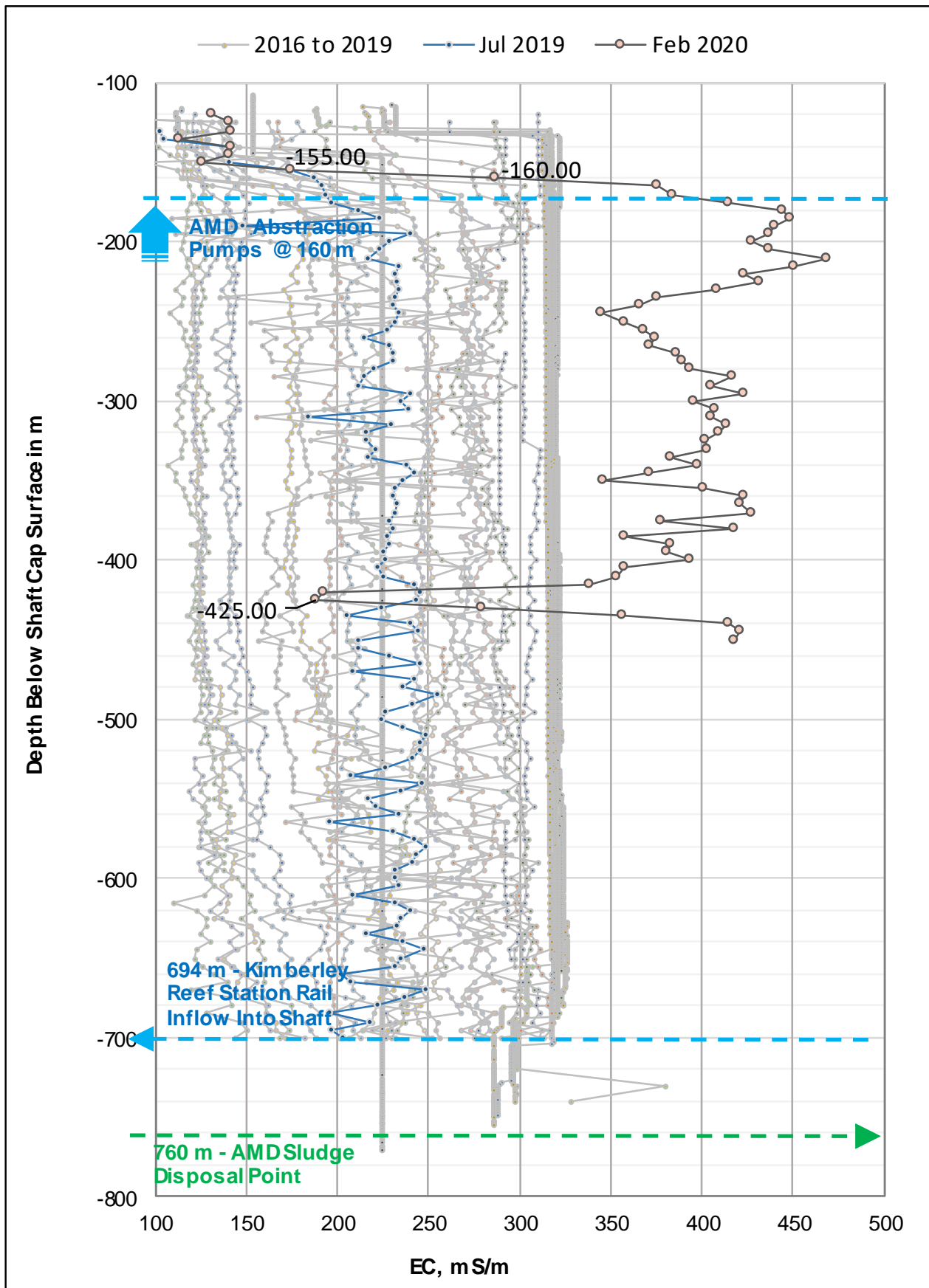


Figure 12-1 Grootvlei # 3 Shaft Profiling, EC

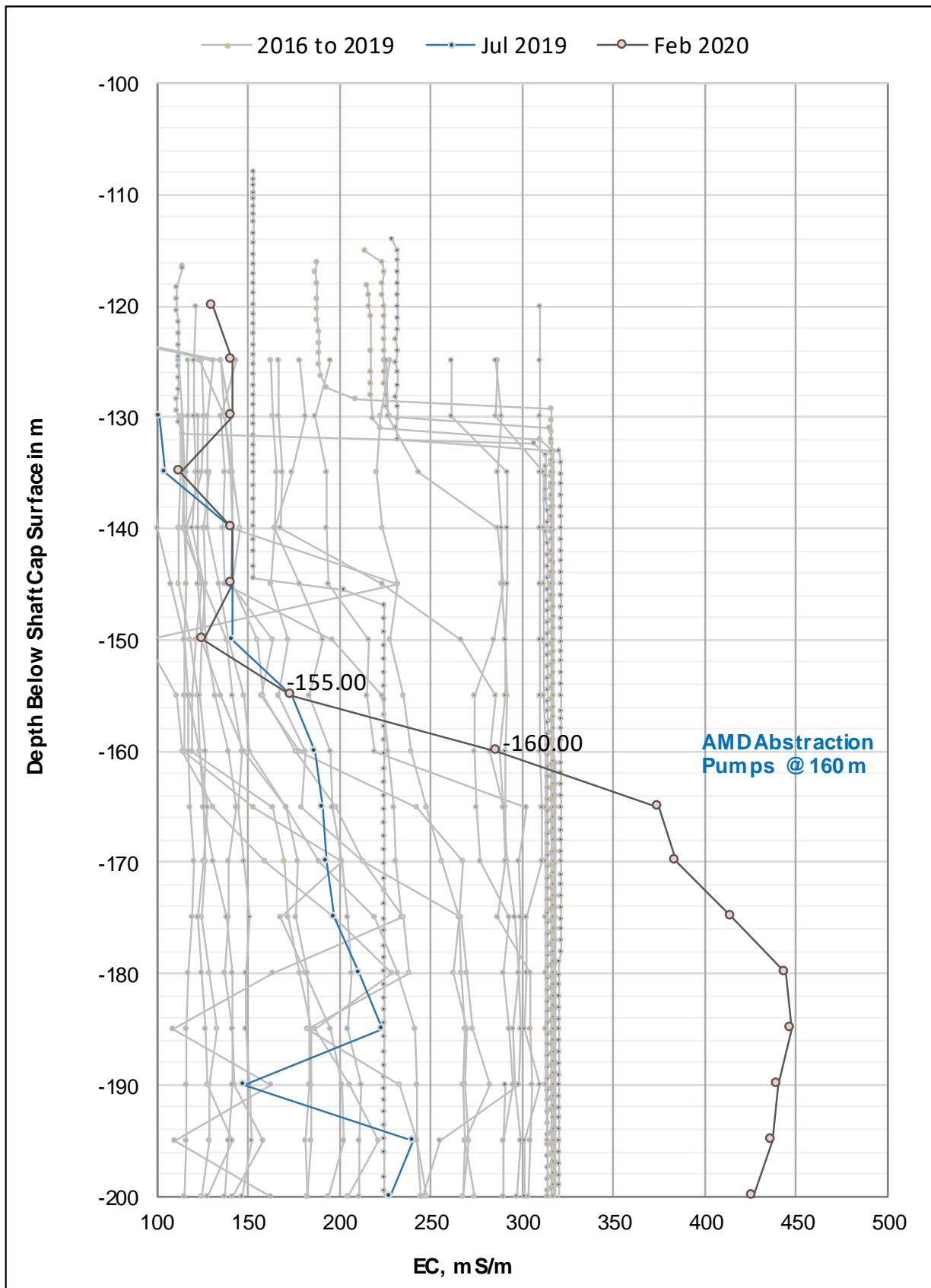


Figure 12-2 Grootvlei # 3 Shaft Profiling Data, EC (-100 m to -200 m)

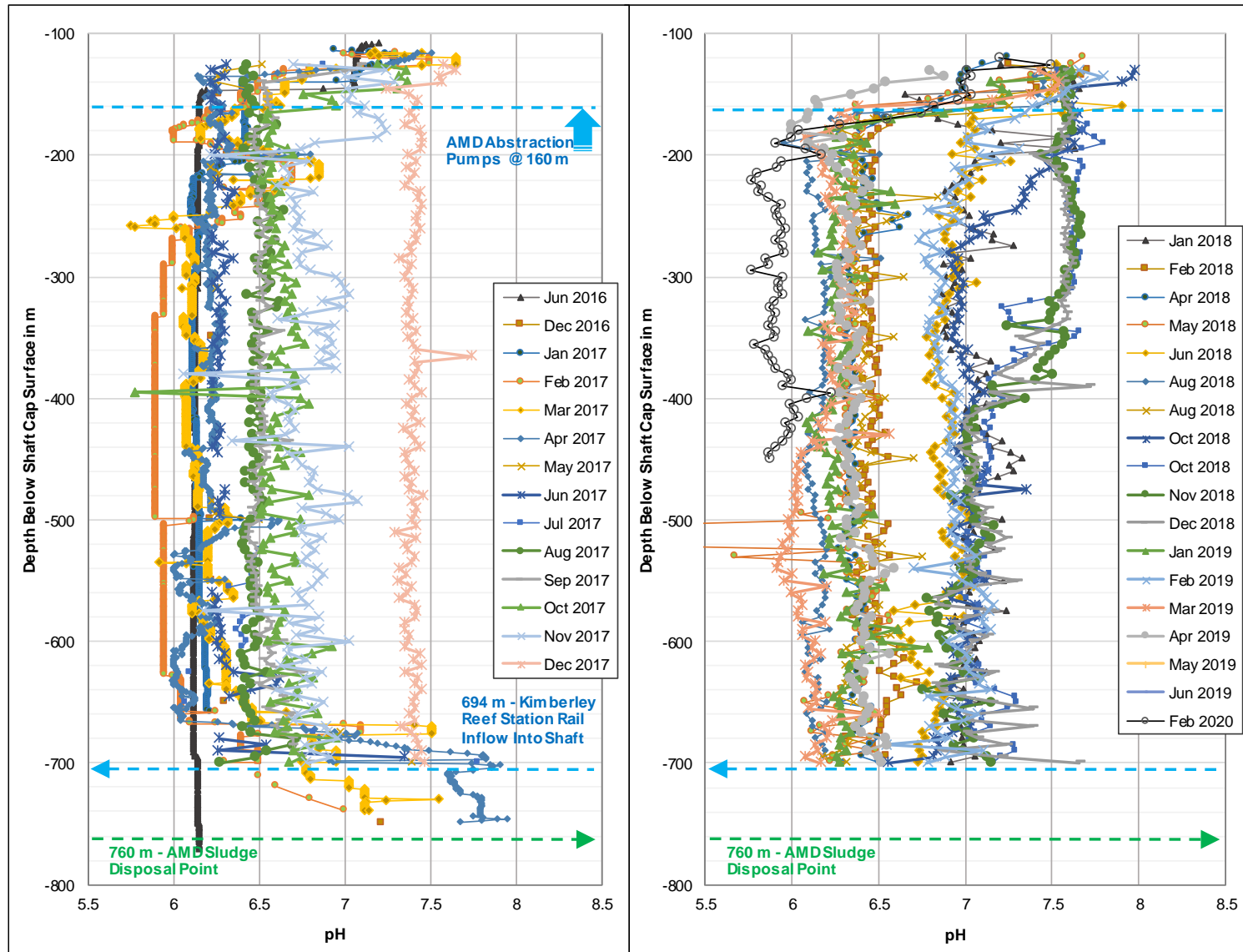


Figure 12-3 Grootvlei # 3 Shaft Profiling Data – pH

12.2 Shaft Water Quality Results

Baseline water monitoring of the shaft water was conducted during June 2016. Routine sampling was conducted thereafter on a monthly basis from December 2016 to July 2019. Samples were taken again on 26 February 2020. Thirty-two sampling runs have been conducted since December 2016. Samples taken from within the shaft were all taken by SM Enviro Pty (Ltd). Samples from the shaft water column were mainly collected at depths of 125 m, 200 m, 500 m and 700 m, as measured from the top of the shaft cap. Samples are therefore referred to in terms of the depth at which they were taken. See Figure 4-2. Samples were also taken at intermediate depths for TSS and turbidity analyses only. During February 2020, samples were only taken at 125 m, 200 m and 400 m as entanglement of equipment was a significant problem during the July 2019 sampling run. During June 2019 and February 2020, samples of the AMD feed to the plant were also taken. Results for samples taken from the shaft are detailed in Table 17-9 to Table 17-17.

As mentioned with the shaft profiling data, it is important to note that the shaft water column represents a dynamic zone where flow is taking place. Monitoring and flow conditions within the shaft water column were therefore not consistent on a month to month basis when monitoring was conducted. Data was therefore evaluated for overall trends and compared to baseline data in order to quantify the impact of sludge disposal.

12.2.1 Total Suspended Solids & Turbidity

One of the most important objectives of monitoring within the shaft is to monitor the possible build-up of sludge discharged by the plant within the shaft. Shaft samples were therefore analysed for Total Suspended Solids (TSS) and turbidity. Detailed results for these parameters are listed in Table 17-15 and Table 17-16 respectively. As can be expected, TSS values and turbidity level trends were observed to behave correspondingly. TSS was however found to be the best indicator of possible sludge build-up as turbidity is limited to a maximum determination limit of 4 000 N.T.U.

During baseline monitoring in June 2016, TSS of 18 mg/L was observed at 125 m. Higher values (117 mg/L to 138 mg/L) at the three deeper sampling locations, down to 700 m, were observed. Thereafter, TSS values varied significantly, initially only at the deepest levels, but by January 2018 were indicative of substantial impact by the sludge disposed in the shaft at 760 m. A highest TSS value of 52 838 mg/L was observed at 700 m during November 2017. Values at depths above 650 m did not exceed 1 000 at any time. Based on the TSS and turbidity data, influence of sludge disposal diminished within the Grootvlei # 3 Shaft during 2018, following the changing of the disposal point to borehole BH8. TSS values at depths above 700 m were all below 200 mg/L from June 2018 to July 2019. During September 2019, sludge was again disposed of into the shaft, with resulting elevated TSS values. This was however observed in the daily plant operation data, as monthly sampling was not conducted at the time.

Cognisance should be taken of the respective historical sludge disposal phases when interpreting the Total Suspended Solids (TSS) and turbidity results in Table 17-15 and Table 17-16. The phases are therefor listed, as follow:

- Jun 2016 – Baseline values obtained prior to sludge disposal;
- Dec 2016 to Dec 2018 – Sludge disposal within the shaft;
- Jan 2018 - Sludge disposal varied between three new deep void sludge disposal boreholes (BH6N, BH1N and BH8) drilled into the ERB void. BH1N and BH8 were drilled to 669 m and 684 m respectively. On 5 January a pressure blowout occurred at BH1N rendering it out of operation. Disposal on 8 -10 January switched to the shaft which resulted in a sharp increase in TSS & turbidity levels as observed at the AMD pump intake levels. Thereafter disposal was switched to BH8;
- Feb 2018 to 18 September 2018 – Sludge disposal via BH8 located approximately 230 m from the shaft, into the ERB mine void at a depth of 684 m.
- 19 September 2018 to 14 January 2019 - No disposal due to breakdown.
- 15 January 2019 to 8 September 2019 – Sludge disposal via BH8 and BH1 (19 Feb. to 12 Mar. and 9 Apr. to 15 Apr.).
- 9 September 2019 to 3 October 2019 - Sludge disposal to shaft, abstraction reduced.
- 4 October 2019 to 6 January 2020 - Sludge disposal via BH8
- 7 January 2020 to 17 February 2020 - No abstraction or disposal, due to maintenance
- 18 February 2020 to 1 March 2020 - Sludge disposal via BH8

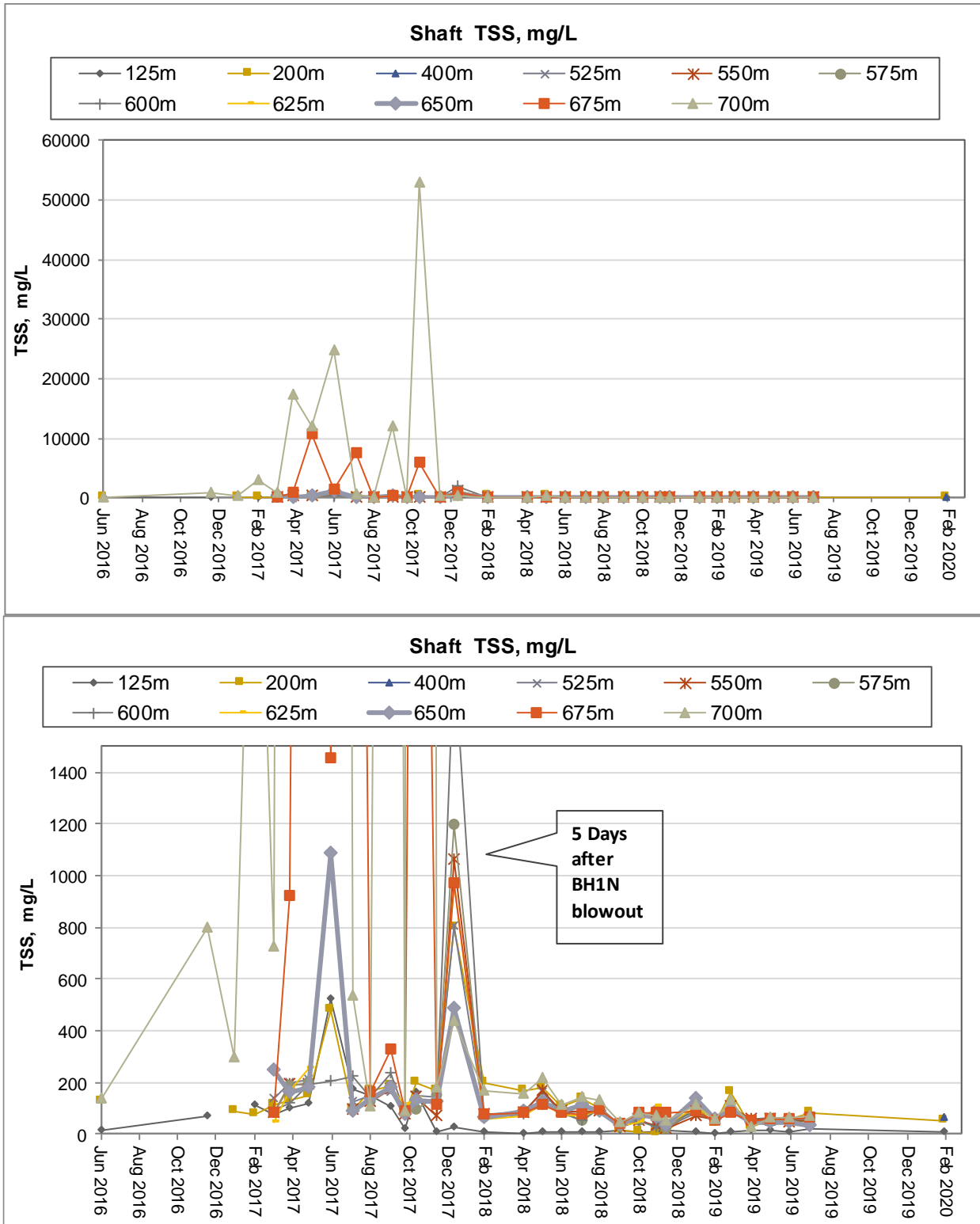


Figure 12-4 Shaft – Total Suspended Solids with Time

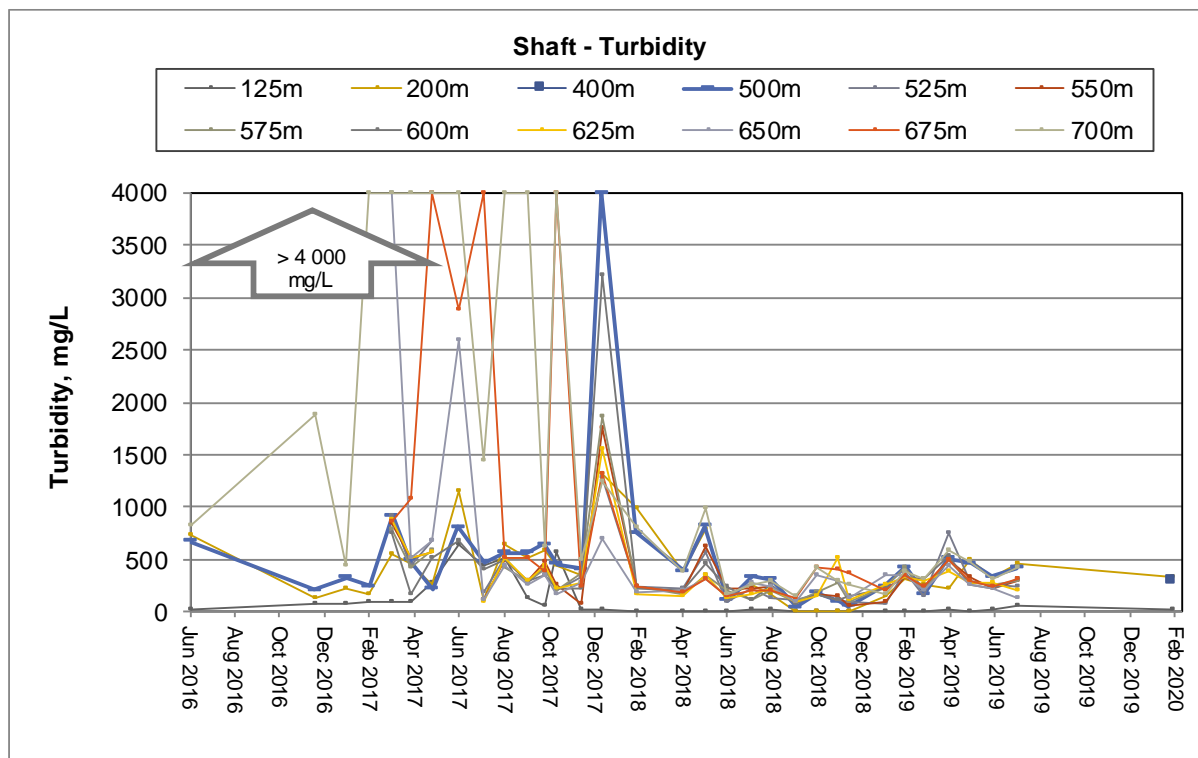


Figure 12-5 Shaft – Turbidity with Time

12.2.2 Hydrochemistry – Macro Constituents

The overall water quality of samples taken from the shaft since June 2016 is illustrated in Figure 12-8. For the years 2017 to 2019, average values were used.

When comparing the baseline results from June 2016 with results obtained during July 2019 and February 2020, some improvement over time can be observed. TDS decreased by 21% on average from June 2016 to July 2019 and February 2020 at depths of 200 m and deeper. At the 125 m level, TDS decreased by 4% from June 2016 to February 2020. See Table 12-3.

For most samples the sulphate constituted approximately 50% per mass of the TDS. The pH of the shaft water column was observed to be neutral to slightly alkaline, with an average pH of 7.35 observed for all shaft samples collected at all four sampling depths to date. See Figure 12-7. pH values at 125 m have varied between 7.9 and 8.5, except during June 2017 to September 2017, when values averaged 6.9. pH values at 200 m to 700 m have been either similar to that at 125 m or displayed values near 6.7.

Macro-chemistry results obtained to date of the shaft water did not indicate adverse impact on the mine void water (raw AMD) by sludge disposal.

Table 12-3 Shaft Samples - Macro Parameters % Change: Jun 2016 to July 2019 and to February 2020

Depth	Date	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	TDS
125m	Jun 2016 Baseline	180	92	78	10	92	569	0.98	1140
	Jul 2019	208	88	82	10	116	724	1.24	1284
	Feb 2020	178	75	67	11	95	540	1.46	1090
	Jul. 2019, % Increase (+) or Decrease (-)	+16	-4	+6	-4	+27	+27	+27	+13
	Feb. 2020, % Increase (+) or Decrease (-)	-1	-18	-14	+6	+3	-5	+49	-4
200m	Jun 2016 Baseline	354	104	120	14	196	1438	0.34	2466
	Jul 2019	313	99	105	12	170	1177	0.40	1888
	Feb 2020	331	97	100	14	175	1052	0.51	1904
	Jul. 2019, % Increase (+) or Decrease (-)	-12	-5	-13	-9	-13	-18	+18	-23
	Feb. 2020, % Increase (+) or Decrease (-)	-6	-7	-17	+1	-11	-27	+52	-23
500m	Jun 2016 Baseline	361	105	122	14	202	1430	0.32	2388
	Jul 2019	326	99	108	13	176	1155	0.36	1856
	Jul. 2019, % Increase (+) or Decrease (-)	-10	-6	-11	-8	-13	-19	+12	-22
700m	Jun 2016 Baseline	356	105	122	14	202	1395	0.55	2396
	Jul 2019	306	99	116	13	169	1147	0.42	1958
	Jul. 2019, % Increase (+) or Decrease (-)	-14	-6	-5	-9	-16	-18	-24	-18

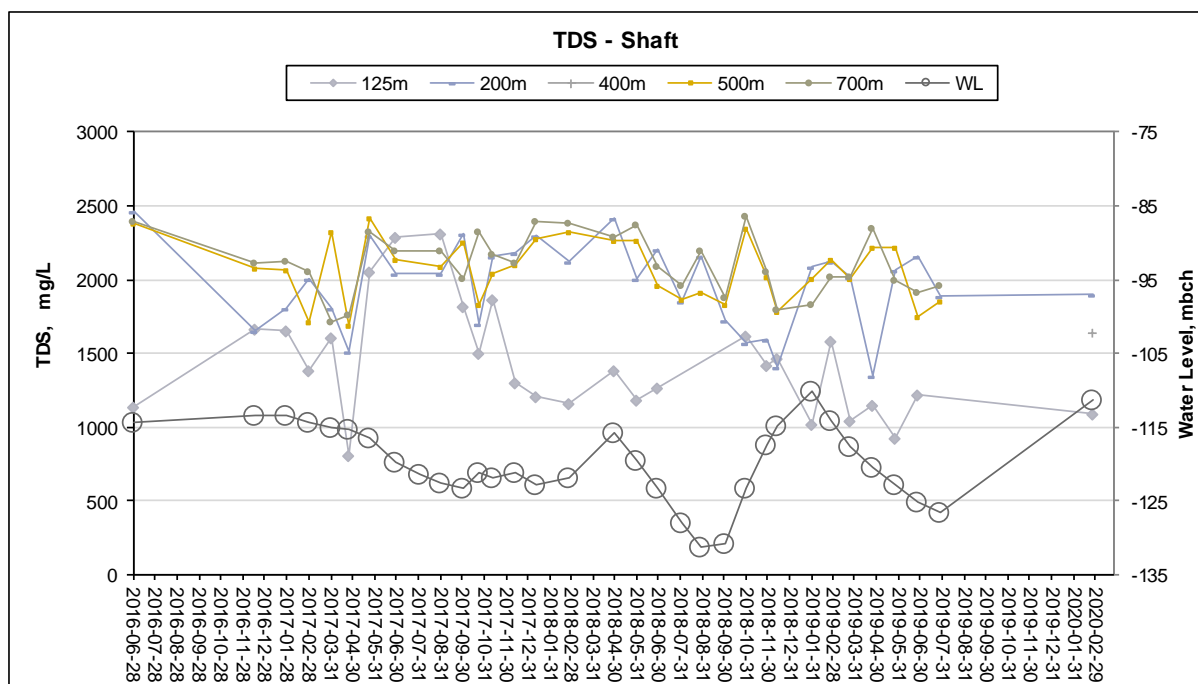


Figure 12-6 Shaft – TDS with Time

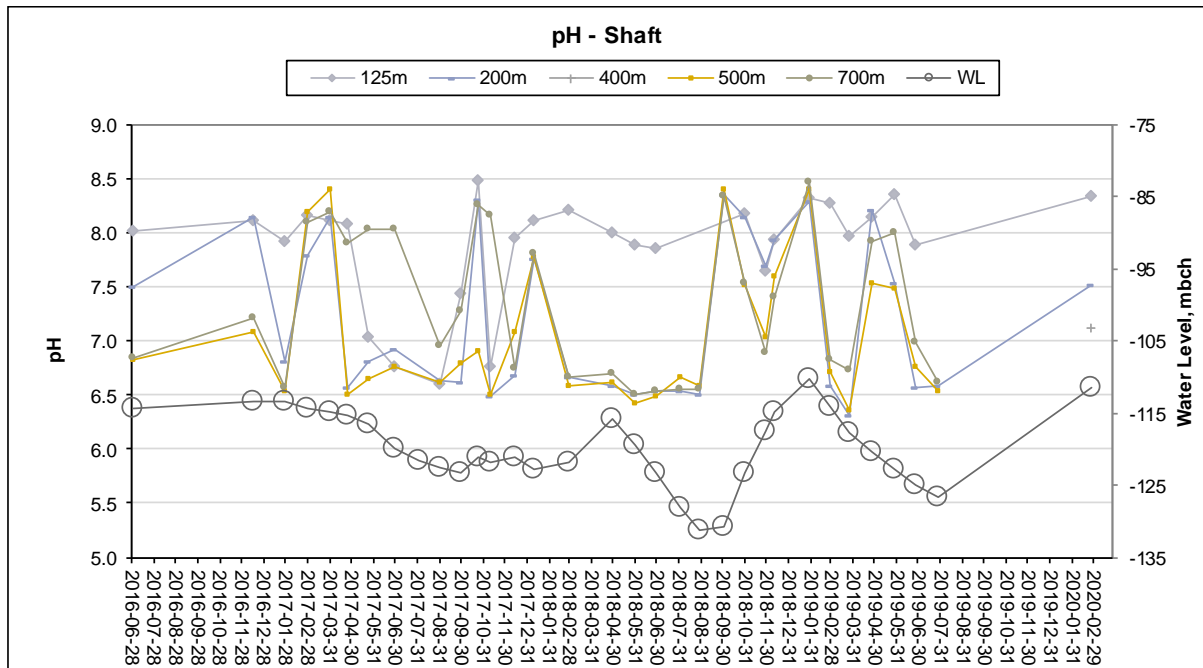


Figure 12-7 Shaft – pH with Time

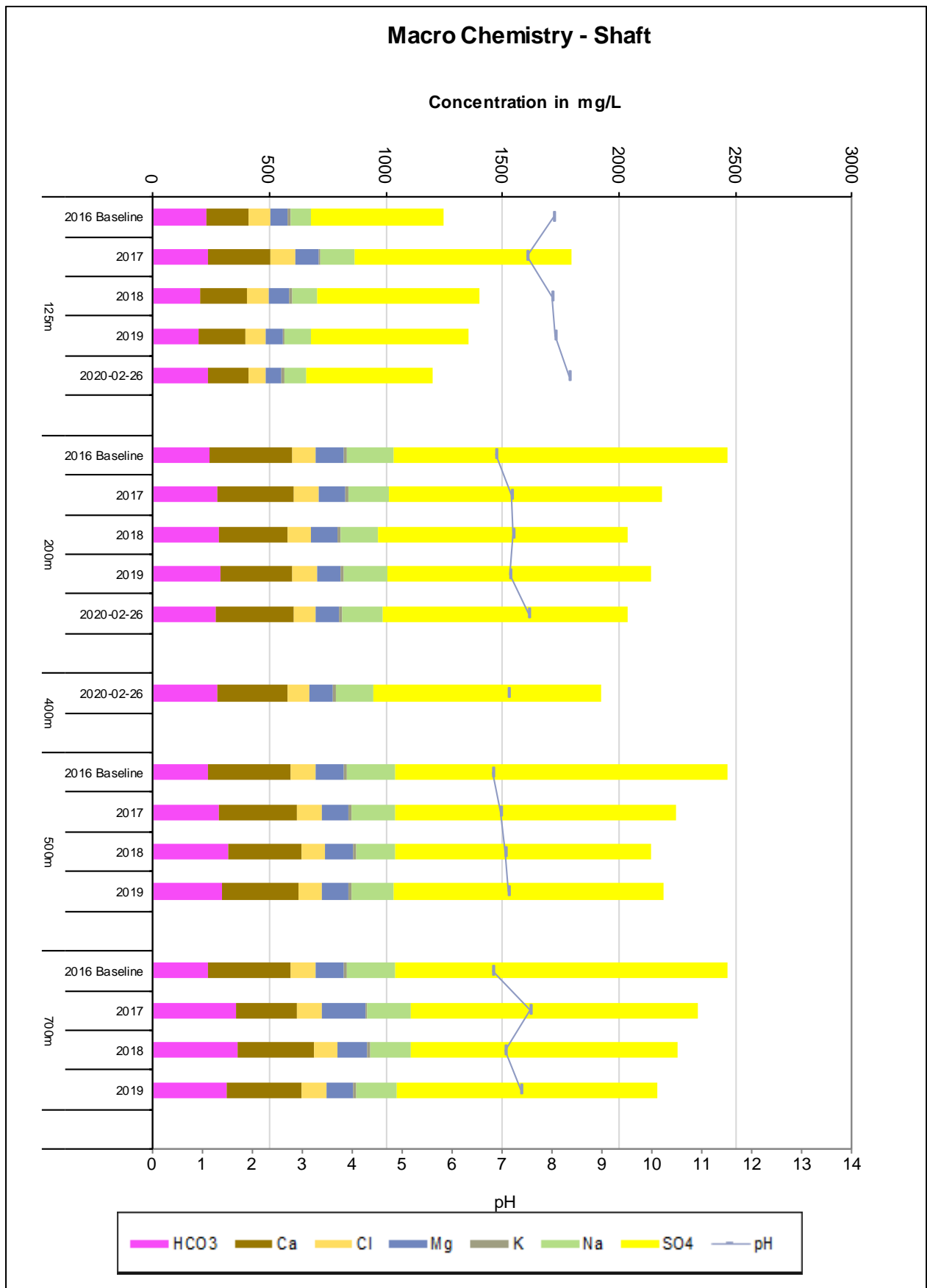


Figure 12-8 Shaft - Chemical Composition, Jun 2016 to Feb 2020

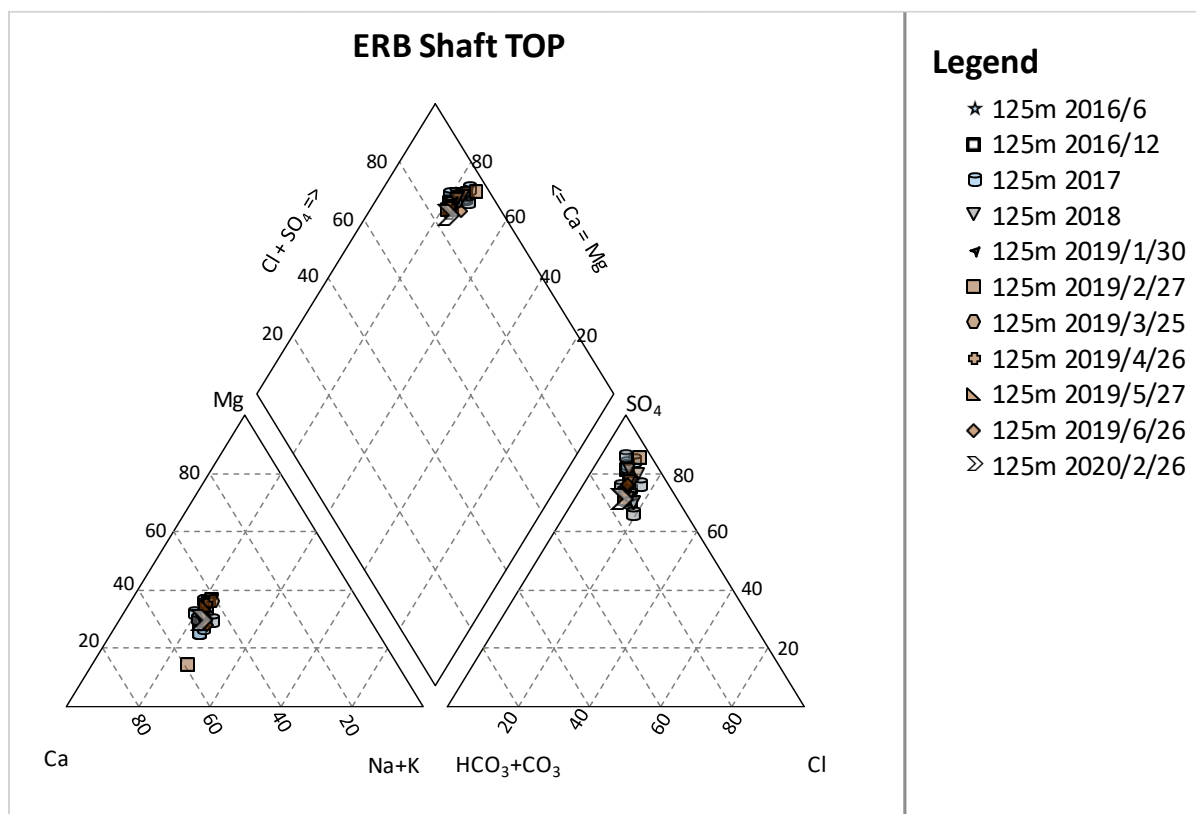


Figure 12-9 Piper Diagram – Shaft – 125 m Samples with Time

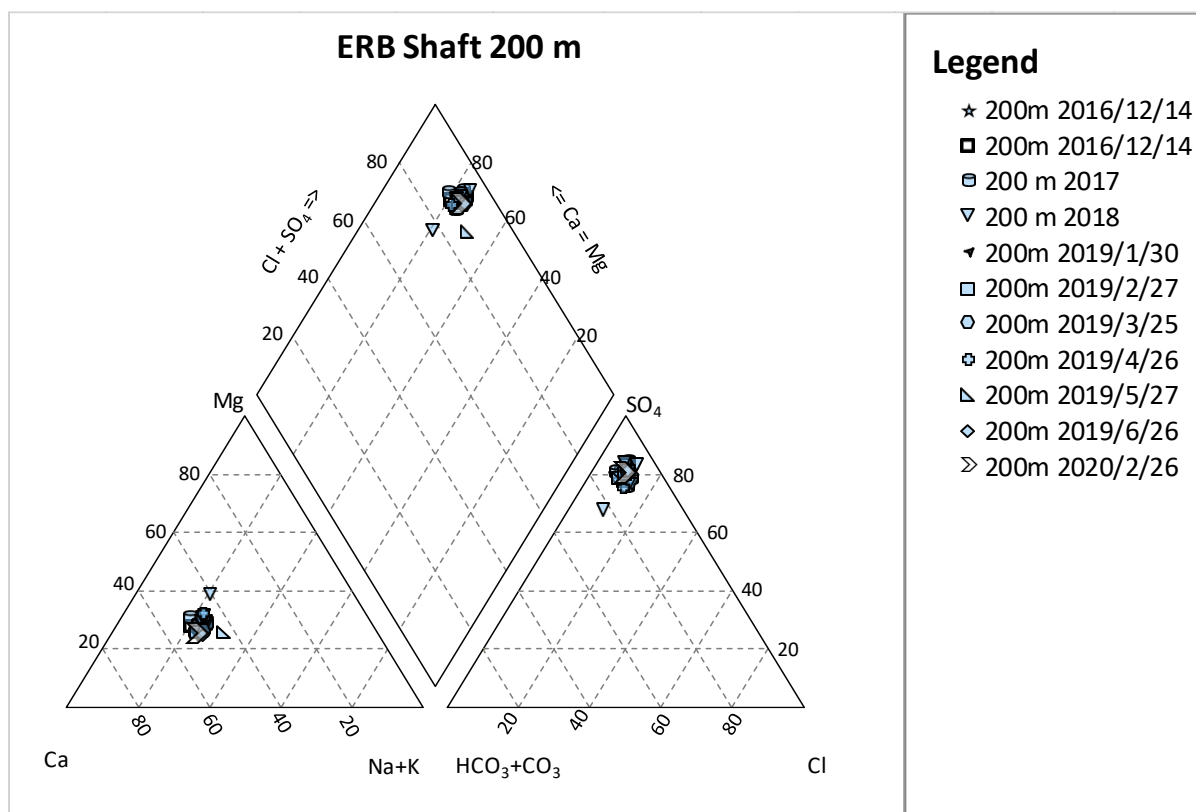


Figure 12-10 Piper Diagram – Shaft – 200 m Samples with Time

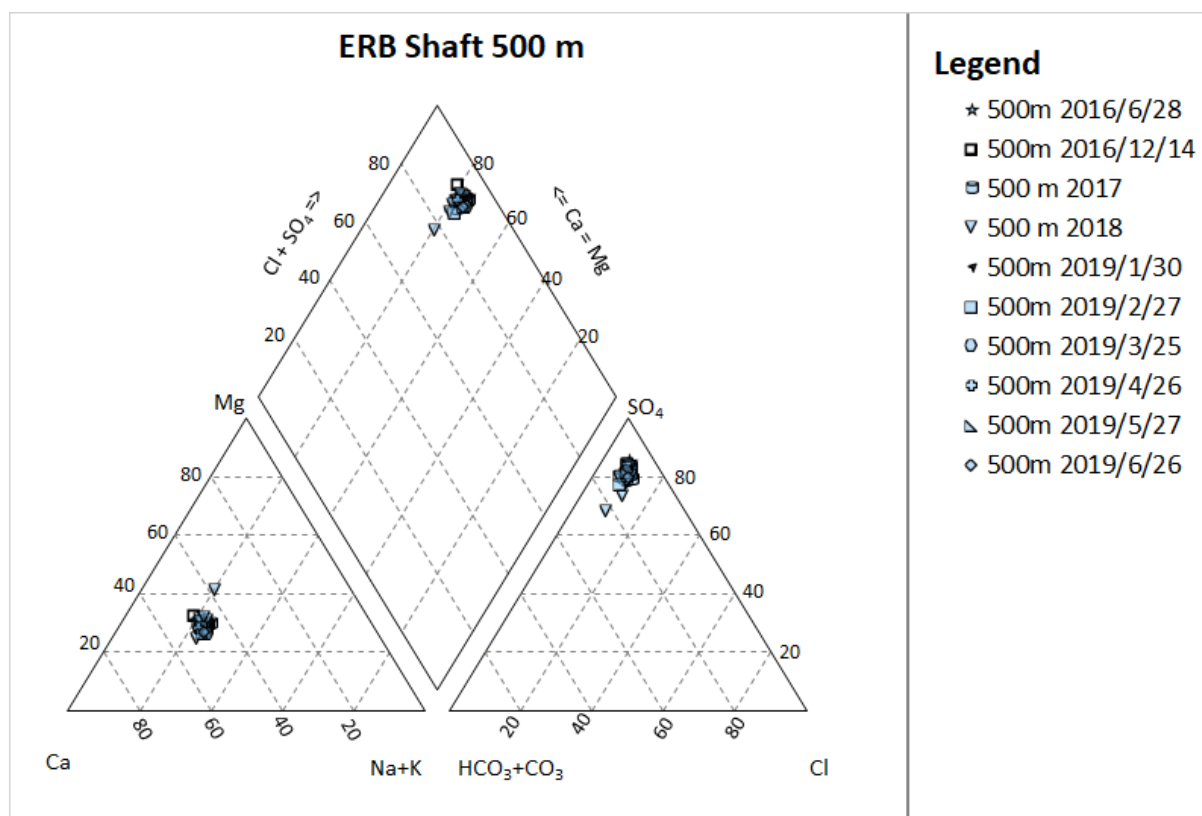


Figure 12-11 Piper Diagram – Shaft - 500 m Samples with Time

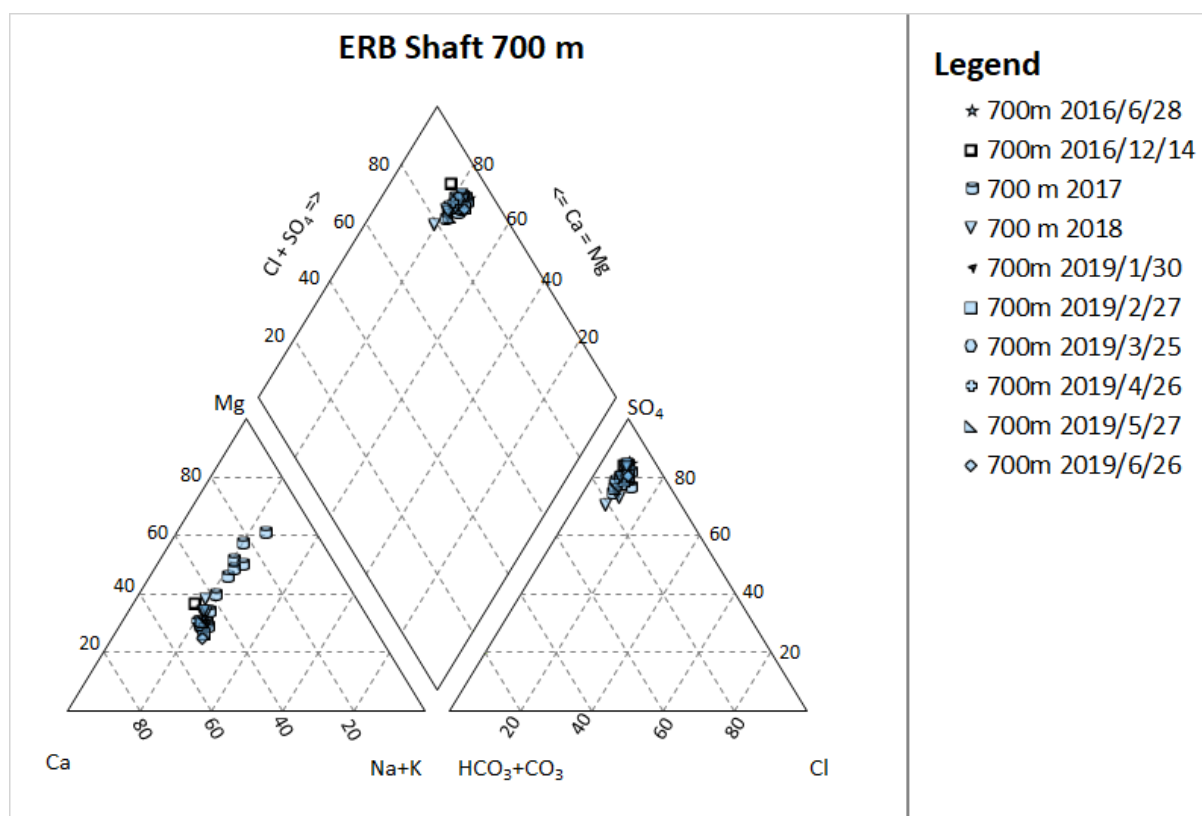


Figure 12-12 Piper Diagram – Shaft- 700 m Samples with Time

The water quality of the respective shaft samples is presented in Piper diagrams in order to observe any changes in quality with depth and time. See Figure 12-9 to Figure 12-12. The water for samples collected from all depths was observed to be very similar in quality, with all being representative of stagnant water with a predominant calcium/ sulphate nature. Changes in the Ca/Mg ratio in samples from 700 m was however evident from the diagram. See Figure 12-12. This ratio was also noted to be high (Ca/Mg = 1.18 on 23 October 2017) when TSS values were low, and vice versa (Ca/Mg =0.58 on 10 January 2018). An inverse correlation between these parameters does however not hold, due to multiple other influences.

Free chlorine was included in analyses for the first time during the May 2019 monitoring. Free chlorine is associated with the effluent from sewage works and under certain conditions can be used as a tracer indicator for the presence of effluent in other water. As a substantial amount of the Blesbokspuit water flow comes from Erwat sewage discharge and then has ingress to the shaft. Free chlorine was only detected in one of nine samples from the shaft taken from May 2019 to July 2019. It was detected just above the limit of detection (0.1 mg/L) at 0.11 mg/L in the sample from 700 m taken during May 2019. The use of free chlorine as tracer for surface water reaching the shaft column does therefor not seem to be a possibility. The parameter was not analysed in the latest samples taken

The sample taken from the AMD feed to the plant during the June 2019 sampling did not differ significantly from the sample taken at 200 m. See Figure 12-13. This was as expected as AMD feed is pumped from approximately 160 m depth. Concentrations for major components in the February 2020 AMD feed sample was however 17% higher than that of the sample taken at 200 m.

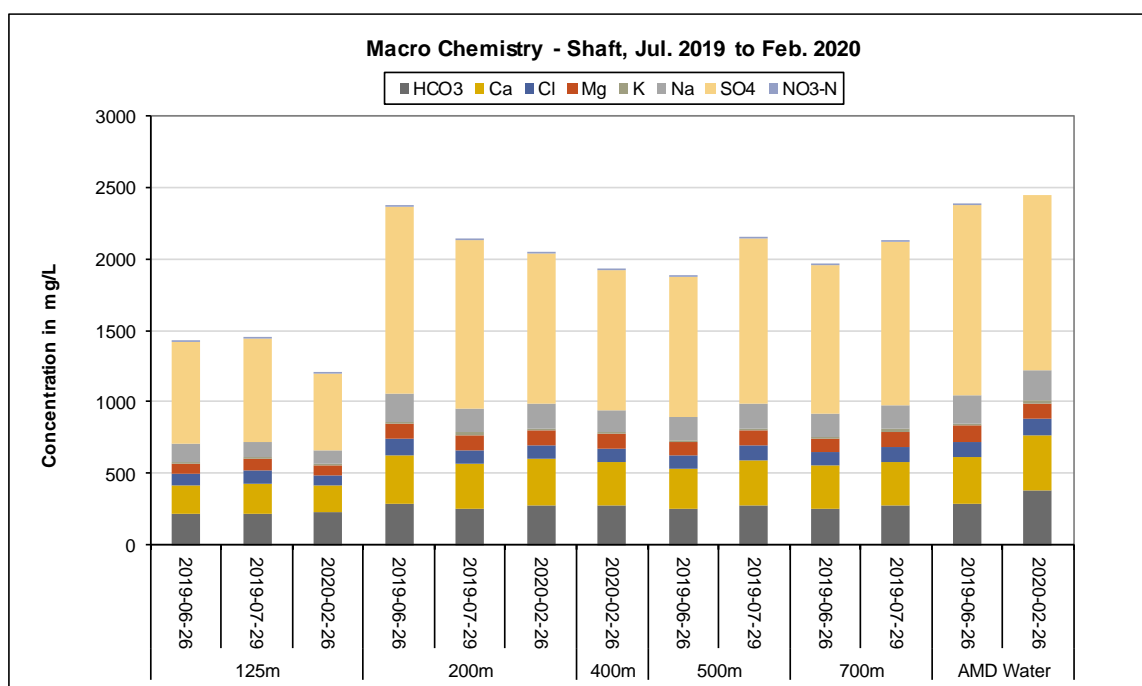


Figure 12-13 Chemical Composition– Shaft and AMD Feed, July 2019 to February 2020

12.2.3 Metals

Metals of relatively significant concentrations detected in the shaft water were Fe, Mn and U.

During June 2016 baseline monitoring the Fe concentration at 125 m was below the detection limit of 0.004 mg/L. The Fe concentrations at 200 m, 500 m and 700 m were almost identical, at 34.6 mg/L, 34.3 mg/L and 34 respectively. See Figure 12-14.

During the thirty-two sampling runs conducted since June 2016, soluble Fe was detected in approximately half of the samples taken at 200 m, 500 m and 700 m. When detected, values were varied, with a highest value of 99 mg/L at 700 m during June 2019. Elevated Fe concentrations can be attributed to the iron utilised in the underground mining construction and the voids which has been flooded for many years. No specific correlation between Fe concentrations and pH could be observed in the data obtained.

Iron concentrations observed for surface and groundwater samples were of very low concentrations or below the detection limit. See Figure 11-9. Iron concentrations in all samples taken at 125 m in the shaft were also below the detection limit of 0.004 mg/L.

Mn has been detected in all samples taken from the shaft except one sample (March 2019 sample from 125 m). See Figure 12-15. During June 2016 baseline monitoring a Mn concentration of 4 mg/L was detected at depths of 200 m, 500 m and 700 m. At 125 m, 0.83 mg/L Mn was detected.

Average Mn concentrations to date were observed to increase from 1.3 mg/L at 125 m to 3.3 mg/L at 200 m and then to 4.6 mg/L at 700 m. Mn concentrations at 200 m during October 2018 to December 2018 average of 0.058 mg/L, significantly lower than more typical values near 4 mg/L. This correlated with the significant overall water quality improvement observed at 200 m during secession of pumping.

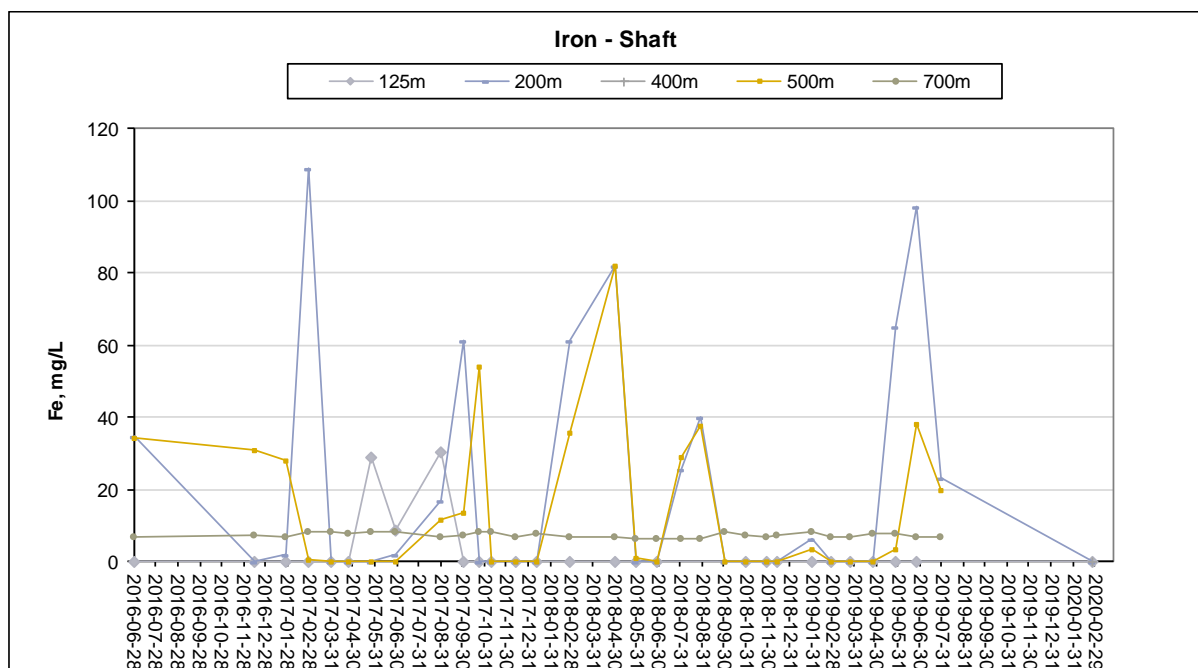


Figure 12-14 Shaft – Iron Concentrations with Time

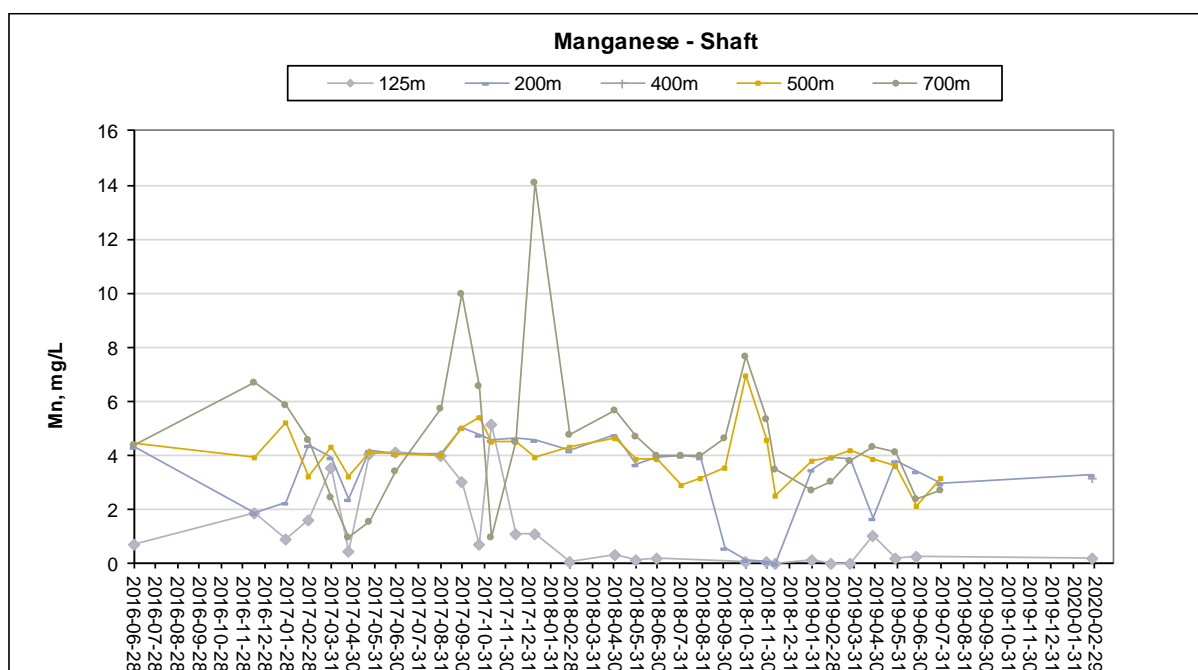


Figure 12-15 Shaft – Manganese Concentrations with Time

According to Hansen (2018), a baseline average uranium concentration in solution of 0.094 mg/L was measured at the shaft during 2004 and 2005, and is representative of pre-ERB basin flooding conditions. During June 2016 an average baseline concentration of 0.010 mg/L was measured for all shaft samples, representing post-ERB basin flooding conditions prior to AMD abstraction and sludge disposal. These levels as well as sample results are illustrated in Figure 12-17. U concentrations over time are illustrated in Figure 12-16.

Following the commencement of AMD abstraction and sludge disposal, uranium was also detected and averaged 0.165 mg/L at the four sampling depths during December 2016. This decreased gradually to 0.056 mg/L during June 2017. From August 2017 to October 2018, uranium was only detected in one sample (0.054 mg/L at 700 m during November 2017) and for other samples were below the detection limit of 0.015 mg/L. This decreasing trend in uranium concentrations observed was a significant improvement from pre-flooding (2004/5) conditions.

Uranium was again detected after AMD abstraction and sludge disposal terminated on 19 September 2018. It was detected in nine of the twelve samples taken to December 2018 and at concentrations from 0.016 mg/L to 0.036 mg/L. It is known that uranium as found naturally in ore can be oxidized by atmospheric oxygen to more water soluble species containing U(VI). It is therefore inferred that the exposure of the shaft void to atmospheric oxygen to a deepest depth of 134 m during September 2018 facilitated the formation of soluble species of U. Rising water levels after 19 September 2018 took the newly formed species into solution. No uranium was detected after a rise in water level of 3.2 m (134 m to 130.4 m) on 1 October 2018. After a rise of 10.6 m by 31 October 2018, uranium was however detected at all three locations below 125 m. It was detected at all four depths during November 2018 and at 500 m and 700 m during December 2018. The detection of uranium down to 700 m and the concentration of 0.036 mg/L at 700 m during December 2018 implies that water moved down the shaft as the water level increased and not up in the shaft.

During January 2019 to March 2019 uranium was not detected in any of the twelve samples taken from the shaft. During April 2019 to February 2020, uranium was detected in fifteen of the seventeen samples taken. Concentrations varied from 0.017 mg/L at 125 m to 0.094 mg/L at 700 m during May 2019. Uranium of 0.047 mg/L and 0.031 mg/L were determined in the samples taken from the AMD feed to the plant during June 2019 and February 2020 respectively.

ERB Treatment Plant monitoring results indicated that no uranium was measured above the detection limit of 0.015 mg/L in surface water and shallow surface groundwater monitoring locations or treated effluent discharged into the Blesbokspruit during the period June 2016 to December 2019 (Report no. E-R-2020-01-20).

The detection of uranium in samples from the shaft taken since Q2 2019, after not being detected during Q1 2019, as well as the concentrations observed at different depths are indicative of the complexity of the dynamics of the shaft water system.

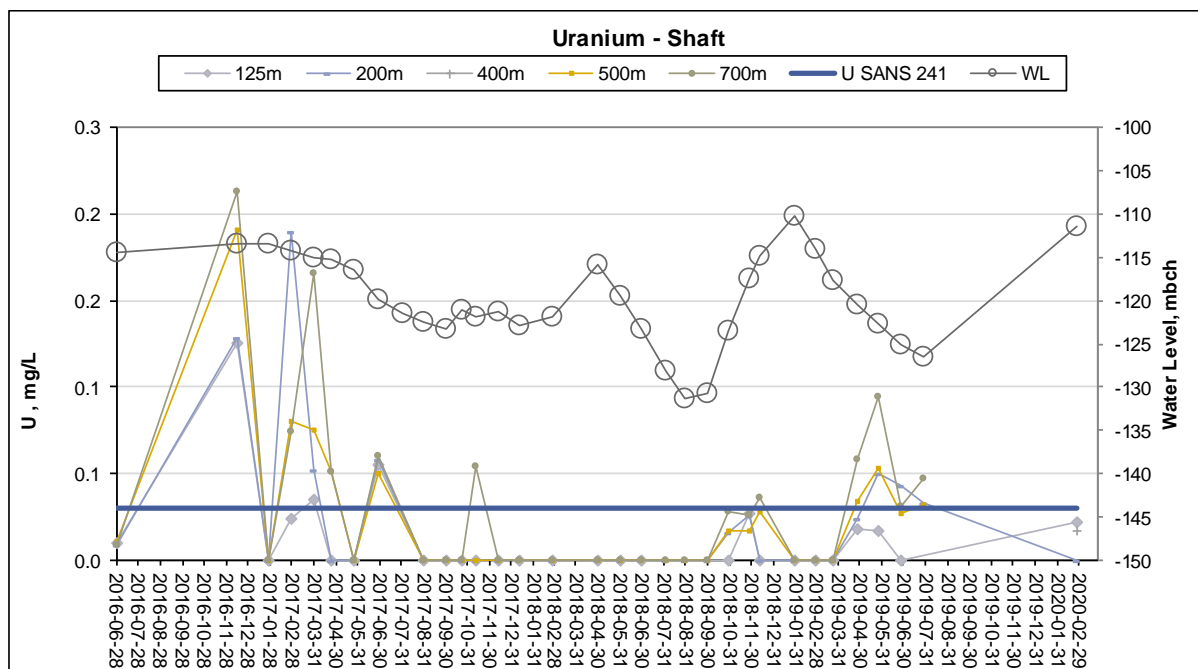


Figure 12-16 Shaft – Uranium Concentrations with Time

Comparison to SANS 241:2011, Drinking Water Standard

The water quality of the shaft was compared to the SANS 241 drinking water standards. This was done in order to evaluate the risk posed to human health in the event that the ECL was compromised and AMD water rose to the level of the shallow dolomite aquifer, thereby compromising an important water source. The shaft water quality has exceeded the SANS 241 drinking water standards in terms of Na, SO₄, EC, TDS, Fe, Mn, U and turbidity. Refer to Table 17-9 to Table 17-14. A risk observed was in terms of exposure to U and its compounds due to the associated chemical and radiological health effects. The three samples taken from the shaft at depth 200 m and deeper during July 2019 exceeded the SANS 241 (2015) limit for uranium of 0.03 mg/L. The three samples taken (125 m, 200 m and 400 m) during February 2020 did not exceed the limit.

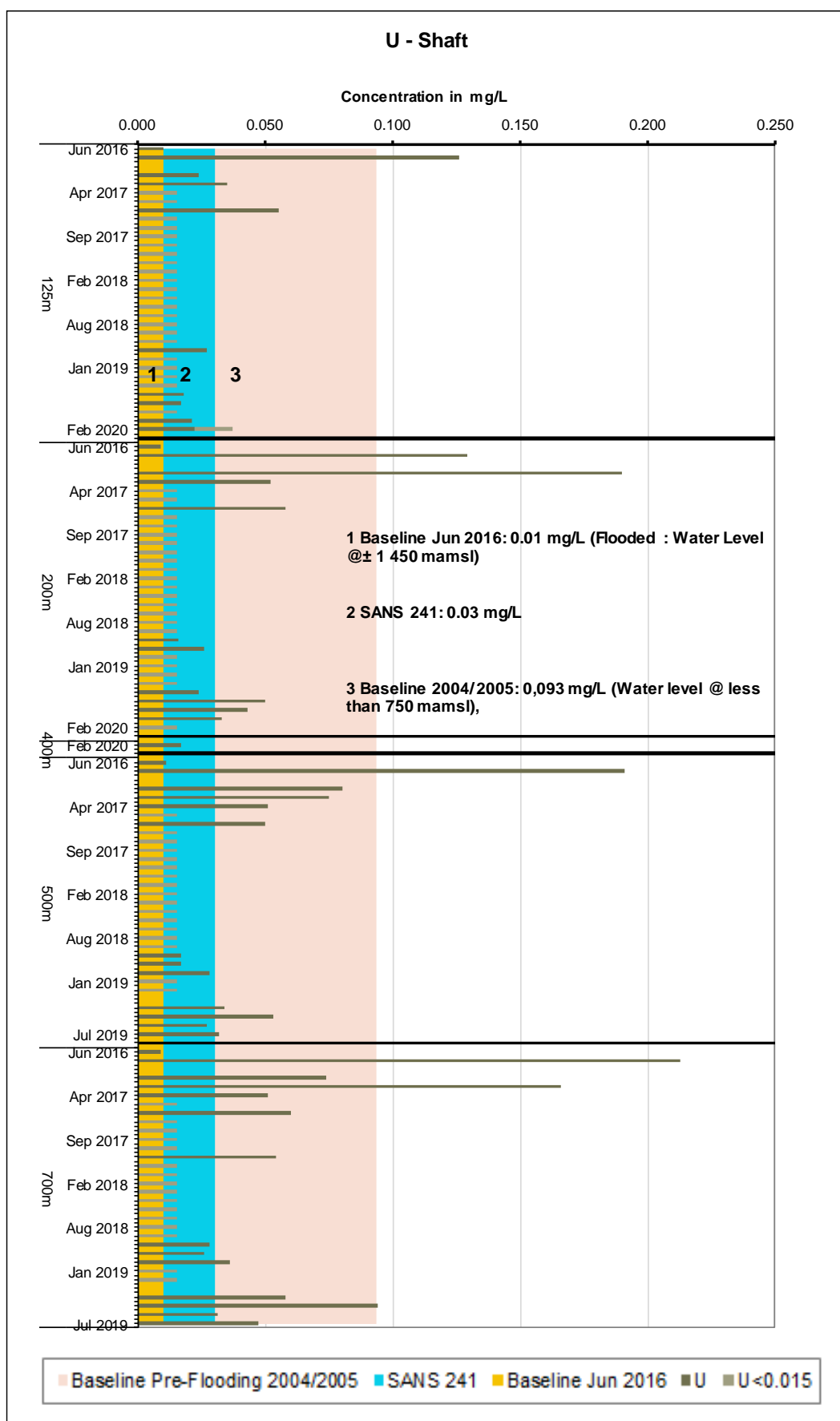


Figure 12-17 Shaft - Uranium Concentrations with Depth

12.3 Deep Void Borehole Monitoring

The locations of the three deep void sludge disposal boreholes are illustrated in Figure 8-2, with location descriptions in Table 8-1. Boreholes BH6N, BH1N and BH8 were respectively sampled during July 2018, September 2018 and November 2018. The boreholes were sampled after being drilled in order to gain baseline data. Results are illustrated in the Piper diagram Figure 12-18 and compared to samples taken from the shaft during December 2017. Similar character was observed for most of the samples. Due to higher sodium concentration however borehole BH6N plotted separate from the rest. This is due to borehole BH6N being drilled to a depth of 1 148 m into Main Reef, whereas BH1N (669 m) and BH8 (684 m) was only drilled up to the Kimberley Reef. ERB void water flow into the shaft is expected to mainly occur at the Kimberley Station Rail level at 694 m, approximately 80 m above the shaft plug at 885 m. Detailed results of inorganic chemistry for the void boreholes are presented in Table 17-18.

Sodium, sulphate, EC and TDS values exceeded their respective SANS 241 (2015) drinking water standard limits at boreholes BH6N and BH8. The turbidity limit was exceeded at BH1N and BH8. See Table 17-18.

Detailed results for hydrocarbons (Terratest) detected in void borehole 1N are presented in Table 17-19.

In terms of metals, Mn exceeded the SANS 241 (2015) drinking water standard limit of 0.4 mg/L at all three boreholes. Borehole BH6N had the lowest Mn concentration of 1.23 mg/L followed by BH8 (2.48 mg/L) and BH1N (2.43 mg/L). The Ni limit of 0.08 mg/L was exceeded at BH8 (0.59 mg/L) and BH1N (0.16 mg/L). The Fe concentration was below the detection limit of 0.004 mg/L at BH6N and BH1N, but exceeded the SANS 241 (2015) drinking water standard limit of 2.0 mg/L at BH8 with a concentration of 6.86 mg/L recorded. Uranium concentrations at all three boreholes were below the detection limit of 0.015 mg/L. See Table 17-18.

Sludge disposal locations, sludge disposal volumes as well as AMD water volume abstracted to date is detailed in Figure 12-19.

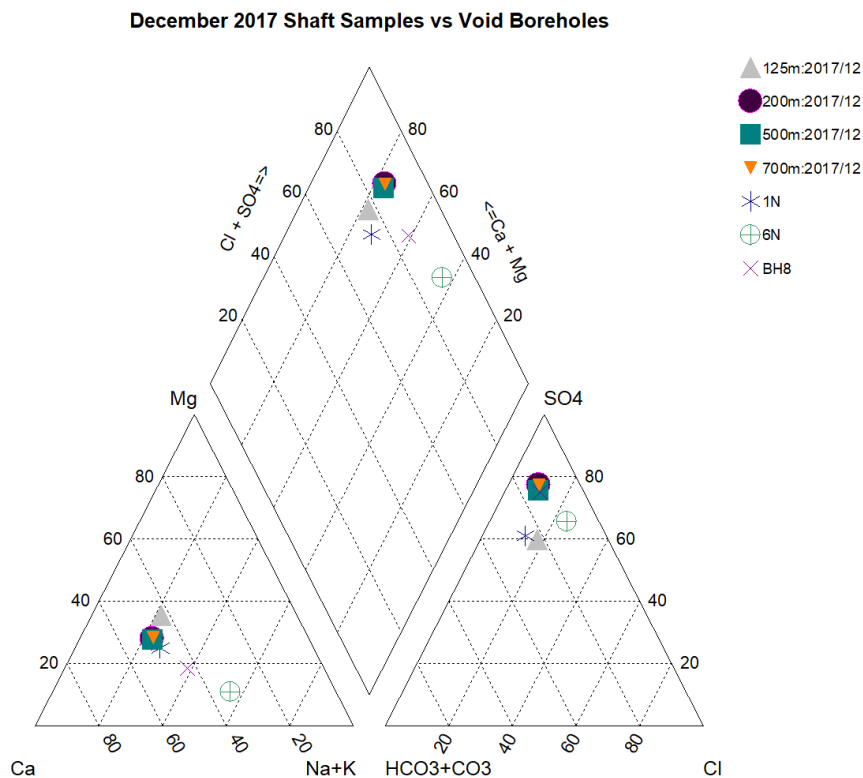


Figure 12-18 Piper Diagram: December 2017 Shaft vs Void Boreholes

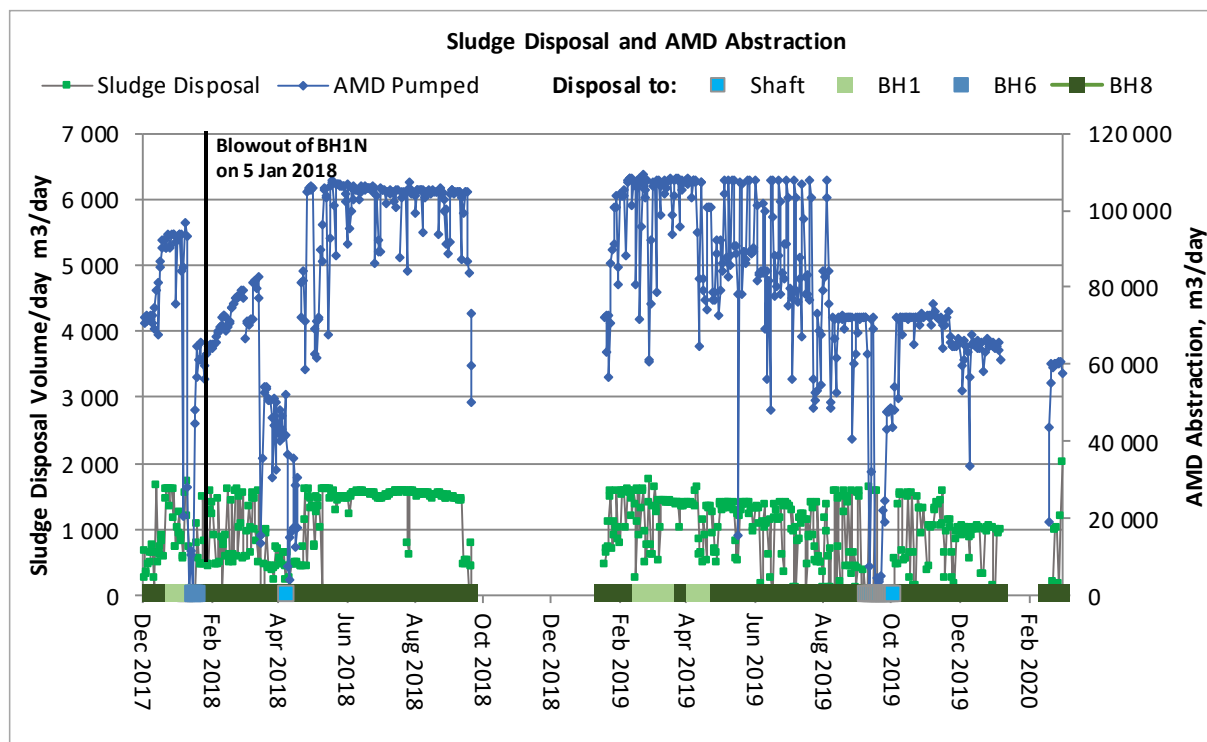


Figure 12-19 December 2017 to February 2020 Sludge Disposal

12.4 Environmental Isotope Study

12.4.1 Introduction

Locations sampled for isotope analyses and the results are detailed in Table 18-1 to Table 18-3.

The tables include the latest isotope results for samples taken during February 2020. The objectives of isotope analyses were, amongst other, to determine the isotope mixing ratios of the shaft water composition in terms of surface and groundwater. Samples from the shaft are referred to by the depth taken below top of shaft.

As part of the baseline monitoring conducted during June 2016, twelve water samples including surface water, groundwater and shaft water were analysed for stable (non-radioactive) environmental isotopes deuterium and oxygen-18. Follow up sampling was conducted during December 2016, April 2018, October 2018, November 2018, June 2018 and December 2018. During 2019, monthly samples were taken in order to gauge seasonal changes more accurately. After problems with entanglement of equipment during the July 2019 sampling, the shaft was not sampled again until February 2020. Other locations were also not sampled between August 2019 and February 2020.

Radioactive environmental tritium was also determined in the initial and 2017 samples. Since April 2018, sampling also included effluent from the ERWAT Welgedacht sewage treatment plant located along the Blesbokspruit some 6 km upstream of the ERB AMD treatment plant. During these sampling runs, the municipal water supply at the plant (Rand Water) was also sampled.

Deuterium and Oxygen-18

Stable (non-radioactive) environmental isotopes, deuterium (^2H , also known as heavy hydrogen) and oxygen-18 (^{18}O) are frequently used for water origin tracing. These isotopes essentially label water molecules, and their concentrations are not influenced or altered by chemical reactions. The stable isotope technique is typically able to provide an estimate of the degree of mixing of water sources, where applicable.

Tritium

Environmental tritium (^3H , also known as hydrogen-3) is a very useful tracer of water and widely used in hydrological studies. Tritium is produced in nature by cosmic ray interaction with the upper atmosphere, and readily oxidised to water in which it is a conservative tracer as it is part of the water molecule. Tritium is radioactive and decays through low-energy beta ray emission with a half-life of 12.43 years. This radioactivity can be measured in the laboratory. Tritium sampling of samples in the shaft was recommended to establish if the water in the shaft is recently recharged or older groundwater.

12.4.2 Results - Deuterium and Oxygen-18

The δD and $\delta^{18}O$ results obtained for each of the sampling runs conducted are illustrated in Figure 12-21 to Figure 12-23. The Global Meteoric Water Line (GMWL) is also indicated on the plots. According to Levin (Nov 2016, Mar 2018, Jun 2018, Mar 2018 & Jun 2018) the typical δD and $\delta^{18}O$ groundwater results plotted to the bottom left of the other samples and close to the GMWL. This was consistent with what was expected for samples directly recharged by rainfall and not exposed to evaporative processes. Results for the surface water samples collected at the Blesbokspruit and the three dams were in the heavier isotope ratio area along what is referred to as the evaporation line, which slopes lower and away from the GMWL. Samples further along this line were more indicative of more evaporation, representing water relatively depleted in the lighter stable isotopes.

Since monitoring commenced, samples from Aston Lake were notable further along the evaporative line than the other surface water samples. Due to its location, Aston Lake is not refreshed by rain water to the extent that the other surface water bodies are. Results for Aston Lake up to June 2019 remained more indicative of evaporation with each subsequent sampling run. A notable change can be observed for the February 2020 sample, which plotted very close to the group of shaft samples and other surface water samples. This would be indicative of replacement of the lake water with fresher water during the latest rainfall season. This has not been observed during previous rainfall seasons during the monitoring period.

The results for a mixture of groundwater and surface water will lie on the evaporation line between the two areas where groundwater and surface water samples plot. This should be considered point in time, due to the seasonal nature of results for surface water samples. Typically, results from different surface water sampling locations would increasingly spread along the evaporation line after the rainfall season and through the winter months. Results would then only converge closer together again after substantial rainfall flushed the drainage system. This effect was most true for the Blesbokspruit samples ESW-01 and ESW-05.

The δD and $\delta^{18}O$ results to date are illustrated in Figure 12-23. Historical results for the different types of samples are presented together. The February 2020 results are also presented together on a graph, for comparison with previous results. The δD and $\delta^{18}O$ results over time are illustrated in Figure 12-21 and Figure 12-22. The lower and more stable values for groundwater samples can readily be distinguished from the higher and more varied values for surface water. Between these ranges of values lies the results for samples from the shaft.

Results for the AMD feed water to the plant have been indistinguishable from that of the shaft taken at four other depths.

Mixing ratios of the shaft water composition in terms of surface and groundwater were calculated from $\delta^{18}\text{O}$ results and are listed in Table 12-4 and illustrated in Figure 12-20. The relevant $\delta^{18}\text{O}$ values over time are illustrated in Figure 12-21. Various factors influences the accuracy of such a calculation and it should be seen as an estimate.

Table 12-4 Percentage Surface Water in Shaft (Based on $\delta^{18}\text{O}$)

	125 m	200 m	400 m	500 m	700 m	Average
2016-06-28	38%	36%	N/A	35%	35%	38%
2017-04-24	77%	67%	N/A	60%	59%	77%
2017-10-23	69%	59%	N/A	65%	13%	69%
2017-11-10	83%	78%	N/A	73%	78%	83%
2018-06-29	49%	61%	N/A	57%	54%	49%
2018-12-12	52%	52%	N/A	51%	49%	52%
2019-01-28	45%	N/A	N/A	N/A	41%	45%
2019-02-26	54%	N/A	N/A	N/A	51%	54%
2019-03-25	52%	N/A	N/A	N/A	50%	52%
2019-04-26	53%	N/A	N/A	N/A	56%	53%
2019-05-27	51%	N/A	N/A	N/A	50%	51%
2019-06-26	46%	45%	N/A	52%	48%	46%
2019-07-29	51%	N/A	N/A	N/A	47%	51%
2020-02-26	77%	79%	79%	N/A	N/A	77%

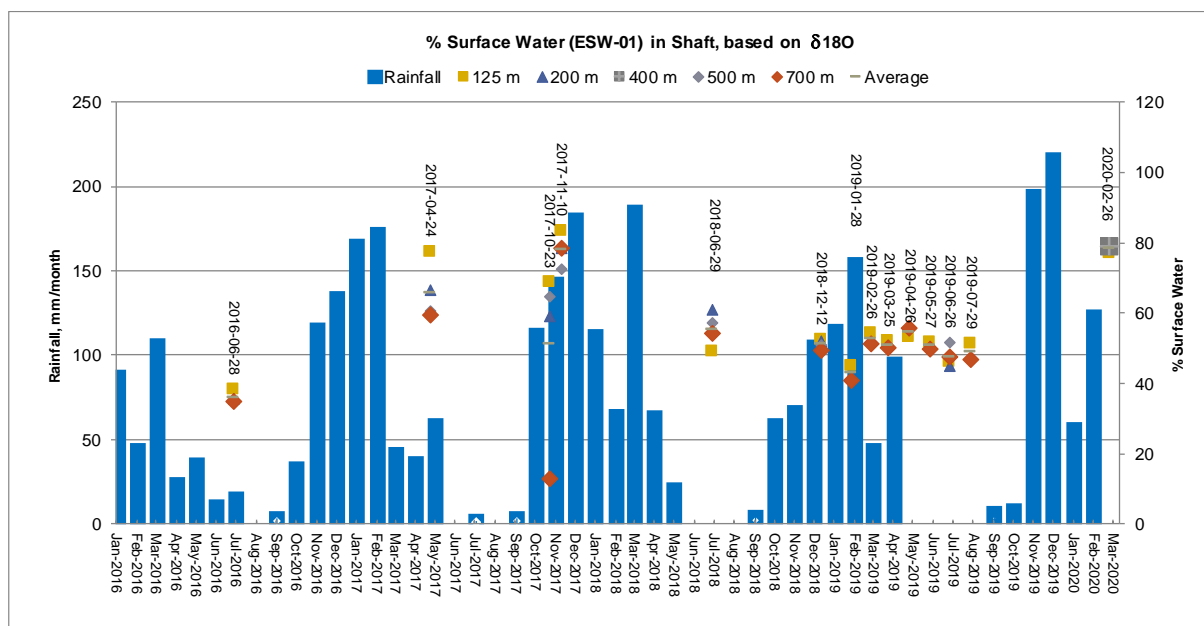


Figure 12-20 % Surface Water in Shaft, based on $\delta^{18}\text{O}$

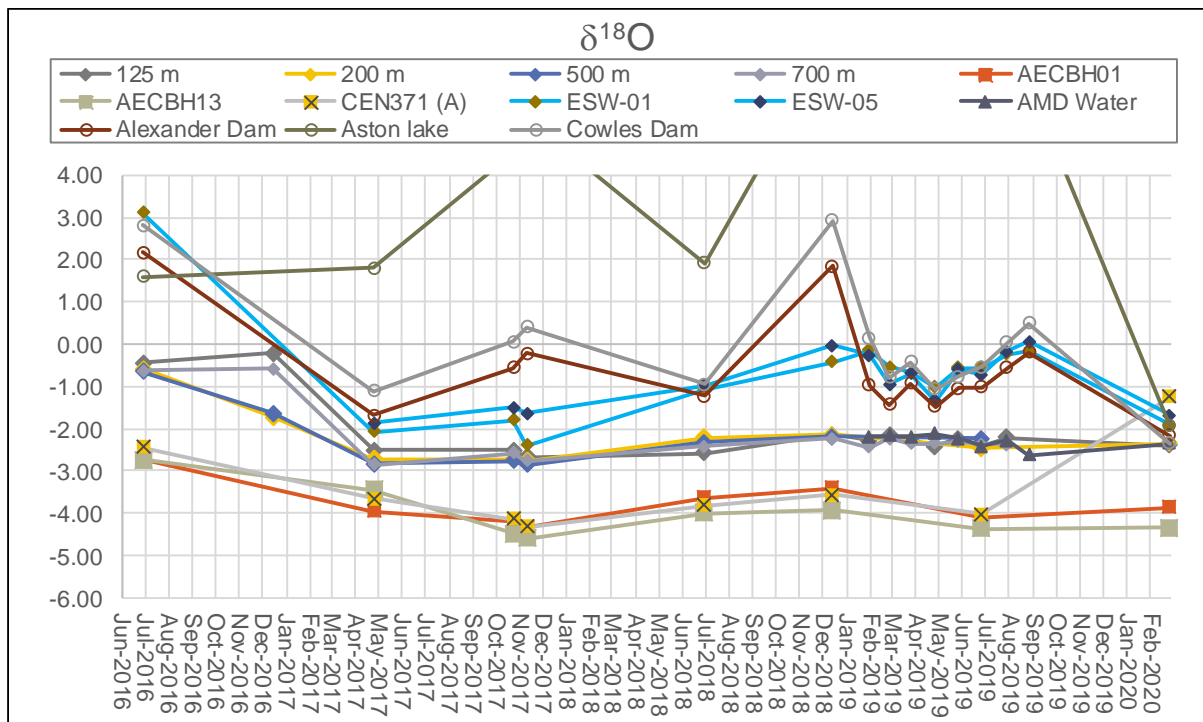


Figure 12-21 Shaft, Groundwater & Surface Water - $\delta^{18}\text{O}$ with Time

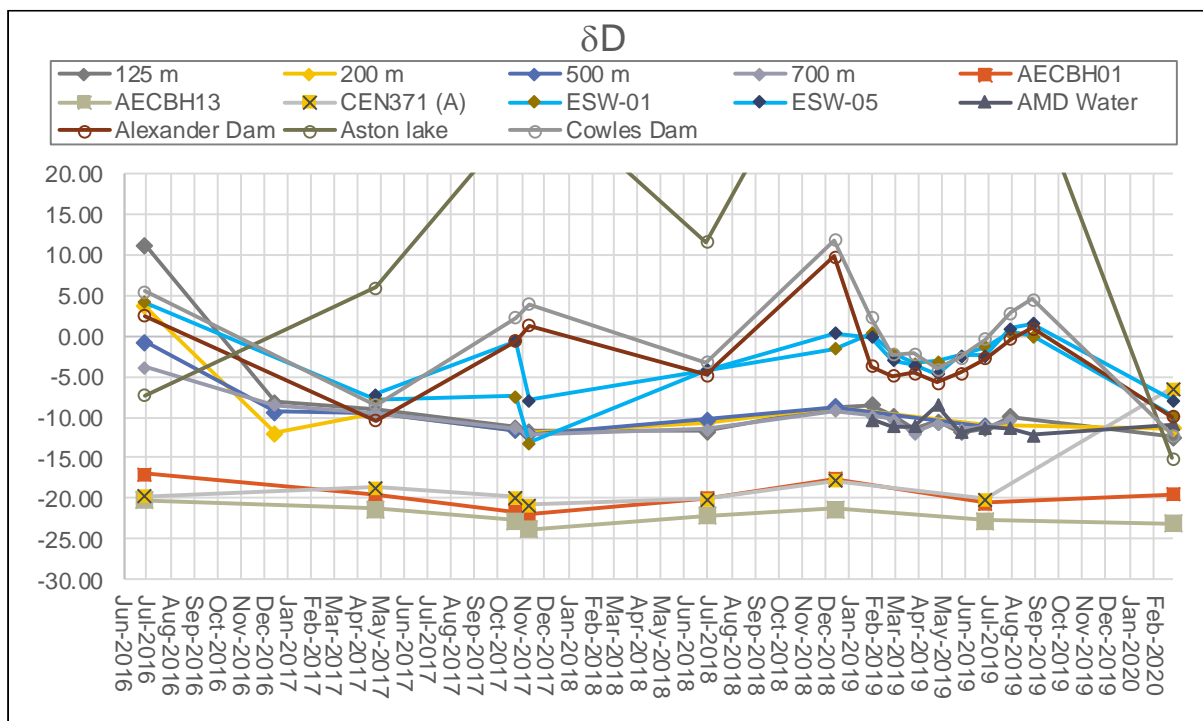


Figure 12-22 Shaft, Groundwater & Surface Water - δD with Time

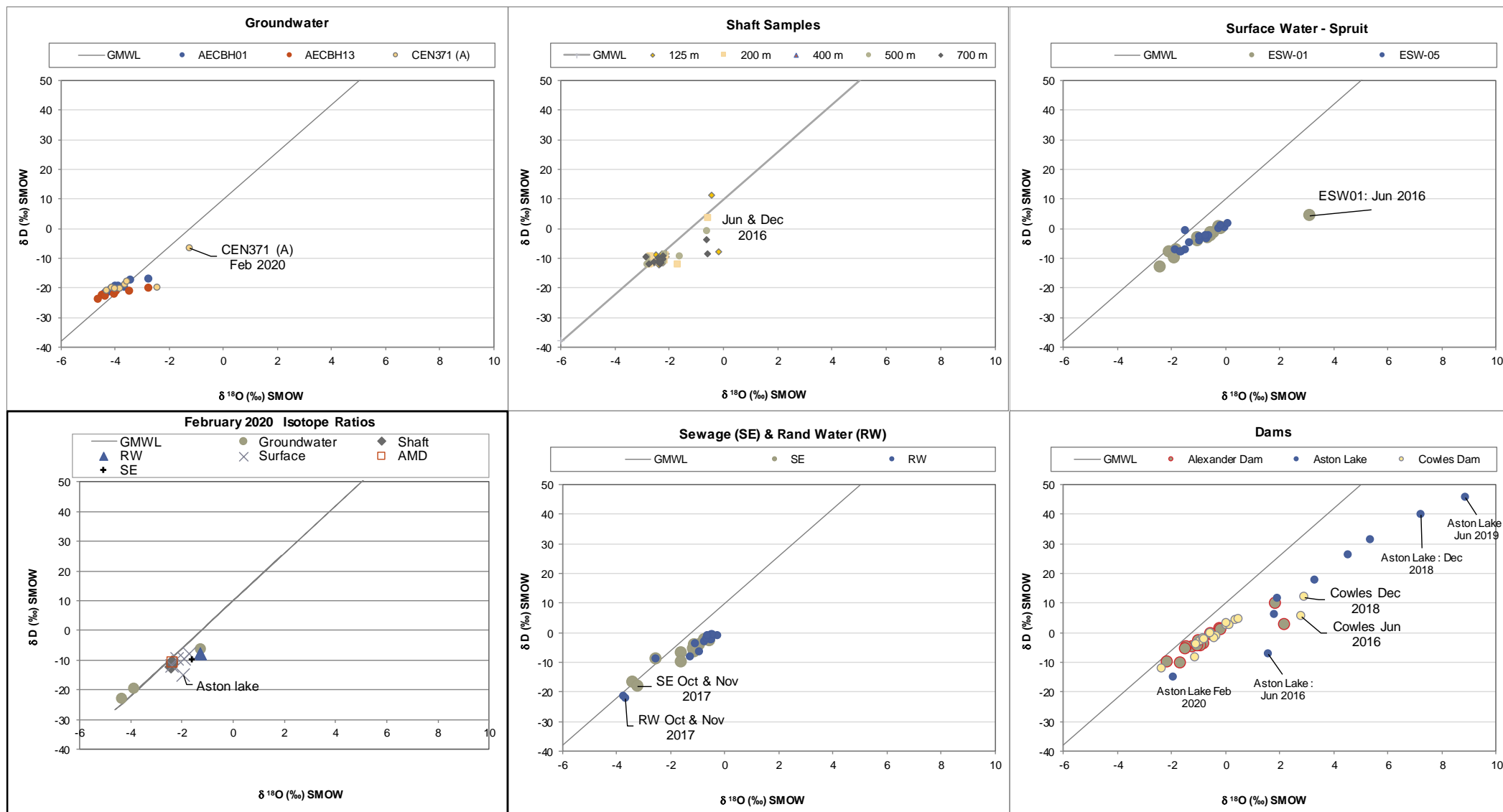


Figure 12-23 Isotope Compositions, Historical & February 2020

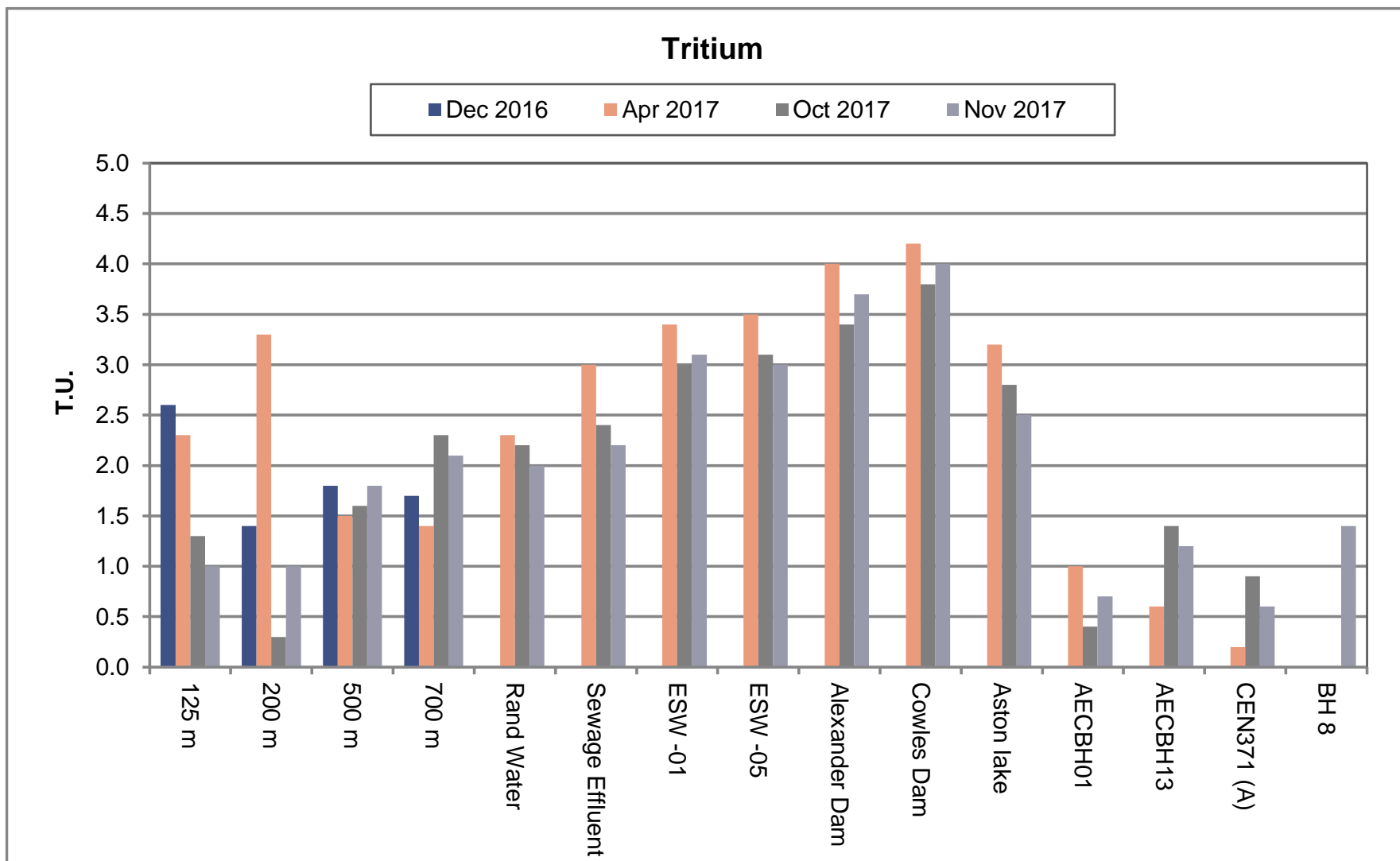


Figure 12-24 Tritium Results

12.4.3 Results - Tritium

The tritium results for samples taken during December 2016 and 2017 are illustrated in Figure 12-24. According to Levin (Mar 2018, Jun 2018 & Mar 2018) tritium results can be summarized as follows:

December 2016 – The analyses of monitoring points in the shaft for tritium was recommended to establish if the water in the shaft is recently recharged or older groundwater. Recent rainwater samples analysed by iTemba Labs showed that rainwater contain tritium in the order of 2.6 TU. The tritium content of sample 125 m clearly demonstrated recent rain water entering the shaft. The lower samples showing in the order of down to a half of the rainwater content could therefore contain water of at least 10 or more years older than present rainwater. The tritium content confirms the stable isotope data which concluded that groundwater enters the shaft.

April 2017 to November 2017 – Tritium analysis was conducted on three set of samples taken during 2017. The Rand Water and Sewage Effluent samples taken indicated tritium value slightly less than what is expected in rainwater (2.6 T.U.). In contrast, the surface water samples taken in the Blesbokspruit and at Alexander Dam, Cowles Dam and Aston Lake displayed higher tritium values, averaging 2.8 T.U. (Aston Lake) to 4.0 T.U. (Cowles Dam). Compared to the other surface water locations, the lower tritium values at Aston Lake was in line with stable isotope results indicating relatively stagnant water in this dam. As tritium in the surface water samples were higher than what is expected in rain water, a source or sources of artificial tritium is possible. Effluent from landfill sites has for instance been shown to have the potential to cause very high and varied tritium results in downstream water (Levin, 2010). The existing boreholes AECBH01, AECBH13 and CEN381 (A) displayed low tritium values which indicate the groundwater in these boreholes is present in a confined aquifer and static if not pumped. Relatively large variations in tritium values were observed for shaft samples taken at 125 m and 200 m. A value of 3.3 T.U. at 200 m during April 2017 was indistinguishable from that of surface water samples taken. A value of 0.3 T.U. at the same location during October 2017 was indistinguishable from that of groundwater samples taken. These observations confirm significant seasonal changes in surface water volumes entering the shaft at depth between 200 m and 500 m. Tritium values for samples from 500 m and 700 m were less varied. These values averaged 1.8 T.U., between the average of 0.88 T.U. for all groundwater samples and the average of 3.38 T.U. for all surface water samples. In general, the tritium results confirmed the stable isotope results that shaft water was a mixture of water from the surface and older groundwater. The tritium value of 1.4 T.U. for the deep void borehole BH8 determined during November 2017 was higher than the average for groundwater (0.88 T.U.). This confirms a significant component of fresher water in BH8.

12.5 ERB AMD Treatment Plant - Operational Data

Operational data for the ERB AMD Treatment Plant was obtained from the plant management. This consisted of daily data for shaft water level readings, abstraction and sludge disposal volumes as well as certain water quality parameters for AMD water and treated water. It must be noted that this data was used at face value. No deduction regarding the accuracy of the data is implied. Data up to 1 March 2020 was received and was complete except for the periods of 19 September 2018 to 15 January 2019 and 7 January 2020 to 17 February 2020, when the plant was not operational. The data was evaluated in order to verify the possible impact of sludge disposal into the ERB void over an extended period of time. Operational data obtained are presented in Figure 12-25 to Figure 12-33. AMD water abstraction and sludge disposal commenced early in July 2016. Daily AMD water quality data was represented by analyses of AMD water abstracted from the shaft via abstraction pumps situated at depths between 160 m and 180 m.

Sludge disposal was expected to impact on the water quality of the shaft. Cognisance should be taken of the respective sludge disposal phases when interpreting the operational data. The phases were listed in 12.2.1.

ERB Mine Void Water Level & AMD Water Abstraction Volumes

The water level as monitored at the Grootvlei #3 Shaft is representative of the ERB basin (void) water level. Since monitoring by Exigo commenced during June 2016, the ERB basin water level has remained below the ECL water level of 100 m. All references to water level of the shaft is in terms of metre below the collar height of the Grootvlei #3 Shaft. The ECL was previously determined in order to protect the dolomitic aquifer which is considered a regional groundwater resource and a potential long-term water supply source. It is therefore inferred that the dolomitic aquifer was not negatively impacted upon as a result of AMD sludge disposal within the ERB void.

The highest water levels during monitoring by Exigo were observed during June 2016 (107.7 m), before plant operation, and mid January 2019 (107.8 m), following four months of plant shutdown. The mine void water level is monitored on a daily basis by ERB plant operations.

Certain events have influenced operations in the past. On 5 January 2018 a pressure blowout occurred at BH1N. Shaft water level at the time was the deepest since abstraction began, at 123.25 m, a decrease of 11.98 m since a water level of 111.28 m recorded on the 19th of July 2016. The blowout negatively affected sludge disposal for some time which in turn negatively affected AMD water abstraction. Water level increased by of 9.10 m to a level of 114.15 m on 20 April 2018. See Figure 12-25. Daily pumping volumes were then increased, resulted in shaft water level decreasing by 0.13 m per day on average, reaching 134.02 m on 17 September 2018.

Following a breakdown of electrical equipment, there was then no AMD abstraction from 19 September 2018 to 15 January 2019. During this period, water level increased by an average of 0.227 m per day and reached 107.8 m on 14 January 2019. See Figure 12-25. Abstraction then commenced again and shaft water level gradually decreased by an average of 0.084 m per day, to a level of 128.72 m on 17 September 2019. Following sludge disposal into the shaft, problems with increased turbidity and TSS was then experienced and abstraction was suspended for two days. Abstraction was then gradually started up again over a period of eighteen days to reach 70 ML per day. Abstraction was adjusted to keep the water level at approximately 125 m during December 2019.

Due to maintenance, the plant was then not operational for 43 days from 7 January 2020 to 17 February 2020. Shaft water level increased by 14.2 m during this period, at a rate of 0.33 m per day. The water level reached 110.96 m when operations commenced again. The last water level in the data received was 111.55 m on 1 March 2020.

The ERB basin water level is influenced by water ingress into the ERB void and AMD abstraction from the ERB void at Grootvlei #3 Shaft. According to Vivier (2018) simulated ingress of water into the ERB basin indicated that approximately 65% originates from the Blesbokspruit and approximately 35% from the shallow Dolomite Aquifer. Seasonal rainfall therefore has a significant impact on the volume of ingress into the ERB basin. ERB AMD Treatment Plant operations on the other hand have a direct impact on the volume of AMD water abstracted from the ERB basin. Daily AMD abstraction volumes and shaft water level data as well as monthly rainfall, daily TSS and sludge disposed for the monitoring period to date are illustrated in Figure 12-25.

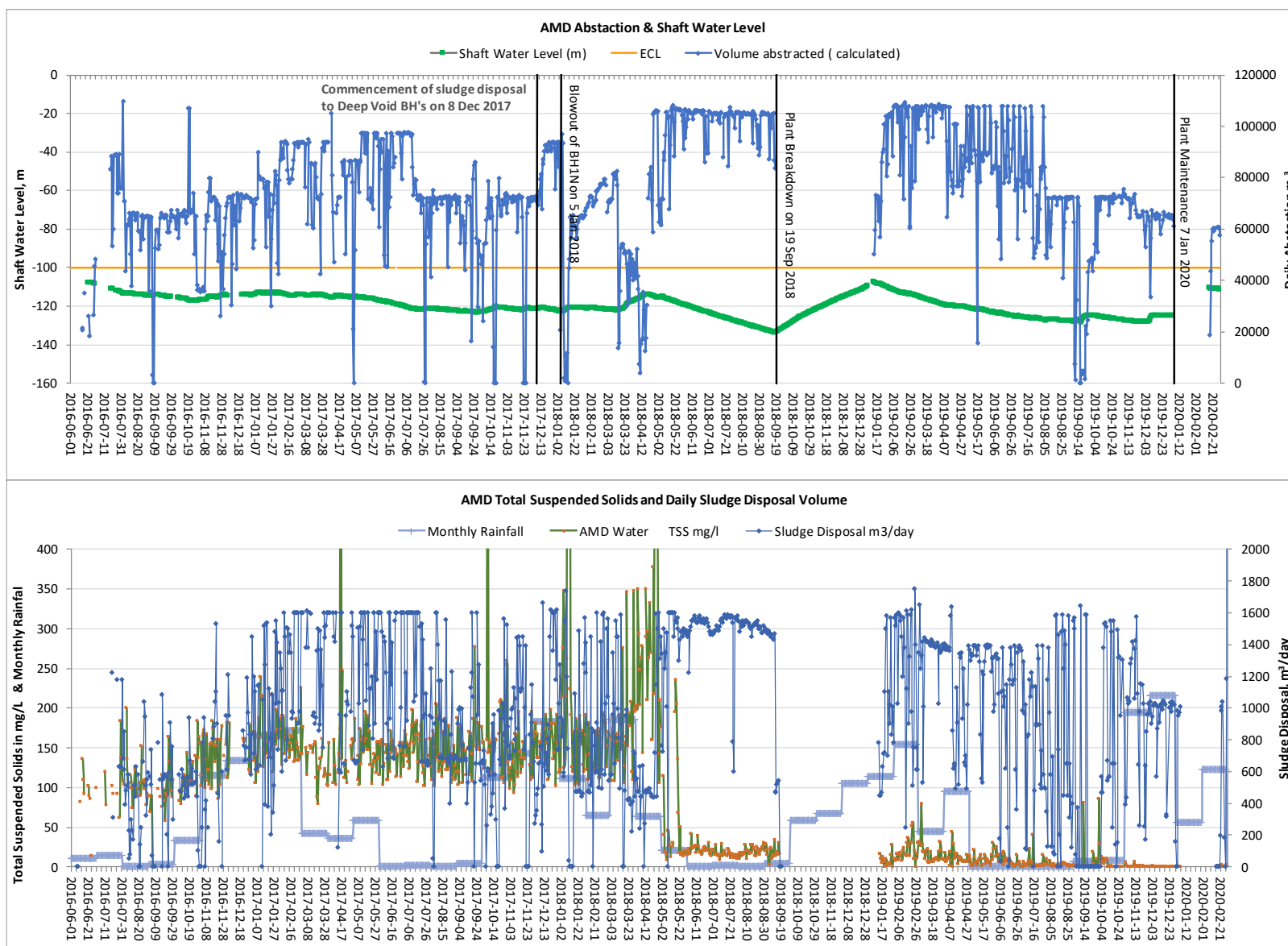


Figure 12-25

AMD Abstraction & Shaft WL, Sludge Disposal & AMD TSS & Monthly Rainfall

Total Suspended Solids & Turbidity

An important objective of the monitoring of the AMD water abstracted is to monitor the build-up of (AMD) sludge levels within the shaft. AMD water was therefore analysed for Total Suspended Solids (TSS) and turbidity. As can be expected, TSS and turbidity levels were observed to behave correspondingly.

For the period 19 July 2016 to 5 January 2018 an average AMD water (plant feed water) TSS level of 154 mg/L was recorded. Following the pressure blowout at BH1N the TSS increased significantly, to 1 880 mg/L on 11 January 2018. Values recovered by 14 January 2018 and were stable until mid-March 2018 when values became varied, with an upward trend reaching 738 mg/L on 25 April 2018. See Figure 12-25 and Figure 12-26. The latter trend coincided with a period with average abstraction of 36 100 m³/day. TSS values decreased significantly to below 20 mg/L during the first week of May 2018 and following some variation during May 2018, have been stable since the last week of May 2018.

AMD water TSS has averaged 7 mg/L during the twelve month to February 2020, with 80% of values below 11 mg/L. This was much lower than the average of 145 mg/L observed prior to the blowout at BH1N and also pre-abstraction values that averaged 89 mg/L during June 2016. The highest three values varied from 79 mg/L to 86 mg/L and were observed on 5 March 2019, 13 September 2019 and 1 October 2019.

Reasonable correlation previously existed between the daily data and the samples taken monthly at locations deeper than 125 m in the shaft. See Figure 12-27. Following the decrease in daily TSS values since May 2018, the values were similar to the monthly samples taken at 125 m. This likely implies that the interface identified during shaft profiling moved lower to below the AMD pumps, located at 160 m. See Figure 12-1.

The same general trend for turbidity was observed than for TSS levels. AMD water turbidity has averaged 17 N.T.U. during the twelve month to February 2020, with 80% of values below 26 N.T.U. Highest values of 398 N.T.U. on 9 September 2019 and 172 NTU on 5 March 2019 were observed. Other values were all below 90 N.T.U.

During 2017 a linear relationship between TSS and turbidity held up to values of 100 N.T.U. for turbidity and 200 mg/L for TSS. Less direct correlation was observed since.

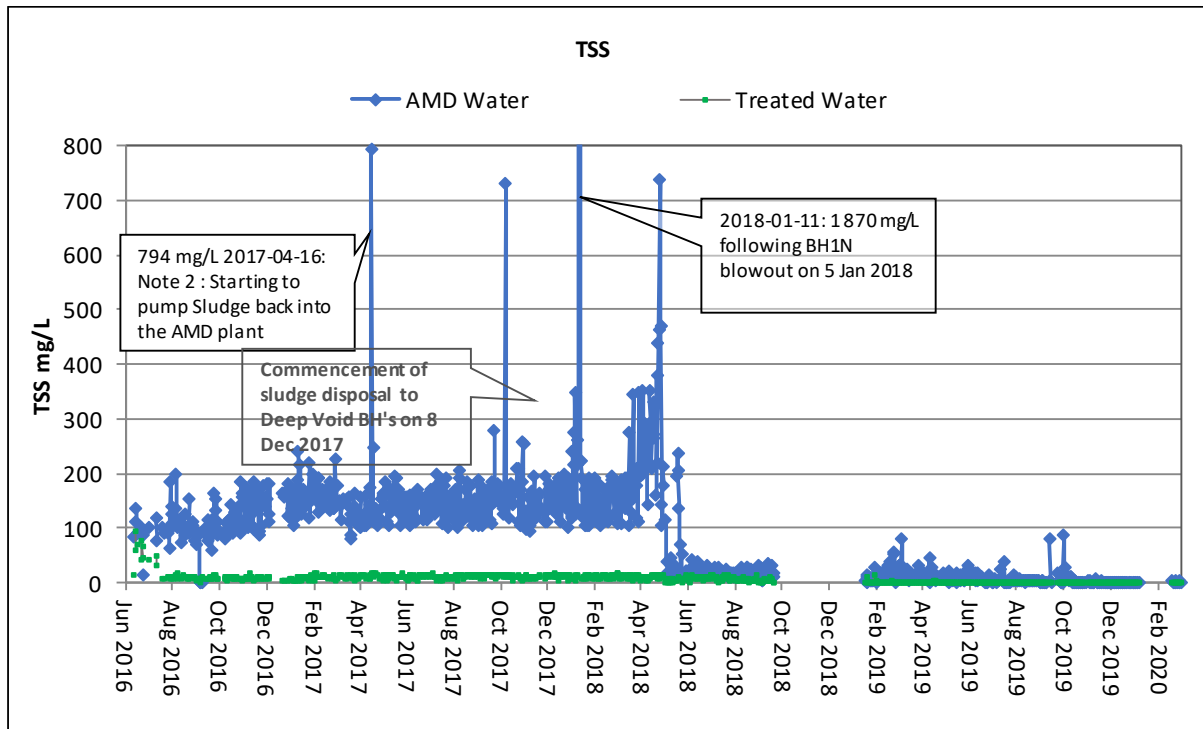


Figure 12-26 AMD Water and Treated Water - Daily TSS with Time

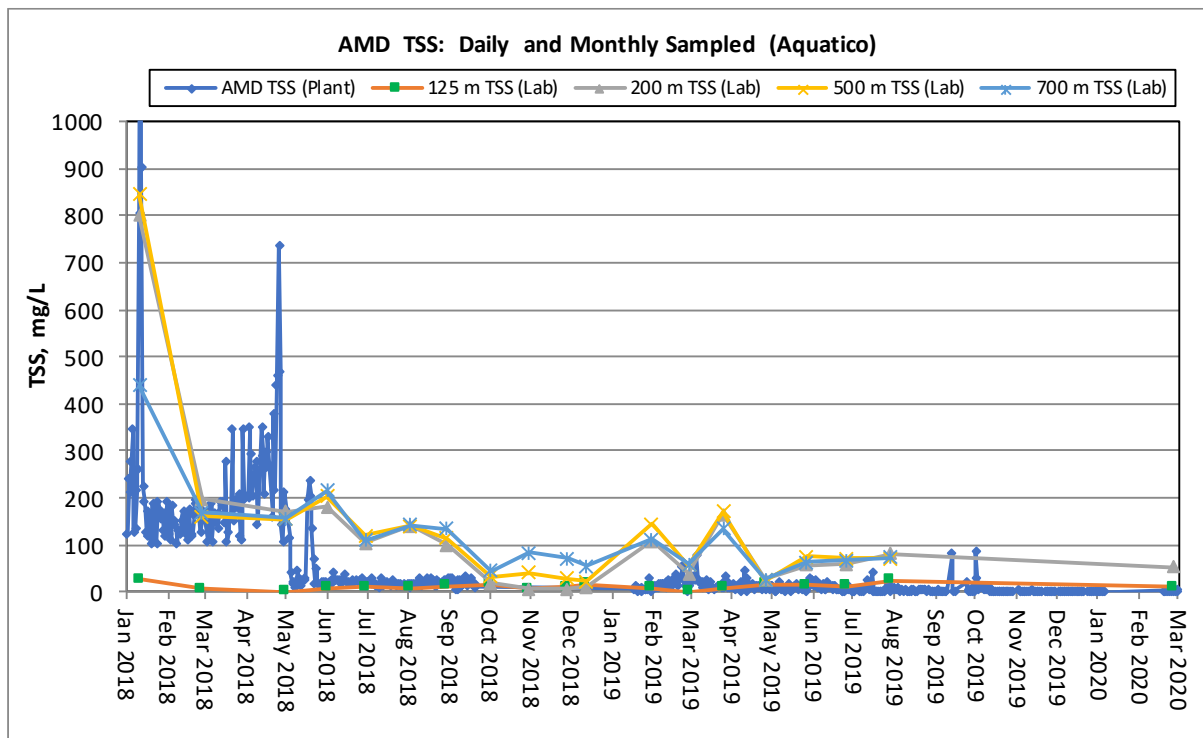


Figure 12-27 Daily TSS with Time and Shaft Sample TSS from Laboratory (2018 to Feb. 2020)

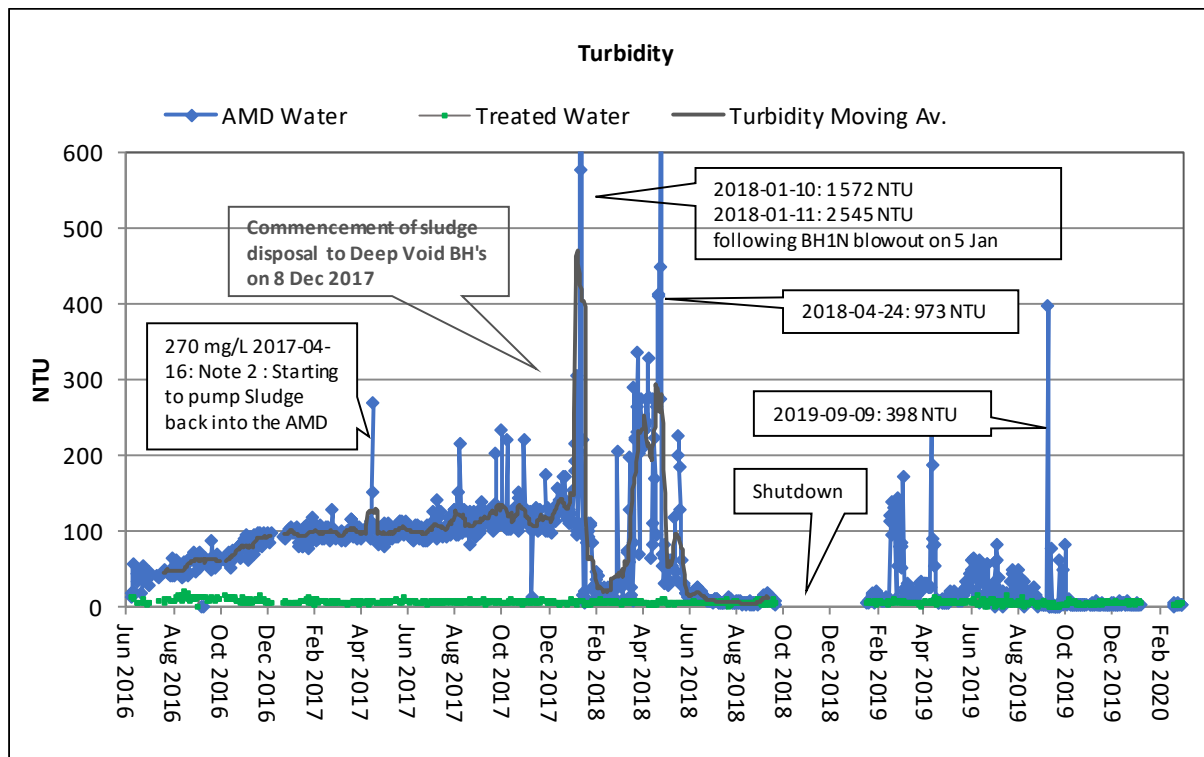


Figure 12-28 AMD Water and Treated Water - Daily Turbidity with Time

pH

No significant change in pH was observed following the commencement of abstraction and sludge disposal in 2016. An slight increasing trend in pH was observed during 2018. pH values average 6.31 during 2016 and 2017 while averaging 6.57 during 2019 to February 2020. See Figure 12-29.

The pH of the treated water as discharged into the Blesbokspruit was generally 2.4 higher than that of the AMD water. pH of treated water averaged 8.75 during 2017, 8.66 during 2018 and 8.53 during January 2019 to February 2020. See Figure 12-29. Slightly lower pH were, averaging 6.22, have been observed since December 2019.

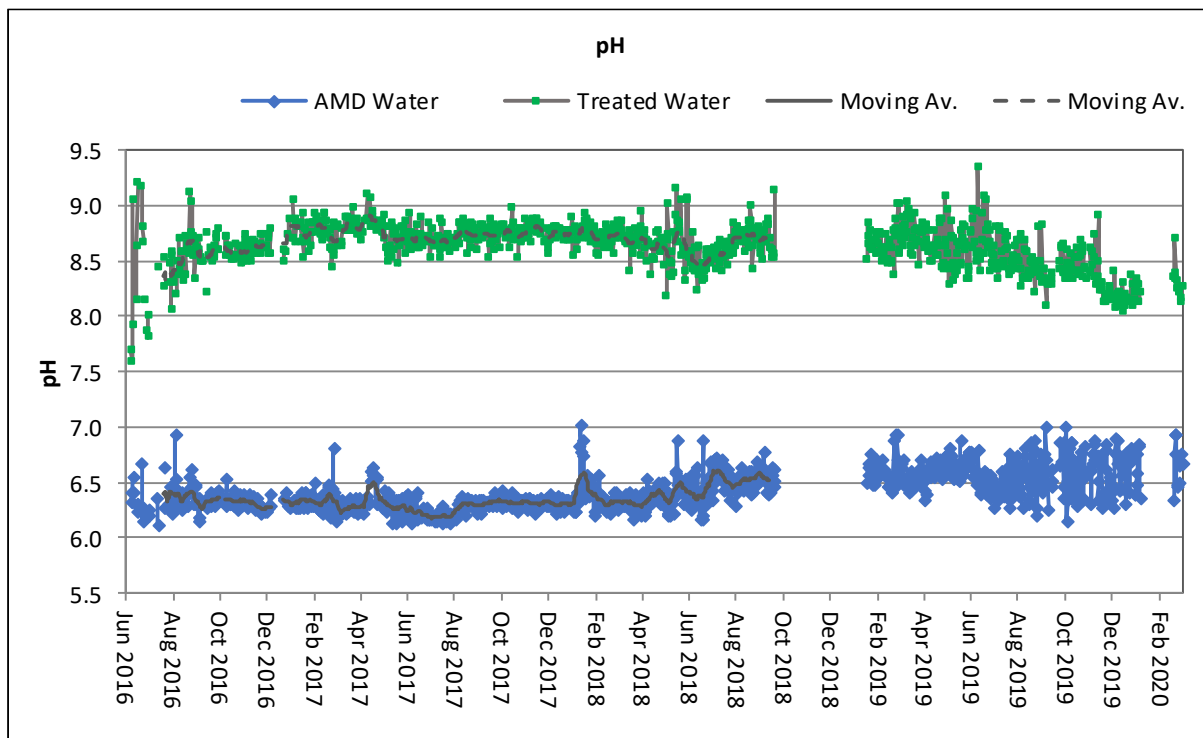


Figure 12-29 AMD Water and Treated Water – Daily pH with Time

EC

EC values for AMD water abstracted by the pumps at 160 m were fairly consistent during the period 11 July 2016 to 31 May 2018. EC averaged 307 mS/m, with 90% of values between 302 mS/m and 313 mS/m. See Figure 12-30.

During the first days of June 2018 a significant decrease in EC values was observed, with variations in values up to September 2018. EC averaged near 300 mS/m until Q3 2019, when a decreasing trend was observed. From December 2019 to February 2020, AMD feed EC averaged 290 mS/m with 80% of values between 286 mS/m and 295 mS/m.

EC values of the treated water have been 45 mS/m lower than that of the AMD water on average.

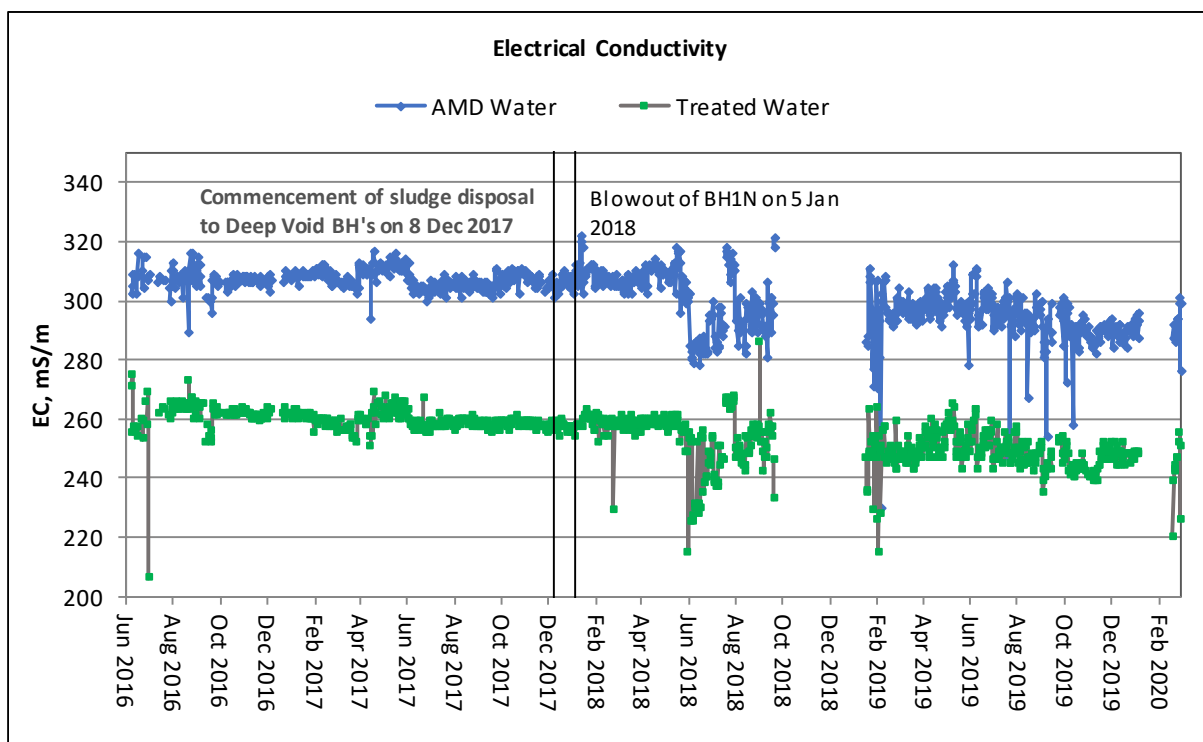


Figure 12-30 AMD Water and Treated Water - Daily EC with Time

Sulphate

Sulphate levels for AMD water abstracted increased from an average of 1 360 mg/L during June 2016 to an average of 1 628 mg/L for the period 1 July 2016 to 24 March 2018. No noticeable change was observed as a result of the pressure blowout observed at BH1N on the 5th of January 2018. Concentrations became much more variable since May 2018. From 25 March to 19 September 2018 sulphate concentrations averaged 1 492 mg/L. Values increased during Q1 2019 and averaged 1654 mg/L during April 2019. A sharp decrease in values was observed from 11 June 2019 (1 718 mg/L) to 12 June 2019 (1 234 mg/L). Values since have averaged 1 233 mg/L, with 80% of values between 1 139 mg/L and 1 323 mg/L. See Figure 12-31.

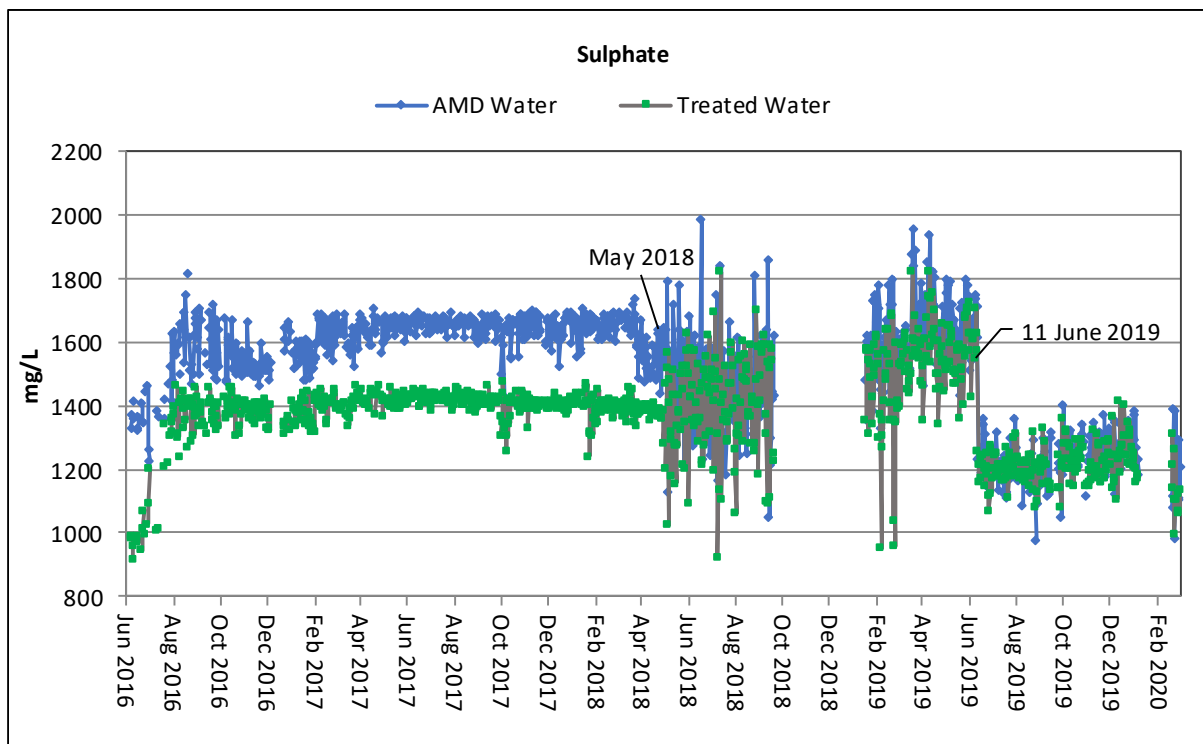


Figure 12-31 AMD Water and Treated Water - Daily Sulphate Concentrations with Time

Iron

Fe concentrations decreased from an average of 121 mg/L during June 2016 to an average of 102 mg/L for the period July 2016 to September 2018. An average Fe concentration of 92 mg/L was observed during December 2019 to February 2020, with 80% of values between 78 mg/L and 99 mg/L. The latest average represents a decrease of 29 mg/L from the June 2016 baseline conditions. See Figure 12-32.

Manganese

Mn concentrations similarly decreased from an average of 22.1 mg/L during June 2016 to an average of 8.63 mg/L for the period July 2016 to September 2018. An average Mn concentration of 4.0 mg/L was observed during December 2019 to February 2020, with 80% of values between 3.8 mg/L and 4.4 mg/L. The latest average represents a decrease of 18 mg/L from the June 2016 baseline conditions. See Figure 12-33.

Summary – ERB AMD Treatment Plant – Operational Data

From the ERB AMD Treatment Plant data obtained it can therefore be concluded that underground sludge disposal into the ERB void up until February 2020 have not displayed a significant negative impact on the ERB mine void water (raw AMD). Additionally it also did not compromise any element of the ERB plant performance and efficiency. The AMD sludge build-up within the shaft water column was not observed to have permanently reached the levels of the AMD abstraction pumps situated at depths between 160 m and 180 m. Elevated turbidity and TSS have at times influenced plant operations for a limited period of a few days. These events were linked to sludge disposal to the shaft itself. Currently there is only one alternative disposal location, namely deep borehole BH8. According to plant management, some problems have been experienced with the capacity of this borehole and an alternative disposal route to the mining void is being investigated.

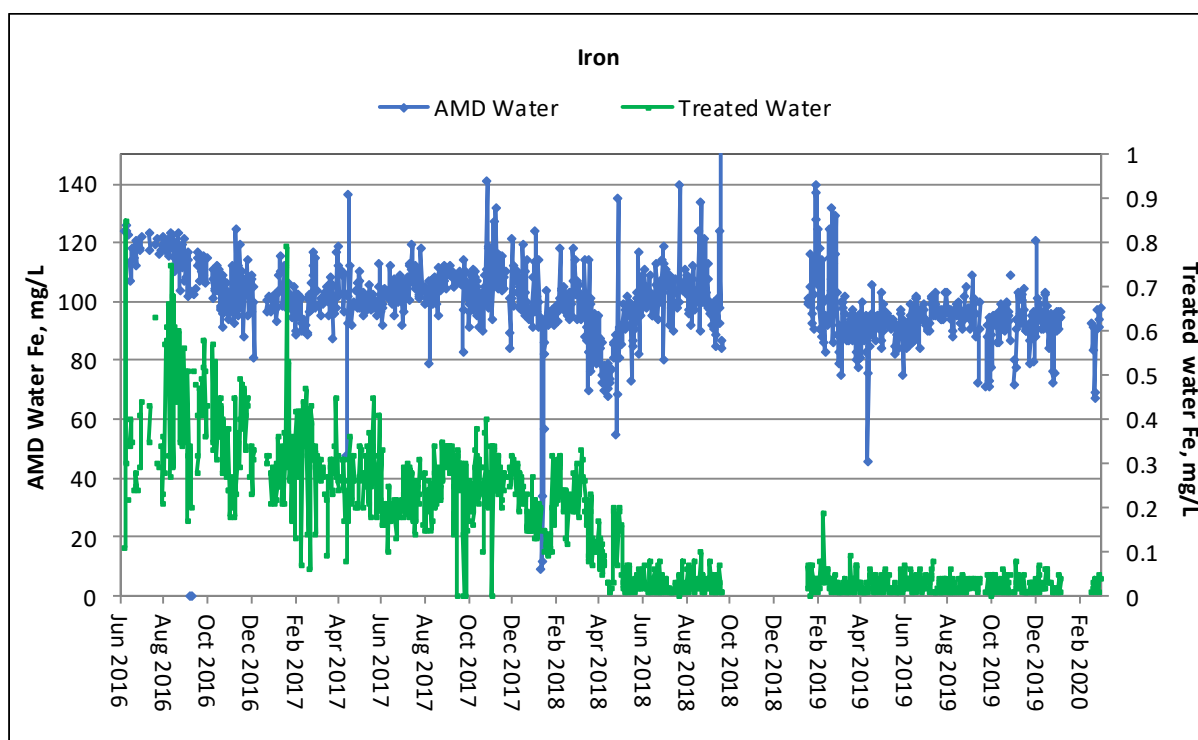


Figure 12-32 AMD Water and Treated Water - Daily Iron Concentrations with Time

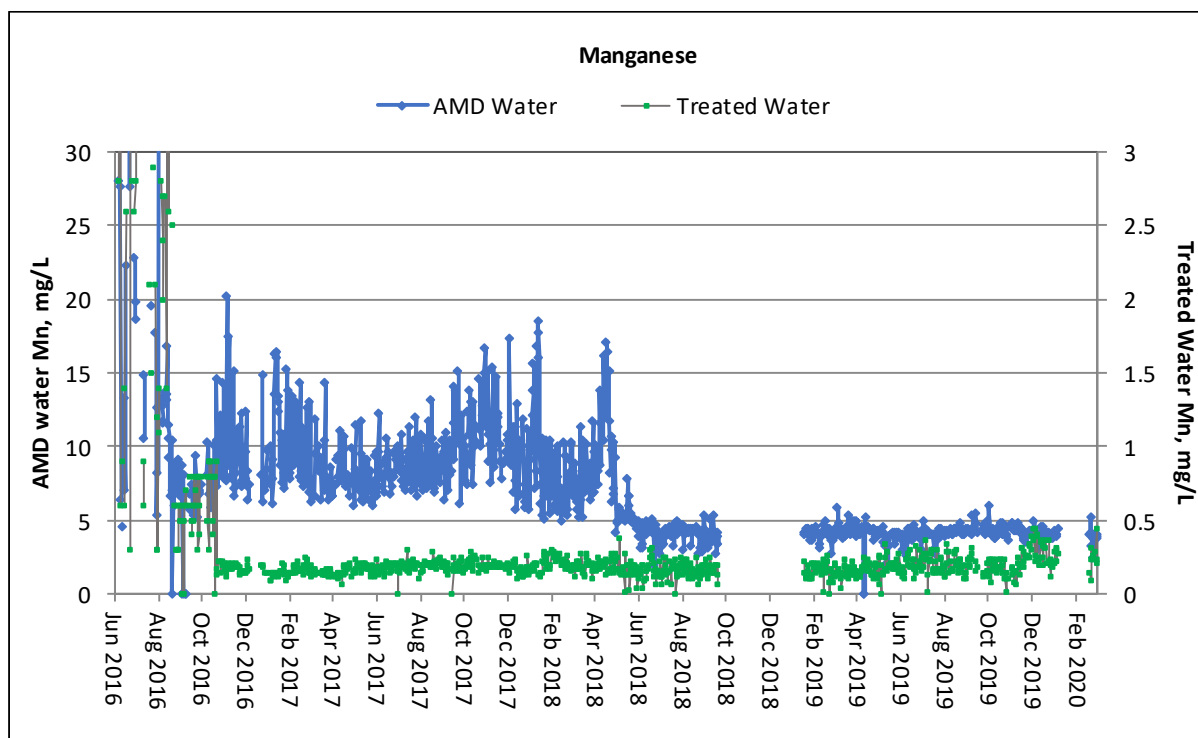


Figure 12-33 AMD Water and Treated Water - Daily Manganese Concentrations with Time

13 CONCLUSIONS

Following monitoring from June 2016 to February 2020, the following was concluded:

7. **Shallow groundwater:** The regional shallow (<100 m depth) groundwater resource represented by the near-surface dolomite aquifer was not negatively impacted as the ECL of the mine void water at 100 m depth was not breached. Furthermore, regional shallow groundwater monitoring conducted within the greater East Rand Basin (ERB) and shallow groundwater monitoring conducted at the ERB AMD Treatment Plant specific monitoring boreholes did not show any negative impacts as a result of the AMD sludge disposal into the shaft (Exigo, Report no. E-R-2020-01-20).

8. **Disposal Options**

- **Intermediate sludge disposal in Shaft (760 m):** The disposal of sludge into the Shaft was considered as a short term solution (1 year to 18 months). The associated increased suspended solids in the AMD feed to the plant during Q4 2017 and later during September 2019 resulted in operational issues.
- **Intermediate (±680 m) & deep (±1 148 m) void sludge disposal via sludge disposal boreholes:** Disposal to boreholes targeting mining voids at a depth of ±680 m and ±1 148 m commenced during December 2018. This pilot study has proven to be a viable alternative to disposal directly in the shaft. From 20 January 2018 to 19 September 2018 sludge was solely disposed at borehole BH8, with the exception of 3 days. During January 2019 to February 2020, disposal was to BH8, except for 29 days to BH1 and limited disposal to the shaft during September 2019.

According to Exigo (2018) the total ERB basin volume was calculated at ±250 mil m³ which would be able to sustain sludge disposal for 860 years (compaction excluded) or at least 400 years if ± 50% filling is assumed. The initial mass balance modelling and risk assessment indicated that sludge disposal is a long-term option that is expected to improve the basin water quality over time.

Elevated turbidity and TSS have at times influenced plant operations for a limited period of a few days. These events were linked to sludge disposal to the shaft itself. Currently there is only one alternative disposal location, namely deep borehole BH8. According to plant management, some problems have been experienced with the capacity of this borehole and an alternative disposal route to the mining void is being investigated.

9. **Impacts of sludge disposal on water quality:** No significant adverse impact on the shaft water (raw AMD) was observed as a result of AMD sludge disposal within the deep void borehole. The AMD sludge disposal was also not observed to be compromising any element of the ERB plant performance and efficiency. This was confirmed by the following:
- Shaft profiling results
 - Shaft hydrochemical data
 - Operational data from ERB AMD plant operations
10. **Sludge build-up in Shaft:** Based on the total suspended solids sampled up to February 2020, sludge disposal in the deep void borehole BH8 at a depth of 684 m did not have a noticeable effect on shaft water quality.
11. **Isotope results:** The isotopes results indicated that the component of water in the shaft that originates from surface water varies from $\pm 40\%$ during the dry season to $\pm 80\%$ during the wet season. The results were similar to a simulated ingress study (Vivier 2018) that indicated that ± 50 ML/d (65%) ingress originates from the Blesbokspruit and ± 25 ML/d (35%) from the Dolomite Aquifer. The surface water flow in the Blesbokspruit is sustained by sewage works discharges of <100 ML/d on the ERB catchment area. If these discharges could be downstream from the basin, it could potentially significantly reduce the ingress/treatment problem.
12. **Shaft water quality results:** In terms of the water quality monitoring conducted at the shaft, the following was observed:
- pH – The pH of the shaft water column was observed to be neutral to slightly alkaline, with an average pH of 7.33 observed for all shaft samples collected at all four sampling depths to date;
 - Hydrochemistry – When comparing the baseline results from June 2016 with results obtained during July 2019 and February 2020, some improvement over time can be observed. TDS decreased by 21% on average from June 2016 to July 2019 and February 2020 at depths of 200 m and deeper. At the 125 m level, with TDS decreased by 4% from June 2016 to February 2020.
 - Metals – February 2020 results for iron concentrations at 125 m, 200 m and 400 m were below 0.02 mg/L. Historically, Fe was detected in approximately half of the samples taken at 200 m, 500 m and 700 m. When detected, values were varied, with a highest value of 99 mg/L at 700 m during June 2019. Manganese has been detected in all samples taken from the shaft except one sample. Average concentrations to date were observed to increase from 1.3 mg/L at 125 m to 3.3 mg/L at 200 m and then to 4.6 mg/L at 700 m.

- Uranium in Shaft:
 - Baseline 2004/2005 pre-basin flooding average concentration was 0.094 mg/L;
 - Baseline June 2016 post-flooding, pre-sludge disposal average concentration was 0.010 mg/L;
 - After an average uranium concentration of 0.056 mg/L observed for all shaft samples during June 2017, uranium was only detected in 2017 again during November 2017 in the sample from 700 m. The value of 0.054 mg/l exceeded the SANS 241 drinking water limit of 0.03 mg/L
 - Uranium was again detected after AMD abstraction and sludge disposal terminated on 19 September 2018. It was detected in nine of the twelve samples taken and at concentrations from 0.016 mg/L to 0.036 mg/L. The concentration of one sample (0.036 mg/L taken at 700 m during December 2018) exceeded the SANS 241 (2015) limit of 0.03 mg/L. It is known that uranium as found naturally in ore can be oxidized by atmospheric oxygen to more water-soluble species containing U(VI). It is therefore inferred that the exposure of the shaft void to atmospheric oxygen to a deepest depth of 134 m during September 2018 facilitated the formation of soluble species of U. Rising water levels after 19 September 2018 took the newly formed species into solution. Uranium was detected at all three locations below 125 m after a rise in water level of 10.6 m by 31 October 2018. It was detected at all four depths during November 2018 and at 500 m and 700 m during December 2018.
 - During January 2019 to March 2019 uranium was not detected in any of the twelve samples taken from the shaft. During April 2019 to February 2020, uranium was detected in fifteen of the seventeen samples taken. Concentrations varied from 0.017 mg/L at 125 m to 0.094 mg/L at 700 m during May 2019. Uranium of 0.047 mg/L and 0.031 mg/L were determined in the samples taken from the AMD feed to the plant during June 2019 and February 2020 respectively.
- Uranium was not measured in concentrations above the detection limit of 0.015 mg/L in surface water and shallow surface groundwater in the vicinity of the ERB treatment plant or in treated effluent discharged into the Blesbokspruit.

13. With reference to the Directive issued by DWS on 20 December 2018, the following conclusions can be made:

- *Disposal of sludge into the deep compartments (> 800 metres below surface) of the abandoned Eastern Basin mine void for a period of 18 months* – Disposal in the shaft was followed by disposal to deep boreholes, that commenced during December 2018. Disposal was mostly to BH8, with limited disposal to BH1 and the shaft itself.
- *Continue geo-hydrological and geo-chemical monitoring programme to evaluate any potential impact of the disposal on the regional water resource* - Exigo was appointed to monitor the relevant water quality. During 2017, a conceptual model, water flow and mass (water quality) balance with dynamic and geochemical models were developed and an initial risk assessment done. It indicated that the sludge disposal is a long-term option that requires further investigation and monitoring verification.
- *The representative surface and groundwater resources that may be impacted by the sludge disposal into the deep compartments of the abandoned Eastern Basin mine void (as determined by the independent specialist), must be assessed on a monthly basis for the following parameters: pH, conductivity, total suspended solids, sulphate, iron, manganese and uranium.* – Surface water samples were taken monthly while groundwater samples at three boreholes within a 7 km radius of the plant were taken bi-annually.
- *Sludge disposal should be terminated immediately with any indication that sludge disposal is adversely impacting on mine void water (raw AMD) and/ or compromising any element of the Eastern Basin plant performance and efficiency* - No significant long-term adverse water quality impacts or plant performance issues have been identified;
- *Progress reports to be submitted to the Department on a monthly basis* - Feedback has been provided;

14 RECOMMENDATIONS

The following were recommended:

- Sludge disposal did not have a negative long-term effect on the overall shaft water quality to date. Monitoring should continue to verify the effect over the medium to long term.
- Based on the monitoring findings of the isolation potential of disposal in the deep parts of the main reef basin, it remains a low/acceptable risk and a long term management option. This will have to be evaluated with more detailed risk assessment and modelling. The monitoring data is critical to support the confidence in the modelling and risk assessment processes.
- The potential build-up of uranium in the deep basin sludge disposal system should be modelled to determine the long-term chemical and radiological risks. More detailed mass balance and geochemical modelling is recommended to determine the long-term behaviour of East Rand Basin (ERB) water treatment plant (WTP) waste sludge which is to be disposed of in the underground mine voids.
- The surface water – groundwater – mine void water interactions should be verified using ongoing isotope and chemical analysis with water balance modelling. The likelihood that discharged water and Blesbokspruit discharges from sewage treatment facilities are recycled should be reviewed.
- The viability of the continuation of sludge disposal into the mining voids at depths of ± 680 m and $\pm 1\,148$ m as a medium to long term solution should be verified by monthly water quality monitoring. The void water should be sampled at the Grootvlei # 3 Shaft.
- Current water quality monitoring at the shaft should be continued at minimum on a monthly basis in order to monitor the anticipated settling of sludge solids to the lower regions of the shaft, as well as the dissolving of the lime portion of the sludge solids.
- The monitoring protocol should be optimised based on previous monitoring results to focus on the critical control parameters.
- The abstraction strategy may be further optimised in terms of cost and risk, in view of the latest monitoring results. Abstraction tempo, water levels and water quality are intricately linked. Operational cost increases with increased abstraction tempo and deeper shaft water levels. The quality of water abstracted from the shaft determines the treatment required and related costs. Water quality has proven to change significantly at depths near the abstraction pumps, making their locality in the shaft critical. The optimisation of these variables remains a priority.

15 ACKNOWLEDGEMENTS

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Special thanks are due to Mr. Nico de Meillon from DWS for monitoring conducted and data gathered over an extended period of time under sometimes challenging circumstances.

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17 APPENDIX A: WATER QUALITY DATA

Table 17-1 Water Quality –Groundwater

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alkalinity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L	mg/L	mg/L				mg/L
AECBH01	2016-06-30	70	26	21	13.5	4.28	11	32	3.12		0.116		0.26	7.6	26	182	70	120		<0.1	<0.002	<0.004	<0.001		
AECBH01	2017-04-24	62	26	30	14.7	5.54	12	32	5.43	<0.005	0.061	24	0.02	6.4	31	202	62	126			<0.002	<0.004	<0.001	<0.015	<0.001
AECBH01	2017-10-23	71	24	21	13	4.12	10	24	2.55	<0.005	0.066	11	0.07	7.0	22	166	71	116	152		<0.002	<0.004	0.021	<0.015	<0.001
AECBH01	2017-11-09	62	25	26	14	4.58	11	26	3.73	<0.005	0.075	17	0.02	6.5	24	184	62	120	68		<0.002	<0.004	0.024	<0.015	<0.001
AECBH01	2018-06-28	60	24	24	13	4.87	12	26	3.44	<0.005	0.024	15	0.04	6.9	20	148	60	115	100		<0.002	<0.004	0.007	<0.015	<0.001
AECBH01	2018-12-13	63	30	40	17	5.54	14	33	8.07	<0.005	0.020	36	0.07	7.0	37	278	63	145	98		0.007	<0.004	0.022	<0.015	<0.001
AECBH01	2019-06-26	83	26	27	13	4.40	11	25	4.02	<0.005	0.082	18	0.12	7.2	29	152	83	119	33	<0.1	0.007	<0.004	0.014	<0.015	<0.001
AECBH01	2020-02-26	68	30	37	16	7.91	15	42	8.22	<0.005	0.028	36	0.15	7.4	38	260	68	141	441		0.013	<0.004	0.025	<0.015	<0.001
Baseline		70	26	21	13.5	4.28	11	32	3.12	<0.005	0.116	24.000	0.26	7.6	26	182	70	120	152	<0.1	<0.002	<0.004	<0.001	<0.015	<0.001

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alkalinity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L	mg/L				mg/L
AECBH13	2016-06-30	466	591	61	209	30	100	1838	0.83		1.56		6.72	8.2	323	2988	473	2337		0.1	<0.002	<0.004	0.716		
AECBH13 (A)	2017-04-24	387	166	55	101	13	77	551	0.43	0.010	1.36	1.89	0.64	7.3	156	1234	388	830			<0.002	<0.004	0.255	<0.015	<0.001
AECBH13 (A)	2017-10-23	437	233	63	128	16	100	829	<0.194	0.112	2.97	<0.859	3.02	7.9	214	1520	440	1109	12		<0.002	<0.004	0.564	<0.015	<0.001
AECBH13 (A)	2017-11-10	482	275	65	179	18	118	963	<0.194	0.023	2.50	<0.859	0.84	7.3	245	1852	482	1424	14		<0.002	<0.004	0.669	<0.015	<0.001
AECBH13 (A)	2018-06-28	521	319	66	192	19	122	1096	0.22	0.027	1.70	0.99	2.04	7.6	283	2022	523	1587	17		<0.002	<0.004	0.734	<0.015	<0.001
AECBH13 (A)	2018-12-13	583	352	72	203	21	127	1268	0.31	0.022	1.98	1.39	1.37	7.4	276	2328	585	1715	36		0.006	<0.004	0.810	<0.015	0.001
AECBH13 (A)	2019-06-26	658	353	79	221	18	123	1257	0.26	0.058	2.96	1.15	3.24	7.7	302	2556	662	1792	25	<0.1	0.006	<0.004	0.788	<0.015	<0.001
AECBH13 (A)	2020-02-26	649	421	77	231	23	144	1522	<0.194	0.155	2.87	<0.859	8.21	8.1	306	2550	657	2003	10		0.003	<0.004	0.887	<0.015	<0.001
Baseline		466	591	61	209	29.90	100	1838	0.83	0.010	1.560	1.89	6.72	8.2	323	2988	473	2337	12	0.1	<0.002	<0.004	0.716	<0.015	<0.001

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alkalinity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L	mg/L				mg/L	
CEN371 (A)	2016-06-30	126	95	19	50	2	23	286	1.90		0.06		2.77	8.4	80	538	129	440		0.1	<0.002	<0.004	<0.001		
CEN371 (A)	2017-04-24	137	80	20	44	2	19	226	2.37	<0.005	0.05	10.50	0.59	7.7	70	530	137	379			<0.002	<0.004	<0.001	<0.015	<0.001
CEN371 (A)	2017-10-23	126	77	20	43	2	18	205	2.15	<0.005	0.06	9.54	0.66	7.7	61	412	126	370	13		<0.002	<0.004	<0.001	<0.015	<0.001
CEN371 (A)	2017-11-09	122	75	18	45	2	19	220	2.41	<0.005	0.15	10.70	0.51	7.7	61	412	122	371	<4.5		<0.002	<0.004	0.002	<0.015	0.002
CEN371 (A)	2018-06-28	134	86	19	46	2	20	232	1.95	<0.005	0.03	8.64	0.74	7.8	67	484	135	404	<4.5		0.003	<0.004	0.002	<0.015	<0.001
CEN371 (A)	2018-12-13	165	78	18	43	2	19	217	2.20	<0.005	0.02	9.76	0.49	7.5	70	528	165	369	1725		0.005	<0.004	0.005	<0.015	<0.001
CEN371 (A)	2019-06-26	160	79	20	44	2	18	239	2.62	<0.005	0.07	11.60	1.18	7.9	70	460	161	376	<4.5	<0.1	0.004	<0.004	0.002	<0.015	<0.001
CEN371 (A)	2020-02-26	125	41	15	17	4	15	77	<0.194	0.005	0.07	<0.859	1.81	8.2	37	250	127	171	22		<0.002	<0.004	0.036	<0.015	<0.001
Baseline		126	95	19	50	1.87	23	286	1.90	<0.005	0.063		2.77	8.4	80	538	129	440	13	0.1	<0.002	<0.004	<0.001	<0.015	<0.001
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 1.5	N/A	N/A	N/A	≥ 5: ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 5	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-2 Water Quality – Surface Water Upstream: ESW-01

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N			mg/L	mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L	mg/L	mg/L					
ESW-01	2015-05-15	200	50	76	0.30	18.0	10.2	67.0	107	0.92				<5	7.6	75	488	200	199			<0.100	0.142	0.096	0.011	
ESW-01	2015-11-23	280	63	89	0.60	16.0	11.2	76.0	43	0.12					7.6	81	486	280	223			<0.100	0.045	0.902	<0.010	
ESW-01	2016-04-15	168	49	73	0.41	18.2	13.8	73.7	117	0.42				0.4	7.4	74	386	168	198			<0.002	<0.004	<0.001	<0.001	
ESW-01	2016-05-23	156	52	61	0.33	15.1	9.8	67.6	87	0.72				0.5	7.6	69	422	157	191			<0.002	<0.004	0.072	<0.001	
ESW-01	2016-06-27	183	56	66	0.23	19.5	11.0	76.7	108	1.30				0.8	7.7	79	486	184	221			<0.002	<0.004	0.108	<0.001	
ESW-01	2016-06-30	167	53	69	0.23	17.5	11.2	82.2	114	1.07		2.72		3.0	8.3	77	388	170	205		0.1	<0.002	<0.004	0.099		
ESW-01	2016-07-25	188	62	75	0.30	21.7	12.8	80.3	143	0.88				3.6	8.3	86	576	191	244			<0.002	<0.004	0.132	0.007	
ESW-01	2017-04-24	141	52	63		19.3	9.6	65.2	110	2.54	<0.005	0.049	11.2	0.6	7.6	52	408	142	208	7		<0.002	<0.004	<0.001	<0.015	<0.001
ESW-01	2017-10-23	168	53	60		17	11.1	74	89	0.70	0.143	1.060	3.09	5.2	8.5	72	456	173	202	20		<0.002	<0.004	0.423	<0.015	<0.001
ESW-01	2017-11-09	147	46	71		16	12.7	82	91	1.85	0.019	1.060	8.17	0.5	7.6	63	432	147	179	46		0.002	<0.004	0.138	<0.015	<0.001
ESW-01	2018-06-28	178	51	72	0.263	20	12.5	90	108	1.63	0.032	1.040	7.23	1.5	7.9	61	500	180	209	19		<0.002	<0.004	<0.001	<0.015	0.001
ESW-01	2018-12-13	220	60	81	0.27	19	11.8	98	102	3.44	<0.005	0.053	15.2	0.9	7.7	74	612	221	227	23		<0.002	<0.004	<0.001	<0.015	<0.001
ESW-01	2019-06-26	175	56	73	0.33	17	13.3	80	102	2.98	0.062	2.020	13.2	1.3	7.9	79	462	176	213	10	<0.1	<0.002	<0.004	0.085	<0.015	<0.001
ESW-01	2020-02-26	154	47	47	0.30	15	7.9	47	78	0.82	0.014	0.134	3.63	3.3	8.4	56	354	157	176	6		<0.002	<0.004	<0.001	<0.015	<0.001
Baseline		200	50	76	0.30	18	10.2	67	107	0.92	N/A	N/A	N/A	<5	7.6	75	488	200	199	N/A		<0.100	0.142	0.096	0.011	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	≤ 1.5	N/A	N/A	≤ 200	≤500	≤11	N/A	N/A		N/A	≥5; ≤9.7	≤170	≤1200	N/A	N/A		≤5	≤0.3	≤2	≤0.4	≤0.030	N/A

Table 17-3 Water Quality – Surface Water Downstream: ESW-03 (Baseline) & ESW-05

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N			mg/L	mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L	mg/L					
ESW-03	2015-05-15	204	64	68	0.30	23	6	51	95	<0.24				<5	7.5	73	462	204	255			<0.100	0.028	0.726	<0.010	
ESW-03	2016-07-25	121	190	94	<0.26	55	12	134	808	1.22				1.9	8.2	179	1300	123	702			<0.002	<0.004	0.170	<0.001	
Baseline		204	64	68	0.30	23	6	51	95	<0.24	N/A	N/A	N/A	<5	7.5	73	462	204	255			<0.100	0.028	0.726	<0.010	
ESW-05	2017-04-24	148	75	68		25	9	73	199	1.10	<0.005	0.108	4.85	0.7	7.7	84	532	149	292	5		<0.002	<0.004	<0.001	<0.015	<0.001
ESW-05	2017-10-23	177	76	71		23	11	81	153	0.64	0.012	0.171	2.81	2.4	8.2	72	564	179	285	6		<0.002	<0.004	0.162	<0.015	0.001
ESW-05	2017-11-09	135	139	80		46	12	118	468	0.43	0.005	0.181	1.90	0.8	7.8	138	976	136	538	36		0.002	<0.004	0.030	<0.015	<0.001
ESW-05	2018-06-28	170	74	70	<0.26	24	12	79	150	1.05	0.006	0.091	4.64	2.6	8.2	88	630	173	281	<4.5		<0.002	<0.004	<0.001	<0.015	<0.001
ESW-05	2018-12-13	209	54	78	0.32	18	13	93	94	2.91	<0.005	0.036	12.90	3.9	8.3	69	516	213	209	18		<0.002	<0.004	<0.001	<0.015	0.005
ESW-05	2019-06-26	165	85	73	0.31	27	14	87	239	1.68	0.006	0.081	7.45	2.9	8.3	96	612	168	325	5	<0.1	<0.002	<0.004	0.062	<0.015	<0.001
ESW-05	2020-02-26	165	54	51	0.31	18	8	52	100	0.25	0.010	0.094	1.11	3.8	8.4	63	372	169	208	<4.5		<0.002	<0.004	<0.001	<0.015	<0.001
Baseline		148	75	68		25	9.15	73	199	1.10	<0.005	0.108	4.9	0.7	7.7	84	532	149	292	5	N/A	<0.002	<0.004	<0.001	<0.010	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	≤ 1.5	N/A	N/A	≤ 200	≤ 500	≤ 11	N/A	N/A	N/A	N/A	≥ 5; ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 5	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-4 Water Quality – Surface Water Alexander Dam

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N			mg/L	mg/L CaCO ₃	pH	mS/m	mg/L	mg/L Ca CO ₃		mg/L	mg/L					
Alexander Dam	2016-06-30	89	32	47	0.20	11.4	8.7	48	67	1.24		0.119		2.1	8.4	48	254	91	126	0.1	<0.002	<0.004	<0.001			
Alexander Dam	2017-04-24	91	38	39		15.2	6.2	38	91	0.38	<0.005	0.090	1.680	0.7	7.9	50	284	92	157	5	<0.002	<0.004	<0.001	<0.015	<0.001	
Alexander Dam	2017-10-23	102	40	58		16.4	11.5	59	91	<0.194	0.012	0.087	<0.859	3.3	8.5	61	398	105	168	18	0.174	<0.004	0.066	<0.015	<0.001	
Alexander Dam	2017-11-09	94	42	58		17.0	11.6	58	91	<0.194	0.020	0.048	<0.859	14.5	9.2	52	350	109	174	<4.5	0.015	<0.004	0.019	<0.015	0.001	
Alexander Dam	2018-06-28	84	30	49		12.0	8.6	54	77	0.25	0.010	0.043	1.120	6.2	8.9	42	274	91	124	6	0.147	<0.004	<0.001	<0.015	<0.001	
Alexander Dam	2018-12-13	154	36	74		15.0	16.9	72	45	<0.194	<0.005	0.126	<0.859	0.6	7.6	65	348	155	152	10	0.007	<0.004	<0.001	<0.015	<0.001	
Alexander Dam	2019-06-26	103	32	47		12.3	6.2	41	71	0.34	<0.005	0.048	1.490	0.7	7.9	46	318	104	130	<4.5	<0.1	0.007	<0.004	0.047	<0.015	<0.001
Alexander Dam	2020-02-26	117	32	38		11.2	7.3	37	51	1.48	<0.005	0.041	6.570	1.3	8.1	42	246	119	125	<4.5		<0.002	<0.004	0.042	<0.015	<0.001
Baseline		88.7	32	46.5	0.2	11.4	8.7	47.9	66.6	1.24	N/A	0.119	N/A	2.07	8.39	47.7	254	90.9	126	N/A	0.1	<0.002	<0.004	<0.001	N/A	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	≤ 1.5	N/A	N/A	≤ 200	≤ 500	≤ 11	N/A	N/A	N/A	N/A	≥ 5; ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 5	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

Table 17-5 Water Quality – Surface Water Cowles Dam

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N			mg/L	mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L	mg/L					
Cowles Dam	2016-06-30	223	86	63	0.24	13.5	9.7	70	81	0.28		0.071		7.2	8.5	76	440	230	270		0.1	<0.002	<0.004	0.013		
Cowles Dam	2017-04-24	172	62	49		15.2	7.1	52	97	0.48	0.015	0.653	2.120	0.9	7.7	64	386	173	217	10		<0.002	<0.004	<0.001	<0.015	0.002
Cowles Dam	2017-10-23	219	73	71		16.0	12.4	86	87	<0.194	0.035	0.608	<0.859	2.5	8.1	66	522	221	247	24		0.053	<0.004	0.002	<0.015	<0.001
Cowles Dam	2017-11-09	223	74	71		17.6	13.8	88	97	0.28	0.020	0.577	1.230	1.6	7.9	70	490	224	257	11		0.049	<0.004	0.126	<0.015	0.001
Cowles Dam	2018-06-28	373	98	71		13.3	9.8	74	23	<0.194	0.039	0.528	<0.859	6.3	8.3	69	544	379	300	16		0.029	<0.004	0.292	<0.015	0.008
Cowles Dam	2018-12-13	553	127	106		15.9	20.5	134	33	<0.194	<0.005	0.040	<0.859	3.6	7.8	121	700	557	383	100		0.162	0.024	0.104	<0.015	<0.001
Cowles Dam	2019-06-26	294	91	63		13.6	8.2	64	57	<0.194	0.011	0.578	<0.859	1.4	7.7	78	470	296	284	8	<0.1	0.037	<0.004	0.242	<0.015	<0.001
Cowles Dam	2020-02-26	151	47	40		11.4	7.1	42	63	0.32	0.015	0.144	1.400	3.6	8.4	49	264	155	164	8		0.033	<0.004	0.005	<0.015	<0.001
Baseline		223	86	63.2	0.24	13.5	9.7	70.2	80.8	0.278	N/A	0.071	N/A	7.22	8.54	75.6	440	230	270	N/A	0.1	<0.002	<0.004	0.013	N/A	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	≤ 1.5	N/A	N/A	≤ 200	≤ 500	≤ 11	N/A	N/A	N/A	N/A	≥ 5; ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 5	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-6 Water Quality – Surface Water Ashton Lake

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	free - Cl ₂	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L								mg/L N			mg/L	mg/L CaCO ₃	pH	mS/m	mg/L	mg/L Ca CO ₃		mg/L	mg/L				
Aston Lake	2016-06-30	103	16.5	16	0.40	10.2	10.3	28	23	0.69		0.109		2.2	8.4	29	176	106	83		0.1	0.233	0.135	<0.001		
Aston Lake	2017-04-24	89	13.5	12		8.4	9.7	19	15	1.00	<0.005	0.083	4.410	0.3	7.5	17	128	90	68	62		0.228	0.023	<0.001	<0.015	0.001
Aston Lake	2017-10-23	106	17.7	16		11.3	10.9	25	21	<0.194	0.016	0.175	<0.859	1.9	8.3	24	188	108	91	74		0.149	<0.004	<0.001	<0.015	<0.001
Aston Lake	2017-11-09	103	14.4	16		12.0	11.8	27	22	<0.194	0.171	0.849	<0.859	5.4	8.8	26	186	109	85	70		0.021	<0.004	<0.001	<0.015	<0.001
Aston Lake	2018-06-28	84	13.3	14		8.4	9.9	23	19	1.06	<0.005	0.043	4.690	0.8	8.0	19	134	85	68	117		0.982	0.484	0.004	<0.015	0.002
Aston Lake	2018-12-13	115	16.4	23		10.3	13.7	36	34	1.62	<0.005	0.057	7.190	0.9	7.9	34	236	115	83	277		0.396	0.278	0.005	<0.015	<0.001
Aston Lake	2019-06-26	130	21.3	34		13.6	12.9	45	66	1.61	<0.005	0.027	7.120	1.6	8.1	44	320	132	109	259	<0.1	1.430	0.765	0.012	<0.015	<0.001
Aston Lake	2020-02-26	138	16.6	16		10.3	13.9	25	29	0.25	0.009	0.112	1.110	2.6	8.3	28	210	141	84	73		6.410	0.005	0.038	<0.015	<0.001
Baseline		103	16.5	15.6	0.4	10.2	10.3	28.2	22.9	0.692	N/A	0.109	N/A	2.24	8.36	29.3	176	106	83	N/A	0.1	0.233	0.135	<0.001	N/A	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	≤ 1.5	N/A	N/A	≤ 200	≤ 500	≤ 11	N/A	N/A	N/A	N/A	≥ 5: ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 5	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

Table 17-7 Water Quality – Rand Water

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N				pH	mS/m	mg/L	mg/L CaCO ₃	mg/L	mg/L					mg/L
Rand Water	2017-04-24	71	19	10	5.5	3.44	8	12	0.96	0.029	0.428	1.0	8.2	14	102	72	70		<0.002	<0.004	<0.001	<0.015	<0.001
Rand Water	2017-10-23	69	19	10	5.6	3.89	8	13	0.49	0.040	0.343	1.8	8.4	18	120	71	70	<4.5	0.160	<0.004	<0.001	<0.015	<0.001
Rand Water	2017-11-09	60	16	11	6.4	4.13	9	18	0.52	0.024	0.355	1.0	8.2	15	90	61	67	9	0.026	<0.004	0.006	<0.015	<0.001
Rand Water	2018-06-28	74	17	10	7.4	3.61	10	21	0.31	0.027	0.370	1.4	8.3	15	104	75	74	<4.5	0.006	<0.004	<0.001	<0.015	<0.001
Rand Water	2018-12-13	86	23	13	7.2	3.71	11	19	0.72	0.005	0.086	1.3	8.2	20	136	87	88	<4.5	0.028	<0.004	<0.001	<0.015	
Rand Water	2019-06-26	91	25	11	6.7	2.99	9	14	0.51	0.020	0.335	1.5	8.2	20	106	93	89	<4.5	0.031	<0.004	<0.001	<0.015	<0.001
Rand Water	2020-02-26	74	22	14	9.0	4.39	14	19	1.52	0.034	0.411	1.4	8.3	24	194	75	92	<4.5	0.008	<0.004	0.012	<0.015	
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 1.5	N/A	N/A	≥ 5: ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

Table 17-8 Water Quality – Sewage Effluent

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	CO ₃	pH	EC	TDS	Alkalinity	Total Hard	SS	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N				pH	mS/m	mg/L	mg/L CaCO ₃	mg/L	mg/L					mg/L
Sewage Effluent	2017-04-24	118	26.0	53	10.1	10.50	61	59	2.13	<0.005	0.266	0.3	7.5	40	308	119	107	21	<0.002	<0.004	<0.001	<0.015	<0.001
Sewage Effluent	2017-10-23	118	36.3	51	10.1	11.80	65	71	1.42	0.049	0.364	3.2	8.5	58	356	121	132	<4.5	<0.002	<0.004	0.194	<0.015	<0.001
Sewage Effluent	2017-11-09	127	31.8	77	11.5	14.80	94	84	1.51	0.018	1.010	0.5	7.6	60	418	128	127	12	0.007	0.021	0.150	<0.015	<0.001
Sewage Effluent	2018-06-28	101	25.7	59	11.0	12.10	75	70	3.90	0.013	0.414	0.7	7.9	47	302	102	109	15	<0.002	<0.004	0.039	<0.015	<0.001
Sewage Effluent	2018-12-13	185	40.1	73	10.6	13.40	90	42	3.14	0.011	0.780	0.5	7.5	69	364	186	144	16	0.017	<0.004	0.007	<0.015	
Sewage Effluent	2020-02-26	113	28.9	55	11.8	11.40	58	59	4.76	<0.005	0.062	1.8	8.2	51	310	115	121	<4.5	0.025	<0.004	0.010	<0.015	
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	N/A	N/A	N/A	≥ 5: ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-9 Water Quality – Shaft 125 m

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Turbidity	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N					mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	NTU	mg/L				mg/L
125m	2016-06-28	230	180	92	78	10	92	569	0.98	0.243	0.010	0.251	4.330	2.3	8.0	176	1140	232	769	17	29	<0.002	<0.004	0.734	0.0100	
125m	2016-12-14	197	270	82	98	12	145	919	2.25	0.449	0.027	0.462	9.980	2.4	8.1	213	1668	199	1078	71	75	<0.002	<0.004	1.850	0.1260	
125m	2017-01-26	123	300	92	89	13	160	968						1.0	7.9	226	1658	124	1115		73	<0.002	<0.004	0.887	NATD	
125m	2017-02-27	250	202	102	99	12	103	680						3.4	8.2	182	1380	253	913	116	95	<0.002	<0.004	1.630	0.0240	
125m	2017-03-30	268	271	118	108	12	124	827	0.52		0.073	1.250		3.2	8.1	206	1602	271	1122	79	103	<0.002	<0.004	3.560	0.0350	
125m	2017-04-24	156	117	68	52	7	65	380	0.60		0.032	0.588	2.670	1.8	8.1	108	804	158	505	101	97	<0.002	<0.004	0.439	<0.015	
125m	2017-05-24	274	347	104	104	12	188	1249	1.14		0.012	2.940	5.040	0.3	7.0	222	2058	274	1295	120	271	<0.002	29.200	4.060	<0.015	
125m	2017-06-28	258	358	107	119	13	206	1281	0.54		0.013	6.300	2.370	0.1	6.8	259	2292	258	1384	520	638	<0.002	8.580	4.110	0.0550	
125m	2017-07-28	261	332	106	122	13	191	1204	0.47		0.006	3.220	2.090	0.1	6.7	254	2022	261	1331	156	553	<0.002	0.098	4.130	<0.015	<0.001
125m	2017-08-30	262	330	94	116	13	186	1467	0.27		<0.005	0.962	1.200	0.1	6.6	269	2316	262	1302	148	520	<0.002	30.300	4.000	<0.015	<0.001
125m	2017-09-30	242	266	101	99	11	144	876	1.24		0.006	0.544	5.500	0.6	7.4	229	1822	242	1072	108	134	0.002	<0.004	3.040	<0.015	<0.001
125m	2017-10-23	150	215	120	84	11	141	749	1.66		0.031	0.231	7.340	4.3	8.5	187	1506	155	882	20	63	<0.002	<0.004	0.723	<0.015	<0.001
125m	2017-11-10	360	312	103	115	12	158	954	0.45		0.013	4.620	1.980	0.2	6.8	235	1860	360	1253	164	560	<0.002	<0.004	5.150	<0.015	0.005
125m	2017-12-13	250	183	118	92	11	101	535	0.94		0.010	0.239	4.150	2.1	8.0	167	1306	252	838	9	19	<0.002	<0.004	1.120	<0.015	0.001
125m	2018-01-10	234	195	121	103	11	119	635	1.37		0.006	0.112	6.060	2.9	8.1	153	1212	237	911	27	26	<0.002	<0.004	1.110	<0.015	0.001
125m	2018-02-26	206	168	95	86	9	95	594	1.09		0.038	0.519	4.840	3.2	8.2	157	1162	209	775	6	10	0.009	<0.004	0.078	<0.015	<0.001
125m	2018-04-30	196	216	97	99	11	118	751	1.66		<0.005	0.052	7.370	1.8	8.0	182	1382	198	947	<4.5	12	<0.002	<0.004	0.347	<0.015	0.005
125m	2018-05-31	212	176	89	88	9	103	626	2.69		<0.005	0.041	11.900	1.6	7.9	154	1190	214	801	8	11	<0.002	<0.004	0.132	<0.015	<0.001
125m	2018-06-29	208	160	86	86	9	98	537	1.32		<0.005	0.034	5.830	1.4	7.9	160	1266	210	754	9	12	<0.002	<0.004	0.178	<0.015	0.002
130m	2018-08-02	225	166	81	83	9	98	582	1.16		0.017	0.631	5.130	1.8	7.9	160	1182	227	758	8	18	<0.002	<0.004	0.143	<0.015	<0.001
135m	2018-08-29	235	173	92	85	9	101	647	1.32		<0.005	0.191	5.830	1.3	7.8	163	1236	236	781	12	25	<0.002	<0.004	0.186	<0.015	0.001
130m	2018-10-01	124	212	100	77	11	122	765	1.62		0.006	0.081	7.180	3.2	8.4	163	1322	128	848	16	2	<0.002	<0.004	0.031	<0.015	<0.001
125m	2018-10-30	192	241	94	89	11	134	928	1.27		0.005	0.079	5.640	2.6	8.2	202	1616	194	968	6	1	0.005	<0.004	0.101	<0.015	<0.001
125m	2018-11-28	210	229	108	89	11	125	797	0.95		<0.005	0.117	4.180	0.9	7.6	183	1416	211	940	10	3	0.003	<0.004	0.046	0.027	<0.001
125m	2018-12-12	210	219	97	90	10	121	775	0.91		<0.005	0.072	4.020	1.7	7.9	175	1462	212	919	15	2	0.011	<0.004	0.017	<0.015	<0.001
125m	2019-01-30	211	183	85	82	11	97	654	1.22		0.005	0.061	5.400	4.3	8.3	161	1020	216	793	7	6	0.003	<0.004	0.124	<0.015	<0.001
125m	2019-02-27	71	314	96	47	14	159	978	0.83		0.220	2.640	3.660	1.3	8.3	192	1580	72	979	<4.5	4	<0.002	<0.004	0.022	<0.015	0.001
125m	2019-03-25	215	153	79	81	9	96	503	1.28		<0.005	0.091	5.650	1.9	8.0	121	1048	217	716	7	6	<0.002	<0.004	<0.001	<0.015	0.009
125m	2019-04-26	236	170	82	83	9	95	607	1.76		0.013	0.238	7.770	3.1	8.2	165	1148	239	765	15	21	<0.002	<0.004	1.020	0.018	<0.001
125m	2019-05-27	219	161	79	79	8	90	547	0.99		0.007	0.092	4.370	4.6	8.4	147	924	224	726	13	12	<0.002	<0.004	0.169	0.017	0.001
125m	2019-06-26	212	199	89	73	9	122	719	1.98		0.006	0.181	8.750	1.5	7.9	171	1214	213	797	12	21	0.002	<0.004	0.233	<0.015	<0.001
130m	2019-07-29	221	208	88	82	10	116	724	1.24		0.006	0.621	5.490	0.5	7.4	179	1284	222	858	23	60	<0.002	<0.004	0.668	0.021	0.001
125m	2020-02-26	234	178	75	67	11	95	540	1.46		0.067	0.809	6.470	4.8	8.3	145	1090	239	720	9	27	<0.002	<0.004	0.228	0.022	<0.001
Baseline		230	180	92	78	10	92	569	0.98	0.243	0.010	0.251	4.330	2.3	8.0	176	1140	232	769	17	29	<0.002	<0.004	0.734	0.010	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 0.9	≤ 1.5	N/A	N/A	N/A	≥ 5: ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 1	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-10 Water Quality – Shaft 200 m

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Turbidity	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N					mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	NTU	mg/L				mg/L
200m	2016-06-28	243	354	104	120	14	196	1438	0.34	0.305	0.011	3.530	1.500	0.2	7.5	311	2466	243	1378	123	741	<0.002	34.600	4.350	0.0090	
200m	2016-12-14	197	256	84	101	12	147	926	2.15	0.471	0.027	0.464	9.530	2.5	8.1	213	1654	200	1056	124	125	<0.002	<0.004	1.880	0.1290	
200m	2017-01-26	193	334	90	100	13	167	1137						0.1	6.8	246	1806	193	1244	87	222	<0.002	1.780	2.280		
200m	2017-02-27	270	366	98	121	14	182	1280						1.6	7.8	272	2008	271	1412	78	173	<0.002	109.000	4.390	0.1900	
200m	2017-03-30	289	307	116	114	13	129	939	<0.194		0.189	2.610		3.9	8.2	231	1808	293	1236	115	551	<0.002	<0.004	3.950	0.0520	
200m	2017-04-24	213	244	88	84	10	125	825	0.79		<0.005	1.550	3.480	0.1	6.6	175	1508	213	956	132	453	<0.002	<0.004	2.360	<0.015	<0.001
200m	2017-05-24	379	369	105	118	14	197	1303	0.79		0.008	3.390	3.480	0.2	6.8	273	2296	379	1407	150	250	<0.002	<0.004	4.210	<0.015	0.00
200m	2017-06-28	231	347	105	115	13	199	1264	0.31		0.013	4.770	1.380	0.2	6.9	250	2040	231	1340	480	1149	<0.002	2.190	4.080	0.0580	<0.001
200m	2017-07-28	240	332	104	120	13	192	1167	0.48		0.306	2.700	2.120	8.2	8.6	232	2070	249	1323	138	464	<0.002	1.310	4.130	<0.015	<0.001
200m	2017-08-30	249	333	94	119	13	189	1222	0.24		<0.005	1.490	1.050	0.1	6.6	265	2046	250	1322	169	650	<0.002	17.000	4.080	<0.015	<0.001
200m	2017-09-30	444	351	97	118	13	193	1391	0.78		<0.005	1.410	3.440	0.2	6.6	251	2312	444	1362	189	520	<0.002	61.400	5.050	<0.015	<0.001
200m	2017-10-23	235	298	117	105	12	167	988	0.37		0.320	3.380	1.650	4.5	8.3	248	1706	239	1177	78	587	<0.002	<0.004	4.740	<0.015	<0.001
200m	2017-11-10	269	347	113	127	14	206	1262	0.22		0.006	4.590	0.969	0.1	6.5	279	2158	269	1390	196	443	<0.002	<0.004	4.590	<0.015	0.003
200m	2017-12-13	278	350	117	121	14	177	1296	0.28		0.014	5.890	1.260	0.1	6.7	256	2180	278	1372	168	349	<0.002	<0.004	4.620	<0.015	0.004
200m	2018-01-10	680	302	116	176	14	177	991	0.23		0.037	1.320	1.040	3.7	7.8	233	2296	683	1479	800	1316	0.004	<0.004	4.590	<0.015	0.001
200m	2018-02-26	267	320	109	121	13	197	1278	0.33		0.010	4.540	1.450	0.1	6.7	259	2130	267	1297	196	991	0.010	61.200	4.200	<0.015	0.008
200m	2018-04-30	269	327	113	123	15	192	1342	0.37		0.006	3.370	1.650	0.1	6.6	306	2412	269	1323	170	393	<0.002	82.300	4.740	<0.015	0.003
200m	2018-05-31	255	315	99	108	12	178	1185	1.76		<0.005	3.170	7.790	0.1	6.5	259	2012	255	1231	180	796	<0.002	<0.004	3.650	<0.015	<0.001
200m	2018-06-29	271	306	96	111	13	176	1073	0.45		0.006	3.360	2.010	0.1	6.5	284	2204	271	1221	104	154	<0.002	<0.004	3.910	<0.015	0.002
200m	2018-08-02	388	331	88	112	14	173	1102	0.25		<0.005	4.400	1.100	0.1	6.5	270	1854	388	1288	140	264	<0.002	25.700	4.000	<0.015	<0.001
200m	2018-08-29	276	343	100	122	14	188	1351	0.38		<0.005	3.970	1.680	0.1	6.5	267	2156	277	1359	100	169	<0.002	40.000	3.950	<0.015	0.001
200m	2018-10-01	121	285	104	83	13	156	978	2.43		0.005	0.058	10.800	2.6	8.4	195	1720	123	1052	18	1	<0.002	<0.004	0.595	<0.015	<0.001
200m	2018-10-30	189	241	92	89	11	132	891	1.45		<0.005	0.060	6.420	2.5	8.1	197	1574	192	968	6	1	0.005	<0.004	0.110	0.016	<0.001
200m	2018-11-28	213	233	107	94	11	126	785	0.93		<0.005	0.066	4.100	1.0	7.7	183	1594	214	967	5	3	0.005	<0.004	0.045	0.026	<0.001
200m	2018-12-12	212	215	97	88	10	119	751	0.86		<0.005	0.097	3.800	1.7	7.9	173	1402	213	900	10	3	0.006	<0.004	0.018	<0.015	<0.001
200m	2019-01-30	291	322	114	117	15	173	1289	0.28		0.280	3.590	1.230	5.4	8.3	271	2086	297	1286	105	157	0.003	6.500	3.510	<0.015	0.001
200m	2019-02-27	282	343	100	108	14	179	1107	0.26		0.007	3.820	1.130	0.1	6.6	230	2128	282	1301	38	319	<0.002	<0.004	3.960	<0.015	0.001
200m	2019-03-25	258	320	101	105	13	190	1079	0.30		<0.005	3.280	1.340	0.0	6.3	249	2014	258	1232	164	258	<0.002	<0.004	3.860	<0.015	0.004
200m	2019-04-26	245	206	86	88	10	109	721	1.61		0.062	0.926	7.120	3.7	8.2	187	1354	249	878	27	224	<0.002	<0.004	1.670	0.024	<0.001
200m	2019-05-27	412	322	104	117	12	263	1265	<0.194		0.040	3.020	<0.859	1.4	7.5	271	2070	413	1286	57	492	<0.002	65.300	3.820	0.050	<0.001
200m	2019-06-26	284	338	119	104	13	197	1311	0.53		0.007	4.260	2.340	0.1	6.6	261	2156	284	1272	59	334	<0.002	98.500	3.430	0.043	<0.001
200m	2019-07-29	255	313	99	105	12	170	1177	0.40		0.006	3.440	1.760	0.1	x	250	1888	256	1214	81	467	<0.002	23.000	2.990	0.033	<0.001
200m	2020-02-26	271	331	97	100	14	175	1052	0.51		0.070	4.910	2.270	0.8	7.5	237	1904	272	1238	52	533	<0.002	0.012	3.310	<0.015	<0.001
Baseline		243	354	104	120	14	196	1438	0.34	0.305	0.011	3.530	1.500	0.2	6.9	311	2466	243	1378	123	741	<0.002	34.600	4.350	0.009	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 0.9	≤ 1.5	N/A	N/A	N/A	≥ 5: ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 1	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	#N/A

^a SANS 241:2015, Edition 2

Table 17-11 Water Quality – Shaft 400 m

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Turbidity	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N					mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	NTU	mg/L				mg/L
400m	2020-02-26	275	300	98	102	13	158	976	0.42		0.024	4.140	1.840	0.3	7.1	246	1638	275	1169	63	525	<0.002	<0.004	3.160	0.017	<0.001
Baseline		275	300	98	102	13	158	976	0.42		0.02	4.14	1.84	0.34	7.12	246	1638	275	1169	63.00	525.00	<0.002	<0.004	3.2	0.017	<0.001
SANS 241 (2015) ^a		N/A	N/A	≤300	N/A	N/A	≤200	≤500	≤11	≤0.9	≤1.5	N/A	N/A	N/A	≥5: ≤9.7	≤170	≤1200	N/A	N/A	N/A	≤1	≤0.3	≤2	≤0.4	≤0.030	#N/A

^a SANS 241:2015, Edition 2

Table 17-12 Water Quality – Shaft 525 m, 550 m, 575 m, 600 m, 625 m, 650 m, 675 m

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Turbidity	Al	Fe	Mn	U
		mg/L CaCO ₃	mg/L						mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	NTU	mg/L			
525m	2017-05-24	370	354	108	125	14	210	1366	0.39	0.006	3.89	1.74	0.152	6.6	276	2438	371	1399	212	673	<0.002	<0.004	4.090	<0.015
550m	2017-05-24	425	353	105	131	14	210	1349	<0.194	0.007	4.63	<0.859	0.166	6.6	280	2410	425	1421	190	563	<0.002	<0.004	4.140	<0.015
575m	2017-05-24	256	354	102	128	14	208	1307	0.82	0.005	3.34	3.63	0.107	6.7	280	2262	256	1411	196	581	<0.002	<0.004	4.220	<0.015
600m	2017-05-24	271	345	101	134	14	209	1329	0.94	<0.005	2.09	4.15	0.111	6.6	280	2258	271	1413	190	515	<0.002	<0.004	4.080	<0.015
625m	2017-05-24	266	361	98	123	14	207	1335	0.94	0.008	4.71	4.17	0.109	6.6	281	2290	266	1408	252	569	<0.002	<0.004	4.260	<0.015
650m	2017-05-24	258	344	98	118	13	210	1325	0.84	0.006	3.94	3.73	0.105	6.6	278	2344	259	1345	178	685	<0.002	36.200	4.000	<0.015
675m	2017-05-24	613	263	97	210	12	200	1342	1.08	0.062	3.98	4.78	2.3	7.6	295	2498	616	1522	10570	≥4000	<0.002	<0.004	7.320	<0.015
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤500	≤11	≤1.5	N/A	N/A	N/A	≥5: ≤9.7	≤170	≤1200	N/A	N/A	N/A	≤1	≤0.3	≤2	≤0.4	≤0.030

^a SANS 241:2015, Edition 2

Table 17-13 Water Quality – Shaft 500 m

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Turbidity	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L							mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	NTU	mg/L				mg/L
500m	2016-06-28	233	361	105	122	14	202	1430	0.32	0.278	0.009	3.530	1.420	0.1	6.8	312	2388	234	1406	117	675	<0.002	34.300	4.440	0.0110	
500m	2016-12-14	231	310	82	128	14	135	1199	0.49	0.101	0.020	3.260	2.190	0.3	7.1	272	2082	231	1301	124	213	<0.002	43.400	3.920	0.1910	
500m	2017-01-26	281	382	95	131	14	198	1362						0.1	6.5	280	2064	281	1493	151	323	<0.002	43.200	5.240		
500m	2017-02-27	282	301	96	111	13	145	953						4.2	8.2	236	1710	286	1209	105	246	<0.002	31.800	3.250	0.0800	
500m	2017-03-30	259	336	112	134	14	209	1326	0.65		0.412	3.750		6.2	8.4	260	2326	265	1391	191	924	<0.002	4.380	4.290	0.0750	
500m	2017-04-24	228	274	98	104	12	162	992	0.48		0.005	3.390	2.130	0.1	6.5	198	1684	228	1113	218	492	<0.002	10.200	3.220	0.0510	<0.001
500m	2017-05-24	369	351	107	127	14	205	1376	0.39		0.006	4.050	1.740	0.2	6.7	277	2412	370	1400	134	218	<0.002	<0.004	4.150	<0.015	0.001
500m	2017-06-28	248	350	107	118	13	204	1276	0.22		0.009	4.280	0.987	0.1	6.8	250	2138	248	1360	590	808	<0.002	7.490	4.050	0.0500	<0.001
500m	2017-07-28	275	331	103	127	13	192	1164	0.47		<0.005	2.680	2.070	0.1	6.6	297	2090	275	1350	152	449	<0.002	0.635	4.130	<0.015	<0.001
500m	2017-08-30	252	325	94	116	13	184	1226	0.23		<0.005	1.340	1.010	0.1	6.6	265	2088	252	1289	149	561	<0.002	42.100	3.980	<0.015	<0.001
500m	2017-09-30	438	358	98	120	13	189	1333	0.34		<0.005	1.420	1.490	0.3	6.8	252	2248	438	1388	194	564	<0.002	60.800	5.040	<0.015	<0.001
500m	2017-10-23	246	288	116	98	11	154	1024	0.20		0.013	3.280	0.890	0.2	6.9	244	1830	247	1124	77	645	<0.002	<0.004	5.380	<0.015	<0.001
500m	2017-11-10	252	349	109	125	14	199	1237	0.24		0.006	4.320	1.070	0.1	6.5	282	2046	252	1386	205	458	<0.002	<0.004	4.510	<0.015	0.001
500m	2017-12-13	280	355	119	121	14	182	1190	0.20		0.026	4.270	0.894	0.3	7.1	251	2100	280	1385	171	411	<0.002	<0.004	4.480	<0.015	0.002
500m	2018-01-10	693	299	112	194	14	181	1034	0.23		0.023	0.814	1.010	3.9	7.8	235	2274	697	1546	846	4000	<0.002	<0.004	3.950	<0.015	<0.001
500m	2018-02-26	272	342	109	118	13	199	1310	0.30		0.007	3.880	1.340	0.1	6.6	263	2320	272	1340	161	756	0.012	38.000	4.340	<0.015	0.002
500m	2018-04-30	263	359	111	101	14	184	1328	0.53		0.005	3.230	2.340	0.1	6.6	292	2264	263	1312	154	387	<0.002	72.300	4.630	<0.015	0.001
500m	2018-05-31	271	326	100	111	12	185	1226	1.77		<0.005	3.400	7.830	0.1	6.4	284	2268	271	1271	202	820	<0.002	<0.004	3.870	<0.015	<0.001
500m	2018-06-29	279	311	97	111	13	184	1078	0.45		0.006	3.560	2.000	0.1	6.5	285	1964	279	1234	120	111	<0.002	<0.004	3.880	<0.015	0.001
500m	2018-08-02	278	266	86	107	12	153	932	0.49		0.005	2.760	2.170	0.1	6.7	245	1862	279	1105	140	337	<0.002	10.600	2.930	<0.015	<0.001
500m	2018-08-29	268	303	99	113	13	162	1094	0.73		<0.005	2.990	3.250	0.1	6.6	239	1912	268	1222	114	307	<0.002	35.300	3.180	<0.015	0.001
500m	2018-10-01	208	289	105	106	13	143	986	1.69		0.087	1.110	7.480	5.0	8.4	231	1832	213	1158	32	80	<0.002	<0.004	3.530	<0.015	<0.001
500m	2018-10-30	397	340	97	134	13	172	1217	<0.194		0.034	2.590	<0.859	1.2	7.5	277	2342	398	1401	41	185	0.003	2.680	6.950	0.017	<0.001
500m	2018-11-28	392	315	115	120	13	162	935	<0.194		0.011	2.540	<0.859	0.4	7.0	238	2022	393	1281	28	101	0.003	<0.004	4.550	0.017	0.002
500m	2018-12-12	267	264	99	109	12	142	928	0.59		0.016	0.902	2.600	1.0	7.6	199	1784	269	1108	22	53	0.005	<0.004	2.510	0.028	<0.001
500m	2019-01-30	286	336	112	115	15	179	1383	0.25		0.339	3.530	1.110	6.9	8.4	276	2006	293	1313	144	244	0.012	4.850	3.800	<0.015	<0.001
500m	2019-02-27	405	343	100	121	14	182	1122	0.24		0.009	3.750	1.070	0.2	6.7	262	2134	406	1355	57	427	<0.002	<0.004	3.950	<0.015	<0.001
500m	2019-03-25	272	333	99	110	14	204	1170	0.83		<0.005	4.040	3.680	0.1	6.4	244	2006	272	1285	170	174	<0.002	9.730	4.220	<0.015	0.001
500m	2019-04-26	301	328	112	113	13	164	1092	0.81		0.044	3.100	3.560	1.0	7.5	264	2224	302	1284	23	512	<0.002	<0.004	3.850	0.034	<0.001
500m	2019-05-27	292	341	103	111	13	195	1205	<0.194		0.045	3.390	<0.859	0.9	7.5	270	2216	293	1309	74	464	<0.002	4.240	3.630	0.053	<0.001
500m	2019-06-26	249	280	96	96	12	162	985	1.11		0.007	2.710	4.920	0.1	6.8	224	1746	249	1095	70	337	<0.002	28.700	2.160	0.027	<0.001
500m	2019-07-29	270	326	99	108	13	176	1155	0.36		<0.005	3.550	1.590	0.1	6.5	254	1856	270	1259	70	416	<0.002	30.200	3.130	0.032	<0.001
Baseline		233	361	105	122	14	202	1430	0.32	0.278	0.009	3.530	1.420	0.1	6.8	312	2388	234	1404	117	675	<0.002	34.300	4.440	0.011	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 0.9	≤ 1.5	N/A	N/A	N/A	≥ 5; ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 1	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	#N/A

^a SANS 241:2015, Edition 2

Table 17-14 Water Quality – Shaft 700 m

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka- linity	Total Hard	SS	Turbidity	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L						mg/L N					mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	NTU	mg/L				mg/L
700m	2016-06-28	243	356	105	122	14	202	1395	0.55	0.292	0.011	3.550	2.430	0.2	6.9	309	2396	243	1394	138	826	<0.002	34.100	4.390	0.0090	
700m	2016-12-14	280	324	78	157	15	135	1262	0.57	0.151	0.025	3.260	2.510	0.4	7.2	287	2114	280	1454	798	1873	<0.002	30.800	6.710	0.2130	
700m	2017-01-26	296	379	93	143	14	200	1363						0.1	6.6	275	2122	296	1535	299	447	<0.002	27.900	5.840	NATD	
700m	2017-02-27	481	224	96	247	14	183	1297						5.6	8.1	285	2054	487	1577	3060	>4000	<0.002	0.617	4.550	0.0740	
700m	2017-03-30	289	212	126	179	13	158	999	0.76		0.108	1.490		4.3	8.2	237	1708	294	1267	725	>4000	<0.002	<0.004	2.450	0.1660	
700m	2017-04-24	273	141	96	216	11	144	975	3.57		0.009	0.261	15.800	2.1	7.9	203	1756	275	1242	17290	>4000	<0.002	<0.004	0.962	0.0510	<0.001
700m	2017-05-24	420	189	97	219	12	196	1323	2.46		0.086	2.230	10.900	4.3	8.0	280	2324	424	1374	12060	>4000	<0.002	<0.004	1.550	<0.015	<0.001
700m	2017-06-28	443	230	105	230	13	197	1305	0.86		0.097	2.970	3.790	4.5	8.0	257	2192	447	1522	24670	>4000	<0.002	<0.004	3.440	0.0600	<0.001
700m	2017-07-28	271	355	99	141	14	201	1378	0.48		<0.005	2.570	2.130	0.1	6.6	301	2288	271	1467	174	476	<0.002	0.801	4.250	<0.015	<0.001
700m	2017-08-30	404	321	94	150	13	187	1209	0.27		0.012	3.280	1.180	0.3	7.0	275	2194	404	1419	108	>4000	0.002	11.500	5.720	<0.015	<0.001
700m	2017-09-30	521	296	97	181	12	186	1101	0.27		0.018	2.100	1.180	0.9	7.3	282	2012	522	1485	12030	>4000	0.002	13.600	10.000	<0.015	<0.001
700m	2017-10-23	364	355	122	131	13	211	1284	0.23		0.217	2.820	1.020	6.0	8.3	291	2324	370	1426	87	618	<0.002	54.000	6.550	<0.015	<0.001
700m	2017-11-10	248	103	95	266	14	201	1221	0.78		0.089	1.330	3.440	3.4	8.2	275	2174	251	1353	52838	4000	0.003	<0.004	0.987	0.0540	<0.001
700m	2017-12-13	277	352	120	124	15	181	1297	0.21		0.008	3.640	0.912	0.1	6.7	278	2114	277	1390	178	498	<0.002	<0.004	4.490	<0.015	0.001
700m	2018-01-10	663	348	102	189	14	184	1080	0.22		0.144	5.170	0.974	4.1	7.8	243	2394	667	1647	439	1241	<0.002	<0.004	14.100	<0.015	0.001
700m	2018-02-26	294	328	107	122	13	192	1287	0.36		0.009	3.680	1.600	0.1	6.7	263	2388	294	1322	169	801	0.013	35.800	4.790	<0.015	0.001
700m	2018-04-30	278	346	96	128	14	179	1391	0.41		0.007	3.330	1.800	0.1	6.7	292	2292	278	1391	156	390	<0.002	82.000	5.660	<0.015	0.001
700m	2018-05-31	290	337	99	123	13	189	1259	2.07		<0.005	3.440	9.160	0.1	6.5	293	2374	290	1348	216	996	<0.002	1.130	4.690	<0.015	<0.001
700m	2018-06-29	293	311	97	115	12	172	1044	0.59		0.006	3.230	2.600	0.1	6.5	283	2092	294	1250	110	161	<0.002	<0.004	3.970	<0.015	<0.001
700m	2018-08-02	356	336	89	114	14	175	1104	0.27		<0.005	3.730	1.190	0.1	6.6	268	1962	356	1309	142	257	<0.002	28.800	4.020	<0.015	<0.001
700m	2018-08-29	285	347	100	120	14	191	1298	0.43		0.006	4.350	1.880	0.1	6.6	268	2192	285	1361	134	301	<0.002	37.700	4.000	<0.015	<0.001
700m	2018-10-01	247	300	103	115	13	156	1004	1.05		0.093	1.470	4.640	5.0	8.3	209	1872	252	1223	44	146	<0.002	<0.004	4.610	<0.015	<0.001
700m	2018-10-30	499	336	98	150	14	172	1236	<0.194		0.042	3.180	<0.859	1.6	7.5	285	2428	501	1457	82	418	0.003	<0.004	7.690	0.028	<0.001
700m	2018-11-28	440	305	117	142	13	170	965	0.44		0.009	2.390	1.960	0.3	6.9	238	2058	440	1346	71	296	0.004	0.199	5.360	0.026	<0.001
700m	2018-12-12	378	273	88	124	12	146	903	0.80		0.016	1.380	3.550	0.9	7.4	209	1798	379	1192	54	265	0.004	<0.004	3.460	0.036	<0.001
700m	2019-01-30	264	285	99	110	14	154	1035	0.28		0.311	2.630	1.260	7.4	8.5	243	1834	272	1165	111	160	0.005	3.510	2.700	<0.015	<0.001
700m	2019-02-27	258	311	99	102	14	178	1057	0.53		0.010	3.440	2.350	0.2	6.8	248	2022	258	1197	58	393	<0.002	<0.004	3.010	<0.015	0.003
700m	2019-03-25	272	316	99	115	12	161	1049	0.27		0.008	3.670	1.190	0.1	6.7	226	2024	272	1263	134	318	<0.002	<0.004	3.800	<0.015	0.001
700m	2019-04-26	370	343	119	130	14	165	1170	0.56		0.119	3.410	2.470	2.9	7.9	273	2342	373	1392	27	594	<0.002	<0.004	4.290	0.058	0.001
700m	2019-05-27	538	388	109	152	14	210	1320	<0.194		0.197	4.830	<0.859	5.1	8.0	299	1990	543	1595	63	472	<0.002	3.640	4.120	0.094	<0.001
700m	2019-06-26	257	293	100	90	12	169	1040	0.97		0.012	2.890	4.300	0.2	7.0	238	1916	257	1103	67	320	0.003	38.200	2.410	0.031	<0.001
700m	2019-07-29	274	306	99	116	13	169	1147	0.42		0.006	3.780	1.860	0.1	6.6	253	1958	274	1242	72	427	<0.002	19.900	2.680	0.047	<0.001
Baseline		243	356	105	122	14	202	1395	0.55	0.292	0.011	3.550	2.430	0.2	6.9	309	2396	243	1391	138	826	<0.002	34.100	4.390	0.009	N/A
SANS 241 (2015) ^a		N/A	N/A	≤300	N/A	N/A	≤200	≤500	≤11	≤0.9	≤1.5	N/A	N/A	N/A	≥5: ≤9.7	≤170	≤1200	N/A	N/A	N/A	≤1	≤0.3	≤2	≤0.4	≤0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-15 Shaft, Suspended Solids

	SS, mg/L																																	
	2016-06-28	2016-12-14	2017-01-26	2017-02-27	2017-03-30	2017-04-24	2017-05-24	2017-06-28	2017-07-28	2017-08-02	2017-08-30	2017-09-30	2017-10-23	2017-11-10	2017-12-13	2018-01-10	2018-02-26	2018-04-30	2018-05-31	2018-06-29	2018-08-02	2018-08-29	2018-10-01	2018-10-30	2018-11-28	2018-12-12	2019-01-30	2019-02-27	2019-03-25	2019-04-26	2019-05-27	2019-06-26	2019-07-29	2020-02-26
125m	17	71		116	79	101	120	520	156	174	148	108	20	164	9	27	6	<4.5	8	9				6	10	15	7	<4.5	7	15	13	12		9
130m																					8		16									23		
135m																						12												
200m	123	0	87	78	115	132	150	480	138	96	169	189	78	196	168	800	196	170	180	104	140	100	18	6	5	10	105	38	164	27	57	59	81	52
400m																																	63	
500m	117	124	151	105	191	218	134	590	152	186	149	194	77	205	171	846	161	154	202	120	140	114	32	41	28	22	144	57	170	23	74	70	70	
525m					139	198	212			126	148	164	83	148	142	806	78	86	160	83	88	86	41	55	25	29	82	52	95	56	65	55	47	
550m					80	192	190			96	128	172	78	142	73	1062	74	80	170	86	87	90	30	53	35	23	72	60	108	56	60	48	59	
575m					84	184	196				128	188	80	96	147	1198	67	86	118	83	49	108	32	53	88	20	108	60	91	51	44	58	58	
600m					95	121	190	206	156	222	144	233	85	125	120	1856	67	76	110	90	52	102	26	54	28	38	88	52	93	51	35	54	65	
625m					45	169	252			90	146	181	116	136	127	967	55	72	118	74	72	92	36	45	108	33	107	59	114	47	58	52	39	
630m								234																										
650m					245	164	178	1084		90	140	183	78	131	126	487	62	86	126	86	113	88	34	75	63	33	138	56	95	46	47	48	31	
675m					80	920	10570	1450		7350	160	329	89	5884	115	969	76	80	110	83	77	94	38	81	83	81	91	54	84	52	60	55	62	
685m									78																									
700m	138	798	299	3060	725	17290	12060	24670	174	534	108	12030	87	52838	178	439	169	156	216	110	142	134	44	82	71	54	111	58	134	27	63	67	72	

Table 17-16 Shaft, Turbidity

	Turbidity, NTU																																	
	2016-06-28	2016-12-14	2017-01-26	2017-02-27	2017-03-30	2017-04-24	2017-05-24	2017-06-28	2017-07-28	2017-08-02	2017-08-30	2017-09-30	2017-10-23	2017-11-10	2017-12-13	2018-01-10	2018-02-26	2018-04-30	2018-05-31	2018-06-29	2018-08-02	2018-08-29	2018-10-01	2018-10-30	2018-11-28	2018-12-12	2019-01-30	2019-02-27	2019-03-25	2019-04-26	2019-05-27	2019-06-26	2019-07-29	2020-02-26
125m	29	75	73	95	103	97	271	638	553	439	520	134	63	560	19	26	10	12	11	12				1	3	2	6	4	6	21	12	21		27
130m																					18		2										60	
135m																						25												
200m	741	135	222	173	551	453	250	1149	464	110	650	520	587	443	349	1316	991	393	796	154	264	169	1	1	3	3	157	319	258	224	492	334	467	533
400m																																		525
500m	675	213	323	246	924	492	218	808	449	471	561	564	645	458	411	4000	756	387	820	111	337	307	44	185	101	53	244	427	174	512	464	337	416	
525m					921	435	673			188	518	278	422	209	339	1281	234	214	562	92	219	133	121	173	105	102	71	393	151	757	291	263	242	
550m					835	507	563			114	496	304	481	259	83	1757	246	192	621	220	220	249	93	176	158	57	86	339	232	493	335	216	296	
575m					792	420	581				425	297	407	196	375	1867	233	167	357	200	119	207	97	182	279	91	235	414	213	498	271	267	295	
600m					746	162	515	684	458	412	490	304	355	222	215	3211	216	205	467	235	108	265	82	172	104	141	225	329	306	531	254	231	318	
625m					877	508	569			92	512	302	434	231	277	1549	169	156	352	123	168	228	100	153	522	114	259	333	293	379	269	271	197	
630m								678																										
650m					>4000	507	685	2589		104	441	251	351	165	286	703	192	212	310	144	270	239	91	346	300	122	345	343	210	446	263	221	138	
675m					865	1083	>4000	2879		>4000	515	515	390	>4000	249	1320	237	177	322	150	209	213	139	421	412	375	198	351	241	499	302	246	316	
685m									415																									
700m	826	1873	447	>4000	>4000	>4000	>4000	>4000	476	1453	>4000	>4000	618	4000	498	1241	801	390	996	161	257	301	146	418	296	265	160	393	318	594	472	320	427	

Table 17-17 Water Quality (Inorganic) – AMD Plant Feed Water

Site name	Date	HCO ₃	Ca	Cl	Mg	K	Na	SO ₄	NO ₃ -N	NH ₃ -N	NH ₄ -N	NO ₃	CO ₃	pH	EC	TDS	Alka-linity	Total Hard	SS	Al	Fe	Mn	U	Th
		mg/L CaCO ₃	mg/L					mg/L N				mg/L CaCO ₃		pH	mS/m	mg/L	mg/L CaCO ₃	mg/L CaCO ₃		mg/L				
AMD Water	2019-06-26	284	327	111	109	14	207	1323	0.31	0.009	5.68	N/A	0.1	6.6	271	2204	284	1265	123	<0.002	82.200	3.850	0.047	0.003
AMD Water	2020-02-26	378	393	111	111	15	208	1232	<0.194	0.022	4.95	<0.859	0.3	7.0	273	2256	379	1439	68	<0.002	0.023	3.790	0.031	
Baseline		284	327	111	109	14	207	1323	0.31	0.009	5.68	N/A	0.1	6.6	271	2204	284	N/A	123	<0.002	82.200	3.850	0.047	N/A
SANS 241 (2015) ^a		N/A	N/A	≤ 300	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 1.5	N/A	N/A	N/A	≥ 5; ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	≤ 0.3	≤ 2	≤ 0.4	≤ 0.030	N/A

^a SANS 241:2015, Edition 2

Table 17-18 Water Quality (Inorganic) – Void Boreholes

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	NO ₃	o-PO ₄ as P	CO ₃	pH	EC	TDS	Alka- linity	COD	Total Hard	SS	SOG	TOC	free - CN	Si	Turbi- dity	
		mg/L CaCO ₃	mg/L							mg/L N					mg/L	mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃			mg/L						
6N	2017-07-24	189	233	269		46	9.5	444	986	0.61		0.03	1.01	2.71		1.98	8.1	249	2038	191									
1N	2017-09-01	237	170	74	0.447	53	14	100	451	0.248	0.07	0.01	1.02	1.10	<0.005	0.60	7.4	143	1070	238	59	644	142	27	5.2	<0.01	7.75	427	
BH8	2017-11-10	286	322	133	0.674	84	11	325	1215	<0.194	0.06	0.01	5.64	<0.859	<0.005	0.15	6.7	293	2178	286	69	1148	292	<0.1	3.81		4.86	1125	
SANS 241 (2015) ^a		N/A	N/A	≤ 300	≤ 1.5	N/A	N/A	≤ 200	≤ 500	≤ 11	≤ 0.9	≤ 1.5	N/A	N/A	N/A	N/A	≥ 5; ≤ 9.7	≤ 170	≤ 1200	N/A	N/A	N/A	N/A	N/A	N/A	N/A	≤ 0.2	N/A	≤ 1

^a SANS 241:2015, Edition 2

Site name	Date	Al	As	B	Cd	Cr	Cr (III)	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	Hg	V	Ba	Mo	Ag	Be	Bi	Ga	Li	Rb	Sr	Te	Tl	Sb	Th
		mg/L																				mg/L										
6N	2017-07-24	0.003									<0.004		1.230				<0.015															<0.001
1N	2017-09-01	<0.002	<0.006	0.209	<0.002	<0.003	<0.01	<0.002	0.050	<0.002	<0.004	<0.004	2.430	0.162	<0.002	0.028	<0.015	<0.004	<0.001	0.055	<0.004	0.002	<0.005	<0.004	0.013	0.014	<0.002	0.409	<0.001	<0.037	<0.001	<0.001
BH8	2017-11-10	<0.002	<0.006	0.443	<0.002	<0.003	<0.01	<0.002	0.092	0.022	6.760	<0.004	2.480	0.589	<0.002	<0.002	<0.015	<0.004	<0.001	0.017	<0.004	0.002	<0.005	0.195	0.020	0.085	0.064	1.230	<0.001	<0.037	<0.001	<0.001
SANS 241 (2015) ^a		≤0.3	≤0.01	≤2.4	≤0.003	≤0.05	N/A	N/A	N/A	≤2	≤2	≤0.01	≤0.4	≤0.07	≤0.04	≤5	≤0.030	≤0.006	N/A	≤0.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	≤0.02	N/A

^a SANS 241:2015, Edition 2

Table 17-19 Water Quality (Hydrocarbons) – Void Boreholes

Site name	Date	Volatile halogenated Hydrocarbons		Nitrogen pesticides		Total Petroleum Hydrocarbons			
		mg/L		mg/L		mg/L	mg/L	mg/L	mg/L
		Trichloromethane		Terbutylazine		TPH C16-C21	TPH C21-C30	TPH C30-C35	TPH (sum C10-C40)
1N	2017-09-01	0.00036		0.00006		0.017	0.058	0.045	0.15

Table 17-20 Water Quality (Eurofins Analytico Lab.) – Shaft

Site name	Date	Arsenic (As)	Antimony (Sb)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Mercury (Hg)	Lead (Pb)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Tin (Sn)	Vanadium (V)	Zinc (Zn)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
125 m	2016-06-28	<0.003	<0.005	0.023	<0.001	<0.0004	<0.002	0.014	<0.003	<0.00004	<0.003	<0.002	0.037	<0.005	<0.005	<0.002	0.017
200 m	2016-06-28	0.095	<0.005	0.016	<0.001	<0.0004	<0.002	0.041	<0.003	<0.00004	<0.003	<0.002	0.220	<0.005	<0.005	<0.002	0.016
500 m	2016-06-28	0.150	<0.005	0.016	<0.001	<0.0004	<0.002	0.043	<0.003	<0.00004	<0.003	<0.002	0.230	<0.005	<0.005	<0.002	0.018
700 m	2016-06-28	0.130	<0.005	0.014	<0.001	<0.0004	<0.002	0.052	<0.003	<0.00004	<0.003	<0.002	0.280	<0.005	<0.005	<0.002	0.018

Table 17-21 Water Quality (Eurofins Analytico Lab.) – Void Borehole 1N

Site name	Date	Arsenic (As)	Antimony (Sb)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Mercury (Hg)	Lead (Pb)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Tin (Sn)	Vanadium (V)	Zinc (Zn)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1N	2017-09-01	0.014	<0.005	0.065	<0.001	<0.004	<0.002	0.085	<0.03	<0.00004	<0.003	<0.02	0.26	<0.005	<0.005	<0.002	<0.088

18 APPENDIX B: ISOTOPE RESULTS

Table 18-1 Isotope Composition Results (Shaft)

	Site Name	Date	δD	$\delta^{18}O$	Tritium	
			(‰) SMOW	(‰) SMOW	(T.U.)	±
Shaft	125 m	2016-06-28	+11.3	-0.44		
	125 m	2016-12-14	-8.1	-0.21	2.6	0.30
	125 m	2017-04-24	-9.1	-2.51	2.3	0.40
	125 m	2017-10-23	-11.3	-2.50	1.3	0.30
	125 m	2017-11-10	-11.7	-2.67	1.0	0.30
	125 m	2018-06-29	-11.8	-2.57		
	125 m	2018-12-13	-8.7	-2.14		
	125 m	2019-01-28	-8.5	-2.27		
	125 m	2019-02-26	-9.8	-2.13		
	125 m	2019-03-25	-11.5	-2.28		
	125 m	2019-04-26	-10.5	-2.43		
	125 m	2019-05-27	-11.8	-2.24		
	125 m	2019-06-26	-11.3	-2.42		
	130 m	2019-07-29	-10.0	-2.20		
	125 m	2020-02-26	-12.4	-2.40		
	200 m	2016-06-28	3.7	-0.59		
	200 m	2016-12-14	-12.0	-1.73	1.4	0.30
	200 m	2017-04-24	-9.4	-2.72	3.3	0.40
	200 m	2017-10-23	-11.6	-2.71	0.3	0.20
	200 m	2017-11-10	-12.0	-2.76	1.0	0.30
	200 m	2018-06-29	-10.7	-2.21		
	200 m	2018-12-13	-8.8	-2.15		
	200 m	2020-02-26	-11.4	-2.35		
	400 m	2020-02-26	-10.8	-2.35		
	500 m	2016-06-28	-0.7	-0.64		
	500 m	2016-12-14	-9.3	-1.63	1.8	0.30
	500 m	2017-04-24	-9.5	-2.84	1.5	0.30
	500 m	2017-10-23	-11.6	-2.76	1.6	0.30
	500 m	2017-11-10	-12.1	-2.85	1.8	0.30
	500 m	2018-06-29	-10.2	-2.32		
	500 m	2018-12-13	-8.8	-2.19		
	500 m	2019-06-26	-11.1	-2.23		
	700 m	2016-06-28	-3.9	-0.64		
	700 m	2016-12-14	-8.5	-0.59	1.7	0.30
	700 m	2017-04-24	-9.5	-2.86	1.4	0.30
	700 m	2017-10-23	-11.4	-2.59	2.3	0.30
	700 m	2017-11-10	-12.0	-2.75	2.1	0.30
	700 m	2018-06-29	-11.5	-2.41		
	700 m	2018-12-13	-9.2	-2.24		
	700 m	2019-01-28	-9.8	-2.44		
	700 m	2019-02-26	-10.2	-2.24		
	700 m	2019-03-25	-12.0	-2.35		
	700 m	2019-04-26	-10.8	-2.35		
	700 m	2019-05-27	-11.5	-2.30		
	700 m	2019-06-26	-11.2	-2.36		
	700 m	2019-07-29	-10.5	-2.37		

Table 18-2 Isotope Composition Results (AMD, Boreholes, Void BHs, Rand Water, Sewage Effluent)

	Site Name	Date	δD	$\delta^{18}O$	Tritium	
			(‰) SMOW	(‰) SMOW	(T.U.)	±
AMD	AMD Water	2019-01-28	-10.3	-2.20		
	AMD Water	2019-02-26	-11.1	-2.17		
	AMD Water	2019-03-25	-11.1	-2.19		
	AMD Water	2019-04-26	-8.5	-2.13		
	AMD Water	2019-05-27	-11.8	-2.24		
	AMD Water	2019-06-26	-11.2	-2.42		
	AMD Water	2019-07-29	-11.4	-2.28		
	AMD Water	2019-08-27	-12.2	-2.62		
	AMD Water	2020-02-26	-10.8	-2.36		
Boreholes	AECBH01	2016-06-28	-17.0	-2.74		
	AECBH01	2017-04-24	-19.5	-3.96	1.0	0.30
	AECBH01	2017-10-23	-21.6	-4.22	0.4	0.20
	AECBH01	2017-11-09	-22.0	-4.34	0.7	0.20
	AECBH01	2018-06-28	-20.0	-3.63		
	AECBH01	2018-12-13	-17.6	-3.40		
	AECBH01	2019-06-26	-20.6	-4.11		
	AECBH01	2020-02-26	-19.5	-3.85		
	AECBH13	2016-06-28	-20.2	-2.75		
	AECBH13	2017-04-24	-21.3	-3.46	0.6	0.20
	AECBH13	2017-10-23	-22.7	-4.48	1.4	0.30
	AECBH13	2017-11-10	-23.8	-4.60	1.2	0.30
	AECBH13	2018-06-28	-22.2	-4.00		
	AECBH13	2018-12-13	-21.3	-3.93		
	AECBH13	2019-06-26	-22.7	-4.37		
	AECBH13	2020-02-26	-23.1	-4.36		
	CEN371 (A)	2016-06-28	-19.8	-2.45		
	CEN371 (A)	2017-04-24	-18.7	-3.65	0.2	0.20
	CEN371 (A)	2017-10-23	-19.9	-4.13	0.9	0.20
	CEN371 (A)	2017-11-09	-20.9	-4.33	0.6	0.20
	CEN371 (A)	2018-06-28	-20.0	-3.81		
	CEN371 (A)	2018-12-13	-17.8	-3.56		
	CEN371 (A)	2019-06-26	-20.1	-4.03		
	CEN371 (A)	2020-02-26	-6.5	-1.26		
Voids	1N	2017-09-01	-9.3	-1.95		
	BH 8	2017-11-10	-12.2	-2.97	1.4	0.30
Rand Water	Rand Water	2017-04-24	-8.9	-2.54	2.3	0.40
	Rand Water	2017-10-23	-21.5	-3.73	2.2	0.30
	Rand Water	2017-11-09	-22.2	-3.68	2.0	0.30
	Rand Water	2018-06-28	-6.5	-0.93		
	Rand Water	2018-12-13	-3.9	-1.10		
	Rand Water	2019-01-28	-3.3	-0.76		
	Rand Water	2019-02-26	-2.5	-0.51		
	Rand Water	2019-03-25	-2.6	-0.49		
	Rand Water	2019-04-26	-2.3	-0.66		
	Rand Water	2019-05-27	-1.0	-0.25		
	Rand Water	2019-06-26	-0.6	-0.48		
	Rand Water	2019-07-29	-0.7	-0.47		
	Rand Water	2019-08-27	-1.2	-0.63		
	Rand Water	2020-02-26	-8.2	-1.26		
Sewage Effluent	Sewage Effluent	2017-04-24	-9.1	-2.55	3.0	0.40
	Sewage Effluent	2017-10-23	-16.8	-3.41	2.4	0.3
	Sewage Effluent	2017-11-09	-18.2	-3.20	2.2	0.30
	Sewage Effluent	2018-06-28	-6.7	-1.11		
	Sewage Effluent	2018-12-13	-4.2	-0.95		
	Sewage Effluent	2019-01-28	-4.1	-1.12		
	Sewage Effluent	2019-02-26	-5.6	-1.15		
	Sewage Effluent	2019-03-25	-5.3	-1.03		
	Sewage Effluent	2019-04-26	-6.8	-1.61		
	Sewage Effluent	2019-08-27	-2.4	-0.76		
	Sewage Effluent	2020-02-26	-10.0	-1.61		

Table 18-3 Isotope Composition Results (Surface Water & Dams)

	Site Name	Date	δ D	$\delta^{18}\text{O}$	Tritium	
			(‰) SMOW	(‰) SMOW	(T.U.)	±
Surface Water	Alexander Dam	2016-06-28	+2.5	+2.17		
	Alexander Dam	2017-04-24	-10.4	-1.69	4.0	0.40
	Alexander Dam	2017-09-01	-3.8	-0.83		
	Alexander Dam	2017-10-23	-0.6	-0.6	3.4	0.3
	Alexander Dam	2017-11-09	1.3	-0.2	3.7	0.4
	Alexander Dam	2018-06-28	-4.8	-1.23		
	Alexander Dam	2018-12-13	9.8	1.85		
	Alexander Dam	2019-06-26	-2.8	-1.01		
	Alexander Dam	2019-07-29	-0.4	-0.56		
	Alexander Dam	2019-08-27	1.0	-0.19		
	Alexander Dam	2020-02-26	-9.9	-2.18		
	Aston Lake	2016-06-28	-7.3	1.6		
	Aston lake	2017-04-24	6.0	1.8	3.2	0.4
	Aston lake	2017-09-01	17.8	3.3		
	Aston lake	2017-10-23	26.3	4.5	2.8	0.3
	Aston lake	2017-11-09	31.1	5.4	2.5	0.3
	Aston lake	2018-06-28	+11.6	+1.91		
	Aston lake	2018-12-13	39.9	7.21		
	Aston lake	2019-06-26	45.5	8.86		
	Aston lake	2020-02-26	-15.0	-1.93		
	Cowles Dam	2016-06-28	5.5	2.81		
	Cowles Dam	2017-04-24	-8.5	-1.1	4.2	0.4
	Cowles Dam	2017-09-01	-1.5	-0.3		
	Cowles Dam	2017-10-23	2.3	0.1	3.8	0.3
	Cowles Dam	2017-11-09	3.9	0.4	4.0	0.4
	Cowles Dam	2018-06-28	-3.3	-0.94		
	Cowles Dam	2018-12-13	11.8	2.93		
	Cowles Dam	2019-06-26	-0.4	-0.54		
	Cowles Dam	2019-07-29	2.9	0.03		
	Cowles Dam	2019-08-27	4.5	0.49		
	Cowles Dam	2020-02-26	-12.2	-2.36		
	ESW-01	2016-06-28	4.2	3.1		
	ESW-01	2017-04-24	-7.8	-2.1	3.4	0.4
	ESW-01	2017-10-23	-7.4	-1.8	3.0	0.3
	ESW-01	2017-11-09	-13.1	-2.4	3.1	0.3
	ESW-01	2018-06-28	-4.2	-1.05		
	ESW-01	2018-12-13	-1.5	-0.43		
	ESW-01	2019-01-28	0.4	-0.14		
	ESW-01	2019-02-26	-2.2	-0.54		
	ESW-01	2019-03-25	-3.3	-0.68		
	ESW-01	2019-04-26	-3.1	-1.03		
	ESW-01	2019-05-27	-2.4	-0.57		
	ESW-01	2019-06-26	-1.3	-0.55		
	ESW-01	2019-07-29	0.5	-0.24		
	ESW-01	2019-08-27	0.0	-0.18		
	ESW-01	2020-02-26	-9.8	-1.92		
	ESW-03	2016-06-28	0.7	2.6		
	ESW-05	2017-04-24	-7.2	-1.87	3.5	0.4
	ESW-05	2017-09-01	-7.3	-1.47		
	ESW-05	2017-10-23	-0.62	-1.5	3.1	0.3
	ESW-05	2017-11-09	-7.9	-1.64	3.0	0.30
	ESW-05	2018-06-28	-4.2	-0.98		
	ESW-05	2018-12-13	0.3	-0.04		
	ESW-05	2019-01-28	-0.1	-0.27		
	ESW-05	2019-02-26	-3.0	-0.95		
	ESW-05	2019-03-25	-3.6	-0.70		
	ESW-05	2019-04-26	-4.7	-1.35		
	ESW-05	2019-05-27	-2.4	-0.61		
	ESW-05	2019-06-26	-2.4	-0.73		
	ESW-05	2019-07-29	1.0	-0.17		
	ESW-05	2019-08-27	1.6	0.07		
	ESW-05	2020-02-26	-7.9	-1.68		

19 APPENDIX C: QUALITY CONTROL

1. All samples to be analysed for chemical parameters are taken in duplicate. Back-up samples are kept at Exigo for a period of 6 months in case a re-analysis is required.
2. All samples taken are logged on a field report form and if at all possible a photo is taken of the sampling location. Only when conflicting with mine policy is a photo not taken. Photo's acts as a secondary timestamp (apart from manual logging) and as reference to the location and condition thereof, at the time of sampling.
3. A GPS coordinate is taken of each sampling location.
4. Both samples taken at a location are fully marked with time, date, location ID, project code and reference to the sampler.
5. At the office all samples are verified against the field form/s. Each sample is given a unique number which is used as reference when submitting to the laboratory
6. Various data evaluation techniques are used. This may include, but are not limited to the following:
 - TDS value calculated according to APHA (American Public Health Association) compared to gravimetrically determined value from lab
 - Ion charge balance calculation and evaluation
 - Expected pH influence on certain species are taken into account
 - EC/TDS ratios are noted and checked for anomalies
 - Comparison between field measurements (pH & EC) and lab results are made
7. QA Samples have been taken since November 2012 on samples from eight projects. These are samples taken in duplicate from existing sampling locations. Results are compared.
8. Exigo water samples are sent to Aquatico Laboratories for analysis. Aquatico is accredited for compliance to ISO 18025:2015 by SANAS (South African National Accreditation System). The facility reference number is T0685 and the laboratory has held accreditation since 2015.
9. Part of the ISO 18025 requirements is participation in a relevant proficiency testing scheme (PTS). Aquatico partakes in the water check PTS facilitated by the SABS (South African Bureau of Standards). Samples are prepared by the SABS and analysed by the participating laboratories. For certain parameters as many as 180 laboratories partakes on a regular basis. Results are compared by the SABS and reported on to the participants. The SABS is accredited as a PTS provider (reference PTS0003) by SANAS, according to requirements of ISO 18043:2010. Exigo has also participated in the same water check PTS since 2015, under its own laboratory identification number and from its own budget. These samples are also analysed by Aquatico. Participation has been in two of the three parameter groups, namely Group 1 (22 metals) and Group 3 (pH, EC, TDS and ten major components). Results have been satisfactory:
 - Group 1, average Z-score of 0.78 for 66 results, April 2019 cycle
 - Group 3, average Z-score of 0.64 for 34 results, June 2019 cycle



East Rand Basin Acid Mine Drainage Treatment Plant:

Quarterly Water Monitoring Report

January 2020– March 2020

TECHNICAL REPORT

A grayscale image of a globe with a dynamic splash of water over the Atlantic Ocean, positioned in the center of the page.

**Innovation in
Sustainability**

Technical Report: E-R-2020-04-16

Prepared for: PROXA (Pty) Ltd

Prepared by: Exigo Sustainability (Pty) Ltd

East Rand Basin Acid Mine Drainage Treatment Plant: Quarterly Water Monitoring Report

January 2020 – March 2020

TECHNICAL REPORT

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NOTATIONS AND TERMS

Cone of depression is a depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a borehole from which water is being withdrawn. It defines the area of influence of a borehole.

A *confined aquifer* is a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.

Drawdown is the distance between the static water level and the surface of the cone of depression.

Groundwater table is the surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

A *fault* is a fracture or a zone of fractures along which there has been displacement.

Observation borehole is a borehole drilled in a selected location for the purpose of observing parameters such as water levels.

Pumping tests are conducted to determine aquifer or borehole characteristics.

Recharge is the addition of water to the zone of saturation; also, the amount of water added.

Static water level is the level of water in a borehole that is not being affected by withdrawal of groundwater.

Total dissolved solids (TDS) is a term that expresses the quantity of dissolved material in a sample of water.

Organoleptic Determinants that affects the smell, taste and appearance of water.

LIST OF ABBREVIATIONS

Abbreviation	Description
AMD	Acid Mine Drainage
ERB	East Rand Basin
COD	Chemical Oxidation Demand
DE	Discharge Effluent
DWS	Department of Water Affairs and Sanitation
DH	Department of Health
cfu	Colony forming units
EC	Electrical Conductivity
MAMSL	Meter Above Mean Sea Level
MAP	Mean Annual Precipitation
mbch	Meter Below Casing Height (i.e. depth to water level as measured from top of casing)
ND	Not Detected
RQO	Resource Quality Objective
SOG	Soap Oil, and Grease
SANAS	South African National Accreditation System
SANS	South African National Standard
SS	Suspended Solids
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
TWQR	Target Water Quality Range
WRC	Water Research Commission
WUL	Water Use License
WTO/TBT	World Trade Organisation / Technical Barriers to Trade
IWUL	Integrated Water Use Licence

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1 INTRODUCTION

1.1 Background

Exigo Sustainability (Pty) Ltd (Exigo) was appointed by Proxa (Pty) Ltd to sample, analyse and interpret the water quality at the East Rand Basin Acid Mine Drainage (ERB AMD) treatment plant.

1.2 Monitoring Objectives

The monitoring was done in accordance with monitoring proposal MON-P-19-070-V1 (period January to October 2020). A hydrochemical groundwater and surface water baseline study for the water treatment plant was conducted in 2015 by Exigo. Monitoring was also conducted by Exigo from April 2016 to July 2016 and since November 2016. No sampling was conducted during March 2018, when no appointment was received.

The objective of the monitoring programme is to:

- Provide reliable data on the quality and chemical composition of the surface- and groundwater.
- Detect and quantify the presence and significance of any polluting substances in the groundwater and/or surface water as soon as possible.
- Detect the possible release or impending release of contaminants from the facility to the groundwater and/ or surface water environment.
- Provide an ongoing performance record for effectively controlling pollution.

2 MONITORING LOCATIONS

The various water monitoring locations for the ERB AMD plant are detailed in Figure 2-1 and Figure 2-2 and listed in Table 2-1. The plant is located some 5 km east of the Springs CBD, east of Johannesburg. The groundwater monitoring locations consists of four boreholes that were drilled in early April 2015, along the plant perimeter.

Surface water monitoring consists of five monitoring locations, namely ESW-01 to ESW-05. The water quality of the Blesbokspruit and one of its tributaries are monitored. Location ESW-05 was added to the schedule during May 2018, with historical data since April 2017. The historical results were from sampling runs conducted for the ERB sludge disposal monitoring project. ESW-05 is located on the eastern bank of the Blesbokspruit, upstream from the ERB Plant discharge point but downstream from the old Tailings Storage Facility (TSF).

Surface water drainage in the area is in a south-eastern direction and includes various wetland areas forming part of the Blesbokspruit drainage system. ESW-01 is the most distant location, approximately 4 km northwest of the plant and upstream in the Blesbokspruit. ESW-02 and ESW-04 are located in a tributary of the Blesbokspruit. The tributary joins the Blesbokspruit from the west at a location south of the Grootvlei Tailings Storage Facility (TSF), upstream from the Plant Discharge Effluent. Note that the

current location ESW-04 is the same as location ESW-05 referred to in the baseline study. The location noted as ESW-04 in the baseline study was not sampled again, due to its close proximity to ESW-02.

Location ESW-03 is the only location downstream from the plant, where water quality would reflect any impact of the plant discharge on the Blesbokspruit. The plant effluent is monitored and sampled where it discharges into the Blesbokspruit system.

Table 2-1 ERB AMD Treatment Plant Monitoring Locations

Identification	Type	Sampling Frequency	Latitude	Longitude	Description
ESW-01	Surface water	Monthly	-26.2145	28.47997	Located approximately 4 km upstream from the plant, in the Blesbokspruit
ESW-02	Surface water	Monthly	-26.2457	28.4716	Located approximately 1.6 km upstream from the plant, in a tributary of the Blesbokspruit, flowing from the west
ESW-03	Surface water	Monthly	-26.2556	28.49832	Located approximately 700 m downstream from the plant, in the Blesbokspruit
ESW-04	Surface water	Monthly	-26.2473	28.48229	Located approximately 500 m upstream from the plant, in a tributary of the Blesbokspruit, flowing from the west
ESW-05	Surface water	Monthly	-26.25017	28.49762	Located on the eastern bank of the Blesbokspruit, upstream from the discharge point and downstream from the old Tailings Storage Facility (TSF)
Discharge Effluent	Process Water	Monthly	-26.2517	28.49143	Discharge point of plant treated AMD water
EBH-01	Groundwater	Quarterly	-26.2493	28.48759	Borehole located just outside the northern corner of the plant area
EBH-02	Groundwater	Quarterly	-26.2499	28.48867	Borehole located half way along the northern perimeter of the plant area
EBH-03	Groundwater	Quarterly	-26.2506	28.49001	Borehole located just inside the eastern corner of the plant area
EBH-04	Groundwater	Quarterly	-26.2515	28.48947	Borehole located along the eastern perimeter of the plant area



Figure 2-1 Regional Map: All water monitoring locations



Figure 2-2

Localised Map: On-site water monitoring locations

3 WATER QUALITY STANDARDS AND SAMPLING METHODOLOGY

3.1 Quality Assurance and Control (QA & QC)

All water samples collected as part of the water monitoring programme were submitted to Aquatico Laboratories (Pty) Ltd for sample analyses. Details pertaining to quality control are provided in Appendix A: Quality Assurance and Control of this report.

3.2 Water Quality Guidelines and Standards Used

The following standards, guidelines and/ or specifications, listed below, were used for interpretation of results. Details regarding these standards, guidelines and/ or specifications are given in Appendix B: Water Quality Standards and Guidelines.

- a) Baseline values
- b) Department of Water and Sanitation, Directive: Effluent Discharge Standards (AMD-DIR-TCTA-01.03.2011).
- c) Wastewater limit values applicable to discharge of wastewater into a water resource GN665; GG36820 (2013).
- d) Department of Water and Sanitation & Rand Water: Resource Quality Objectives (RQO) for the Blesbokspruit Catchment, C21E (2003).

3.3 Sampling Methodology

Best practise methodologies were used to conduct each sampling run. Detailed sampling protocol and methodologies employed by Exigo personnel are discussed in Appendix C: Sampling Methodology of this report.

4 MONITORING RESULTS AND DISCUSSION

4.1 Rainfall

Rainfall data since February 2017 was obtained from daily observations from the manual rain meter located at the plant. Monthly rainfall data preceding this period was sourced from the Weather Underground website (<https://www.wunderground.com/>) for rainfall at ORT Airport, located approximately 25 km west northwest of the plant. During Q1 2020, an average monthly rainfall of 72 mm was measured. This was 32 mm less than the average of 104 mm/ month measured during Q1 2019.

Table 4-1 Monthly Rainfall Data

Month	2018	2019	2020
January	111	114	56
February	64	154	123
March	185	44	36
April	63	95	-
May	20	0	-
June	0	0	-
July	0	0	-
August	0	0	-
September	4	6	-
October	58	8	-
November	67	194	-
December	105	200	-
TOTAL	677	815	215

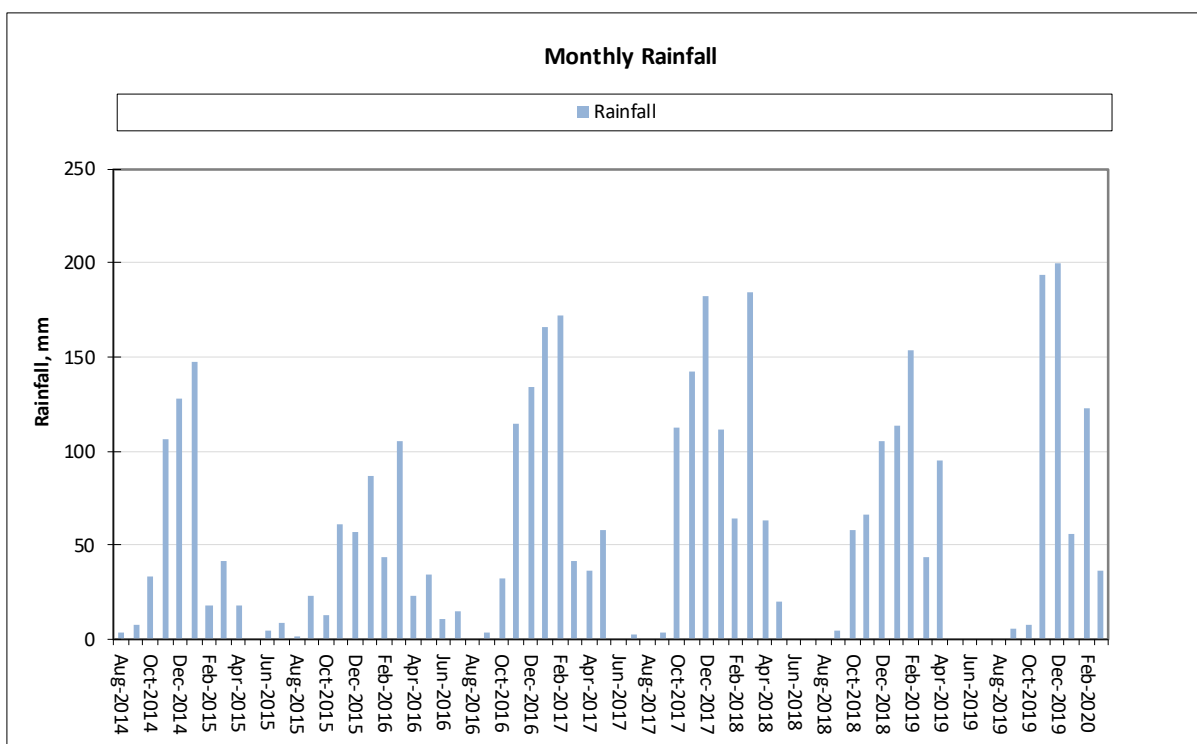


Figure 4-1 Monthly rainfall over time

4.2 Groundwater Levels

Water levels are measured as depth to water level in m, as measured from top of the borehole casing. Figure 4-2 is a graphical representation of the borehole depths and water levels as recorded during March 2020. Groundwater levels as measured since May 2015 are illustrated in Figure 4-3 and Figure 4-4.

The following was observed for the groundwater levels following the March 2020 monitoring:

- Water levels at boreholes EBH-01, EBH-02 and EBH-04 decreased on a quarterly basis, from December 2019 to March 2020. Decrease in water level varied from 0.08 m to 0.43 m. The average quarterly water level change was a decrease of 0.23 m.
- On an annual basis, average water levels increased by 0.18 m from 1.63 m during March 2019 to 1.45 m during March 2020 at EBH-01, EBH-02 and EBH-03.
- The shallowest water level of 0.83 m was measured at borehole EBH-01 during January 2020.
- The deepest water level during Q1 2020 was 7.93 m measured at borehole EBH-04 during January and March 2020. Throughout monitoring, water levels at borehole EBH-04 have been at least 5 m deeper than at the other three boreholes. The other three boreholes are located closer to the Blesbokspruit and less influenced by seasonal changes due to recharge by rainfall. Annually, the water level at borehole EBH-04 decreased by 0.11 m, from 7.82 m during March 2019 to 7.93 m during March 2020.

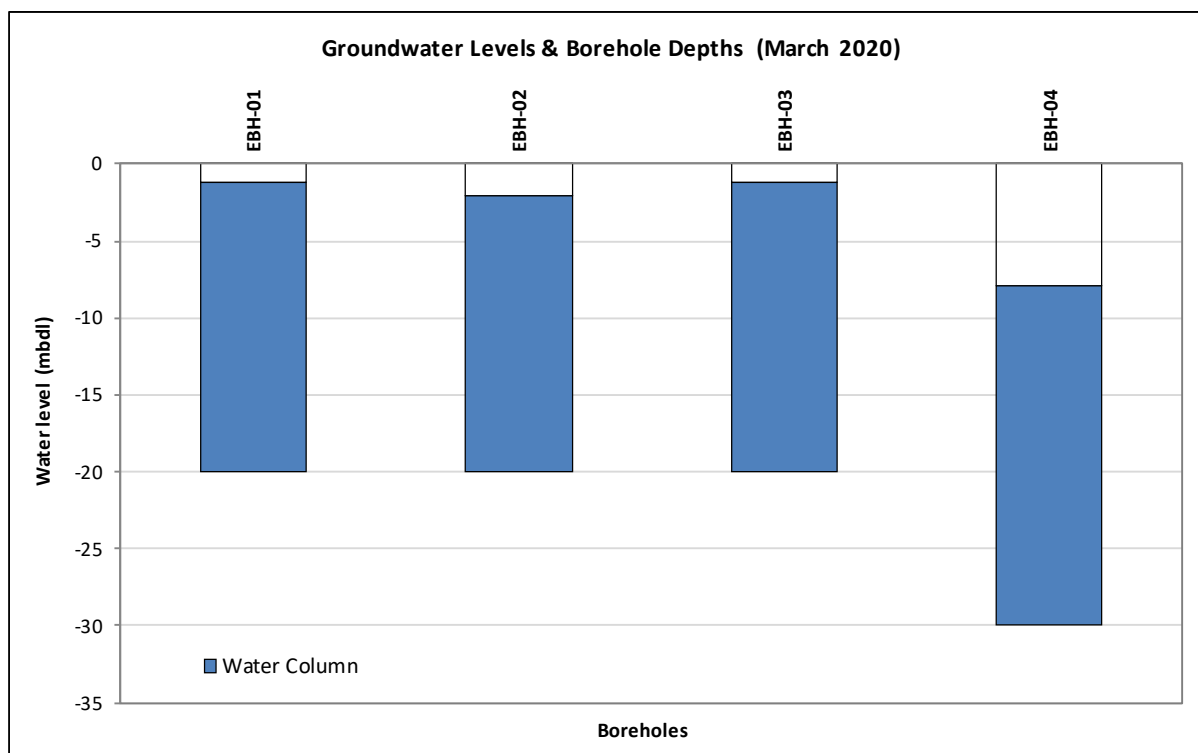


Figure 4-2

Groundwater Levels and Borehole Depths

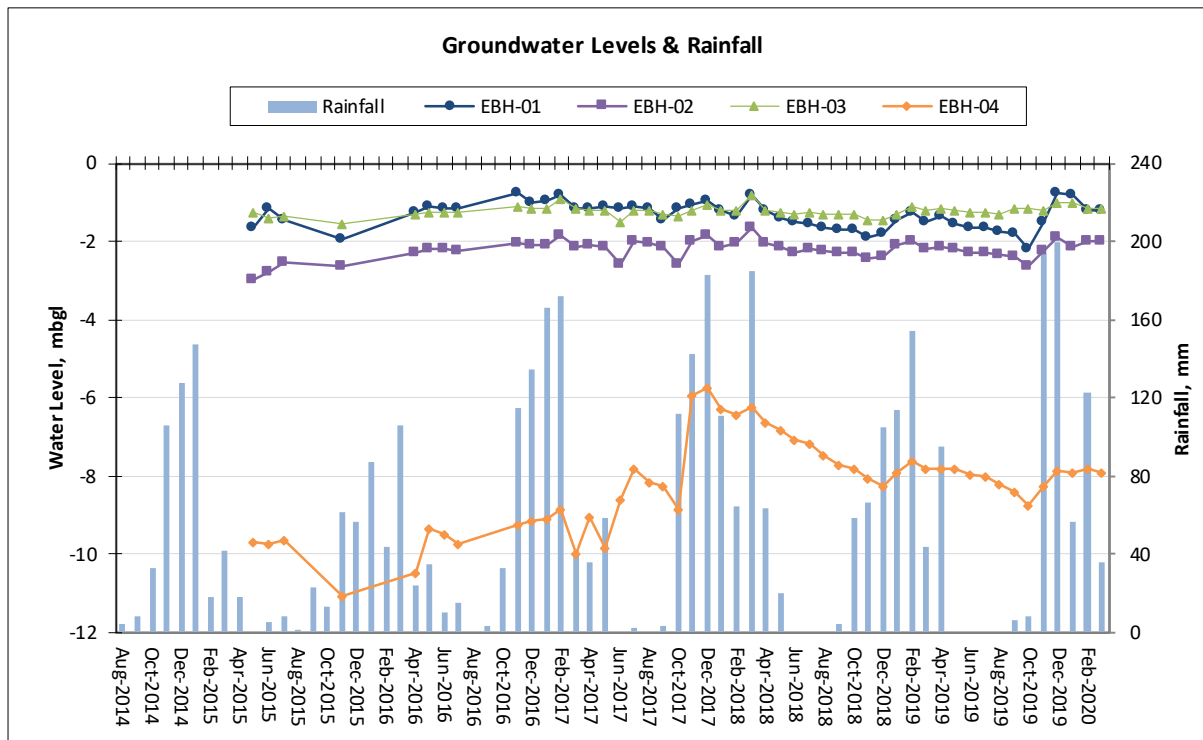


Figure 4-3 ERB AMD Treatment Plant - Groundwater Levels: All boreholes

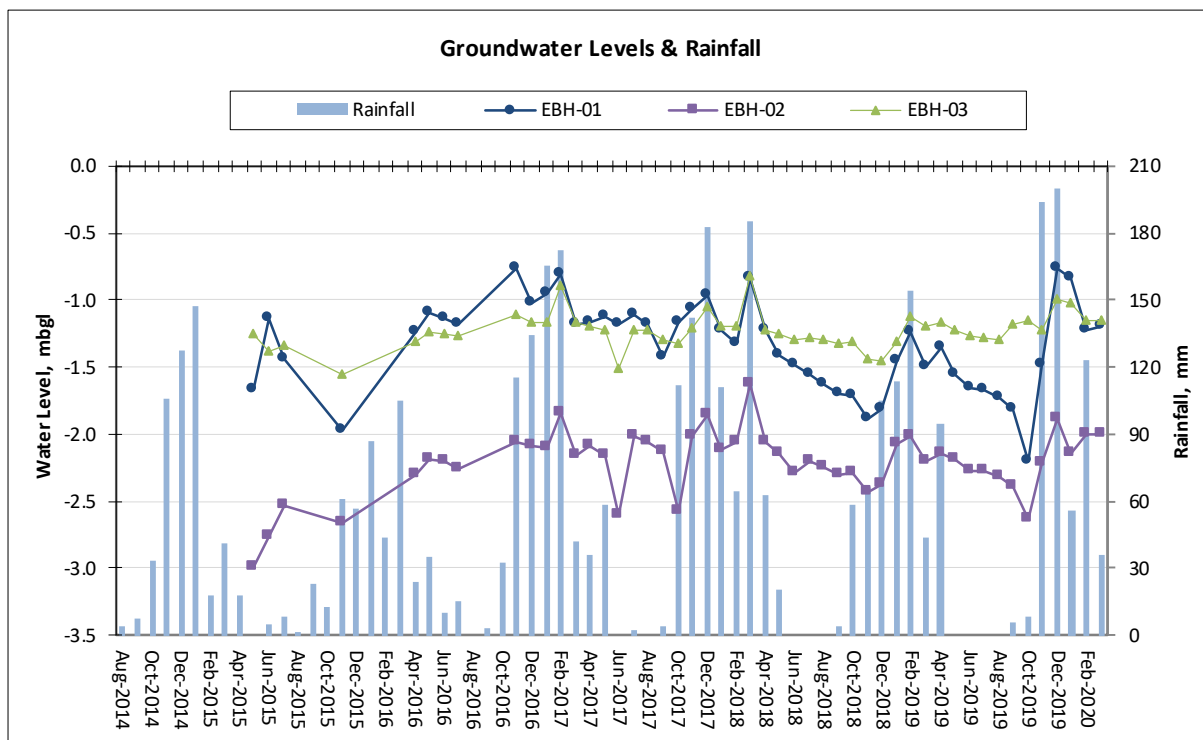


Figure 4-4 ERB AMD Treatment Plant - Groundwater Levels: EBH-01, EBH-02 & EBH-03

4.3 Hydrochemistry Results

4.3.1 Groundwater

Groundwater quality is monitored by means of four on-site boreholes located near the perimeter fence of the plant. Water quality results obtained are illustrated in Figure 4-7 to Figure 4-14 and detailed in Table 11-1 to Table 11-4. Water quality data obtained with the baseline study during May and November 2015 were also included in the results.

All four boreholes were successfully sampled during the March 2020 sampling run. Groundwater composition in terms of the major components during March 2020 is illustrated in Figure 4-6 while that of December 2019 is illustrated in Figure 4-5. Water quality remained relatively varied between the different boreholes.

The latest results were plotted on a Piper diagram (Figure 4-7) in order to determine the water type and the major chemical characteristics. The following was observed:

- Borehole EBH-01 and EBH-04 displayed characters toward that of stagnant water. The characters for EBH-02 and EBH-03 were less defined, being more of a mixed character. Ionic nature was relatively mixed and varied for all four samples. See Figure 4-7. EBH-02 displayed a potassium/sodium chloride nature. Water characteristics were similar to what have been observed during previous monitoring at times. See Figure 4-8.
- At EBH-01, sulphate concentration increased from 22 mg/L during September 2019 to 103 mg/L during December 2019. This increase resulted in some change in water character, which was sustained throughout March 2020. Historically, significantly elevated sulphate concentrations (above 550 mg/L) were observed during May 2015, October 2017 and December 2017. These concentrations were reflected in the water character. See Figure 4-8.

Of the trace metals analysed for in the groundwater samples taken during March 2020, barium was detected in all four samples. Manganese (below 0.4 mg/L) and copper (below 0.02 mg/L) were detected in EBH-01, EBH-03 and EBH-04, while zinc (below 0.01 mg/L) was detected at EBH-02 and EBH-04. The baseline value for barium was exceeded at EBH-01 and EBH-03 and for manganese at EBH-03. More detailed observations for each borehole are presented in the sections below.

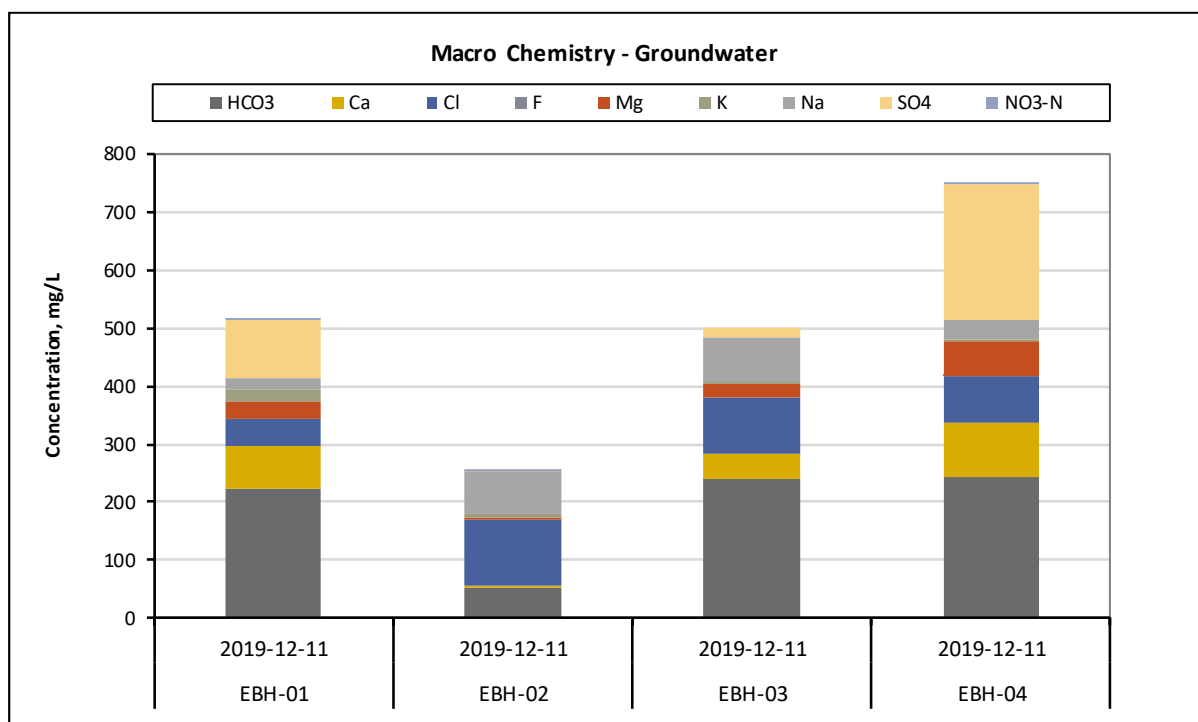


Figure 4-5 Groundwater Comparative Chemical Composition – December 2019

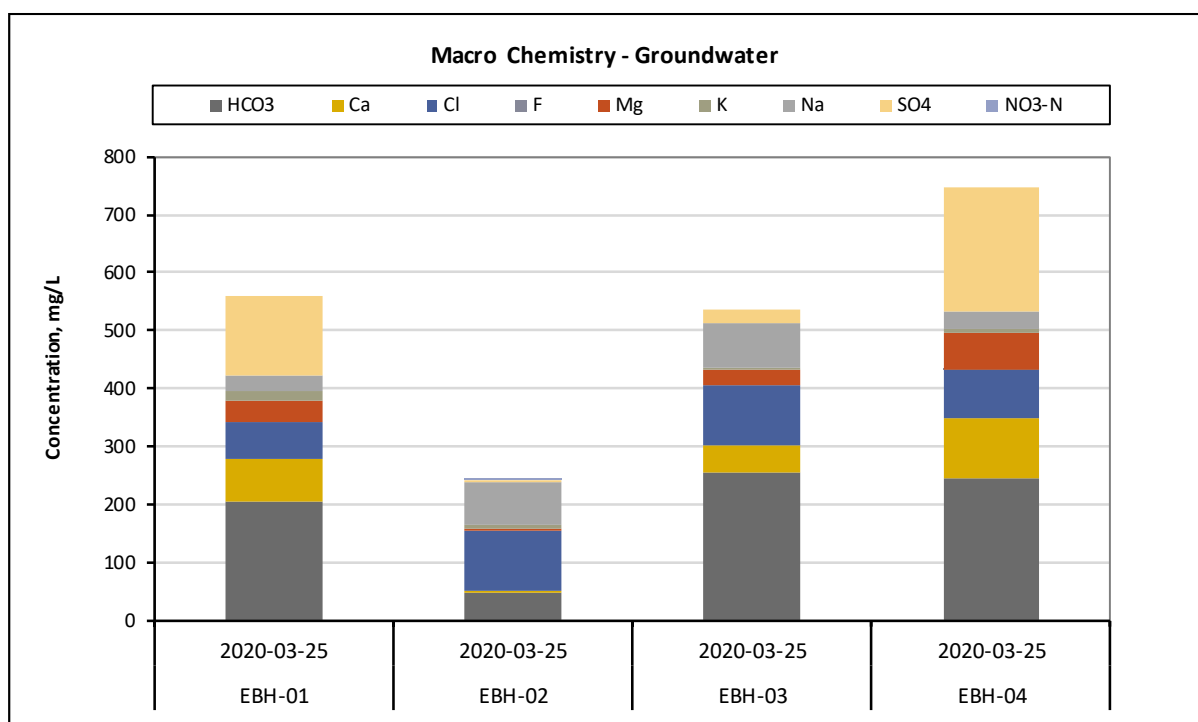


Figure 4-6 Groundwater Comparative Chemical Composition – March 2020

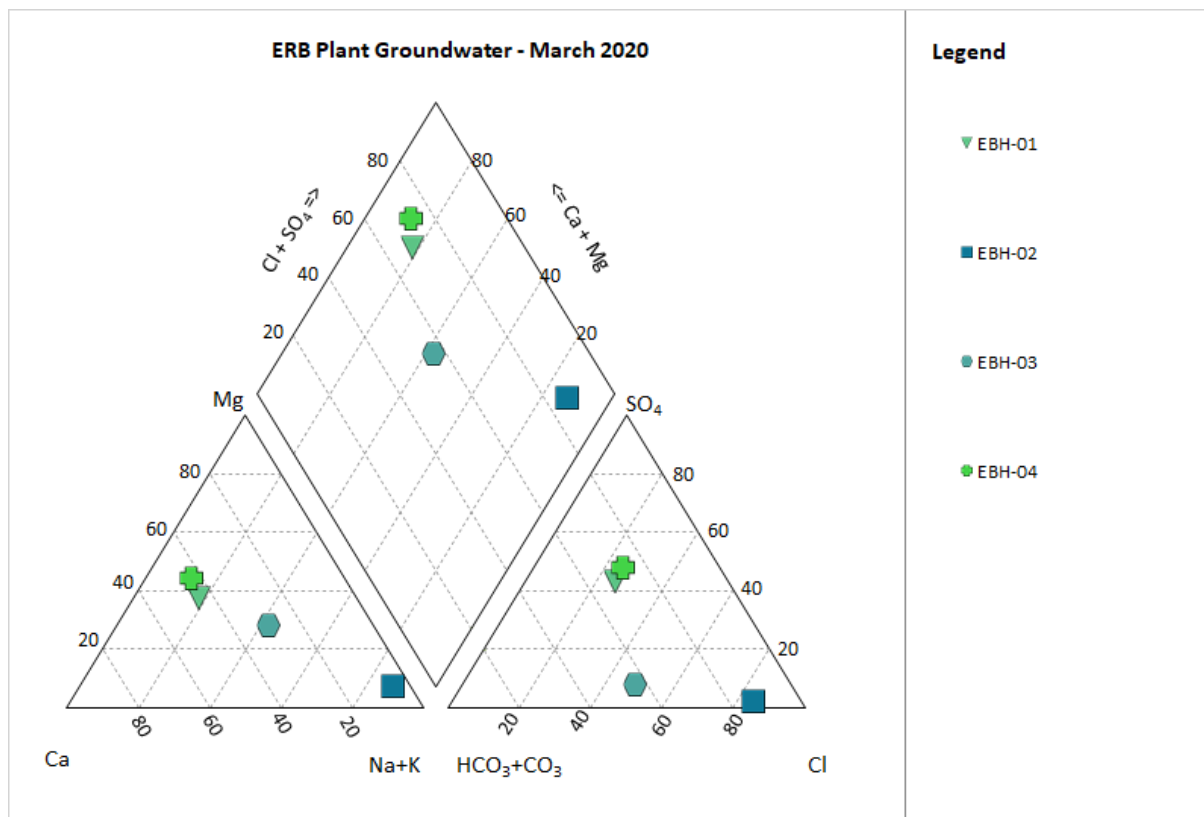


Figure 4-7 Piper Diagram – Groundwater (March 2020)

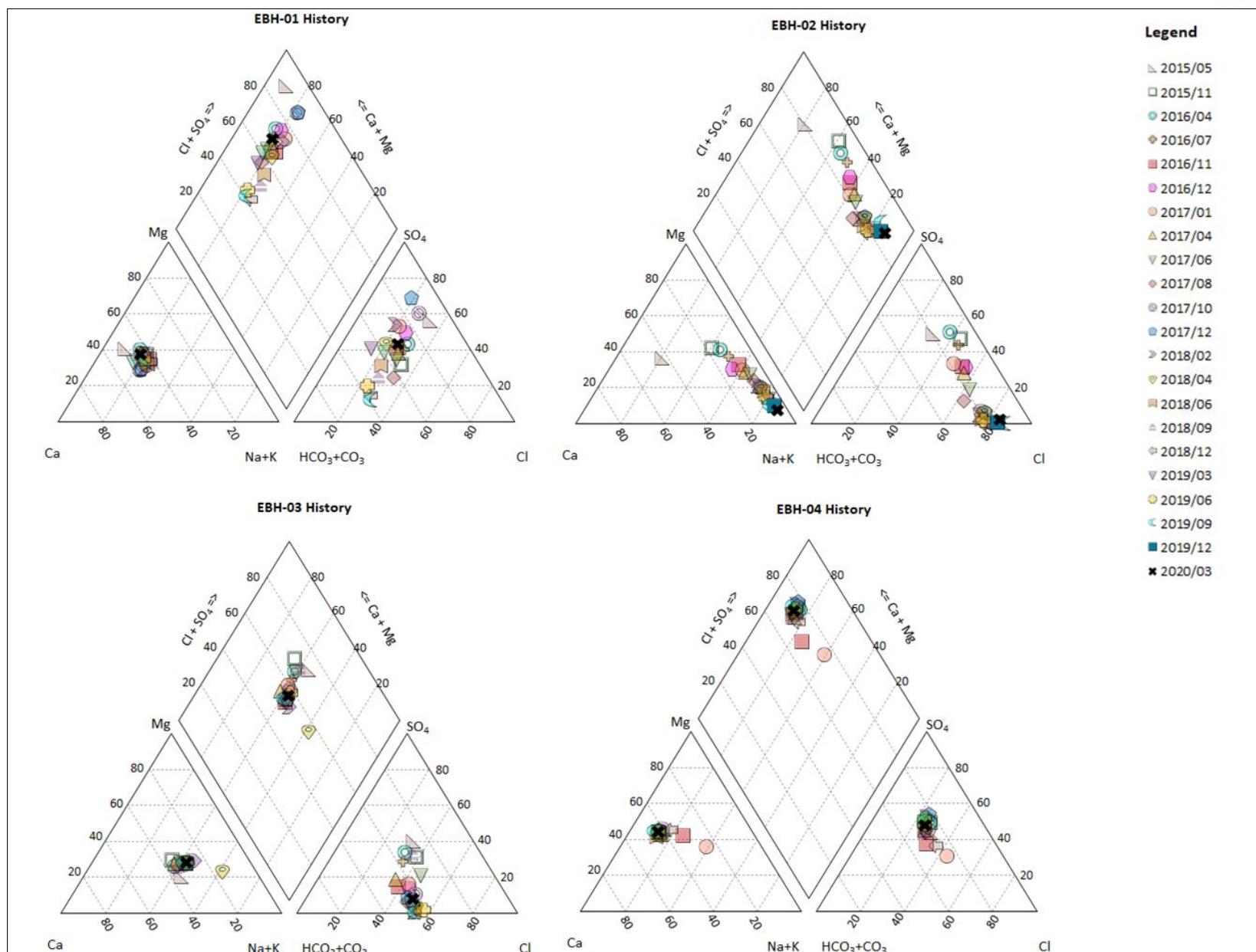


Figure 4-8 Piper Diagrams – Groundwater history

4.3.1.1 Borehole EBH-01

EBH-01 is located outside the northern corner of the plant area. Some variations in water quality have historically been observed at the borehole and are detailed in Appendix E: HISTORICAL OVERVIEW. Although various parameters were elevated when deteriorated water quality was observed, sulphate concentrations affected water character as well. See See Figure 4-8 and Figure 4-10.

A TDS value of 432 mg/L was observed during March 2020 and was similar to values observed during the last two years. See Figure 4-11.

The water qualities at EBH-01 during the latest sampling runs (December 2019 and March 2020) relative to the other boreholes are illustrated in Figure 4-5 and Figure 4-6, relative to the other boreholes.

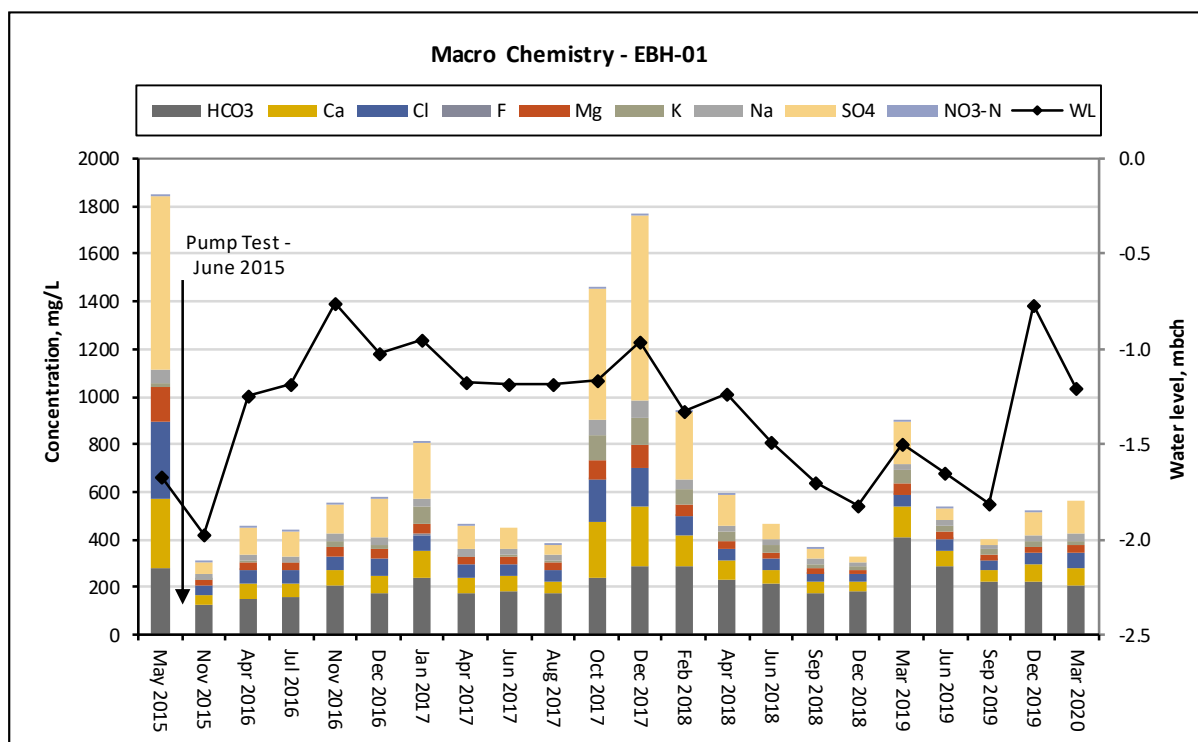


Figure 4-9 Comparative Chemical Composition – EBH-01

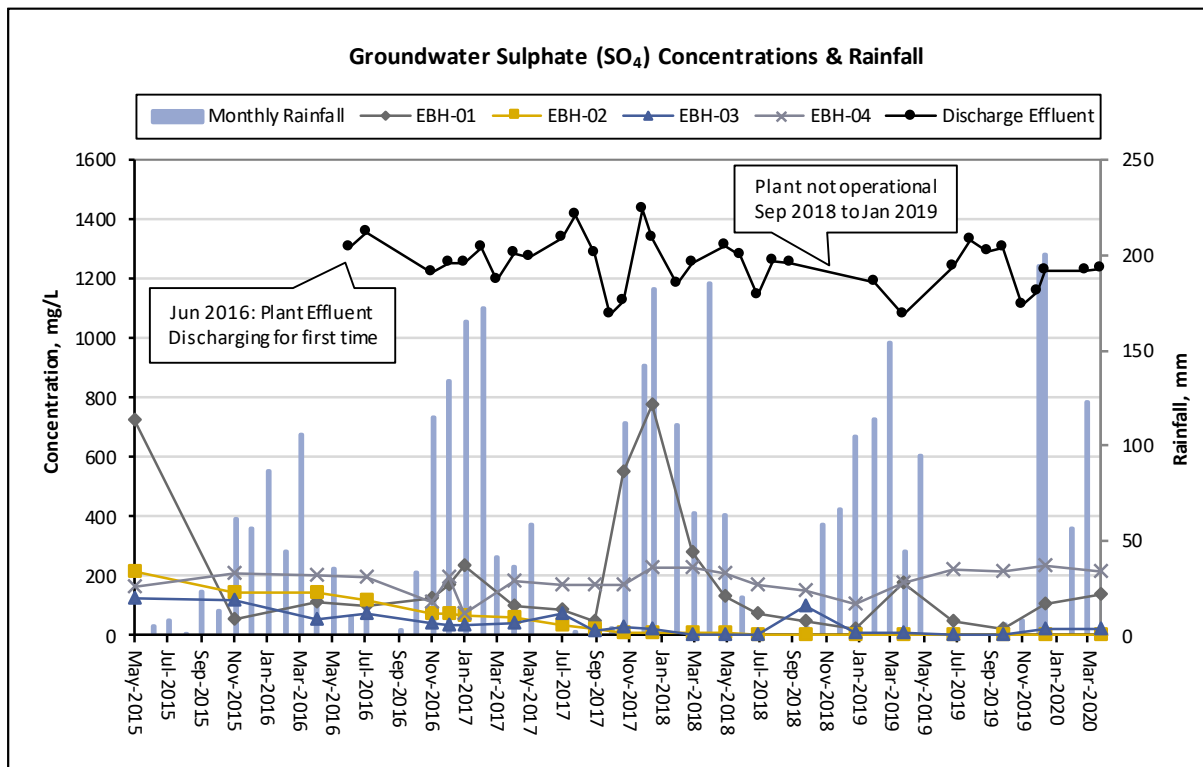


Figure 4-10 Groundwater - Sulphate Concentrations

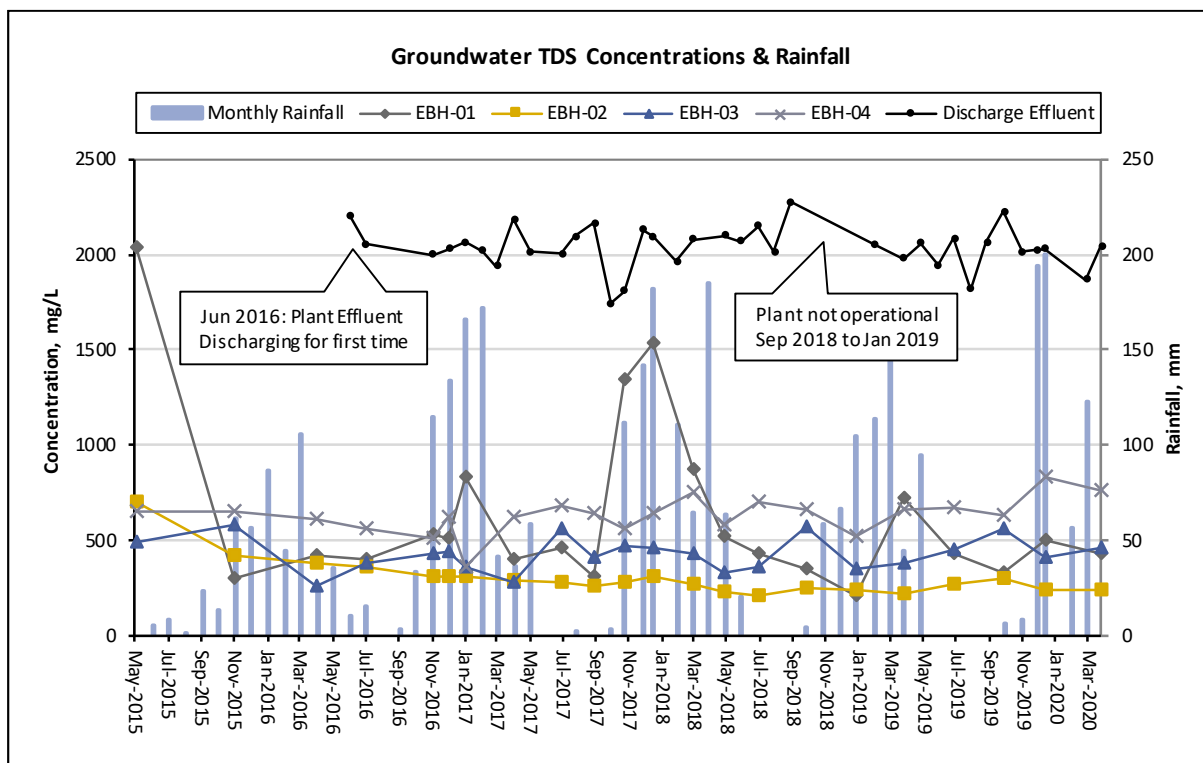


Figure 4-11 Groundwater - TDS Concentrations

4.3.1.2 Borehole EBH-02

EBH-02 is located along the northern perimeter of the plant area. The overall water quality of borehole EBH-02 generally improved from 2015 to Q4 2017, with very little change thereafter. See Figure 4-12. TDS varied from 202 mg/L to 304 mg/L during the last two years and averaged 241 mg/L. Improvement has been due to a decrease in total hardness and sulphate concentrations. Sulphate decreased to below the detection limit during September 2018 and was only detected in three samples since. See Figure 4-10. Sodium and potassium concentrations have been notably constant over time. Results indicated an increase in chloride concentrations during the last four sampling runs, with concentrations exceeding 100 mg/L for the first time since monitoring commenced.

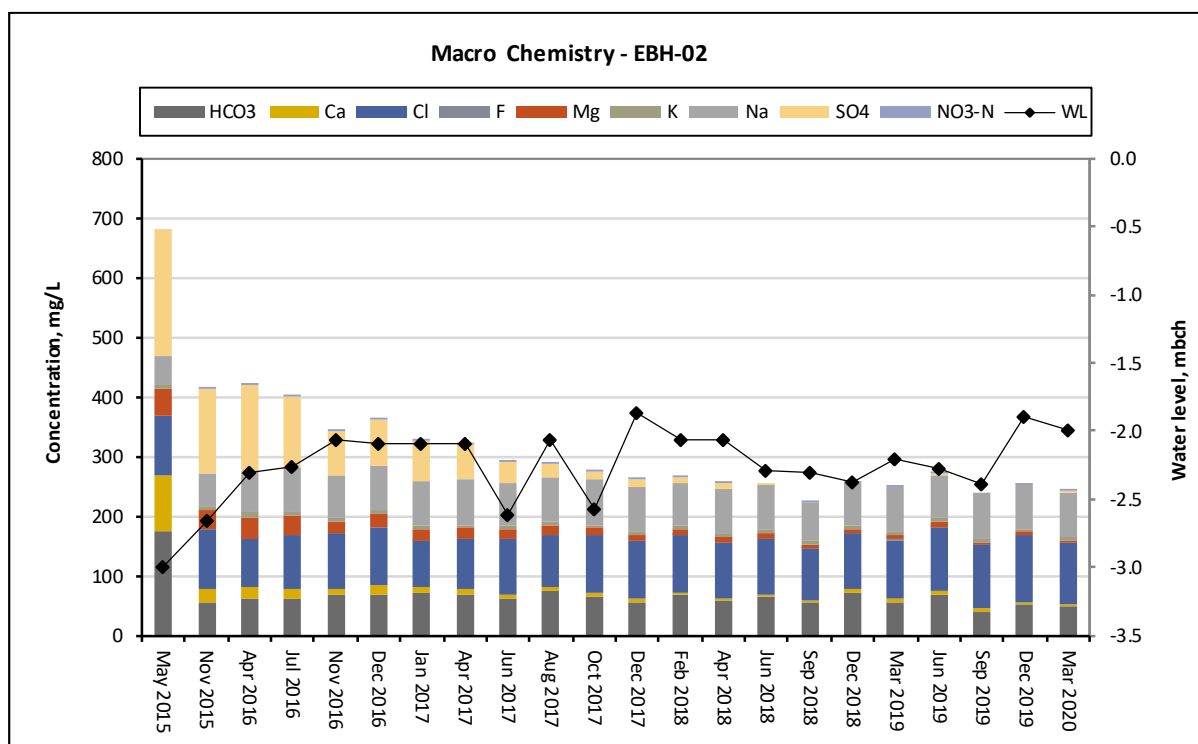


Figure 4-12 Comparative Chemical Composition – EBH-02

4.3.1.3 Borehole EBH-03

EBH-03 is located inside the eastern corner of the plant area. The overall water quality of borehole EBH-03 deteriorated slightly from December 2019 to March 2020, however was similar to what have been observed at the borehole historically. See Figure 4-13. The concentrations for most major components have been reasonably varied since monitoring commenced, with no significant trends observed.

TDS concentrations at the borehole has varied from 256 mg/L to 576 mg/L. Sulphate concentration spiked to 99 mg/L during September 2018, similar to initial (May 2015 and November 2015) concentrations. Sulphate values below 10 mg/L were then observed, until the December 2019 and March 2020 concentrations of 19 mg/L and 21 mg/L, respectively. See Figure 4-10.

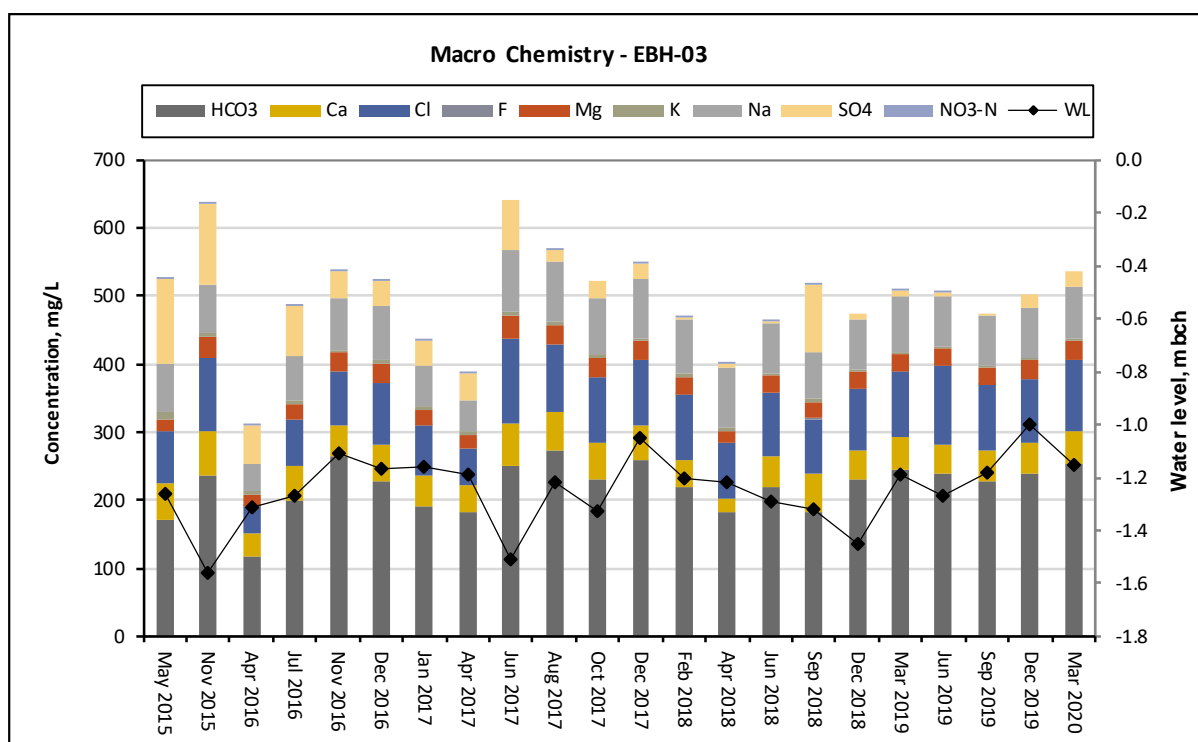


Figure 4-13 Comparative Chemical Composition – EBH-03

4.3.1.4 Borehole EBH-04

EBH-04 is located along the eastern perimeter of the plant area. The long-term average TDS at the borehole is 629 mg/L and relatively little variation in water quality has been observed over time. A TDS value of 760 mg/L observed during March 2020 was 21% above the long-term average. The overall water quality of borehole EBH-04 remained relatively unchanged from December 2019 to March 2020. An improving trend was observed during 2018. See Figure 4-14.

Results from November 2016, January 2017 and December 2018 sampling run were significantly different in terms of lower values for most major components, except sodium. Slightly different water character for these samples can be noted in Figure 4-8.

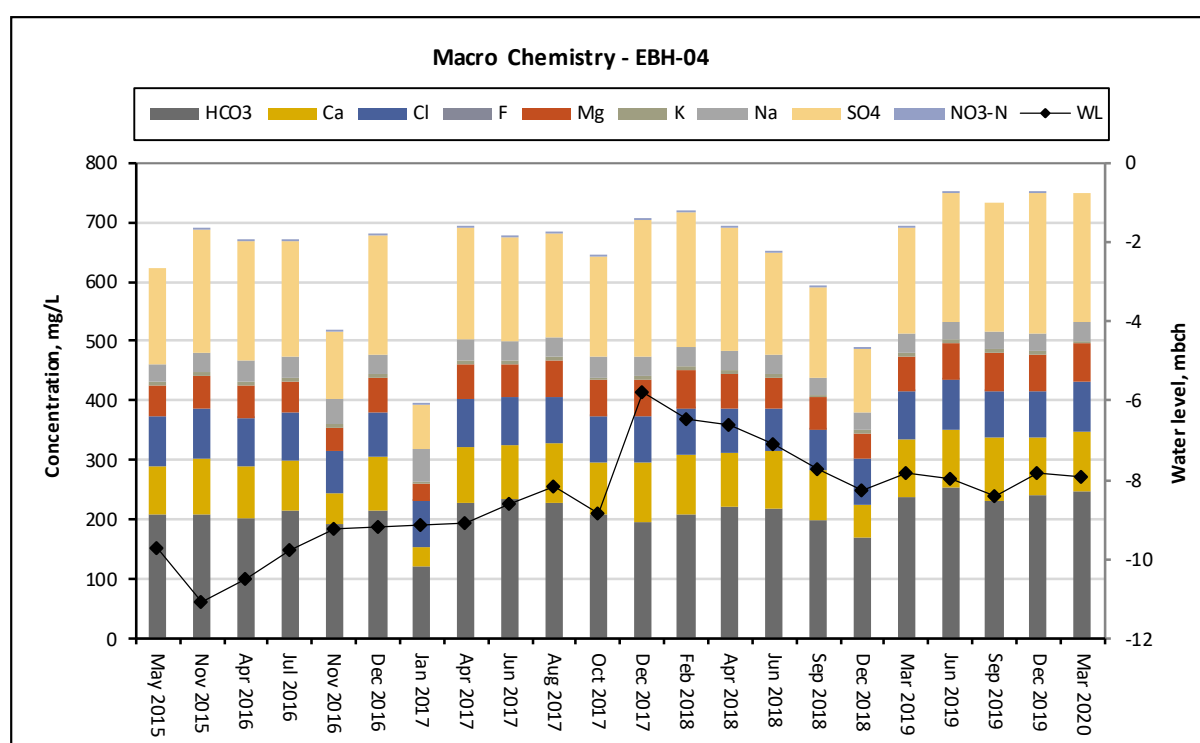


Figure 4-14 Comparative Chemical Composition – EBH-04

4.3.1.5 Groundwater Quality - Comparison Against Baseline Values

Quality results obtained for groundwater monitoring locations were compared against the baseline data for each location. The baseline values for water quality parameter were obtained from the May 2015 monitoring results. Comparison against baseline values is indicative of whether the plant or any other activities is having an adverse effect on the water quality of that particular sampling point. If water quality remains unchanged at a location, statistically it can be expected that, on average, 50% of monitoring results will exceed the initial baseline values. The parameters that exceeded baseline values during March 2020 are listed in Table 4-2. From 59% to 93% of water quality parameters were below baseline values per borehole during March 2020. See Table 4-3.

Table 4-2 Groundwater Water Quality Comparison Against Baseline Values, Parameters Exceeding

	Baseline Values	
	EBH-01	EBH-02
2020-03-25	K 14 (10) Ba 0.08 (0.056)	Cl 105 (98) Na 75 (49) NO ₃ -N 0.45 (0.24)
	EBH-03	EBH-04
	2020-03-25	HCO ₃ 254 (172) Cl 104 (74) Mg 28 (19) Na 78 (73) EC 81 (77) Alk 258 (172) Total Hard 233 (213) Mn 0.26 (0.17) Ba 0.15 (0.035)
		HCO ₃ 246 (208) Ca 101 (82) Cl 86 (85) F 0.39 (0.2) Mg 62 (50) K 5.6 (5.2) Na 32 (30) SO ₄ 215 (164) EC 104 (90) TDS 760 (648) Alk 251 (208) Total Hard 510 (411)

*Notation: Parameter, parameter value (Baseline value); ----- implies no exceedance; All values in mg/L except EC (mS/m)

Table 4-3 Percentage of Groundwater Parameters Below Baseline Value

	EBH-01	EBH-02	EBH-03	EBH-04
2020-03-25	93%	89%	68%	59%
Average	77%			

4.3.2 Process Water

The only process water sampling point is located where effluent (treated AMD water) from the plant is being discharged. Effluent has been sampled since first been found discharging during the June 2016 sampling run. The location is scheduled for monthly sampling and was sampled thirty-six times in total to date. During September 2018 to December 2018, February 2019, as well as January 2020 samples could not be taken as effluent was not discharging at the time of sampling. Samples were also not taken during August 2016 to October 2016, when no appointment for monitoring was made. Effluent is discharged into the Blesbokspruit drainage system. See Figure 2-2. Water quality results obtained for the effluent are illustrated in Figure 4-16 and detailed in Table 11-5.

The latest monitored water quality of the Discharge Effluent was generally similar to previously observed. See Figure 4-16. The TDS concentrations of 2 046 mg/L during March 2020 was within the range historically observed. Sulphate concentration of 1 235 mg/L was within 2% of the long-term average of 1 248 mg/L.

Water character has been unchanged over time, with only the September 2019 sample slightly different in character. See Figure 4-15.

Discharge Effluent water quality was compared to limits provided by the client, as per DWS Directive (AMD-DIR-TCTA-01.03.2011), as well as the wastewater limit values applicable to discharge of wastewater into a water resource GN665; GG36820 (2013). The compliance for the quarterly period is summarised in Table 4-4.

Table 4-4 Discharge Effluent comparison: DWS Directive (AMD-DIR-TCTA-01.03.2011) & Wastewater limit (GN665; GG36820, 2013)

Sampling Location	Sampling Month	Comply – Yes/No	Exceedances		
			Parameter	Limit	Sample Parameter Value
Compliance to Limits – DWS Directive (AMD-DIR-TCTA-01.03.2011)					
Discharge Effluent	January 2020	N/A	N/A	N/A	N/A
	February 2020	Yes	----	----	----
	March 2020	Yes	----	----	----
Compliance to Limits – Wastewater Limit (GN665; GG36820, 2013)					
Discharge Effluent	January 2020	N/A	N/A	N/A	N/A
	February 2020	No	EC	150 mS/m	243 mS/m
			Manganese	0.1 mg/L	0.212 mg/L
			Copper	0.01 mg/L	0.014 mg/L
	March 2020	No	EC	150 mS/m	261 mS/m
			Manganese	0.1 mg/L	0.240 mg/L
			Copper	0.01 mg/L	0.018 mg/L

N/A – Not sampled

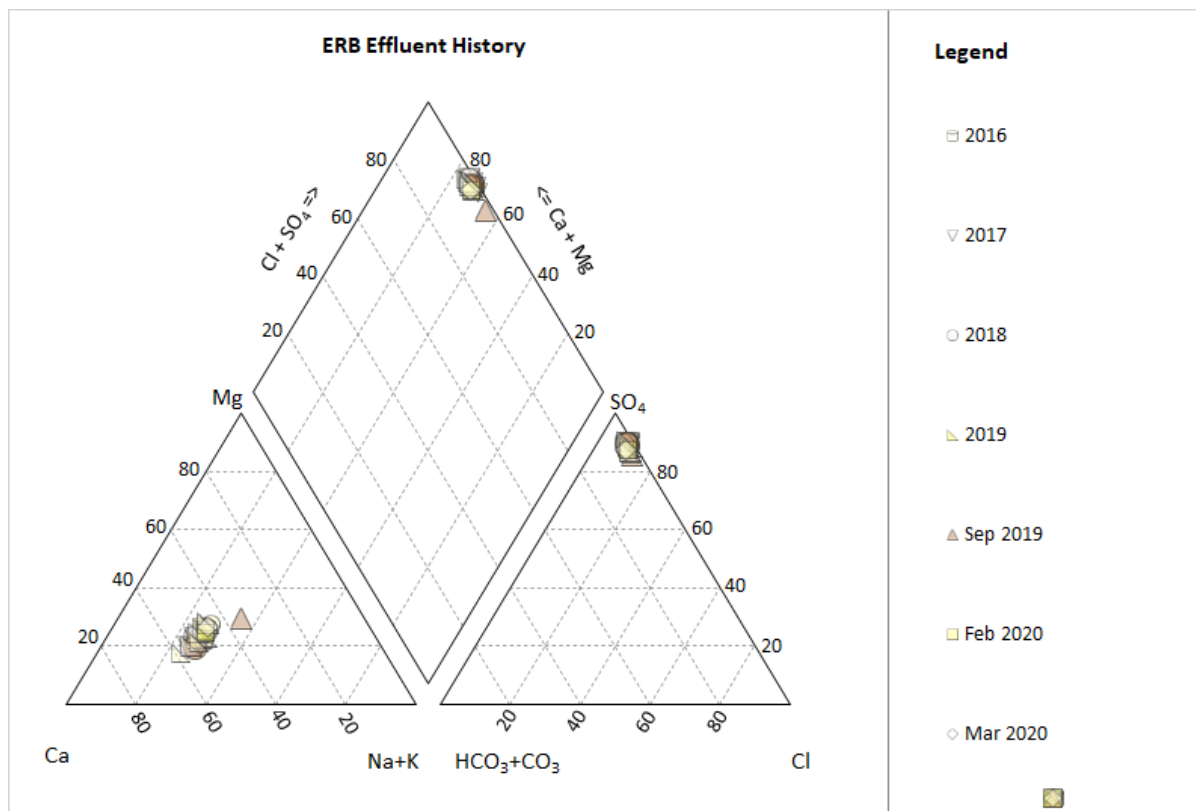


Figure 4-15 Piper Diagrams – Effluent History

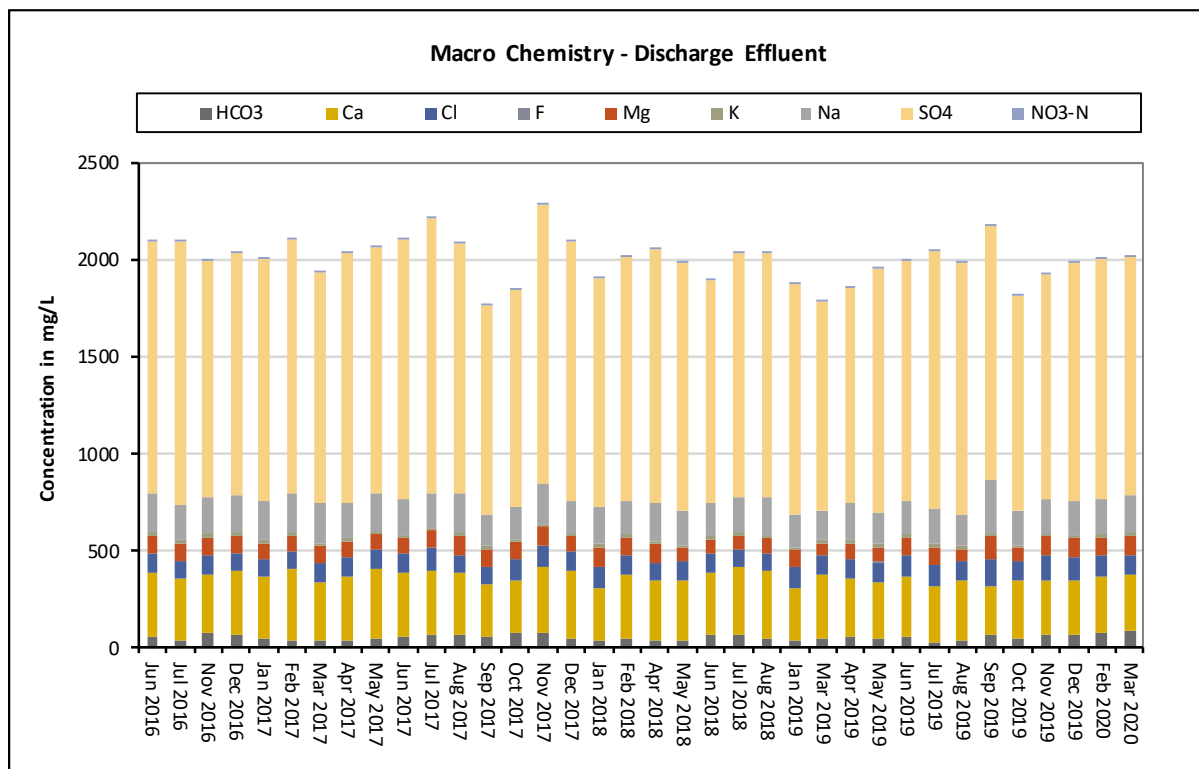


Figure 4-16

Comparative Chemical Composition – Discharge Effluent

4.3.3 Surface Water

Five surface water monitoring locations were successfully sampled during Q1 2020. Water quality results obtained are illustrated in Figure 4-19 to Figure 4-21 and detailed in Table 11-6 to Table 11-10. Surface water sulphate concentrations over time are illustrated in Figure 4-22 and Figure 4-23 for different locations. Daily plant abstraction is also indicated and this can be considered as indicative of plant effluent discharge.

ESW-01 is located approximately 4 km upstream from the plant, on the Blesbokspruit. ESW-02 and ESW-04 are respectively located 1.6 km and 500 m upstream from the plant, in a tributary of the Blesbokspruit joining from the west. ESW-05 is located on the eastern bank of the Blesbokspruit and the closest upstream location from the ERB plant. ESW-03 is located approximately 700 m downstream from the plant on the Blesbokspruit. See Figure 2-1. Water quality at ESW-03, when compared to upstream water quality, is indicative of any impact of the plant Discharge Effluent on the Blesbokspruit system.

Since June 2016, when treated water from the plant was first observed to be discharging, an impact on the downstream surface water (ESW-03) was noted in the associated elevated sulphate concentrations (Figure 4-20 and Figure 4-22). Sulphate concentrations of up to 800 mg/L have been observed at ESW-03. Increasing sulphate concentrations at ESW-03 during the winters of 2018 and 2019 were indicative of build-up of components associated with the plant effluent downstream of the effluent discharge location. The effect of seasonal rainfall is also apparent from Figure 4-20, as lower sulphate concentrations are observed at ESW-03 following the onset of summer rainfall during each year. Some build up of sulphate during the winter months at ESW-05 is also apparent from Figure 4-20.

At the upstream ESW-01 and ESW-04, the background sulphate concentrations averaged below 100 mg/L throughout monitoring. See Figure 4-22.

Following rainfall of 194 mm during November 2019, the sulphate concentration of 77 mg/L at ESW-03 on 11 December 2019 was not significantly different from the 73 mg/L observed at ESW-02. The plant was also operating at reduced capacity for some time before the sampling and abstraction averaged 65 ML/day during the last month before the December 2019 sampling. This compares to 100 ML/day at full capacity. The plant was not operational from 7 January to 18 February 2020. Sulphate concentration was unchanged at ESW-03, at 77 mg/L, during sampling on 28 January 2019. During February 2020 and March 2020, sulphate concentrations of respectively 324 mg/L and 359 mg/L were again typical for the season and indicative of the effect of effluent discharge. This can be observed in the overall surface water quality for these month in Figure 4-19, where December 2019 to March 2020 results are illustrated. TDS values for surface water over time is illustrated in Figure 4-21.

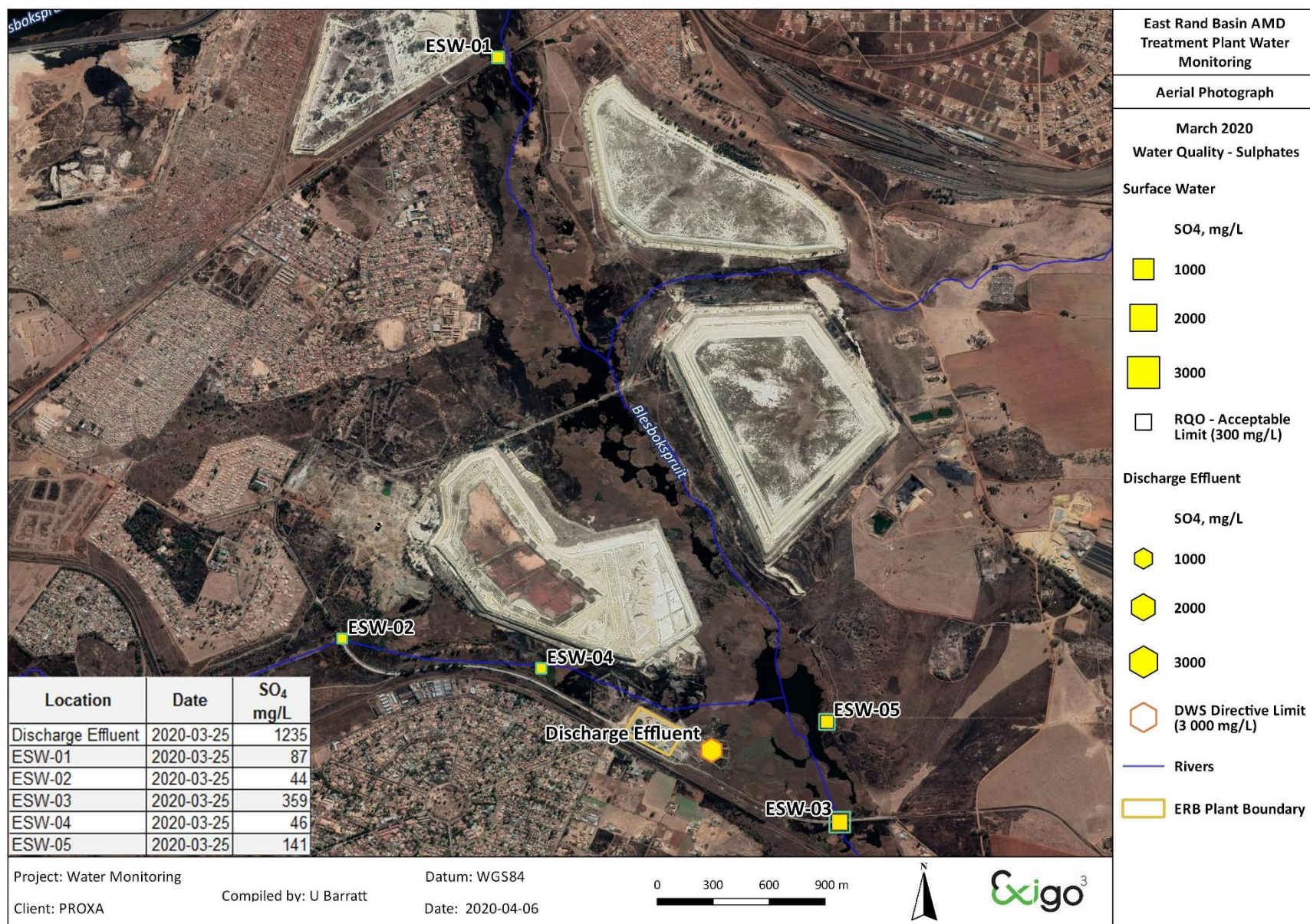


Figure 4-17

Map: Sulphate Concentrations, Surface Water – March 2020

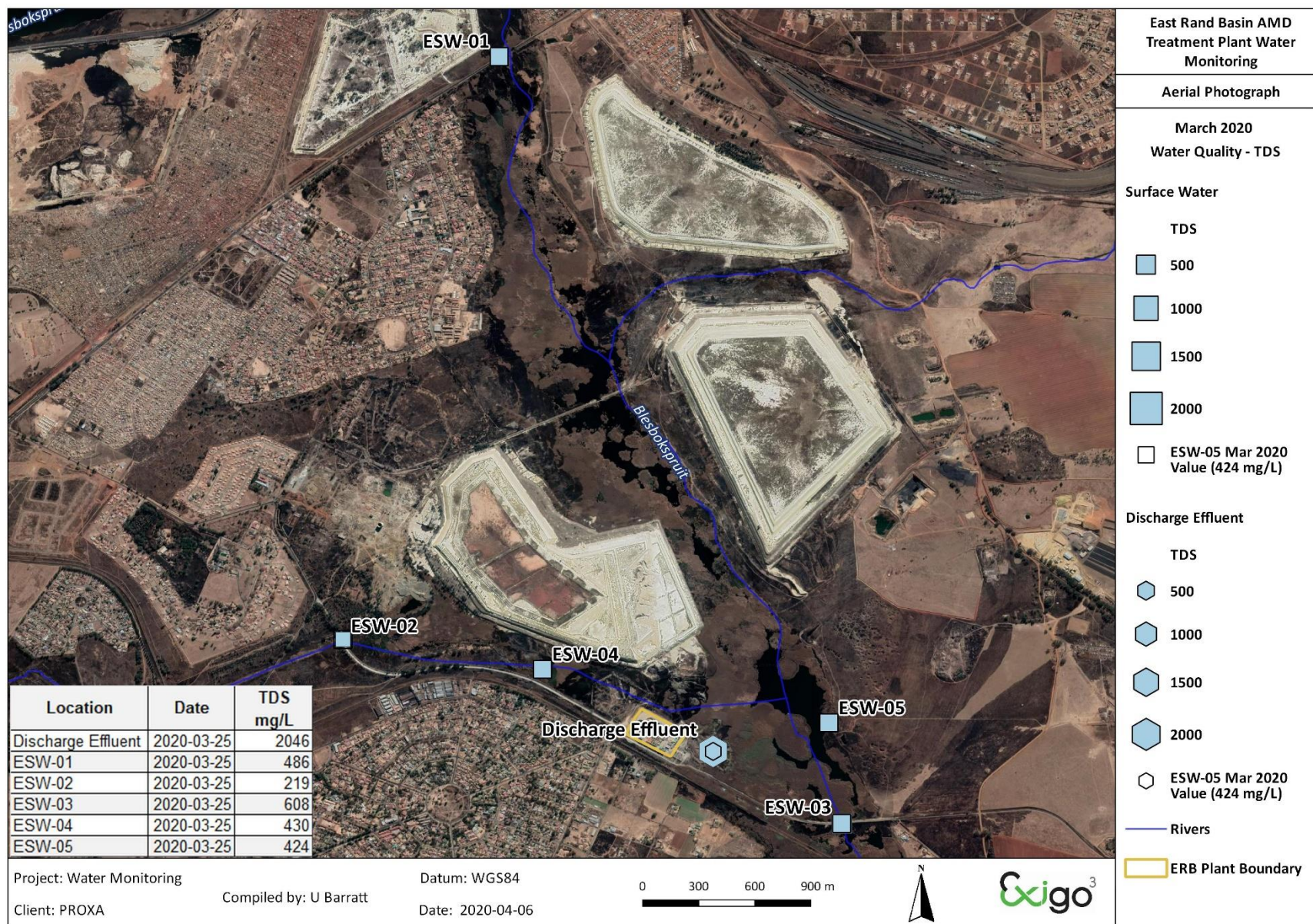


Figure 4-18

Map: TDS Concentrations, Surface Water – March 2020

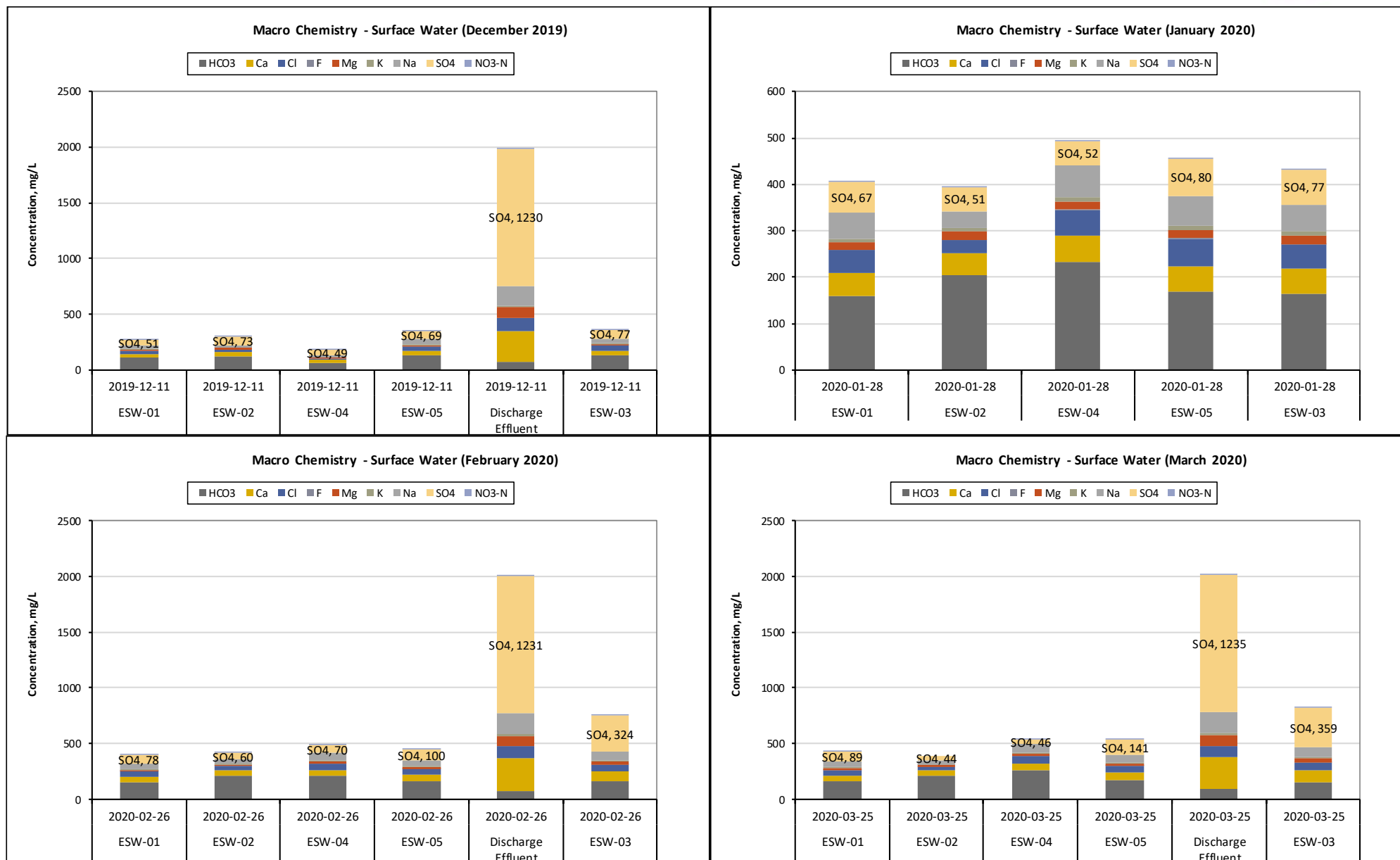


Figure 4-19 Comparative Chemical Composition – Upstream (ESW-01, ESW-02, ESW-04 & ESW-05), Downstream (ESW-03) and Effluent

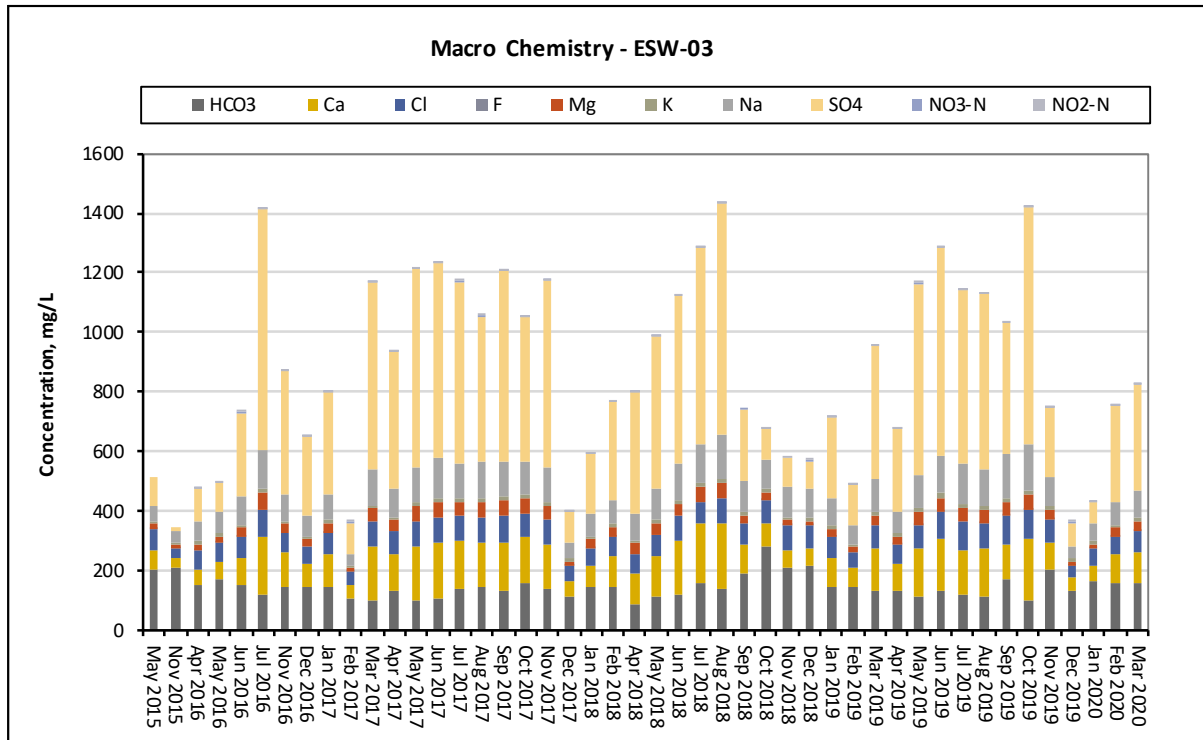


Figure 4-20 Comparative Chemical Composition – Downstream (ESW-03)

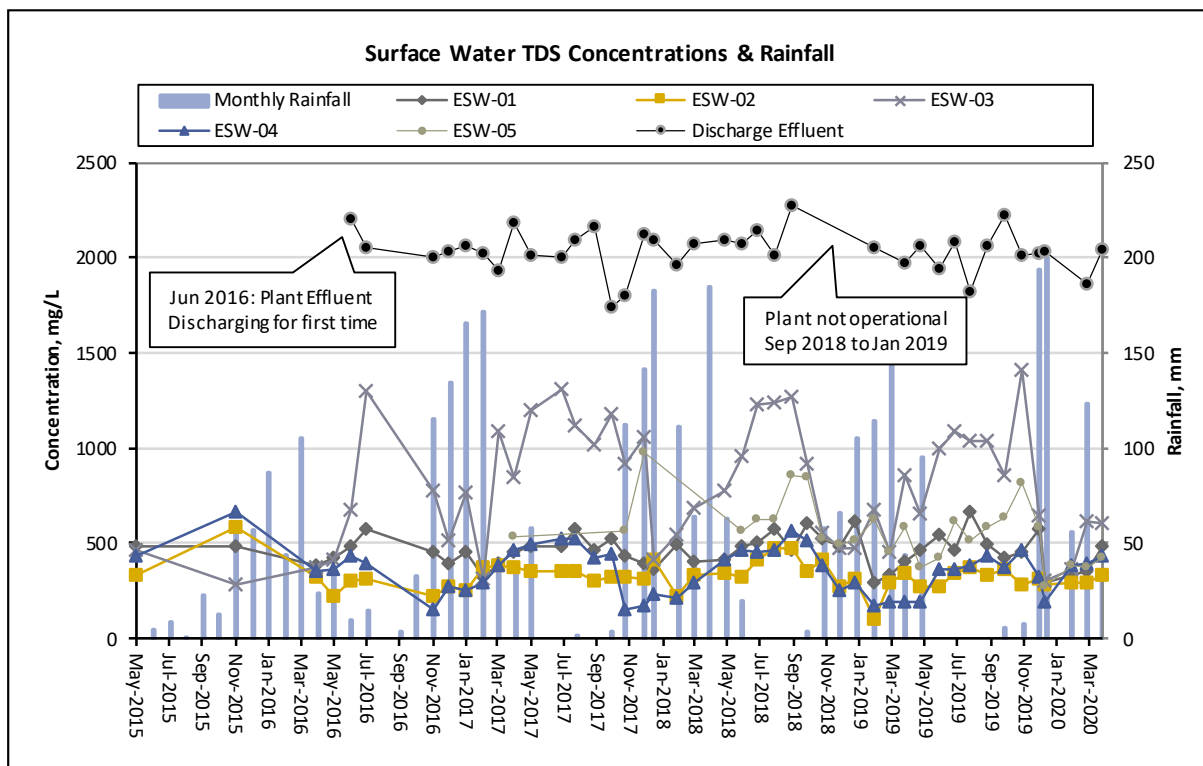


Figure 4-21 Surface Water – TDS Concentrations

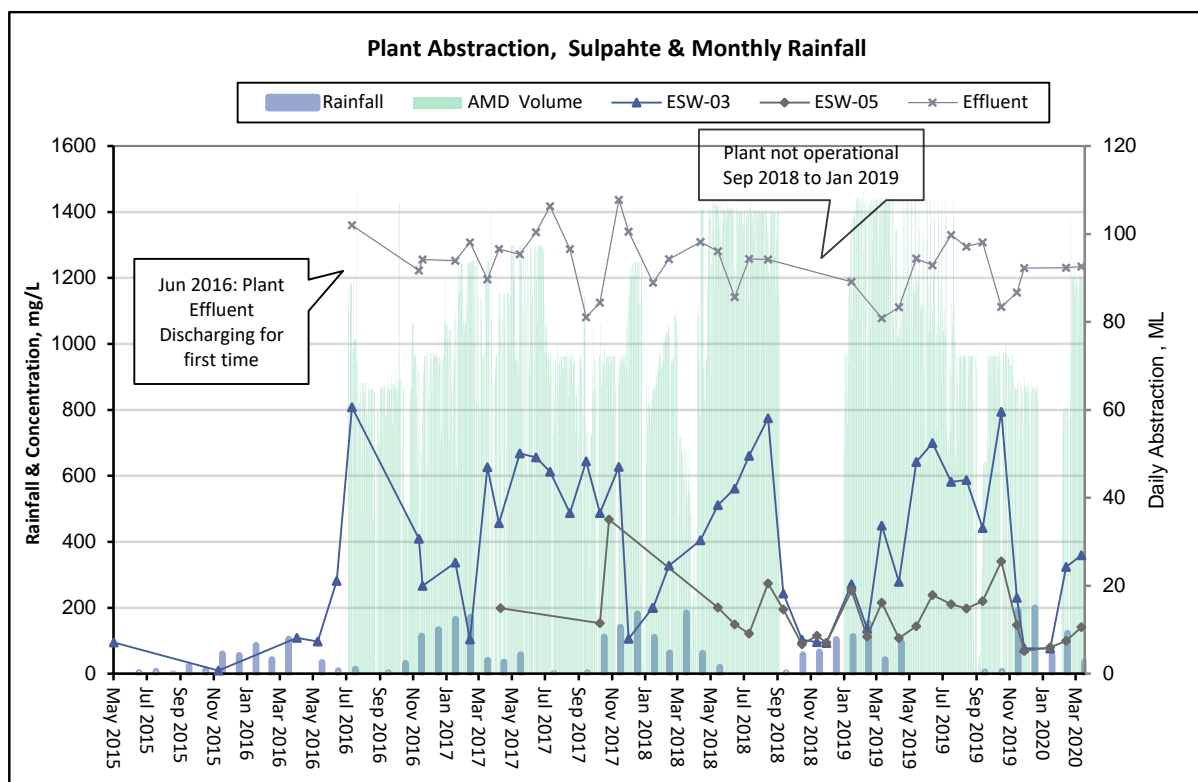


Figure 4-22 Surface water sulphate concentrations (ESW-03 & ESW-05)

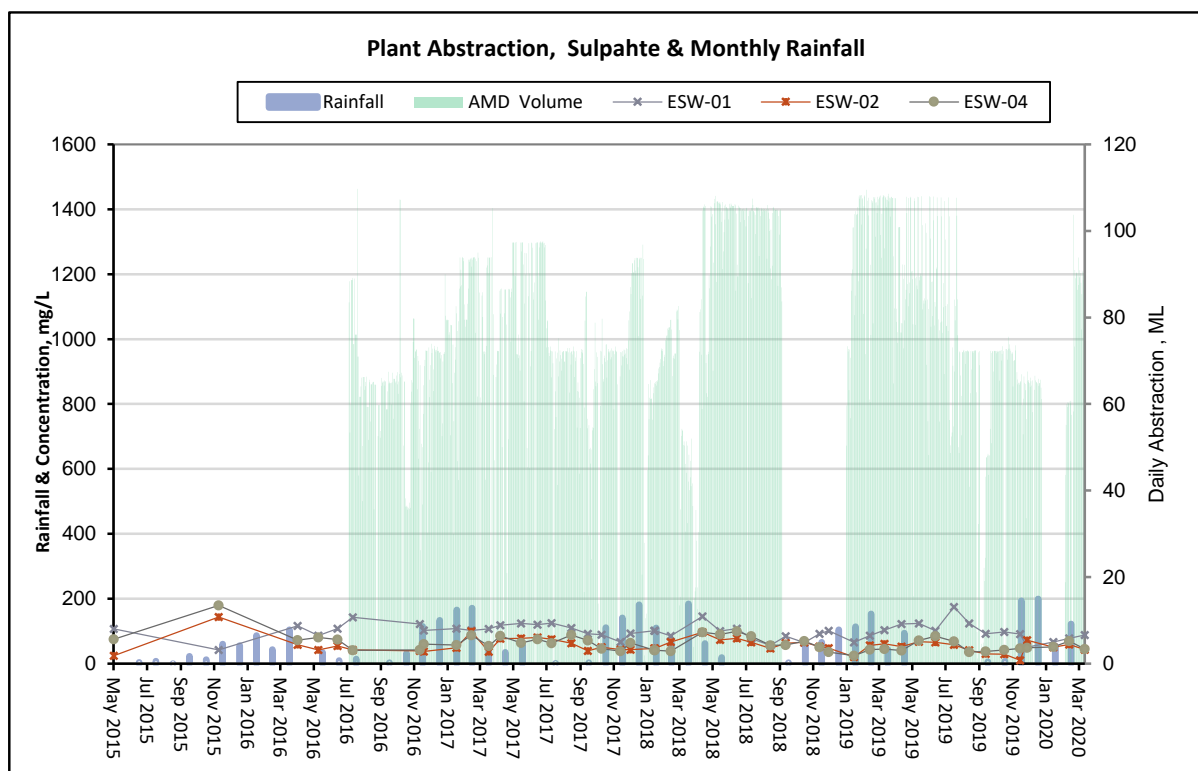


Figure 4-23 Surface Water – Sulphate Concentrations (ESW-01, ESW-02 & ESW-04)

4.3.3.1 Surface Water Comparison Against DWS Catchment RQO

Quality results obtained for surface water monitoring points were compared against the DWS catchment C21E resource quality objectives (RQO). The RQO classification of each sample is detailed in Table 11-6 to Table 11-10. Each sample was classified according to its parameter with the less ideal RQO classification.

During Q1 2020, fifteen surface water samples were taken of which six (40%) were within the acceptable RQO range, six (40%) within the tolerable and only three (20%) within the unacceptable category. None of the samples were classified as ideal. See Table 4-5. The three samples taken at ESW-02 were the only samples classified in the unacceptable range and this was due to elevated ammonium (NH₄-N) concentrations.

Table 4-5 Surface Water - Percentage of Samples within RQO Ranges

	Quarterly Percentage Classification (Jan – Mar 2020)					Total
	ESW-01	ESW-02	ESW-03	ESW-04	ESW-05	
Ideal	0%	0%	0%	0%	0%	0%
Acceptable	20%	0%	7%	0%	13%	40%
Tolerable	0%	0%	13%	20%	7%	40%
Unacceptable	0%	20%	0%	0%	0%	20%

5 CONCLUSIONS

The following was concluded for monitoring conducted up to March 2020:

- During Q1 2020, an average monthly rainfall of 72 mm was measured. This was 32 mm less than the average of 104 mm/ month measured during Q1 2019.
- On an annual basis, average water levels increased by 0.18 m from 1.63 m during March 2019 to 1.45 m during March 2020 at EBH-01, EBH-02 and EBH-03. Throughout monitoring, water levels at borehole EBH-04 have been at least 5 m deeper than at the other three boreholes. At EBH-04, the water level decreased by 0.11 m, from 7.82 m during March 2019 to 7.93 m during March 2020.
- EBH-01 – A TDS value of 432 mg/L was observed during March 2020 and was similar to values observed during the last two years.
- EBH-02 - Sulphate concentrations decreased to below the detection limit during September 2018 and have remained below 4 mg/l since. TDS of 236 mg/L during March 2020 was similar to values that have averaged 241 mg/L during the last two years.
- EBH-03 – A TDS value of 458 mg/L was observed during March 2020 and overall water quality was similar to what have been observed at the borehole historically. The concentrations for most major ions have been reasonably varied since monitoring commenced, with no significant trends observed.
- EBH-04 - A TDS value of 760 mg/L observed during March 2020 was 21% above the long-term average of 629 mg/L. Relatively little variation in water quality has been observed over time.
- The Discharge Effluent could not be sampled during January 2020 as it was not discharging at the time. Effluent water quality has remained relatively unchanged since plant discharge and its monitoring commenced during June 2016. EC values have varied from 243 mS/m to 261 mS/m, exceeding the wastewater limit value (150 mS/m) applicable to discharge of wastewater into a water resource, GN665; GG36820 (2013). Non-compliance to the wastewater limit was also due to elevated copper and manganese concentrations. Effluent water quality has complied with the limits of the DWS directive for the plant since monitoring commenced. Sulphate of 1 235 mg/L during March 2020 was within 2% of the long-term average of 1 248 mg/L.
- Since June 2016, when treated water from the plant was first observed to be discharging, an impact on the Blesbokspuit system was noted at the downstream monitoring location, ESW-03. Sulphate concentrations were affected the most and values of up to 800 mg/L have been observed at ESW-03. At the upstream ESW-01 and ESW-04, the background sulphate concentrations averaged below 100 mg/L.
- Sulphate concentration remained below 80 mg/L at ESW-03 during January 2020, when the plant was not operational. AMD abstraction and effluent discharge resumed on 18 February 2020 and sulphate concentrations of 324 mg/L and 359 mg/L respectively during February and March 2020 were again typical for the season under plant operational conditions.

6 RECOMMENDATIONS

The following was recommended:

- Water monitoring should continue as per current scope of work in order to monitor impact that the ERB Plant might have on the receiving environment.
- Aquatic biomonitoring should be conducted upstream and downstream of the effluent discharge point to assess impact on the local biota.

7 REFERENCES

DEA/EIA/0000498/2011: Environmental authorisation registration number 12/12/20/2403.

Department of Water and Sanitation (DWS), Rand Water. 2003. The Reservoir: Water Resource Information Centre for the Vaal Barrage & Vaal Dam catchment forums: Blesbokspruit Catchment Water Quality Guidelines http://www.reservoir.co.za/forums/vaalbarrage/klipriver_forum/klip_documents/KRF_WQGuidelines.pdf. Date accessed: 24 July 2018.

Department of Water and Sanitation Directive: Effluent Discharge Standards (AMD-DIR-TCTA-01.03.2011)

Exigo Sustainability. 2014. East Rand Basin Water Treatment Plant: Surface Water and Groundwater Monitoring Protocol. Report no. AS-R-2013-12-18.

Exigo Sustainability. 2015. East Rand Basin: Acid mine drainage treatment plant - Hydrogeochemical baseline study. Technical Report G15/022-GC1.

Exigo Sustainability. 2015. East Rand Basin: Acid mine drainage treatment plant - Hydrogeochemical baseline study. Technical Report G15/022-GC2.

Wastewater limit values applicable to discharge of wastewater into a water resource (GN665; GG36820, 2013).

Water Research Commission (WRC), The Department of Water Affairs and Forestry (DWAF), The Department of Health, 2000. Quality of domestic water supplies. Volume 2: Sampling Guide. WRC No TT117/99.

8 APPENDIX A: QUALITY ASSURANCE AND CONTROL

1. All samples to be analysed for chemical parameters are taken in duplicate. Back-up samples are kept at Exigo for a period of 6 months in case a re-analysis is required.
2. All samples taken are logged on a field report form and if at all possible, a photo is taken of the sampling location. Only when conflicting with mine policy is a photo not taken. Photo's acts as a secondary timestamp (apart from manual logging) and as reference to the location and condition thereof, at the time of sampling.
3. A GPS coordinate is taken of each sampling location.
4. Both samples taken at a location are fully marked with time, date, location ID, project code and reference to the sampler.
5. At the office all samples are verified against the field form/s. Each sample is given a unique number which is used as reference when submitting to the laboratory
6. Various data evaluation techniques are used. This may include, but are not limited to the following:
 - TDS value calculated according to APHA (American Public Health Association) compared to gravimetrically determined value from lab
 - Ion charge balance calculation and evaluation
 - Expected pH influence on certain species are taken into account
 - EC/TDS ratios are noted and checked for anomalies
 - Comparison between field measurements (pH & EC) and lab results are made
7. QA Samples have been taken since November 2012 on samples from eight projects. These are samples taken in duplicate from existing sampling locations. Results are compared.
8. Exigo water samples are sent to Aquatico Laboratories for analysis. Aquatico has been accredited for compliance to ISO 17025:2015 by SANAS (South African National Accreditation System) since 2015. The facility reference number is T0685 and the laboratory has held accreditation
9. Part of the ISO 17025 requirements is participation in a relevant proficiency testing scheme (PTS). Aquatico partakes in the water check PTS facilitated by the SABS (South African Bureau of Standards). Samples are prepared by the SABS and analysed by the participating laboratories. For certain parameters as many as 170 laboratories partakes on a regular basis. Results are compared by the SABS and reported on to the participants. The SABS is accredited as a PTS provider (reference PTS0003) by SANAS, according to requirements of ISO 17043:2010. Exigo has also participated in the same water check PTS since 2015, under its own laboratory identification number and from its own budget. These samples are also analysed by Aquatico. Participation has been in two of the three parameter groups, namely Group 1 (22 metals) and Group 3 (pH, EC, TDS and ten major components). Results have been satisfactory:
 - Group 1, average Z-score of 0.81 for 66 results, October 2019 cycle
 - Group 3, average Z-score of 0.51 for 32 results, December 2019 cycle

9 APPENDIX B: WATER QUALITY STANDARDS AND GUIDELINES

9.1 Baseline

Water quality for surface and groundwater monitoring points were compared against baseline data obtained during the first time a particular monitoring point was sampled. This serves as an indication if the mine or any other activities had an adverse effect on the water quality of that particular sampling point. If water quality remains unchanged at a location, statistically it can be expected that, on average, 50% of monitoring results will exceed the baseline values.

9.2 DWS Directive: Effluent Discharge Standards (AMD-DIR-TCTA-01.03.2011)

The Department of Water and Sanitation (DWS) issued a directive on the 6th of April 2011 with the approval of effluent discharge standards for High Density Sludge (HDS) plants treating AMD in the Witwatersrand goldfields. The standards for the Discharge Effluent are given in Table 9-1 below.

Table 9-1 **Approved effluent discharge standards for HDS plants treating AMD in the Witwatersrand goldfields**

Determinant	Unit	Limit
pH		6.5 – 9.5
Iron	mg/L	<1
Manganese	mg/L	<10
Aluminium	mg/L	<1
Sulphate	mg/L	≤3 000
Electrical Conductivity	mS/m	≤450
Turbidity	NTU	<30

9.3 General Wastewater Limits (GN 1191; GG20526, 1999)

The Discharge Effluent was compared to the Wastewater limit values applicable to discharge of wastewater into a water resource (GN665; GG36820, 2013). It is important to note that samples are only evaluated for compliance to certain criteria from the guideline or standard and reported as such. Compliance does not necessarily imply compliance to the guideline or standard as a whole. The specific water quality criteria evaluated and accompanying test results are included in table form in the report.

9.4 DWS Resource Quality Objectives (RQO's) for the Blesbokspruit Catchment (2003)

Water quality results were compared to the instream water quality objectives for the Blesbokspruit Catchment, as requested by the client. The following limits are applicable and indicated in below.

In-stream Water Quality Guidelines for the Blesbokspruit Catchment

Effective: June 2003

Variables	Measured as	Ideal Catchment Background	Acceptable Management Target	Tolerable Interim Target	Unacceptable
Physical					
Conductivity	mS/m	< 45	45 - 70	70 - 120	> 120
Dissolved Oxygen	mg/l O ₂		> 6.0	5.0 - 6.0	< 5.0
pH	pH units	6.5 - 8.5			< 6.5; > 8.5
Suspended Solids	mg/l	< 20	20 - 30	30 - 55	> 55
Organic					
Chemical Oxygen Demand	mg/l	< 20	20 - 35	35 - 55	> 55
Macro Elements					
Aluminium (Al)	mg/l		< 0.3	0.3 - 0.5	> 0.5
Ammonia (NH ₄)	mg/l	< 0.1	0.1 - 1.5	1.5 - 5.0	> 5.0
Chloride (Cl)	mg/l	< 80	80 - 150	150 - 200	> 200
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l	< 0.1	0.1 - 0.5	0.5 - 1.0	> 1.0
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Nitrate (NO ₃)	mg/l	< 0.5	0.5 - 3.0	3.0 - 6.0	> 6.0
Phosphate (PO ₄)	mg/l	< 0.2	0.2 - 0.4	0.4 - 0.6	> 0.6
Sodium (Na)	mg/l	< 70	70 - 100	100 - 150	> 150
Sulphate (SO ₄)	mg/l	< 150	150 - 300	300 - 500	> 500
Quality of Domestic water supplies: volume 1: Assessment Guide was used for below limits					
Arsenic (As)	mg/l	< 0.010	0.01 - 0.05	0.05 - 0.2	> 0.2
Cadmium (Cd)	mg/l	< 0.003	0.003 - 0.005	0.005 - 0.020	> 0.020
Calcium (Ca)	mg/l	0 - 10	80 - 150	150 - 300	> 300
Copper (Cu)	mg/l	0 - 0.5	1 - 1.3	1.3 - 2.0	> 2.0
Zinc (Zn)	mg/l	< 3	3 - 5	5 - 10	> 10
Bacteriological					
Faecal coliforms	counts/100ml		< 126	126 - 1,000	> 1,000
Biological					
Daphnia	% survival	100	90 - 100	80 - 90	< 80

10 APPENDIX C: SAMPLING METHODOLOGY

The sampling methodology employed can be summarised as follow:

1. Confirm sampling location by means of GPS equipment and site-specific information (description, pictures, coordinates, etc.) as contained in the sampling manual. Take photographs and record coordinates of sampling location on field form (sample register/ sample data sheet).
2. Determine sample type, sample technique and container type from information as supplied on field form.
3. Sample for microbiological constituents – using a sterilised bottle as supplied by an accredited laboratory. Avoid contact with the inner surface of the bottle or cap. Fill the sample bottle without rinsing. Replace cap immediately.
4. Sample for physio-chemical determinants – remove the cap of the new clean sample bottle, but do not contaminate inner surface of cap and neck of sample bottle with hands. Rinse the bottle thoroughly with water to be sampled. Fill the sample bottle completely and seal immediately with cap without leaving any air space above the sample.
5. Determine field measurements (e.g. pH, EC, TDS & temperature) with a calibrated hand held instrument and record on field form.
6. Sample containers are labelled in a clear and unambiguous manner that is durable, and contain the following information:
 - a. A unique sample name
 - b. Project code
 - c. Date of sampling
 - d. The name of the sampler
7. Complete field form (data sheet) for each sample location with the sampling time and date, sample type, container type used, sampler name and any other relevant information applicable.
8. Keep sample containers dust-free and out of any direct sunlight. Do not freeze samples. Microbiological samples are immediately stored at 4°C and delivered to a SANAS accredited laboratory within 24 hours. Many laboratories may prefer this rather than preservation in the field and will then conducts the necessary preparation and preservation in the laboratory as soon as the samples are received. Samples for chemical analysis should also be kept cool and reach the laboratory preferably within one day.

A secure chain of custody system is employed when delivering samples to SANAS accredited laboratories which follow approved laboratory analysis techniques.

11 APPENDIX D: WATER QUALITY DATA

Table 11-1 Water Quality – Groundwater EBH-01

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
		mg/L CaCO ₃					mg/L			mg/L N		mg/L N		mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L	
EBH-01	2017-12-15	284	255	162	<0.263	94	114	73	779	0.31	0.069			0.8	7.5	197	1530	284	0.02	1025	
EBH-01	2018-02-27	288	133	74	0.39	52	63	44	280	0.35	0.042			3.8	8.1	123	868	292	0.07	546	
EBH-01	2018-04-26	231	82	46	<0.263	35	35	28	132	0.35	0.033			1.6	7.9	68	514	233	0.04	348	
EBH-01	2018-06-28	212	63	42	<0.263	28	29	25	70	<0.194	0.063			1.4	7.9	70	426	214	0.04	272	
EBH-01	2018-09-25	178	44	37	0.35	21	18	22	45	0.23	<0.006			6.3	8.6	56	344	184	0.19	196	
EBH-01	2018-12-13	185	39	32	<0.263	19	12	20	22	<0.194	0.064			1.2	7.9	39	206	186	0.04	174	
EBH-01	2019-03-25	410	126	50	0.27	54	50	28	179	0.49	0.370			2.2	7.8	117	718	412	0.03	535	
EBH-01	2019-06-26	286	68	44	0.29	33	27	23	49	0.24	0.126			5.2	8.3	71	428	291	0.10	304	
EBH-01	2019-09-26	219	53	39	0.27	26	20	21	22	<0.194	<0.065			0.7	7.5	55	326	220	0.02	240	
EBH-01	2019-12-11	223	75	44	<0.263	30	23	18	103	0.23	0.107			0.3	7.1	73	500	223	0.01	311	
EBH-01	2020-03-25	205	75	61	<0.263	38	14	28	137	<0.194	<0.065	0.268	0.014	2.5	8.1	78	432	208	0.06	345	<0.008
Baseline		280	290.0	328	<0.2	145.0	10.2	63	728	0.24	N/A	N/A	N/A	<5	7.0	248	2040	280	N/A	1321	N/A

Site name	Date	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
		mg/L																			
EBH-01	2017-12-15	<0.002	<0.006	<0.002	<0.003	<0.002	0.004	<0.002	<0.004	<0.004	0.393	<0.002	<0.002	0.026	<0.015	<0.001	0.048	0.021	<0.001		0.002
EBH-01	2018-02-27	<0.002	<0.006	<0.002	<0.003	<0.002	0.008	0.007	<0.004	<0.004	0.140	<0.002	<0.002	<0.002	<0.015	<0.001	0.038	0.013	<0.001		<0.001
EBH-01	2018-04-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.040	0.004	<0.001		0.001
EBH-01	2018-06-28	<0.002	<0.006	<0.002	<0.003	<0.002	0.024	<0.002	<0.004	<0.004	0.016	<0.002	<0.002	<0.002	<0.015	<0.001	0.029	0.004	<0.001		<0.001
EBH-01	2018-09-25	<0.002	<0.006	<0.002	<0.003	<0.002	0.018	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.044	<0.004	<0.001		<0.001
EBH-01	2018-12-13	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.017	<0.004	<0.001		<0.001
EBH-01	2019-03-25	0.077	<0.006	<0.002	<0.003	<0.002	<0.003	0.012	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.053	<0.004	<0.001		0.001
EBH-01	2019-06-26	<0.002	<0.006	<0.002	<0.003	<0.002	0.026	0.010	<0.004	<0.004	0.053	<0.002	<0.002	<0.002	<0.015	<0.001	0.049	0.007	<0.001		0.001
EBH-01	2019-09-26	<0.002	<0.006	<0.002	<0.003	<0.002	0.006	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.034	<0.004	<0.001		<0.001
EBH-01	2019-12-11	<0.002	<0.006	<0.002	<0.003	<0.002	0.005	0.019	0.017	<0.004	0.007	<0.002	<0.002	<0.002	<0.015	<0.001	0.027	0.006	<0.001		0.001
EBH-01	2020-03-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.013	<0.004	<0.004	0.121	<0.002	<0.002	<0.002	<0.015	<0.001	0.080	<0.004	<0.001	<0.004	
Baseline		<0.100	<0.010	<0.005	<0.025	N/A	0.153	<0.025	<0.025	<0.010	0.256	<0.025	<0.010	<0.025	<0.010	<0.025	0.056	<0.025	N/A	N/A	N/A

Table 11-2 Water Quality – Groundwater EBH-02

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
		mg/L CaCO ₃					mg/L			mg/L N		mg/L N		mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L	
EBH-02	2017-12-15	56	5.4	97	<0.263	11	5.57	74	11	0.53	0.070			3.9	8.9	41	304	60	0.37	59	
EBH-02	2018-02-27	67	6.0	95	<0.263	11	6.39	71	8	0.38	0.073			4.2	8.8	41	262	71	0.34	61	
EBH-02	2018-04-26	57	5.7	93	<0.263	10	5.70	74	9	0.32	0.043			3.1	8.8	39	230	61	0.29	57	
EBH-02	2018-06-28	63	5.2	92	<0.263	10	6.11	75	4	<0.194	0.044			4.7	8.9	36	202	68	0.40	52	
EBH-02	2018-09-25	54	4.4	87	<0.263	6	4.70	65	<0.141	0.24	<0.006			0.8	8.2	41	244	55	0.08	37	
EBH-02	2018-12-13	71	4.8	95	<0.263	7	5.32	71	<0.141	0.47	0.061			0.5	7.9	41	236	72	0.04	40	
EBH-02	2019-03-25	56	4.9	99	<0.263	7	6.22	77	<0.141	0.25	0.093			2.1	8.6	31	220	58	0.20	41	
EBH-02	2019-06-26	69	5.4	107	<0.263	7	6.89	73	3	0.22	0.123			5.1	8.9	47	268	75	0.39	44	
EBH-02	2019-09-26	39	5.4	106	<0.263	5	5.46	77	<0.141	<0.194	<0.065			0.4	8.0	45	292	40	0.05	34	
EBH-02	2019-12-11	53	3.8	112	<0.263	5	6.00	73	1	0.23	0.119			1.2	8.4	46	240	54	0.12	28	
EBH-02	2020-03-25	47	3.8	105	<0.263	3	5.75	75	3	0.45	0.119	0.155	<0.005	0.3	7.8	45	236	47	0.03	23	<0.008
Baseline		176	93.0	98	<0.2	48.0	6.20	49	213	<0.24	N/A	N/A	N/A	<5	7.3	102	698	176	N/A	430	N/A

Site name	Date	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
		mg/L																			
EBH-02	2017-12-15	0.009	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	<0.001	<0.002	<0.002	0.006	<0.015	<0.001	0.012	0.006	0.001		<0.001
EBH-02	2018-02-27	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.011	<0.004	<0.001		<0.001
EBH-02	2018-04-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.009	<0.004	<0.001		<0.001
EBH-02	2018-06-28	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.009	0.005	<0.001		<0.001
EBH-02	2018-09-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.007	<0.004	<0.001		<0.001
EBH-02	2018-12-13	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	<0.002	0.004	<0.001		<0.001
EBH-02	2019-03-25	0.290	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.008	<0.004	<0.001		<0.001
EBH-02	2019-06-26	0.011	<0.006	<0.002	<0.003	<0.002	<0.003	0.002	<0.004	<0.004	0.002	<0.002	<0.002	<0.002	<0.015	<0.001	0.006	0.006	<0.001		<0.001
EBH-02	2019-09-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	<0.002	<0.004	<0.001		<0.001
EBH-02	2019-12-11	0.009	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.006	0.007	<0.001		<0.001
EBH-02	2020-03-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	0.007	<0.015	<0.001	0.005	<0.004	<0.001	<0.004	
Baseline		<0.100	<0.010	<0.005	<0.025	N/A	<0.025	<0.025	<0.025	<0.010	0.119	<0.025	<0.010	<0.025	<0.010	<0.025	0.171	<0.025	N/A	N/A	N/A

Table 11-3 Water Quality – Groundwater EBH-03

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
		mg/L CaCO ₃					mg/L			mg/L N		mg/L N		mg/L CaCO ₃	pH	mS/m	mg/L		mg/L CaCO ₃		mg/L
EBH-03	2017-12-15	259	52	94	0.29	30	3.50	86	25	0.31	0.060			0.5	7.4	64	462	260	0.01	253	
EBH-03	2018-02-27	220	38	96	0.32	27	4.94	80	1	0.29	0.007			5.4	8.4	56	430	225	0.13	206	
EBH-03	2018-04-26	182	20	83	0.28	18	3.96	90	5	0.32	0.033			6.7	8.6	46	324	189	0.20	122	
EBH-03	2018-06-28	220	45	92	<0.263	26	3.62	74	2	0.20	0.043			1.1	7.7	52	358	221	0.03	218	
EBH-03	2018-09-25	183	55	81	0.44	24	5.78	69	99	0.30	<0.006			6.0	8.6	72	564	189	0.18	235	
EBH-03	2018-12-13	230	43	91	<0.263	26	2.79	72	9	<0.194	0.061			0.4	7.3	61	352	231	0.01	214	
EBH-03	2019-03-25	245	48	96	<0.263	27	3.25	80	9	0.25	0.075			0.6	7.4	46	380	246	0.01	228	
EBH-03	2019-06-26	238	44	116	0.29	25	3.52	72	5	0.53	0.127			1.0	7.7	75	446	239	0.02	215	
EBH-03	2019-09-26	227	47	94	0.29	26	2.43	73	1	<0.194	<0.065			0.3	7.1	72	560	227	0.01	226	
EBH-03	2019-12-11	240	45	94	<0.263	26	2.91	76	19	<0.194	0.073			0.3	7.1	78	406	240	0.01	218	
EBH-03	2020-03-25	254	48	104	<0.263	28	2.79	78	21	<0.194	0.094	0.134	0.009	4.2	8.2	81	458	258	0.09	233	<0.008
Baseline		172	54.0	74	<0.2	19.0	9.80	73	122	0.24	N/A	N/A	N/A	<5	7.8	77	486	172	N/A	213	N/A

Site name	Date	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
		mg/L																			
EBH-03	2017-12-15	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	2.460	<0.004	0.314	<0.002	<0.002	0.015	<0.015	<0.001	0.113	0.004	<0.001		<0.001
EBH-03	2018-02-27	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.002	<0.004	<0.004	0.051	<0.002	<0.002	<0.002	<0.015	<0.001	0.102	<0.004	<0.001		<0.001
EBH-03	2018-04-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.056	<0.004	<0.001		<0.001
EBH-03	2018-06-28	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.272	<0.002	<0.002	<0.002	<0.015	<0.001	0.124	<0.004	<0.001		0.004
EBH-03	2018-09-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	0.207	<0.002	<0.002	<0.002	<0.015	<0.001	0.110	<0.004	<0.001		<0.001
EBH-03	2018-12-13	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.048	<0.002	<0.002	<0.002	<0.015	<0.001	0.071	<0.004	<0.001		<0.001
EBH-03	2019-03-25	0.097	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.177	<0.002	<0.002	<0.002	<0.015	<0.001	0.123	<0.004	<0.001		<0.001
EBH-03	2019-06-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	0.652	<0.004	0.272	<0.002	<0.002	<0.002	<0.015	<0.001	0.122	<0.004	<0.001		<0.001
EBH-03	2019-09-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.128	<0.002	<0.002	<0.002	<0.015	<0.001	0.119	<0.004	<0.001		<0.001
EBH-03	2019-12-11	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.011	<0.004	<0.004	0.245	<0.002	<0.002	<0.002	<0.015	<0.001	0.134	<0.004	<0.001		<0.001
EBH-03	2020-03-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.011	<0.004	<0.004	0.260	<0.002	<0.002	<0.002	<0.015	<0.001	0.147	<0.004	<0.001	<0.004	
Baseline		<0.100	<0.010	<0.005	<0.025	N/A	<0.025	<0.025	0.033	<0.010	0.169	<0.025	<0.010	<0.025	<0.010	<0.025	0.035	0.031	N/A	N/A	N/A

Table 11-4 Water Quality – Groundwater EBH-04

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
		mg/L CaCO ₃					mg/L			mg/L N		mg/L N		mg/L CaCO ₃	pH	mS/m	mg/L		mg/L CaCO ₃		mg/L
EBH-04	2017-12-15	196	99	77	0.36	64	5.31	32	231	0.31	0.069			0.5	7.5	82	638	197	0.02	511	
EBH-04	2018-02-27	209	101	77	0.36	64	6.03	33	227	0.31	<0.006			0.8	7.6	99	746	210	0.02	514	
EBH-04	2018-04-26	221	93	74	0.34	59	5.40	32	206	0.30	0.034			0.8	7.6	78	582	221	0.02	473	
EBH-04	2018-06-28	219	95	73	0.27	52	5.83	31	171	0.22	0.050			1.0	7.7	89	704	220	0.03	453	
EBH-04	2018-09-25	199	83	70	0.40	53	4.66	30	151	0.24	<0.006			7.9	8.6	92	658	207	0.21	424	
EBH-04	2018-12-13	168	57	78	0.29	42	4.96	30	105	0.26	0.061			0.5	7.5	62	518	169	0.02	318	
EBH-04	2019-03-25	238	98	79	0.39	60	5.80	33	179	0.28	0.075			0.6	7.4	92	658	239	0.01	492	
EBH-04	2019-06-26	254	96	85	0.40	60	6.30	30	219	0.26	0.140			1.0	7.6	101	670	255	0.02	486	
EBH-04	2019-09-26	231	106	79	0.42	65	5.08	30	218	<0.194	<0.065			0.4	7.2	104	632	231	0.01	532	
EBH-04	2019-12-11	242	95	80	0.33	59	5.84	32	235	0.40	0.254			0.4	7.2	108	834	242	0.01	482	
EBH-04	2020-03-25	246	101	86	0.39	63	5.63	32	215	<0.194	0.068	0.279	0.023	4.9	8.3	104	760	251	0.11	510	<0.008
Baseline		208	82.0	85	<0.2	50.0	5.20	30	164	<0.24	N/A	N/A	N/A	<5	7.6	90	648	208	N/A	411	N/A

Site name	Date	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
		mg/L																			
EBH-04	2017-12-15	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.371	<0.002	<0.002	0.030	<0.015	<0.001	0.113	0.004	<0.001		<0.001
EBH-04	2018-02-27	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	0.161	<0.004	0.311	<0.002	<0.002	0.002	<0.015	<0.001	0.161	<0.004	<0.001		<0.001
EBH-04	2018-04-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.164	<0.002	<0.002	<0.002	<0.015	<0.001	0.160	<0.004	<0.001		<0.001
EBH-04	2018-06-28	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	0.322	<0.002	<0.002	0.003	<0.015	<0.001	0.152	<0.004	<0.001		0.003
EBH-04	2018-09-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	0.257	<0.002	<0.002	<0.002	<0.015	<0.001	0.141	<0.004	<0.001		<0.001
EBH-04	2018-12-13	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.163	<0.002	<0.002	<0.002	<0.015	<0.001	0.084	<0.004	<0.001		<0.001
EBH-04	2019-03-25	0.046	<0.006	<0.002	<0.003	<0.002	<0.003	0.006	<0.004	<0.004	0.277	<0.002	<0.002	<0.002	<0.015	<0.001	0.151	<0.004	<0.001		<0.001
EBH-04	2019-06-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.014	0.217	<0.004	0.357	<0.002	<0.002	<0.002	<0.015	<0.001	0.146	0.005	<0.001		<0.001
EBH-04	2019-09-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.257	<0.002	<0.002	<0.002	<0.015	<0.001	0.143	<0.004	<0.001		0.001
EBH-04	2019-12-11	0.028	<0.006	<0.002	<0.003	<0.002	<0.003	0.015	<0.004	<0.004	0.303	<0.002	<0.002	<0.002	<0.015	<0.001	0.143	<0.004	<0.001		<0.001
EBH-04	2020-03-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.018	<0.004	<0.004	0.379	<0.002	<0.002	0.002	<0.015	<0.001	0.153	<0.004	<0.001	<0.004	
Baseline		<0.100	<0.010	<0.005	<0.025	N/A	<0.025	<0.025	0.633	<0.010	0.409	<0.025	<0.010	<0.025	<0.010	<0.025	0.171	<0.025	N/A	N/A	N/A

Table 11-5 Water Quality – Process Water

Site name	Date	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₃ -N	NH ₄ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	Turbidity	free - CN
		mg/L CaCO ₃					mg/L			mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃			N.T.U.	mg/L
Discharge Effluent	2019-05-27	48	291	101	0.805	75	18	162	1259	3.35	3.00			0.38	7.9	243	1942	49	0.04	1036	4.6	
Discharge Effluent	2019-06-26	56	313	103	<0.263	91	20	174	1238	0.99	0.77	0.128	3.330	0.50	8.0	248	2086	57	0.05	1158	4.0	<0.008
Discharge Effluent	2019-07-30	27	289	111	<0.263	92	14	187	1330	5.81	4.59			1.00	8.6	255	1820	28	0.2	1100	2.6	
Discharge Effluent	2019-08-27	34	317	90	<0.263	69	14	167	1295	2.61	2.43			1.06	8.5	250	2064	35	0.17	1074	1.0	
Discharge Effluent	2019-09-26	69	246	136	0.291	126	13	275	1308	4.40	3.98	0.007	0.050	2.76	8.6	246	2226	72	0.21	1133	2.8	<0.008
Discharge Effluent	2019-10-30	46	299	97	<0.263	72	13	179	1112	4.16	3.90			0.33	7.9	240	2014	47	0.04	1044	1.4	
Discharge Effluent	2019-11-28	67	281	124	<0.263	104	15	179	1156	4.73	4.16			0.63	8.0	243	2022	67	0.05	1130	3.2	
Discharge Effluent	2019-12-11	71	278	116	<0.263	101	14	178	1230	5.42	3.78	0.006	0.060	1.49	8.4	247	2030	72	0.11	1110	1.9	<0.008
Discharge Effluent	2020-02-26	75	292	110	<0.263	91	15	188	1231	0.91	0.75	0.193	5.540	0.61	7.9	243	1868	75	0.04	1102	2.4	<0.008
Discharge Effluent	2020-03-25	91	286	104	<0.263	98	15	189	1235	7.11	5.09	0.015	0.180	1.84	8.3	261	2046	93	0.11	1119	3.7	<0.008
Wastewater Limit (2013) ^a		N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	15	15	6	6	N/A	5.5-9.5	150	N/A	N/A	N/A	N/A	N/A	0.02
Directive Limits ^b		N/A	N/A	N/A	N/A	N/A	N/A	N/A	3000	N/A	N/A	N/A	N/A	N/A	6.5-9.5	450	N/A	N/A	N/A	N/A	30	N/A

Site name	Date	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
		mg/L																			
Discharge Effluent	2019-05-27	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.012	<0.004	<0.004	0.098	<0.002	<0.002	<0.002	<0.015	<0.001	<0.002	<0.004	<0.001		0.001
Discharge Effluent	2019-06-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.016	<0.004	<0.004	0.176	<0.002	<0.002	<0.002	<0.015	<0.001	<0.002	<0.004	<0.001		<0.001
Discharge Effluent	2019-07-30	<0.002	<0.006	<0.002	0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.145	<0.002	<0.002	<0.002	<0.015	<0.001	0.002	<0.004	<0.001		0.002
Discharge Effluent	2019-08-27	<0.002	<0.006	<0.002	0.051	<0.002	<0.003	0.009	<0.004	<0.004	0.066	<0.002	<0.002	<0.002	<0.015	<0.001	<0.002	<0.004	<0.001		<0.001
Discharge Effluent	2019-09-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.014	<0.002	<0.002	<0.002	<0.015	<0.001	<0.002	<0.004	<0.001		0.001
Discharge Effluent	2019-10-30	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.014	<0.004	<0.004	0.081	<0.002	<0.002	<0.002	<0.015	<0.001	0.003	<0.004	<0.001		0.001
Discharge Effluent	2019-11-28	0.037	<0.006	<0.002	<0.003	<0.002	<0.003	0.02	<0.004	<0.004	0.183	<0.002	<0.002	0.005	<0.015	<0.001	0.003	<0.004	<0.001		0.001
Discharge Effluent	2019-12-11	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.017	<0.004	<0.004	0.084	<0.002	<0.002	<0.002	<0.015	<0.001	0.002	<0.004	<0.001		<0.001
Discharge Effluent	2020-02-26	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.014	<0.004	<0.004	0.212	<0.002	<0.002	<0.002	<0.015	<0.001	0.002	<0.004	<0.001	<0.004	<0.001
Discharge Effluent	2020-03-25	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.018	<0.004	<0.004	0.240	<0.002	<0.002	<0.002	<0.015	<0.001	0.004	<0.004	<0.001	<0.004	
Wastewater Limit (2013) ^a		N/A	0.02	0.005	N/A	0.05	N/A	0.01	0.3	0.01	0.1	N/A	0.02	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Directive Limits ^b		1.000	N/A	N/A	N/A	N/A	N/A	N/A	1.000	N/A	10.000	N/A	N/A	N/A	0.050	N/A	N/A	N/A	N/A	N/A	N/A

^a Discharge of Water into a Water Resource - GN 665; GG36820

^b Ref: AMD-DIR-TCTA-01.03.2011

Table 11-6 Water Quality – Surface Water (Upstream) ESW-01

Site name	Date	RQO Classification	HCO ₃ mg/L CaCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alkalinity	Hydroxide Alkalinity	Total Hard	free - CN
				mg/L							mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃			mg/L
ESW-01	2019-04-25	Acceptable	157	57	54	0.31	16	7.9	54	122	1.34	0.536	1.440		2.6	8.3	68	464	159	0.09	210	
ESW-01	2019-05-27	Tolerable	150	49	66	0.27	17	11.7	71	124	2.59	0.228	0.292		1.8	8.1	73	546	152	0.06	192	
ESW-01	2019-06-26	Tolerable	175	56	73	0.33	17	13.3	80	102	2.98	0.528	2.020		1.3	7.9	79	462	176	0.04	213	
ESW-01	2019-07-30	Unacceptable	195	55	94	0.30	18	14.8	107	175	1.68	0.287	8.650		1.2	7.8	99	664	196	0.03	211	
ESW-01	2019-08-27	Tolerable	174	62	77	0.28	19	13.8	93	124	1.98	0.466	3.510		0.5	7.5	95	494	174	0.02	232	
ESW-01	2019-09-26	Unacceptable	146	47	69	0.33	15	11.6	76	93	3.43	1.330	3.500		0.5	7.6	72	424	146	0.02	181	
ESW-01	2019-10-30	Unacceptable	149	38	83	0.29	13	13.7	92	98	1.32	0.374	3.600		0.7	7.7	78	450	150	0.03	147	
ESW-01	2019-11-28	Unacceptable	219	62	71	0.32	17	14.2	80	91	1.54	1.170	1.050		4.1	8.3	82	578	223	0.10	225	
ESW-01	2019-12-11	Unacceptable	110	32	26	<0.263	13	7.7	28	51	2.08	1.180	0.605		0.3	7.5	39	292	111	0.01	132	
ESW-01	2020-01-28	Acceptable	159	50	49	0.34	16	9.3	55	67	1.04	0.171	0.595	0.011	0.6	7.6	63	334	159	0.02	191	<0.008
ESW-01	2020-02-26	Acceptable	154	47	47	0.30	15	7.9	47	78	0.82	<0.065	0.134	0.014	3.3	8.4	56	354	157	0.11	176	<0.008
ESW-01	2020-03-25	Acceptable	161	48	54	0.30	15	7.2	55	89	1.90	0.221	0.210	0.026	4.3	8.5	61	486	166	0.14	182	<0.008
Ideal					<80	<0.19	<8		<70	<150	<0.5		0.1			6.5-8.5	<45					
Acceptable					80-150	0.19-0.70	8-30		70-100	150-300	0.5-3.0		0.1				45-70					
Tolerable					150-200	0.70-1.00	30-70		100-150	300-500	3.0-6.0		1.5				70-120					
Unacceptable					>200	>1.00	>70		>150	>500	>6.0		5.0			<6.5>8.5	>120					

Site name	Date	RQO Classification	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
			mg/L																			
ESW-01	2019-04-25	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.008	0.020	<0.002	<0.002	<0.015	0.001	0.033	0.007	<0.001		<0.001
ESW-01	2019-05-27	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	0.025	0.011	<0.002	0.018	<0.015	0.001	0.030	0.009	<0.001		<0.001
ESW-01	2019-06-26	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.085	0.014	<0.002	0.049	<0.015	0.001	0.029	0.016	<0.001		<0.001
ESW-01	2019-07-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.119	0.009	<0.002	<0.002	<0.015	0.001	0.032	0.013	<0.001		<0.001
ESW-01	2019-08-27	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.004	<0.004	<0.004	0.099	0.006	<0.002	0.017	<0.015	0.003	0.033	0.006	<0.001		<0.001
ESW-01	2019-09-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	0.002	0.014	<0.004	<0.001		<0.001
ESW-01	2019-10-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	0.152	<0.002	<0.002	0.021	<0.015	0.003	0.025	0.006	<0.001		<0.001
ESW-01	2019-11-28	Unacceptable	<0.002	0.008	<0.002	<0.003	<0.002	<0.003	0.010	<0.004	<0.004	<0.001	0.020	<0.002	0.002	<0.015	0.001	0.033	0.031	<0.001		<0.001
ESW-01	2019-12-11	Unacceptable	0.079	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	0.007	<0.004	0.007	<0.002	<0.002	<0.002	<0.015	0.002	0.024	0.004	<0.001		<0.001
ESW-01	2020-01-28	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	<0.004	<0.004	0.009	0.007	<0.002	<0.002	<0.015	0.002	0.030	<0.004	<0.001	<0.004	<0.001
ESW-01	2020-02-26	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.002	<0.004	<0.004	<0.001	0.011	<0.002	<0.002	<0.015	0.001	0.020	<0.004	<0.001	<0.004	<0.001
ESW-01	2020-03-25	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.006	<0.004	<0.004	0.022	0.010	<0.002	0.006	<0.015	<0.001	0.023	<0.004	<0.001	<0.004	
Ideal										<0.1		<0.2										
Acceptable										0.10		0.20										
Tolerable										0.50		0.50										
Unacceptable										1.00		1.00										

DWS Catchment C21E RQO Limits

Table 11-7 Water Quality – Surface Water (Upstream) ESW-02

Site name	Date	RQO Classification	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
			mg/L CaCO ₃	mg/L						mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L		
ESW-02	2019-04-25	Tolerable	160	40	27	0.28	15	6.6	26	53	0.24	0.077	5.000		2.3	8.2	46	274	163	0.08	160	
ESW-02	2019-05-27	Unacceptable	180	47	29	0.32	16	7.2	31	68	0.20	0.064	5.620		2.7	8.2	53	278	183	0.08	182	
ESW-02	2019-06-26	Unacceptable	217	51	34	0.34	18	8.4	35	66	0.33	0.137	7.210		1.3	7.8	60	344	218	0.03	202	
ESW-02	2019-07-30	Unacceptable	213	46	31	0.29	17	7.2	37	59	0.33	0.114	8.370		1.1	7.7	59	372	214	0.03	186	
ESW-02	2019-08-27	Unacceptable	191	48	28	0.32	17	7.6	36	42	0.21	0.139	6.420		0.8	7.7	62	330	192	0.02	190	
ESW-02	2019-09-26	Unacceptable	241	49	28	0.41	18	6.2	36	30	<0.194	<0.065	13.000		0.9	7.6	60	362	242	0.02	195	
ESW-02	2019-10-30	Unacceptable	215	42	24	0.38	15	7.0	31	29	0.28	0.078	8.530		0.9	7.7	54	286	216	0.02	165	
ESW-02	2019-11-28	Unacceptable	218	44	30	0.29	15	6.5	37	11	0.25	0.094	7.360		3.2	8.2	53	318	221	0.08	171	
ESW-02	2019-12-11	Unacceptable	121	44	19	<0.263	13	5.5	21	73	1.23	0.524	1.440		0.3	7.4	43	282	122	0.01	163	
ESW-02	2020-01-28	Unacceptable	205	47	29	0.32	17	7.0	37	51	0.34	0.102	6.970	0.099	0.6	7.5	59	298	206	0.02	189	<0.008
ESW-02	2020-02-26	Unacceptable	214	47	34	0.34	17	7.6	35	60	0.22	0.108	9.260	0.622	3.2	8.2	57	296	218	0.08	188	<0.008
ESW-02	2020-03-25	Unacceptable	214	45	31	0.31	16	7.1	34	44	<0.194	0.072	6.350	0.527	4.4	8.3	55	332	219	0.11	178	<0.008
Ideal					<80	<0.19	<8		<70	<150	<0.5		0.1			6.5-8.5	<45					
Acceptable					80-150	0.19-0.70	8-30		70-100	150-300	0.5-3.0		0.1				45-70					
Tolerable					150-200	0.70-1.00	30-70		100-150	300-500	3.0-6.0		1.5				70-120					
Unacceptable					>200	>1.00	>70		>150	>500	>6.0		5.0			<6.5>8.5	>120					

Site name	Date	RQO Classification	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
			mg/L																			
ESW-02	2019-04-25	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.004	0.020	<0.002	0.002	<0.015	0.001	0.045	<0.004	<0.001		<0.001
ESW-02	2019-05-27	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.006	<0.004	<0.004	0.177	<0.002	<0.002	0.005	<0.015	<0.001	0.044	<0.004	<0.001		<0.001
ESW-02	2019-06-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	0.008	<0.004	0.195	<0.002	<0.002	<0.002	<0.015	<0.001	0.052	<0.004	<0.001		<0.001
ESW-02	2019-07-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.194	<0.002	<0.002	<0.002	<0.015	<0.001	0.046	<0.004	<0.001		<0.001
ESW-02	2019-08-27	Unacceptable	0.028	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	0.236	<0.002	<0.002	<0.002	<0.015	0.001	0.051	<0.004	<0.001		<0.001
ESW-02	2019-09-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.142	<0.002	<0.002	<0.002	<0.015	<0.001	0.041	<0.004	<0.001		<0.001
ESW-02	2019-10-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.005	0.015	<0.004	0.578	<0.002	<0.002	<0.002	<0.015	<0.001	0.069	<0.004	<0.001		<0.001
ESW-02	2019-11-28	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.368	<0.002	<0.002	<0.002	<0.015	0.001	0.065	<0.004	<0.001		0.001
ESW-02	2019-12-11	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	0.001	0.069	0.004	<0.001		0.004
ESW-02	2020-01-28	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	<0.004	<0.004	0.278	<0.002	<0.002	<0.002	<0.015	0.001	0.071	<0.004	<0.001	<0.004	<0.001
ESW-02	2020-02-26	Unacceptable	0.219	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	0.004	<0.002	<0.002	<0.002	<0.015	<0.001	0.067	<0.004	<0.001	<0.004	<0.001
ESW-02	2020-03-25	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.006	<0.004	<0.004	0.346	<0.002	<0.002	<0.002	<0.015	<0.001	0.069	<0.004	<0.001	<0.004	
Ideal										0.10		0.20										
Acceptable			<0.3							0.10		0.20										
Tolerable			0.30							0.50		0.50										
Unacceptable			0.50							1.00		1.00										

DWS Catchment C21E RQO Limits

Table 11-8 Water Quality – Surface Water (Downstream) ESW-03

Site name	Date	RQO Classification	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
			mg/L CaCO ₃	mg/L						mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃		mg/L		
ESW-03	2019-04-25	Tolerable	133	90	64	0.28	26	9.4	76	279	1.23	0.101	0.144		2.4	8.3	96	654	135	0.10	330	
ESW-03	2019-05-27	Unacceptable	110	161	82	0.27	42	13.4	111	642	1.59	0.045	0.143		1.4	8.1	154	1000	111	0.07	577	
ESW-03	2019-06-26	Unacceptable	132	172	90	0.28	50	15.8	123	700	2.01	0.167	0.423		1.3	8.0	159	1084	134	0.05	633	
ESW-03	2019-07-30	Unacceptable	121	147	98	<0.263	44	14.2	134	582	2.09	0.162	0.572		0.7	7.8	157	1036	122	0.03	547	
ESW-03	2019-08-27	Unacceptable	112	160	87	0.27	42	14.7	127	587	1.32	0.161	0.556		0.5	7.7	161	1034	112	0.02	570	
ESW-03	2019-09-26	Unacceptable	167	122	96	0.33	40	12.8	150	442	0.66	0.093	0.772		1.2	7.9	133	860	168	0.04	471	
ESW-03	2019-10-30	Unacceptable	97	209	95	0.28	57	12.6	153	794	1.06	0.109	0.401		0.5	7.8	194	1408	97	0.03	756	
ESW-03	2019-11-28	Unacceptable	203	91	79	0.31	28	12.9	99	230	0.36	0.099	0.158		4.6	8.4	106	646	208	0.12	341	
ESW-03	2019-12-11	Unacceptable	132	43	42	0.27	13	9.5	43	77	2.60	1.460	0.141		0.4	7.5	54	308	132	0.02	162	
ESW-03	2020-01-28	Acceptable	165	53	53	0.33	18	9.2	57	77	0.45	0.078	0.229	0.005	0.7	7.7	66	366	165	0.02	206	<0.008
ESW-03	2020-02-26	Tolerable	157	94	61	0.28	31	9.4	74	324	0.50	0.167	0.412	0.034	2.9	8.3	97	620	160	0.10	361	<0.008
ESW-03	2020-03-25	Tolerable	155	108	71	0.29	34	9.9	88	359	1.23	0.114	0.148	0.012	3.3	8.4	112	608	158	0.11	408	<0.008
Ideal					<80	<0.19	<8		<70	<150	<0.5		0.1			6.5-8.5	<45					
Acceptable					80-150	0.19-0.70	8-30		70-100	150-300	0.5-3.0		0.1				45-70					
Tolerable					150-200	0.70-1.00	30-70		100-150	300-500	3.0-6.0		1.5				70-120					
Unacceptable					>200	>1.00	>70		>150	>500	>6.0		5.0			<6.5>8.5	>120					

Site name	Date	RQO Classification	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
			mg/L																			
ESW-03	2019-04-25	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.001	0.020	<0.002	<0.002	<0.015	0.002	0.020	0.004	<0.001		<0.001
ESW-03	2019-05-27	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.011	<0.004	<0.004	0.086	0.008	<0.002	0.007	<0.015	<0.001	0.021	0.006	<0.001		<0.001
ESW-03	2019-06-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.013	<0.004	<0.004	0.115	0.011	<0.002	0.011	<0.015	<0.001	0.017	0.010	<0.001		0.002
ESW-03	2019-07-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.056	0.021	<0.002	<0.002	<0.015	<0.001	0.021	0.012	<0.001		<0.001
ESW-03	2019-08-27	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.074	0.026	<0.002	0.006	<0.015	0.001	0.023	0.005	<0.001		<0.001
ESW-03	2019-09-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	0.001	0.008	<0.004	<0.001		<0.001
ESW-03	2019-10-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.013	<0.004	<0.004	0.237	0.019	<0.002	0.004	<0.015	<0.001	0.018	<0.004	<0.001		<0.001
ESW-03	2019-11-28	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.013	<0.004	<0.004	<0.001	0.014	<0.002	0.003	<0.015	<0.001	0.023	0.026	<0.001		<0.001
ESW-03	2019-12-11	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.002	0.013	<0.002	<0.002	<0.015	0.001	0.019	0.007	<0.001		0.002
ESW-03	2020-01-28	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	<0.004	<0.004	0.110	0.011	<0.002	0.002	<0.015	0.002	0.030	<0.004	<0.001	<0.004	<0.001
ESW-03	2020-02-26	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	0.034	0.007	<0.002	<0.002	<0.015	<0.001	0.028	0.004	<0.001	<0.004	<0.001
ESW-03	2020-03-25	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.012	<0.004	<0.004	0.028	0.008	<0.002	0.004	<0.015	<0.001	0.025	<0.004	<0.001	<0.004	
Ideal										0.10		0.20										
Acceptable										0.10		0.20										
Tolerable										0.50		0.50										
Unacceptable										1.00		1.00										

DWS Catchment C21E RQO Limits

Table 11-9 Water Quality – Surface Water (Upstream) ESW-04

Site name	Date	RQO Classification	HCO ₃ mg/L CaCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃ mg/L CaCO ₃	pH	EC mS/m	TDS mg/L	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
ESW-04	2019-04-25	Acceptable	65.4	23	16	<0.263	8.36	5.48	13	40	1.05	0.302	0.335		0.7	8.0	25	188	66.1	0.05	91	
ESW-04	2019-05-27	Tolerable	201	53	45	0.30	19.4	7.55	44	72	2.42	0.144	0.645		3.3	8.2	63	368	204	0.09	212	
ESW-04	2019-06-26	Tolerable	194	57	42	0.32	20.6	10.40	42	85	4.00	0.175	0.166		2.6	8.2	62	364	197	0.07	226	
ESW-04	2019-07-30	Tolerable	197	53	40	0.30	19.2	8.60	43	69	2.45	0.131	0.088		2.4	8.1	62	380	199	0.06	212	
ESW-04	2019-08-27	Unacceptable	229	57	34	0.32	20.4	9.17	43	36	0.46	0.125	0.203		2.5	8.1	64	432	231	0.06	226	
ESW-04	2019-09-26	Unacceptable	241	61	38	0.38	21.4	4.95	52	38	0.98	0.143	0.142		2.1	8.0	62	378	243	0.05	239	
ESW-04	2019-10-30	Unacceptable	254	52	52	0.41	17.4	6.69	74	43	0.86	0.338	2.970		1.1	7.7	71	460	255	0.02	200	
ESW-04	2019-11-28	Unacceptable	180	44	37	0.28	13.4	5.21	43	47	0.56	0.374	1.170		3.4	8.3	52	320	184	0.10	165	
ESW-04	2019-12-11	Tolerable	63.7	24	16	<0.263	8.43	4.18	14	49	1.31	0.086	0.046		0.1	7.3	29	196	63.8	0.01	94	
ESW-04	2020-01-28	Tolerable	232	58	56	0.36	17.8	9.08	68	52	0.76	0.328	2.760	0.049	0.9	7.6	74	380	233	0.02	217	<0.008
ESW-04	2020-02-26	Tolerable	206	51	64	0.34	16.3	10.20	66	70	1.72	1.560	3.830	0.392	4.4	8.4	69	394	210	0.11	193	<0.008
ESW-04	2020-03-25	Tolerable	261	59	71	0.35	16	11.80	74	46	0.34	0.242	4.380	0.449	6.3	8.4	77	430	268	0.13	213	<0.008
Ideal					<80	<0.19	<8		<70	<150	<0.5		0.1			6.5-8.5	<45					
Acceptable					80-150	19-0.70	8-30		70-100	150-300	0.5-3.0		0.1				45-70					
Tolerable					150-200	70-1.00	30-70		100-150	300-500	3.0-6.0		1.5				70-120					
Unacceptable					>200	>1.00	>70		>150	>500	>6.0		5.0			<6.5>8.5	>120					

Site name	Date	RQO Classification	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
ESW-04	2019-04-25	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	0.004	<0.002	0.002	<0.015	0.001	0.033	<0.004	<0.001		<0.001
ESW-04	2019-05-27	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	0.100	<0.002	<0.002	0.002	<0.015	<0.001	0.057	<0.004	<0.001		<0.001
ESW-04	2019-06-26	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.065	<0.002	<0.002	<0.002	<0.015	<0.001	0.051	<0.004	<0.001		<0.001
ESW-04	2019-07-30	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.036	<0.004	<0.001		<0.001
ESW-04	2019-08-27	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.003	<0.004	<0.004	0.280	<0.002	<0.002	<0.002	<0.015	0.001	0.029	<0.004	<0.001		<0.001
ESW-04	2019-09-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.315	<0.002	<0.002	<0.002	<0.015	<0.001	0.027	<0.004	<0.001		<0.001
ESW-04	2019-10-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	1.190	<0.002	<0.002	0.005	<0.015	0.001	0.057	<0.004	<0.001		<0.001
ESW-04	2019-11-28	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.029	<0.002	<0.002	0.005	<0.015	<0.001	0.053	<0.004	<0.001		<0.001
ESW-04	2019-12-11	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.006	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	0.001	0.031	<0.004	<0.001		0.001
ESW-04	2020-01-28	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	<0.004	<0.004	0.388	<0.002	<0.002	<0.002	<0.015	0.001	0.063	<0.004	<0.001	<0.004	<0.001
ESW-04	2020-02-26	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	<0.001	0.061	<0.004	<0.001	<0.004	<0.001
ESW-04	2020-03-25	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.006	<0.004	<0.004	0.027	<0.002	<0.002	<0.002	<0.015	<0.001	0.039	<0.004	<0.001	<0.004	
Ideal										0.10		0.20										
Acceptable										0.10		0.20										
Tolerable										0.50		0.50										
Unacceptable										1.00		1.00										

DWS Catchment C21E RQO Limits

Table 11-10 Water Quality – Surface Water (Upstream) ESW-05

Site name	Date	RQO Classification	HCO ₃	Ca	Cl	F	Mg	K	Na	SO ₄	NO ₃ -N	NO ₂ -N	NH ₄ -N	NH ₃ -N	CO ₃	pH	EC	TDS	Alka- linity	Hydroxide Alkalinity	Total Hard	free - CN
			mg/L CaCO ₃	mg/L						mg/L N				mg/L CaCO ₃	pH	mS/m	mg/L	mg/L CaCO ₃			mg/L	
ESW-05	2019-04-25	Acceptable	133	51	56	0.29	16	9	56	108	1.19	0.085	0.070		2.6	8.3	64	378	136	0.10	192	
ESW-05	2019-05-27	Tolerable	162	59	66	0.29	18	11	67	144	1.28	0.040	0.098		3.8	8.4	75	420	166	0.13	223	
ESW-05	2019-06-26	Tolerable	165	85	73	0.31	27	14	87	239	1.68	0.079	0.081		2.9	8.3	96	612	168	0.09	325	
ESW-05	2019-07-30	Tolerable	174	65	95	0.30	21	14	104	211	2.31	0.239	0.871		1.2	7.9	102	520	175	0.04	251	
ESW-05	2019-08-27	Unacceptable	159	69	84	0.29	21	15	101	198	1.09	0.207	0.500		0.9	7.8	105	586	160	0.03	261	
ESW-05	2019-09-26	Unacceptable	177	80	94	0.35	27	13	122	220	0.64	0.130	0.548		5.2	8.5	103	632	183	0.16	312	
ESW-05	2019-10-30	Unacceptable	152	101	89	0.31	29	13	119	341	0.80	0.151	0.629		1.2	7.9	124	812	153	0.04	371	
ESW-05	2019-11-28	Unacceptable	216	75	77	0.33	22	13	92	148	0.59	0.203	0.229		4.7	8.4	91	590	221	0.12	277	
ESW-05	2019-12-11	Unacceptable	131	41	39	0.27	13	9	42	69	2.39	1.620	0.269		0.4	7.6	54	272	131	0.02	154	
ESW-05	2020-01-28	Acceptable	169	55	60	0.39	18	9	63	80	0.39	0.103	0.143	0.006	1.7	8.0	66	380	171	0.05	212	<0.008
ESW-05	2020-02-26	Acceptable	165	54	51	0.31	18	8	52	100	0.25	<0.065	0.094	0.01	3.8	8.4	63	372	169	0.12	208	<0.008
ESW-05	2020-03-25	Tolerable	175	63	63	0.81	20	9	66	141	0.64	0.084	0.205	0.026	5.2	8.5	74	424	180	0.16	241	<0.008
Ideal					<80	<0.19	<8		<70	<150	<0.5		0.1			6.5-8.5	<45					
Acceptable					80-150	0.19-0.70	8-30		70-100	150-300	0.5-3.0		0.1				45-70					
Tolerable					150-200	0.70-1.00	30-70		100-150	300-500	3.0-6.0		1.5				70-120					
Unacceptable					>200	>1.00	>70		>150	>500	>6.0		5.0			<6.5>8.5	>120					

Site name	Date	RQO Classification	Al	As	Cd	Cr	Cr (VI)	Co	Cu	Fe	Pb	Mn	Ni	Se	Zn	U	V	Ba	Mo	Sb	Hg	Th
			mg/L																			
ESW-05	2019-04-25	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	0.021	<0.002	<0.002	<0.015	0.002	0.023	0.004	<0.001		<0.001
ESW-05	2019-05-27	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.007	<0.004	<0.004	0.009	0.011	<0.002	0.015	<0.015	0.001	0.027	0.009	<0.001		<0.001
ESW-05	2019-06-26	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.010	<0.004	<0.004	0.062	0.015	<0.002	0.018	<0.015	0.001	0.026	0.015	<0.001		<0.001
ESW-05	2019-07-30	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.035	0.027	<0.002	<0.002	<0.015	<0.001	0.032	0.019	<0.001		<0.001
ESW-05	2019-08-27	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.005	<0.004	<0.004	0.094	0.025	<0.002	0.013	<0.015	0.002	0.031	0.008	<0.001		<0.001
ESW-05	2019-09-26	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002	<0.002	<0.002	<0.015	0.001	0.009	<0.004	<0.001		<0.001
ESW-05	2019-10-30	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.010	<0.004	<0.004	0.596	0.015	<0.002	<0.002	<0.015	0.001	0.024	0.005	<0.001		0.001
ESW-05	2019-11-28	Unacceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.012	<0.004	<0.004	<0.001	0.016	<0.002	0.003	<0.015	0.001	0.031	0.028	<0.001		<0.001
ESW-05	2019-12-11	Unacceptable	0.007	<0.006	<0.002	<0.003	<0.002	<0.003	0.008	<0.004	<0.004	0.006	0.009	<0.002	<0.002	<0.015	0.002	0.019	0.007	<0.001		<0.001
ESW-05	2020-01-28	Acceptable	0.175	<0.006	<0.002	<0.003	<0.002	<0.003	0.010	<0.004	<0.004	0.021	0.007	<0.002	<0.002	<0.015	0.002	0.028	<0.004	<0.001	<0.004	<0.001
ESW-05	2020-02-26	Acceptable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.002	<0.004	<0.004	<0.001	0.006	<0.002	<0.002	<0.015	0.001	0.028	0.004	<0.001	<0.004	<0.001
ESW-05	2020-03-25	Tolerable	<0.002	<0.006	<0.002	<0.003	<0.002	<0.003	0.009	<0.004	<0.004	<0.001	0.012	<0.002	0.004	<0.015	<0.001	0.029	<0.004	<0.001	<0.004	
Ideal										0.10		0.20										
Acceptable										0.10		0.20										
Tolerable										0.50		0.50										
Unacceptable										1.00		1.00										

DWS Catchment C21E RQO Limits

12 APPENDIX E: HISTORICAL OVERVIEW

12.1 Groundwater

Borehole EBH-01

TDS values from 206 mg/L to 1 530 mg/L were observed at borehole EBH-01 after the initial relatively elevated value of 2 040 mg/L (May 2015). Most (77%) of TDS values obtained since have been below 820 mg/L. During the initial monitoring in May 2015, total hardness, sulphate and chloride concentrations at EBH-01 were on average four times that observed at the other three boreholes. Initial water quality was likely due to a local groundwater source. Significant improvement in water quality was then observed during November 2015, which probably relates to the pump test conducted on the borehole during June 2015. TDS remained below 1 000 mg/L until August 2017.

Significant deterioration was observed during October 2017 and December 2017, with average TDS of 1 437 mg/L. During this deterioration the values of some parameters (sodium, calcium, sulphate and alkalinity) were within 25% of their May 2015 values. Potassium concentrations above 100 mg/L were however notably elevated compared to May 2015. Despite some similarities, the December 2017 deteriorated water quality was thus likely due to different dynamics than what was present during May 2015. Water quality was restored by April 2018 and further improved towards December 2018. Surface water, AMD water abstracted from the East Rand Basin, as well as ERB Plant Discharge Effluent were evaluated as possible sources that could have resulted in the deteriorated water quality observed at borehole EBH-01 during Q4 2017. It was inferred that none of these could be considered as likely sources/ causes of the deterioration in water quality as observed at borehole EBH-01 at the time. The possibility exists that the deterioration might have been due to historic Grootvlei Mine mining activities, processes, or possible chemical spills at the area northwest and west from borehole EBH-01. Google Earth satellite imagery detailed in Figure 12-2 illustrates what the area and surroundings of borehole EBH-01 looked like in March 2010, compared to September 2017. This possibility could be further investigated should the need arise.

After the lowest TDS observed to date of 206 mg/L during December 2018, values during 2019 varied from 326 mg/L to 718 mg/L.

Borehole EBH-01

After the initial sampling run (May 2015), significant improvement in water quality was observed to November 2015. As with EBH-01, this probably relates to the pump test conducted on the boreholes during June 2015.



Figure 12-1 Borehole EBH-01 – Satellite Imagery - Mar 2010

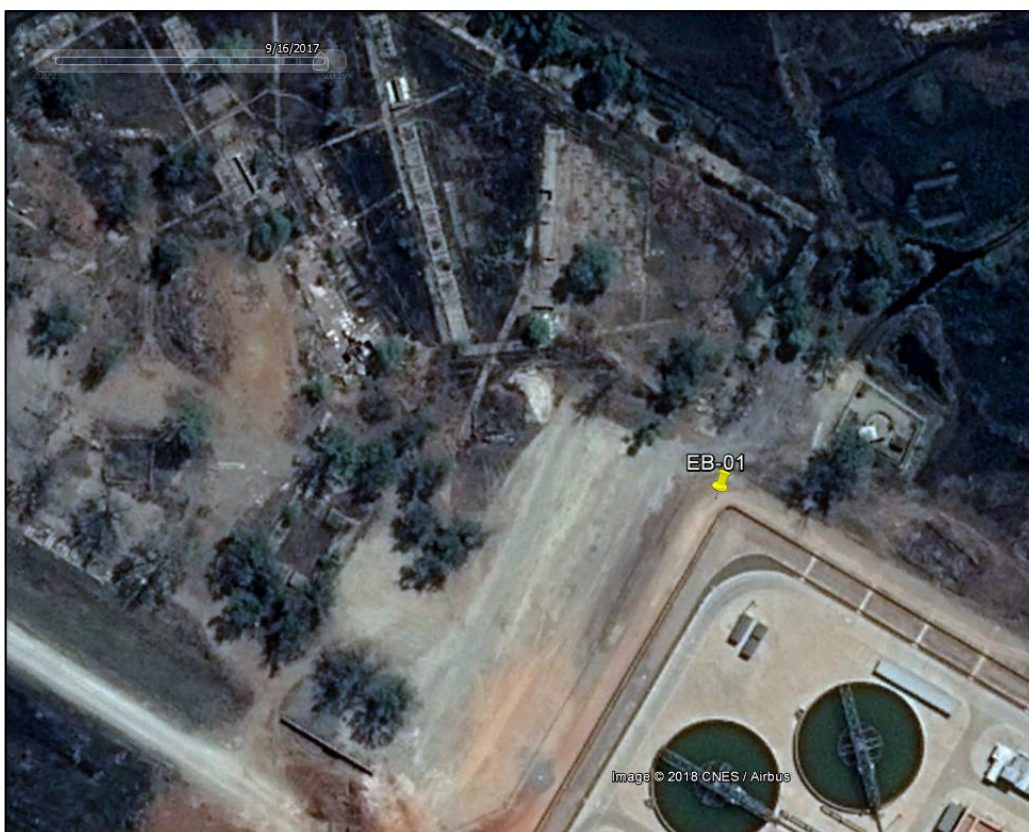


Figure 12-2 Borehole EBH-01 – Satellite Imagery - Sep 2017