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Harmony Mponeng- TSF Spring Hydrogeological Investigation (PHASE 1)

Version - Final

14 April 2025

GCS Project Number: 24-0660

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EXECUTIVE SUMMARY

The **Harmony Mponeng Tailings Storage Facility (TSF) Hydrogeological Investigation** aims to assess the hydrogeology of the Mponeng TSF, located near Carletonville, Gauteng Province.

The investigation is a result of AngloGold Ashanti assessing the most feasible way to accommodate the Life of Mine (LoM) tailings at Mponeng TSF in 2018

- Option 2B was recommended – Extend TSF Footprint East (to the current footprint of the return water dams (RWDs)
- This will result in the TSF footprint extending over a spring, originally reported by Fritz Wagener (Jones, Wagener and Martinelli and Associates, 1978)

GCS previously completed hydrogeological assessments for the Mponeng TSF (GCS, 2019; GCS, 2020) to evaluate potential clean water diversion, spring diversion and cut-off trench designs for the water management at the Mponeng TSF. The spring poses a risk in terms of TSF stability and water management, and the hydrogeological regime needs to be understood to inform the pre-feasibility designs.

Study Objectives

The investigation centres around the following key objectives:

- **Identifying the source of the spring**: To ascertain whether water observed at the northeastern corner of the TSF originates from a natural spring or from contaminated rainwater seepage associated with the TSF.
- **Characterizing Hydrogeology**: To evaluate the hydrogeological regime of the aquifers beneath the TSF, including the spring and other sources of seepage.
- **Seepage Management Strategies**: To provide insights into proposed designs managing the spring water, rainfall induced seepage and process water seepage from the TSF.

Findings

- **Spring**: The investigation confirmed the presence of a natural spring at the northeastern corner of the TSF, identified by ambient groundwater quality (based on EC readings) and surface discharge.
- **Contamination Risks**: The spring water is collected in a downstream seepage control dam from where it was diverted via a pipeline over the TSF and discharged below the TSF. The seepage control dam is contaminated by rainfall-induced seepage from the TSF. This has necessitated the need to alternative collection system above the seepage control dam to divert the clean spring discharge into the water course

Recommendations

GCS proposes three potential mitigation strategies to be considered for implementation during the remaining operations and post-closure phases of the Mponeng TSF expansion that will cumulatively result in a dramatic improvement of the environmental impacts on the surrounding environment:

1. **Management of the Spring**: GCS recommends that a spring capture system be implemented in the northeastern corner of the TSF to capture clean groundwater and divert the water away from the TSF.
2. **Management of Stormwater Runoff:** Divert clean runoff from the area above (north)of the TSF to prevent the water entering the TSF seepage control systems
3. **Seepage control at the toe of the TSF.** Large volumes of contaminated rainwater seepage are evident along the southern toe of the TSF, driven by groundwater mounding induced by the TSF. New monitoring boreholes indicate artesian conditions due to the high phreatic surface in the unlined TSF. GCS proposes a series of scavenger boreholes to intercept the TSF seepage and pump the water into the return water dam for reuse.

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1 INTRODUCTION

GCS (Pty) Ltd was appointed by Golden Core Trade and Investments (Pty) Ltd (Mponeng Mine) to undertake a hydrogeological investigation of the Mponeng TSF (the Mponeng TSF).

AngloGold Ashanti assessed the most feasible way to accommodate the LoM tailings at Mponeng TSF in 2018

- Option 2B was recommended – Extend TSF Footprint East (to the current footprint of the RWDs)
- This will result in the TSF footprint extending over a spring, originally reported by Fritz Wagener (Wagener & Associates).

GCS previously completed hydrogeological assessments for the Mponeng TSF (GCS, 2019; GCS, 2020) to evaluate potential clean water diversion, spring diversion and cut-off trench designs for the water management at the Mponeng TSF. The spring poses a risk in terms of TSF stability and water management, and the hydrogeological regime needs to be understood to inform the pre-feasibility designs.

2 WORK UNDERTAKEN

The objective of the study was to confirm the presence of a spring at the Mponeng TSF as reported, and advise on remediation measures that can be undertaken during both the TSF expansion and closure processes

1. Field data was collected to verify conceptual understanding of the Mponeng TSF hydrogeology.
    I. Electro-resistivity tomography (ERT) lines were conducted to verify the origin of the spring and investigate potential rainwater-induced seepage from the TSF.
    II. Three (3) groundwater boreholes were drilled to verify the hydrogeological conditions associated with the northern side of the Mponeng TSF.
    III. Field parameters and EC logs were taken from the newly drilled boreholes to characterize zones of flow and determine if the borehole water signatures indicate source water from rain-induced toe seepage or natural groundwater recharge
    IV. Slug tests were done to determine aquifer hydraulic parameters and compare hydraulic conductivities between different boreholes.
2. Data from the field investigation, along with available data from reports and other desktop sources were used to conceptualize the hydrogeology of the TSF.

3. Results of the Investigation

    I. The report focuses on drivers contributing to the formation of the spring, as well as rainwater-induced seepage from the Mponeng TSF.

    II. Preferential flow paths and groundwater occurrence areas are described based on available field data and historical sources for the Mponeng TSF.

4. Inform preliminary water management strategies and designs

    To address mitigation measures that can be implemented at the Mponeng TSF, three (3) options are recommended for consideration:

    I. Option 1: Spring Water Management through spring capture

    II. Option 2: Surface Water Management at TSF through extended stormwater management infrastructure

    III. Option 3: Interception of rainfall-induced toe seepage through scavenger wells for retention and re-use.

3 METHODOLOGY

3.1 Overview of Previous work at the Mponeng TSF

The following works have been completed by GCS at the Mponeng TSF prior to this report:

- Project 18-0701 - Groundwater Assessment for the Mponeng TSF Complex (GCS, 2019)
- Project 20-0888 - Mponeng TSF Complex Conceptual Design at Pre-Feasibility Level for Seepage Containment Structures and Spring Diversion (GCS, 2020)
- Project 24-0321 - West Wits Monitoring Borehole Re-Drilling (GCS, 2024)

GCS is has also undertaken groundwater monitoring at the Mponeng TSF and surrounding areas in 2023.

3.2 Electro-Resistivity Tomography Survey

ERT is a process in which electrical current is introduced into the subsurface and measured at various points using an array of electrodes embedded into the ground surface. By varying the spacing between the point at which current is introduced, and the point at which the resistance is measured, different observation depths are achieved. The result is a 2D pseudo section or "slice" of the sub surface's apparent electrical resistivity. This can help identify groundwater, contaminants and subsurface layers by their electrical resistivity signature.

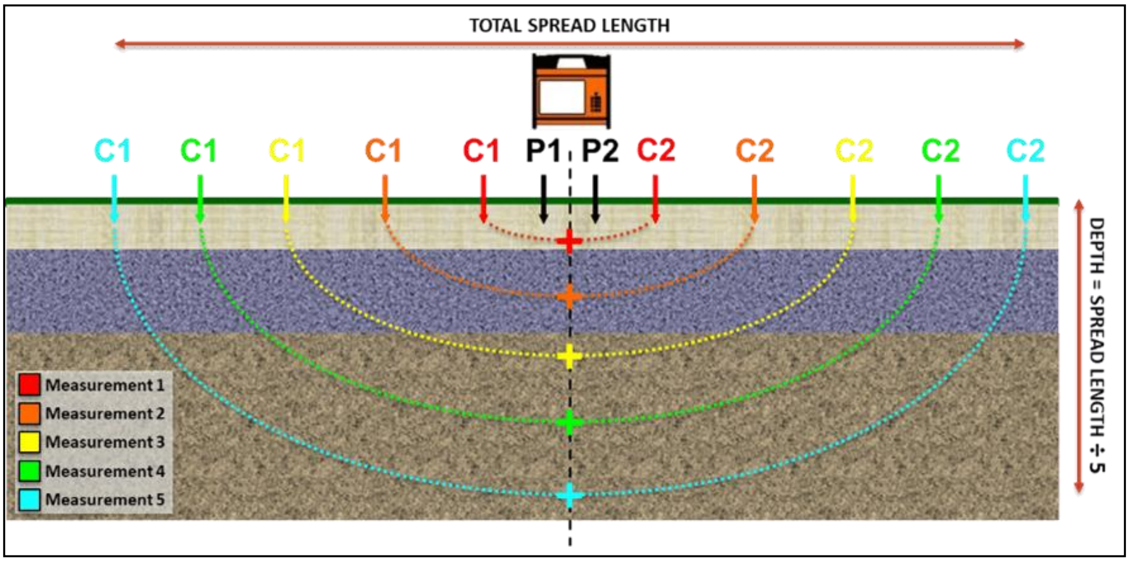


Figure 3-1: Typical Resistivity Electrode Array Setup (Guideline Geo, 2024)

3.3 Depth of Investigation (DOI)

- The DOI is identified as the depth at which the sensitivity or cumulative contribution from the measurements falls below a threshold, indicating that the data at these depths are largely inferred rather than measured.
- The DOI estimate helps avoid over-interpretation of deeper layers and areas that may not be resolved to an extent where they accurately represent reality. This is represented as a shaded portion of the pseudo-section.

The geophysical pseudo sections are available in Section 4 of the report.

3.4 EC and Temperature Profiles

Electrical conductivity (EC) profiles of the three (3) new boreholes were measured at maximum intervals of 0.5m to assess changes in water chemistry with depth. These profiles provide insights into water quality, fracture zones, and groundwater flow characteristics with depth. Temperature was also logged for each borehole, and bulk water chemistry measurements were collected during the development phase of drilling to evaluate the initial chemical state of the water at each intersection. The EC profiles were taken using a Solinst TLC dip meter, while the field EC and pH was analysed using a HANNA probe. The results are discussed as part of the borehole characterization in Section 5.1

3.5 Slug Testing

To calculate the aquifer hydraulic properties, slug tests were conducted on each borehole. This test involved inducing a piezometric head change by injecting water into the boreholes, then measuring the recovery of the water level back to its rest water level. Data were used to calculate the hydraulic conductivity of the aquifer/s. The tests were conducted using an automatic piezometric level logger, and the data was analysed using the Bouwer and Rice (1976) solution for confined aquifer systems. The results are presented in Table 3-1:

Table 3-1: Slug Test Results

Results	OBS1	OBS2	OBS3
K [m/s]	9.75E-05	6.14E-06	3.24E-06
K [m/d]	8.42	0.53	0.28

The slug test results for the three boreholes revealed notable differences in hydraulic conductivity, with OBS1 showing high conductivity of **8.42 m/d**, while Boreholes 2 and 3 exhibited much lower values of **0.53 m/d** and **0.28 m/d**, respectively. The individual data fittings for each borehole interpretation are presented **Appendix A.** The resulting hydraulic conductivities are discussed as part of the borehole characterization in Section 5.1

4 ERT SURVEY RESULTS

ERT Surveys were conducted around the reported location of the spring to determine the most likely pathways of groundwater movement. Three (3) lines, with a total distance of ~1800m were conducted at the Mponeng TSF. The coordinates and details of the lines are presented in Table 4-1, with their locality and site the Mponeng TSF geology presented in Figure 4-5.

Table 4-1: Resistivity Survey Locations

Line ID	Line Length [m]	Start Coordinates (WGS84)		End Coordinates (WGS84)	
		Latitude (Y)	Longitude (X)	Latitude (Y)	Longitude (X)
Line 1	800	-26.448375	27.412105	-26.449542	27.404178
Line 2	200	-26.449243	27.408726	-26.451438	27.408812
Line 3	800	-26.451741	27.408671	-26.457854	27.404450

4.1 Line 1

Line 1 (Figure 4-1) is 800m long and located upgradient of the TSF and the seepage/spring area. In general, the resistivity of the area is very high (ranging from 100 Ohm.m to 2000 Ohm.m and upwards). Several electrodes failed directly within the suspected flow path of the spring. This indicates that the area has extremely high resistance, with the subsurface behaving as an electrical insulator. The zone of failure was investigated with a second electrode array (200m), and all electrodes failed in this area, ruling out the possibility of equipment failure.

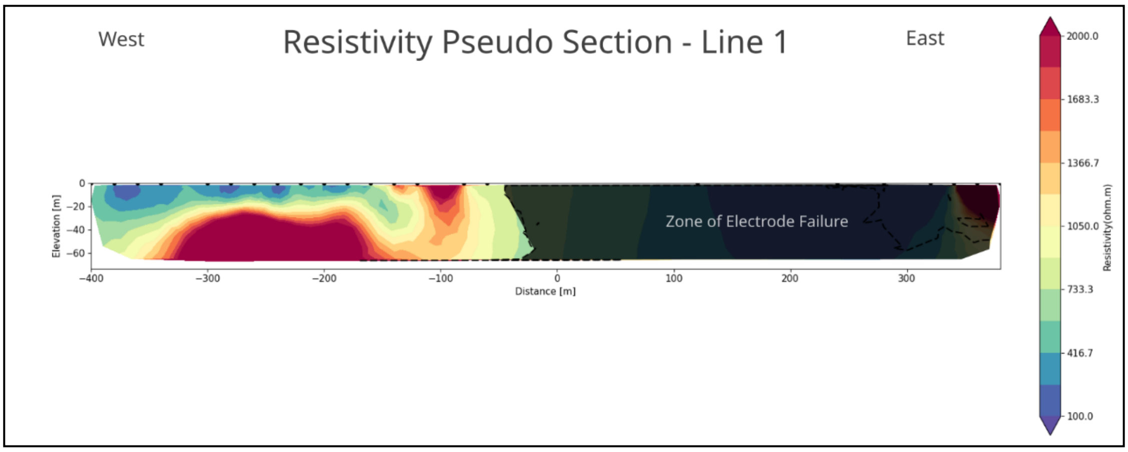


Figure 4-1: Pseudo Section (Line 1)

Due to the electrode failure, the shallow interception trench upgradient of this zone was inspected. Results revealed dry, weathered mudstone from very shallow depths. The dry mudstone particles and the air pockets between them are believed to be the cause of the electrode failure (refer to Figure 4-2).

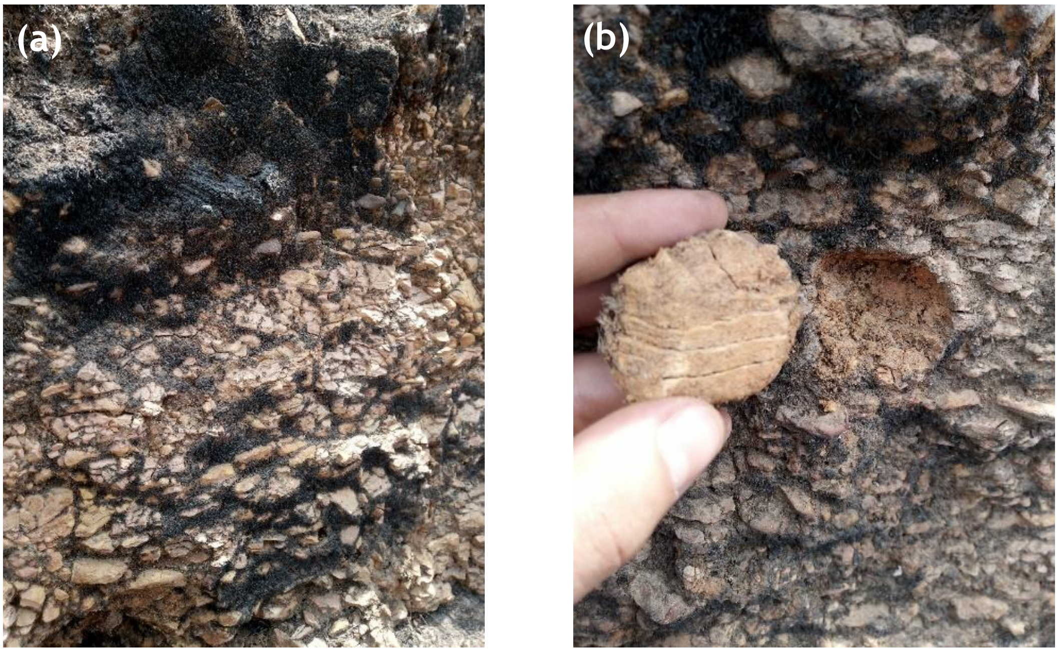


Figure 4-2: **A profile of the geology upgradient of the spring (a), and a close view of the mudstone clasts (b) the material is expected to have low infiltration potential.**

4.2 Line 2

Line 2 (Figure 4-3) is 200m long and located directly between the TSF and the area of seepage/spring flow. The resistivity in this zone trends from 7 Ohm.m to 50 Ohm.m and is much lower than was observed at line 1. This can be the result of elevated salt ions in the TSF material underlying the array. It is likely that this zone could be the result of toe seepage migrating under the TSF.

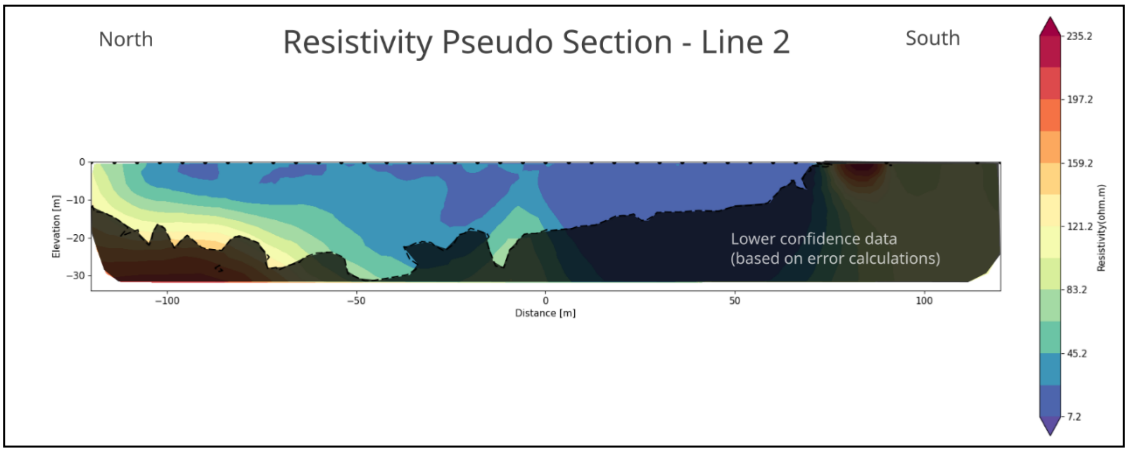


Figure 4-3: **Pseudo Section (Line 2)**

4.3 Line 3

Line 3 (Figure 4-4) is 200m long and located further south on the boundary of the TSF. The results indicate similarly low resistivity values in the range of 7 to 60 Ohm.m. a high resistivity (1200 Ohm.m) is present around the center of the survey line. This is likely caused by high resistivities on the contact zone between the two underlying lithologies.

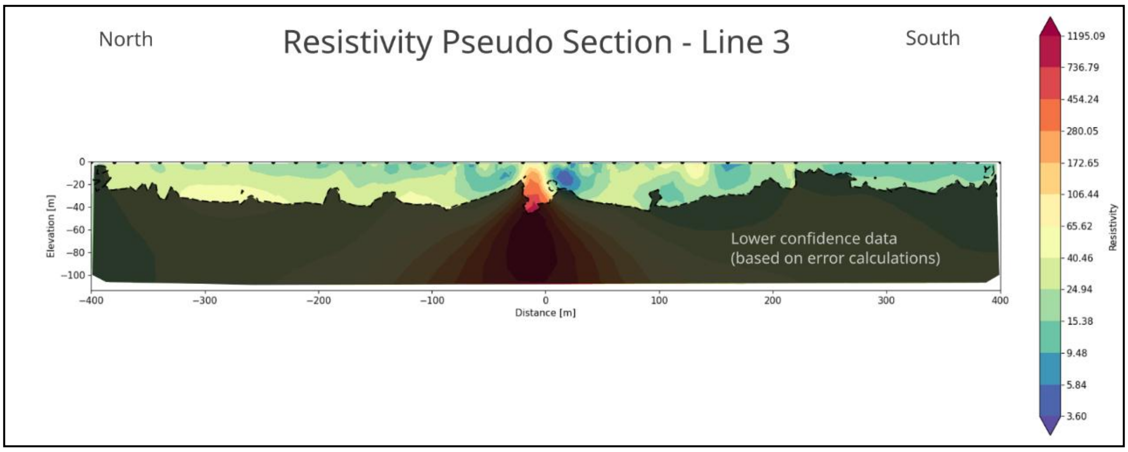


Figure 4-4: Pseudo Section (Line 3)

4.4 Conclusion

Line 1 indicates a more resistive profile (maximum readings of 2000 Ohm) than line 2 (maximum readings of 235.2 Ohm) and line 3 (max reading 1195 Ohm). Line 2 and 3, which are located downgradient of the Mponeng TSF both have less resistive profiles than line 1, which is located upgradient of the Mponeng TSF. Resistivity is lowered both by the solute content, and presence of groundwater in the subsurface. The results therefore indicate that shallow groundwater is present on the eastern toe slope of the TSF.

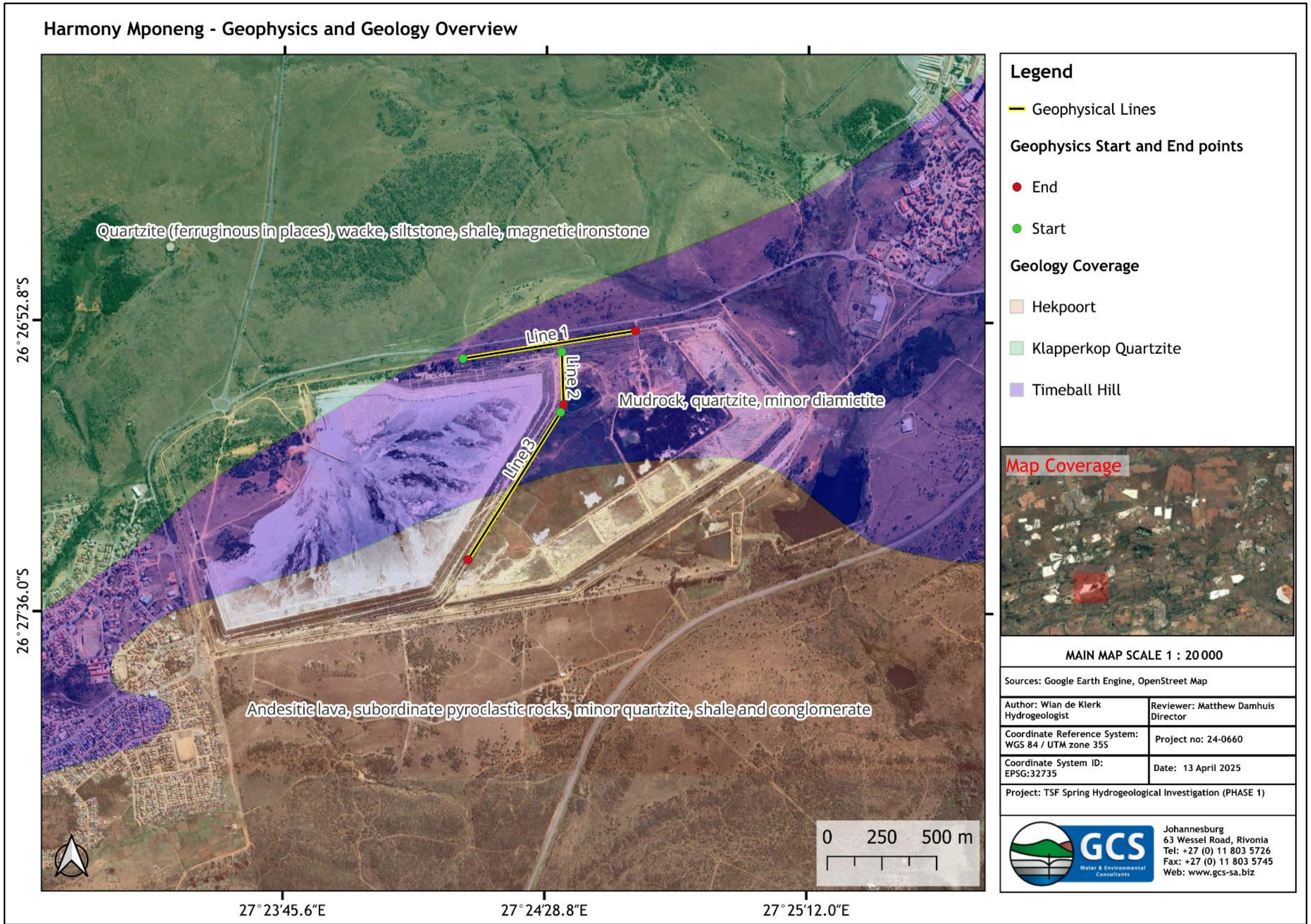


Figure 4-5: Geophysics locations and underlying geology (Geological Survey [South Africa], 1986)

5 DRILLING PROGRAMME

GCS conducted drilling of three (3) hydrogeological characterisation boreholes at the Mponeng TSF. The locations and the siting motivations of each observation borehole are provided in Table 5-1 and Figure 5-1. The location of NBH2 (GCS, 2024) is also indicated, as it is referred later in the report.

Table 5-1: Location of Observation Boreholes

Name	Coordinates (WGS84)		Siting Motivation
	x	y	
OBS1	27.40884	-26.44948	To investigate the location upgradient of the spring
OBS2	27.41359	-26.45675	To investigate the wetland south of the spring
OBS3	27.41641	-26.44795	To investigate ambient groundwater to the northeast of the TSF

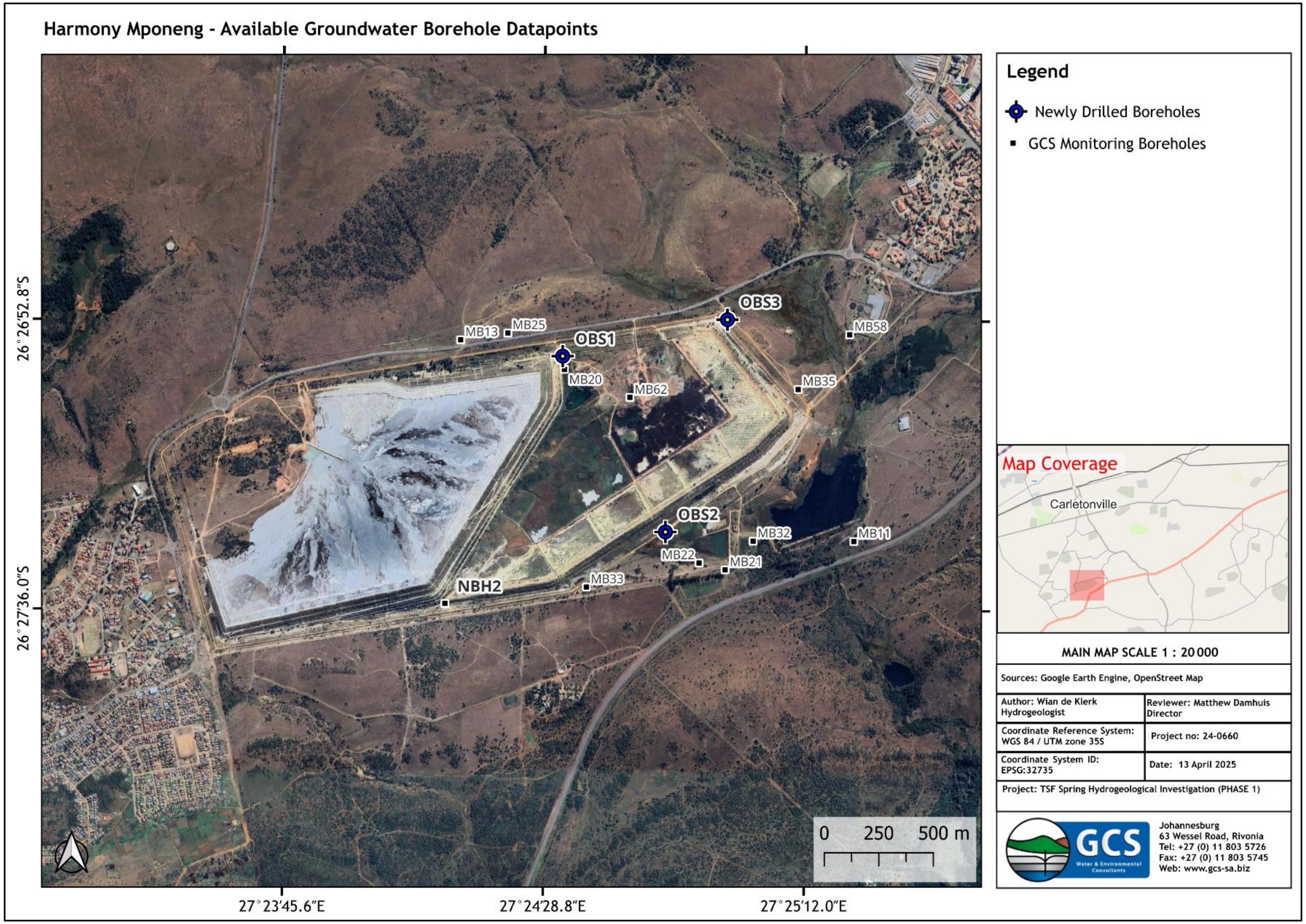


Figure 5-1: Overview of boreholes referenced in this report

5.1 Borehole Characterization

5.1.1 OBS1

OBS1 (Figure 5-2) was sited to the North of the Mponeng TSF, site of the spring to collect water chemistry data and determine if the water source is indeed a spring. The water level in this borehole was shallow, at 1.08mbgl. The hydrogeological log of borehole OBS1 is provided in Figure 5-5

Construction

OBS 1 was drilled to a depth of 24m and constructed with 177mm diameter steel casing down to a depth of 12m. The borehole was then fitted with 24m of Class 9 UPVC, Perforated from 3mbgl. The annulus was filled with gravel pack, and a lockable standpipe and cement block was installed for secure access.

Geology

The geology is red soil mixed with cobbles, gravels, and other materials. The varied formations between 2mbgl and 17mbgl are derived from authorized historical waste dumping at the Mponeng TSF (GCS, 2018), with varied composition among the gravel and cobble pieces. Two water strikes were noted in the borehole, a shallow water strike within the first meter with the most significant increase in water volume observed at the contact between the andesite and the weathered zone at 21mbgl.

EC and Temperature Profile

The water from OBS1 was generally clear during development with a low pH, low electrical conductivity (EC), and low total dissolved solids (TDS). The EC profile was taken 24 hours after drilling was completed, with lower values (below 500 µS/cm) observed from 11 to 18 meters. This represents the perforated section of the borehole. Above 11 meters (in the cased section with limited flow) and below 18 meters, the EC values were higher (approximately 1000 µS/cm).

After three days, a significant improvement in water clarity and quality was noted, with the EC dropping to ~200 µS/cm throughout the water column. This change indicates that drilling has disturbed conditions in the borehole, particularly visible in the upper and lower portions of the borehole, with the water returning to ambient conditions after a short time. These observations point to the presence of a stable, clean aquifer with minimal contamination

Hydraulic Conductivity

OBS1 had a tested hydraulic conductivity of 8.42 m/d (Section 3.5). This is an order of magnitude greater than OBS2 and OBS3 and indicates that OBS1 has increased flow potential relative to the other areas investigated.

Figure 5-2: OBS1 Headworks

5.1.2 OBS2

OBS2 (Figure 5-3) was drilled on the southern side of the Mponeng TSF, to be downgradient of potential environmental impacts, and within a wetland area. The water level in this borehole is artesian and pushed out above the upper confining clay layer once drilling has stopped. The hydrogeological log of borehole OBS2 is provided in Figure 6 5

Construction

OBS2 was drilled to a depth of 24m and constructed with 177mm diameter steel casing down to a depth of 9m. The borehole was then fitted with 24m of 165mm diameter, Class 9 UPVC, Perforated from 3mbgl. The annulus was filled with gravel pack, and a lockable standpipe and cement block was installed for secure access.

Geology

The uppermost layer, from 0 to 4 meters, consisted of humic black clay. Below which is a poorly structured light brown sludge from 4 to 10 meters, identified as fine TSF slurry. Below this, from 10 to 24 meters, black slate was encountered, similar the formation found upgradient of the Mponeng TSF. Artesian groundwater conditions were observed. This was also identified in borehole NBH2 (GCS project 24-0123) also drilled in the area south of the TSF. The artesian conditions in NBH2 were encountered within a water strike in the black shale formation. A similar water strike was encountered at OBS2 at a depth of 10m.

EC and Temperature Profile

The EC of OBS2 revealed saline conditions relative to the other boreholes at the Mponeng TSF, with EC values exceeding 4000 µS/cm (an order of magnitude above readings in OBS1 and OBS2).

The artesian conditions of OBS2, considered in conjunction with the elevated EC readings relative to OBS1 and OBS3 (a result of increased solute load) indicates that the downgradient groundwater system chemistry and flow behaviour is being altered by the Mponeng TSF.

Hydraulic Conductivity

OBS2 had a tested hydraulic conductivity of 0.53 m/d (Section 3.5).

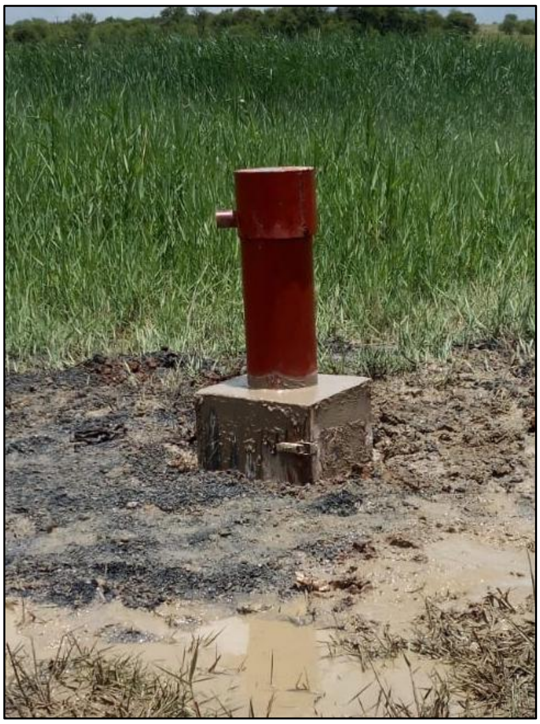


Figure 5-3: OBS2 Headworks

5.1.3 OBS3

OBS3 (Figure 5-4) was drilled to the northeast of the TSF to assess piezometric water levels and evaluate geological conditions, as no prior datapoints were available in this area. A summary page of OBS3 is provided in Figure 5-7.

Construction

OBS 2 was drilled to a depth of 24m and constructed with 177mm diameter steel casing down to a depth of 9m. The borehole was then fitted with 24m of 165mm diameter, Class 9 UPVC, Perforated from 3mbgl. The annulus was filled with gravel pack, and a lockable standpipe and cement block was installed for secure access.

Geology

The borehole revealed a surface layer (2m thick) of yellow-brown soil, underlain by red-brown mudstone that was moist from 6 to 8 meters in depth. Below this, the geology transitioned into yellow-brown mud and eventually black slate at greater depths (16 meters. A water strike was encountered at 16 meters, corresponding to the contact zone between the mudstone and black slate).

EC and Temperature Profile

OBS3 showed very clear water with a low EC of 180 µS/cm and TDS of around 90 ppm. The pH was slightly basic at 8.1, and the water quality appeared unaffected by TSF pollution. The EC profile was heterogeneous, with slightly lower EC values near the static water level compared to the deeper sections of the borehole. This indicates that some surface water contributes to the borehole at shallow depths, but most of the water appears to originate from the black shale formation.

The temperature profile of Borehole 3 is particularly notable. Surface water temperatures were around 21°C but dropped quickly to 19.5°C at 10 meters, with the primary water strike at 16 meters. This suggests that the colder, cleaner water originates from a deeper, confined or semi-confined aquifer in the black shale. The borehole’s low EC and stable temperature profile indicate high-quality groundwater with minimal influence from surface or anthropogenic contaminants

Hydraulic Conductivity

OBS2 had a tested hydraulic conductivity of 0.28 m/d (Section 3.5).

Figure 5-4: OBS3 Headworks

Name: OBS1	Date:14/01/2025	EC Profile	Temperature Profile	Geological Strip Log & Borehole Construction

Description of Construction

Depth	Component
0 - 12	Solid Steel 177mm
0 -3	Solid Class 9 UPVC
3 - 24	Perforated Class 9 UPVC
0 - 24	Gravel Pack

Comments / Observations

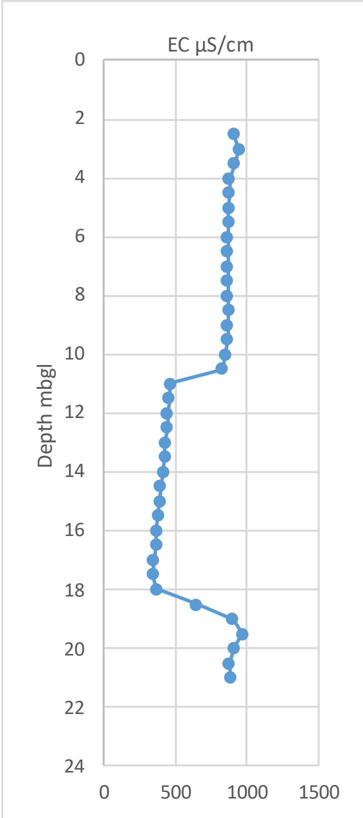
Water chemistry during development:

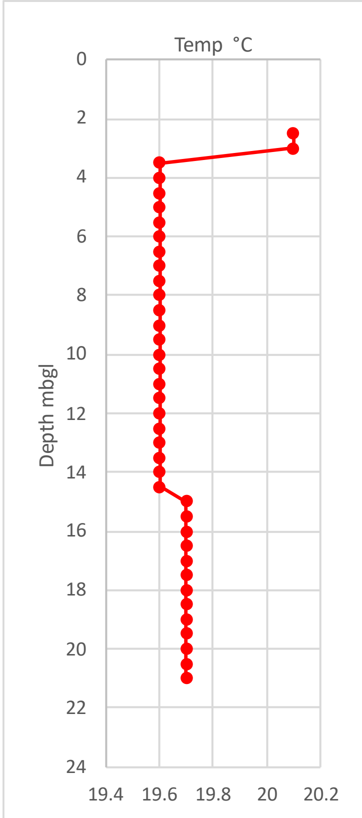
PH	6.1
EC	300 µS/cm

During the EC profile, low EC flow was found in the middle-perforated section of the borehole (11m-18m), however after 3 days the whole borehole had an EC of ~234 µS/cm

Water Strikes: 1m, 21m

Static water level: 1.08 mbgl





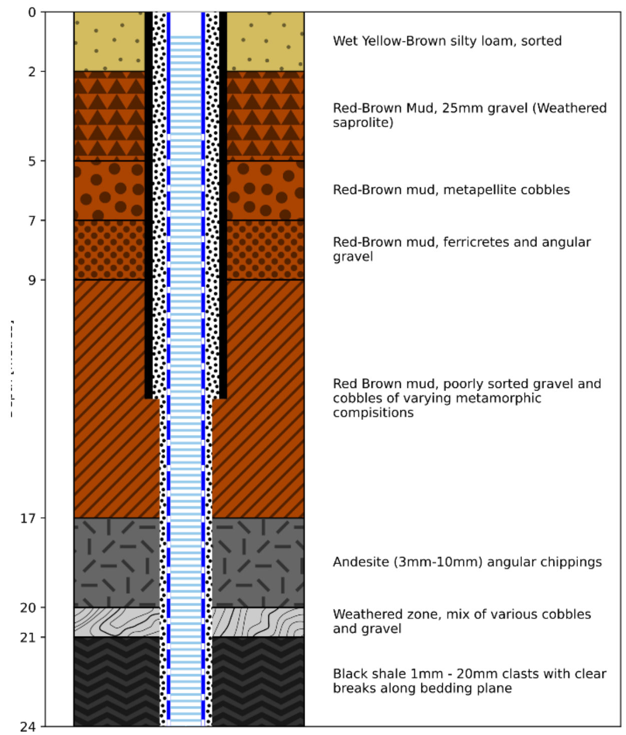


Figure 5-5: Borehole OBS1 hydrogeological log

Name: OBS2	Date:15/01/2025	EC Profile	Temperature Profile	Geological Strip Log & Borehole Construction

Description of Construction

Depth	Component
0 - 9	Solid Steel 177mm
0 -3	Solid Class 9 UPVC
3 - 24	Perforated Class 9 UPVC
0 - 24	Gravel Pack

Comments / Observations

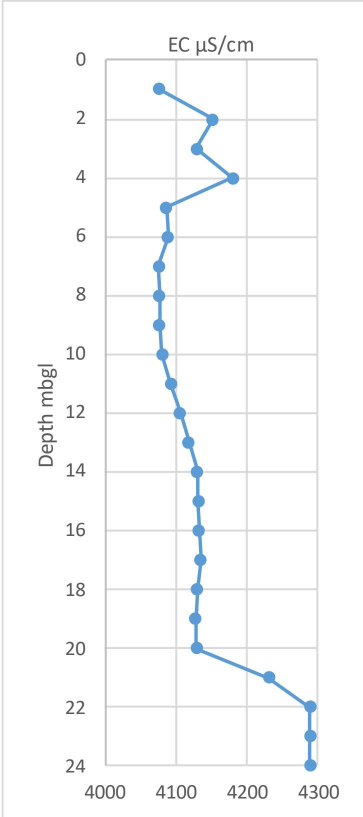
Water chemistry during development:

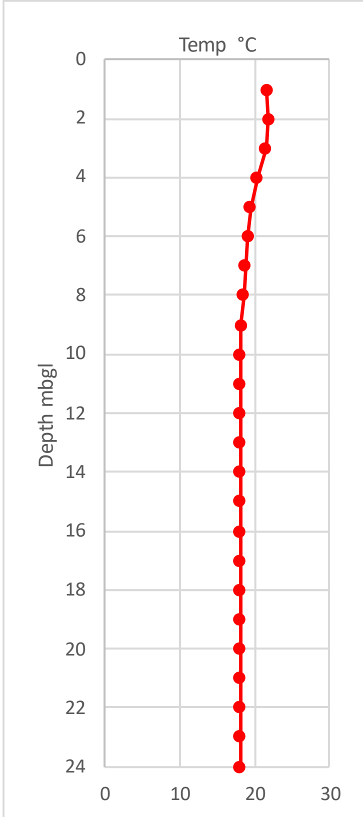
PH	7.1
EC	4170 µS/cm

Water had a silver biofilm on top during sampling.

Water Strikes: 1m, 4m, 10m

Static water level: Artesian





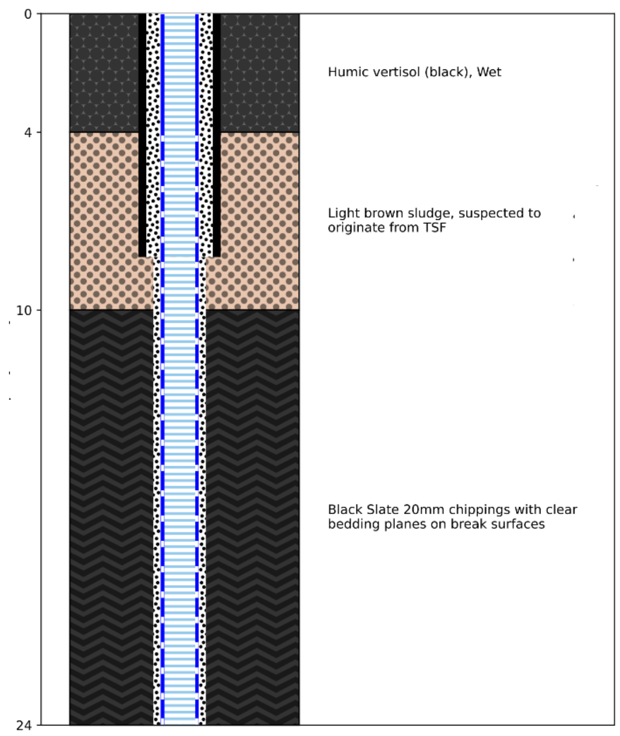


Figure 5-6: Borehole OBS2 hydrogeological log

Name: OBS3	Date:16/01/2025
Description of Construction	
Depth	Component
0 - 12	Solid Steel 177mm
0 -3	Solid Class 9 UPVC
3 - 24	Perforated Class 9 UPVC
0 - 24	Gravel Pack

Comments / Observations

Water chemistry during development:

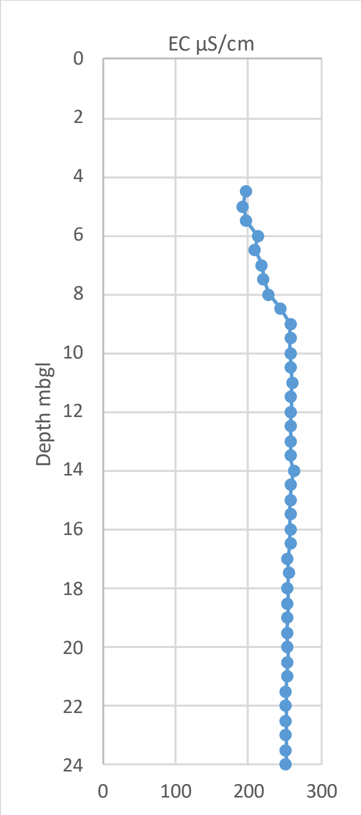
PH	8.1
EC	180 µS/cm

Water appears clean.

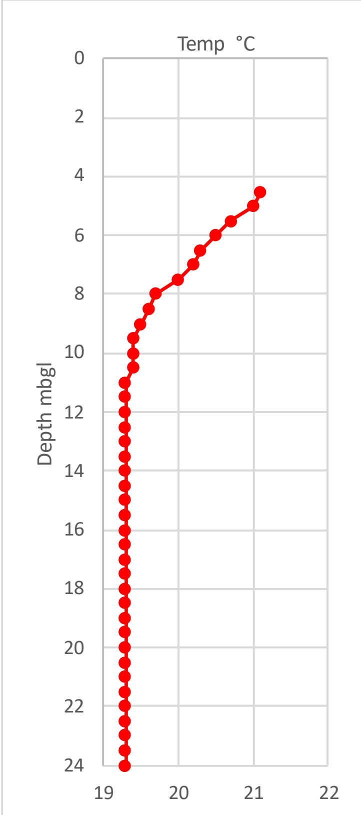
Water Strikes: 16m

Static water level: 3.4 mbgl

EC Profile



Temperature Profile



Geological Strip Log & Borehole Construction

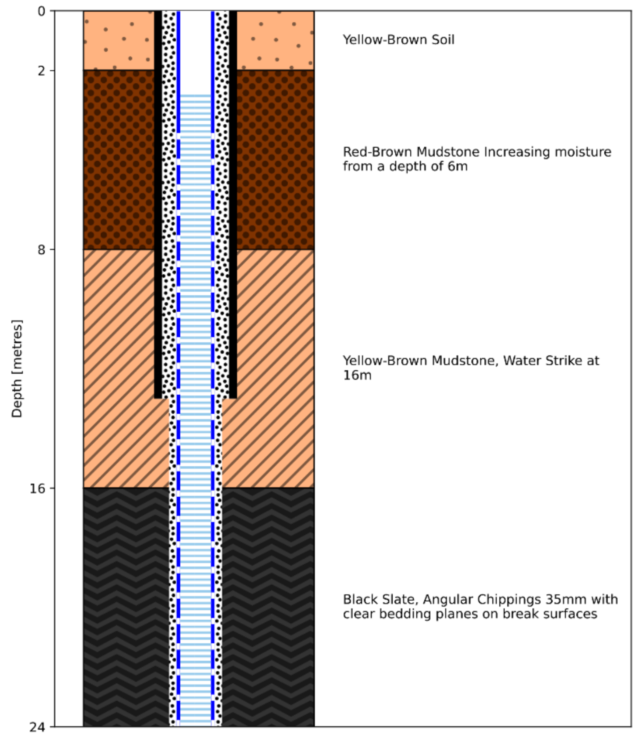


Figure 5-7: Borehole OBS3 hydrogeological log

6 HYDROGEOLOGICAL CONCEPUALIZATION

6.1 Regional Geology & Structure

The Mponeng TSF Area is constructed on top of Pretoria Group sediments belonging to the Transvaal Supergroup (Figure 6-1). The Timeball Hill quartzite formation forms the Gatsrand, also known as the West Witwatersrand ridge, and makes up the geology to the north, upgradient of the Mponeng TSF. To the south of the ridge the ground slopes away under the Timeball hill shales towards the valley. The predominant portion of the Mponeng TSF is built upon the Timeball hill shales without the presence of a geomembrane or lining material, allowing hydraulic interaction between the TSF and underlying aquifer. The Hekpoort andesite discordantly overlies the sedimentary formations on the southern perimeter of the Mponeng TSF property

Several fault related lineaments can be observed in the area (refer to in Figure 6-1 and Figure 6-2). The lineaments trend in a north-westerly direction – perpendicular to the strike of the Transvaal supergroup sediments and metasediments (GCS, 2019).

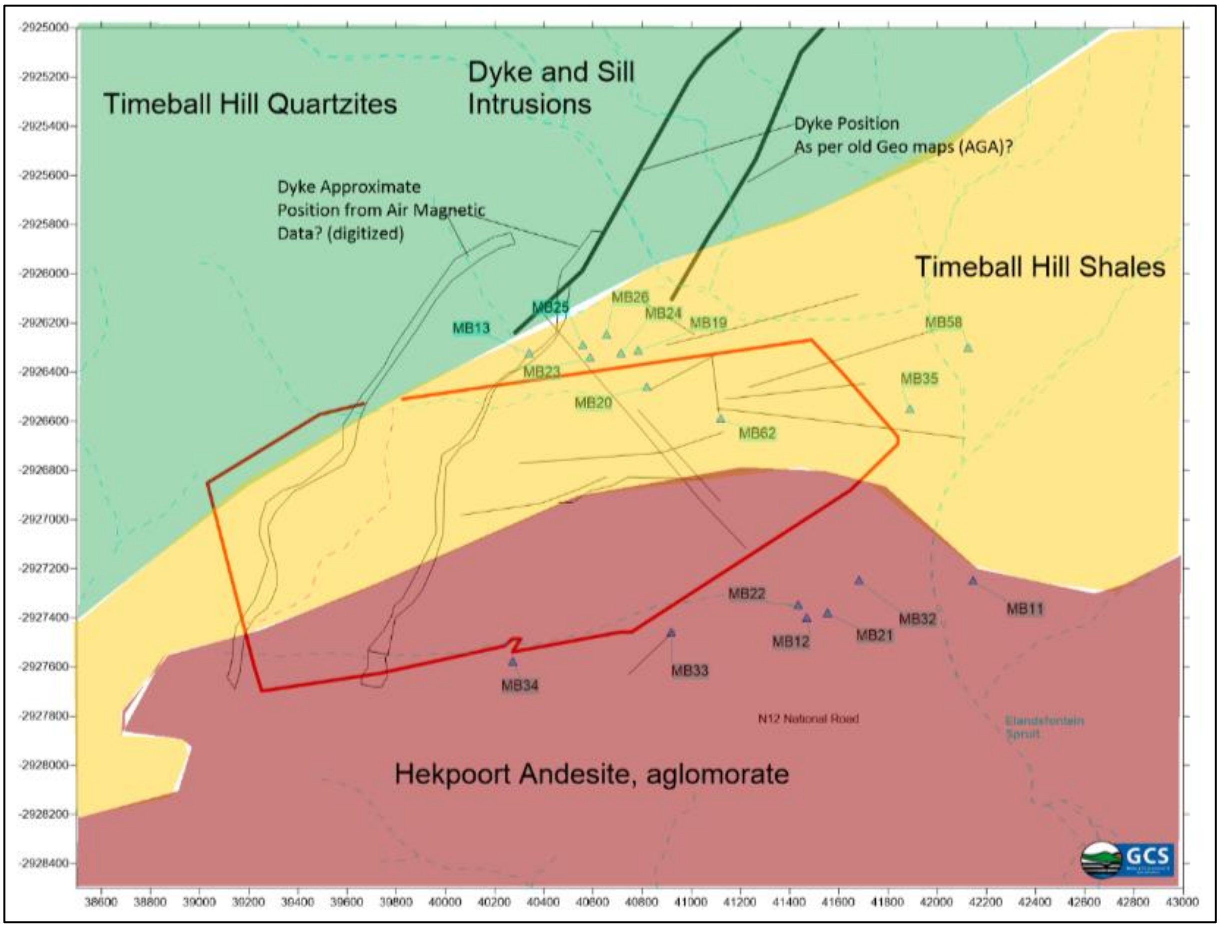


Figure 6-1: Regional Geological Setting with potential dyke locations (GCS, 2019)

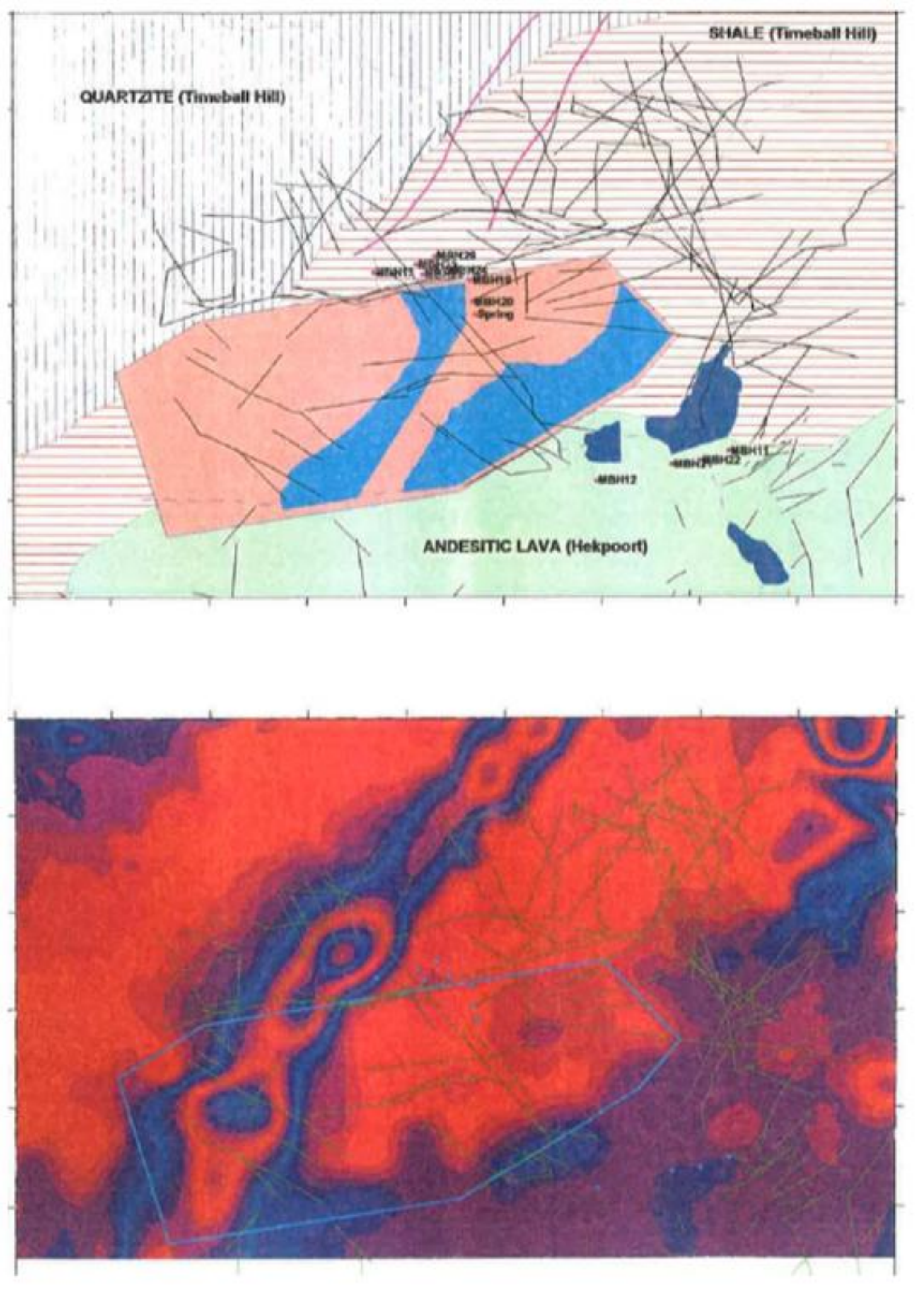


Figure 6-2: Structural lineaments mapped and site-specific aeromagnetic data (GCS, 2019) taken from (Van Rensburg & Bush, 2001)

6.2 Hydrogeological Conceptualization

The Mponeng TSF conceptual model integrates data from prior GCS investigations, supplemented by this investigation which included geophysics, drilling, slug testing and EC profiling.

To investigate the shale formation, its depth was calculated using the 3-point method from available areas of known geological intersection (Figure 6-6). The results show that changes in the apparent strike and dip of the shale occur between the north and south portions of the Mponeng TSF. This is the result of a geological lineament or fault.

Available monitoring data for the Mponeng TSF was used to create coverage datasets representing groundwater elevation (Figure 6-4), groundwater EC distribution (Figure 6-3), and a calculated delineation of potential artesian sites at the TSF (Overlay of areas where the piezometric GW level exceeds the surface topography, refer to Figure 6-5). The processed dataset used to create these coverages is provided in Appendix B.

The spring is located upgradient of the TSF and the groundwater quality indicated that the spring is not impacted on by the TSF seepage before the water reaches surface. The groundwater TDS increases by roughly 4000 µS/cm between OBS1 and OBS2, indicating that interaction is taking place between the spring water, and contaminated rainwater seepage from old portions of the Mponeng TSF. The general direction of groundwater movement is in a southeast direction (Figure 6-4).

6.2.1 Cross Sections

Furthermore, conceptual cross sections (Figure 6-7) were drawn from geological data that was acquired from OBS1, OBS2 and NBH2. Data for NBH2 is sourced from project 24-0321 (GCS, 2024). Based on this information, the TSF was constructed on top of and to the south of the shale outcrop and surrounding geological contacts (Cross section AC). The TSF is not lined with a geomembrane which results in the contaminated rainwater seepage from the TSF recharging the underlying aquifer/s, resulting in a contamination plume that will migrate downgradient towards the toe of the TSF.

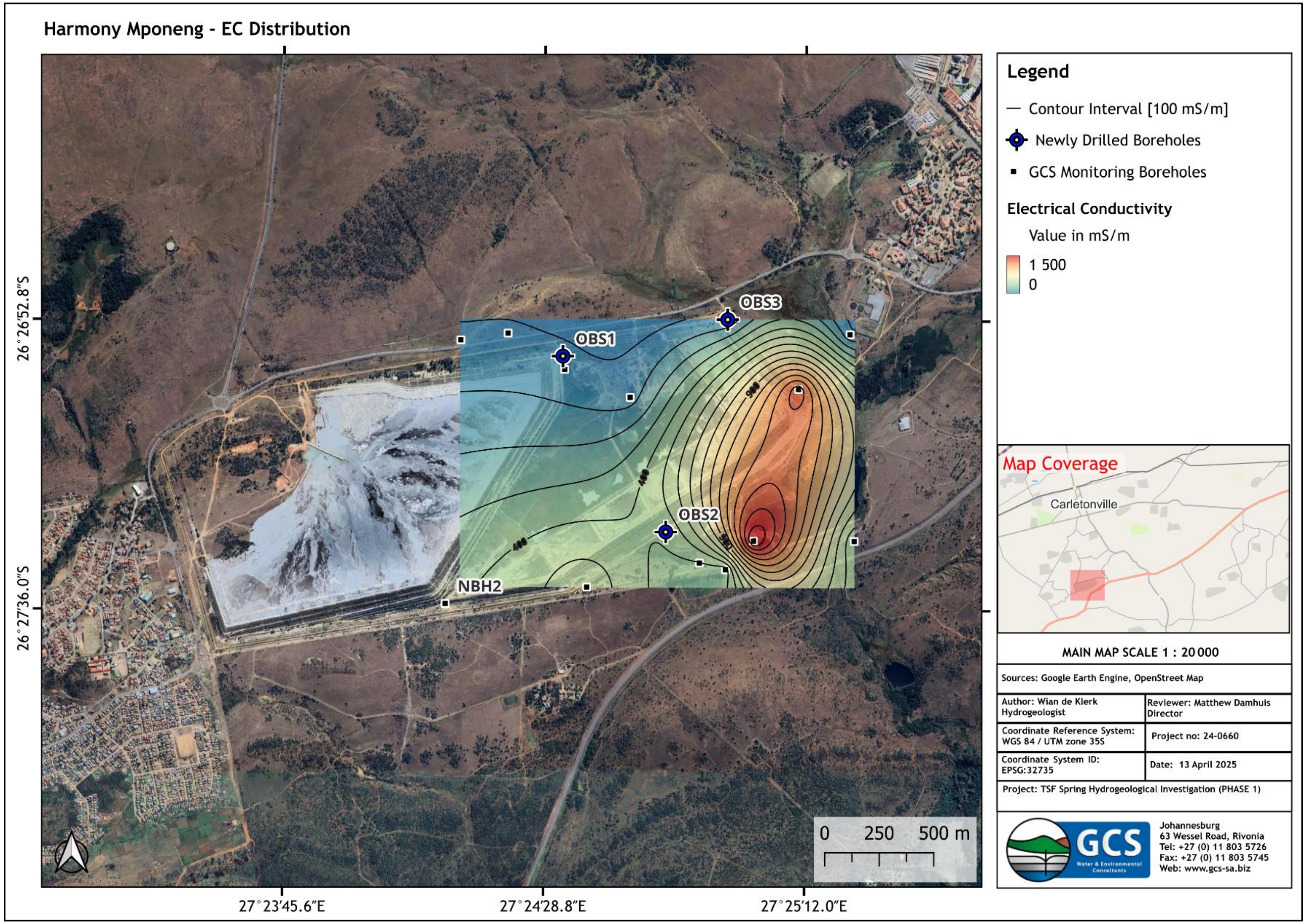


Figure 6-3: Groundwater EC map based on latest available monitoring data

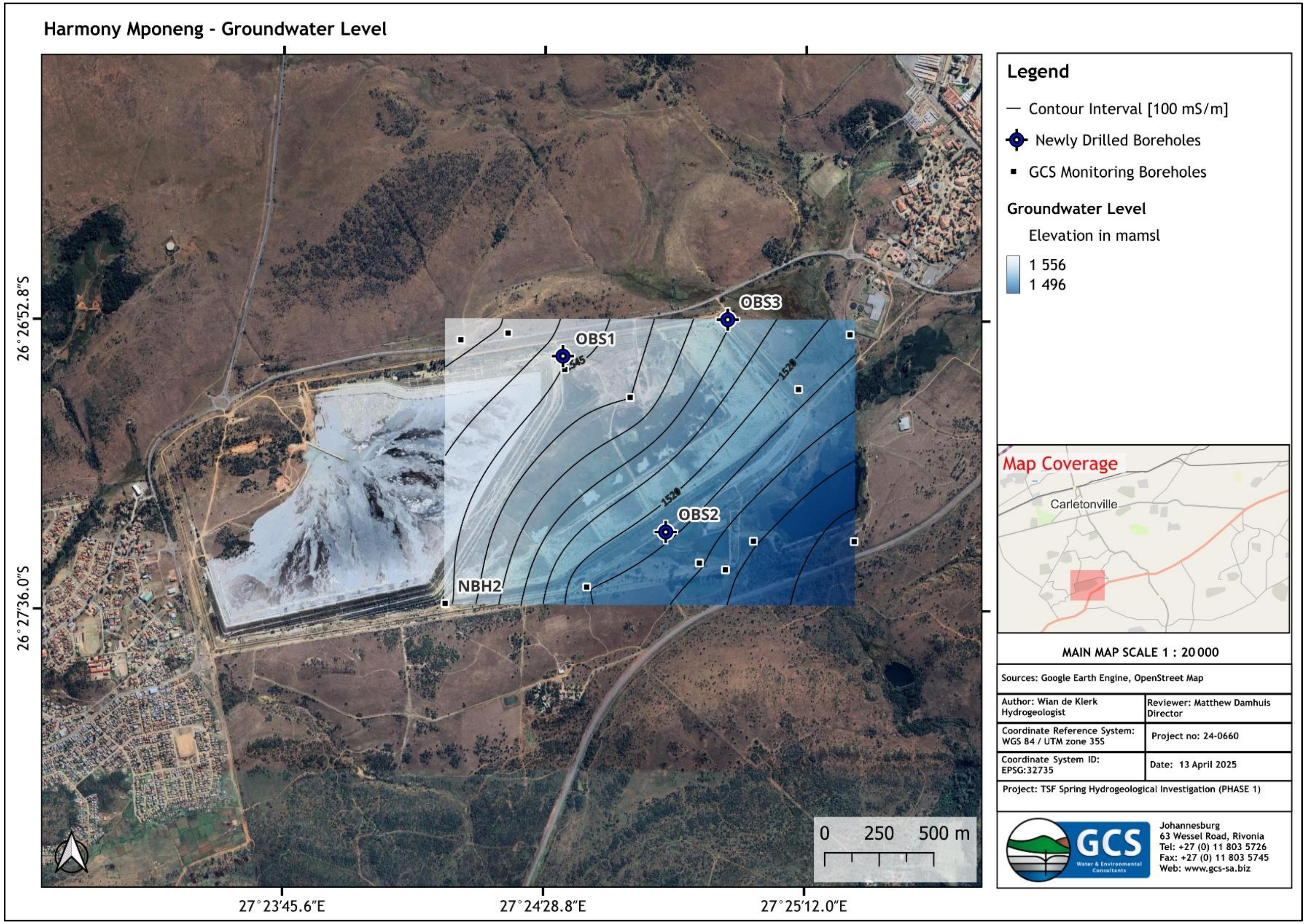


Figure 6-4: Groundwater level map based on latest available monitoring data

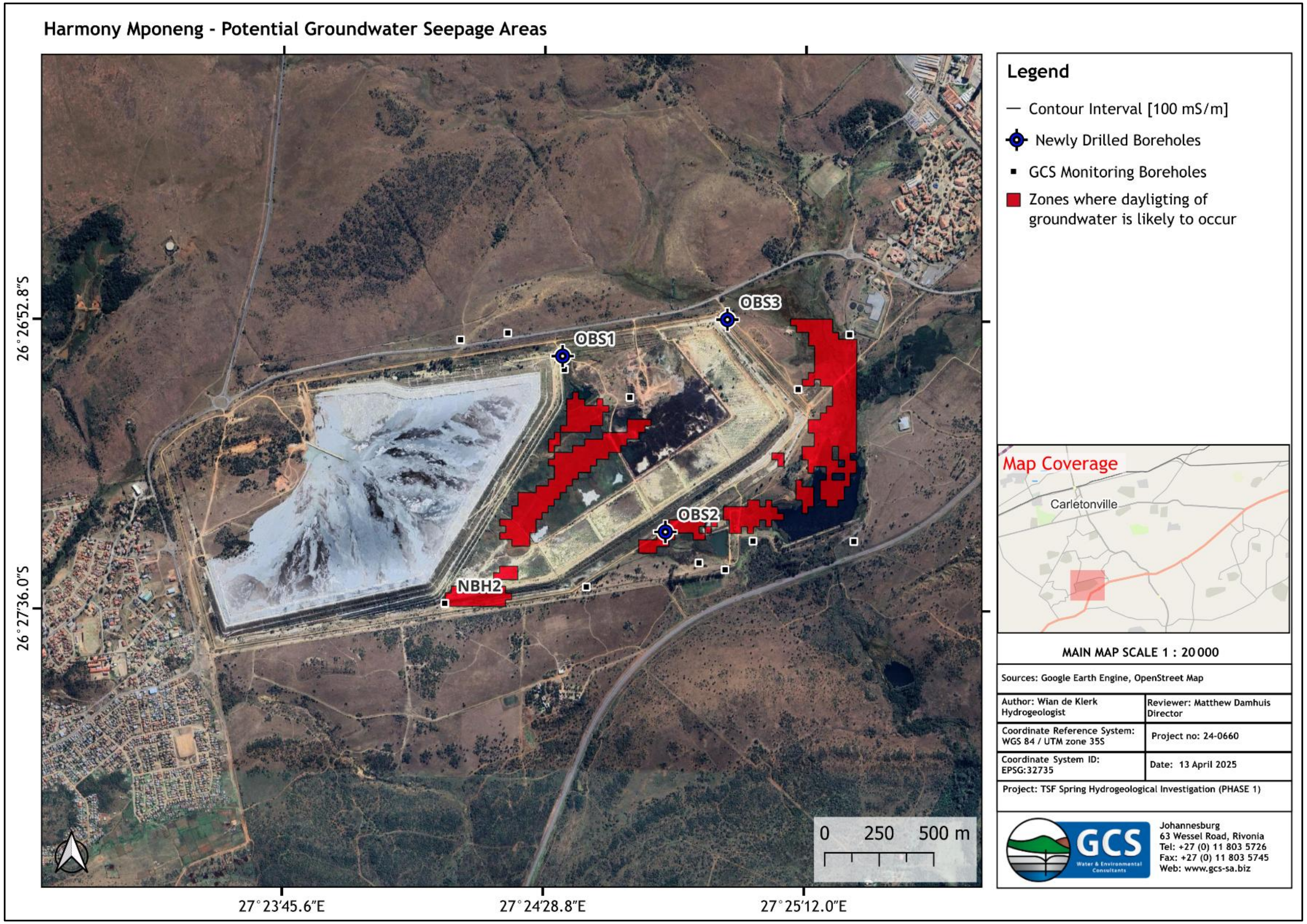


Figure 6-5: Potential areas of artesian conditions indicated in red.

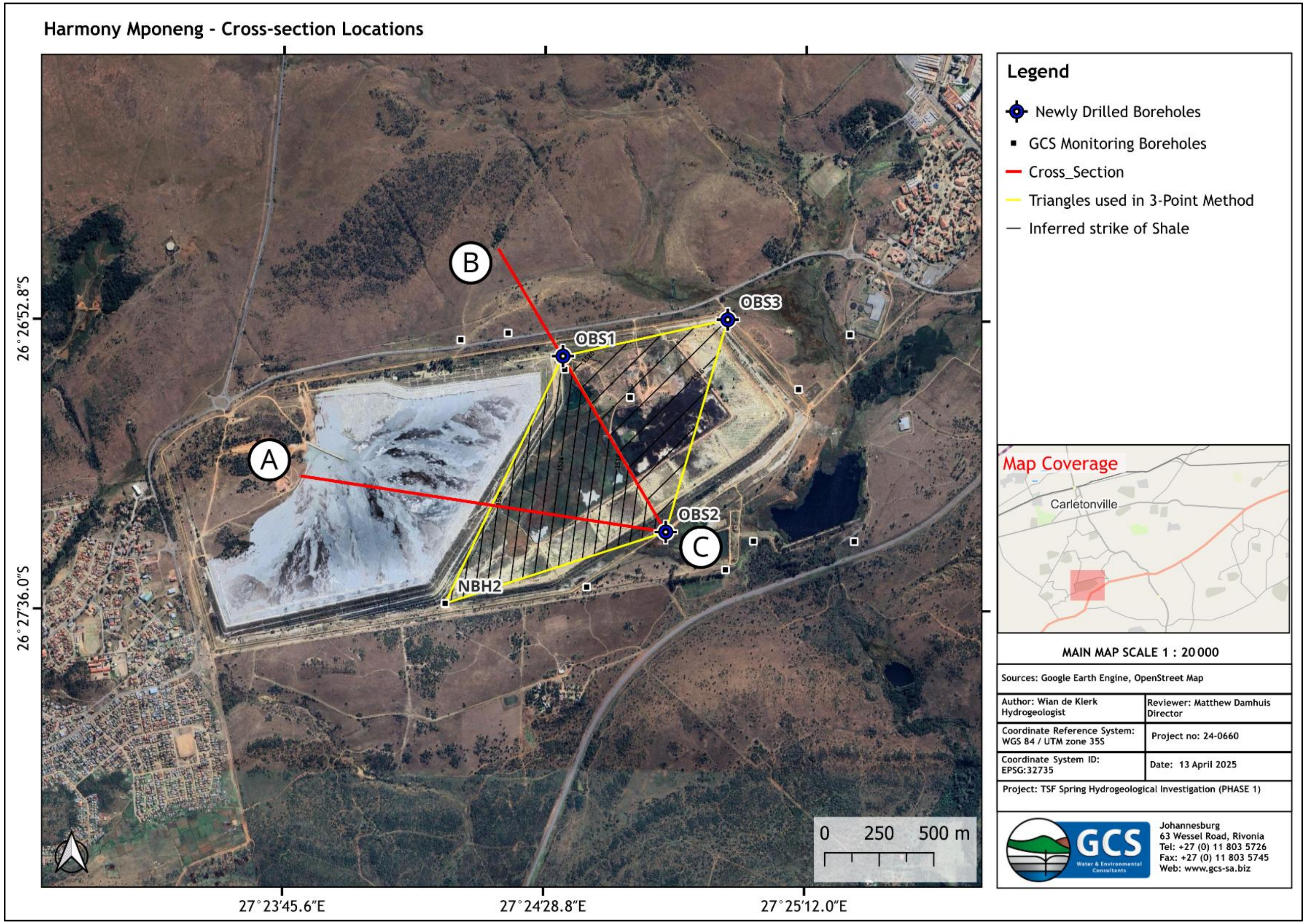


Figure 6-6: Overview of the inferred shale layer dip directions using the 3-point method. Cross-sections indicated in red.

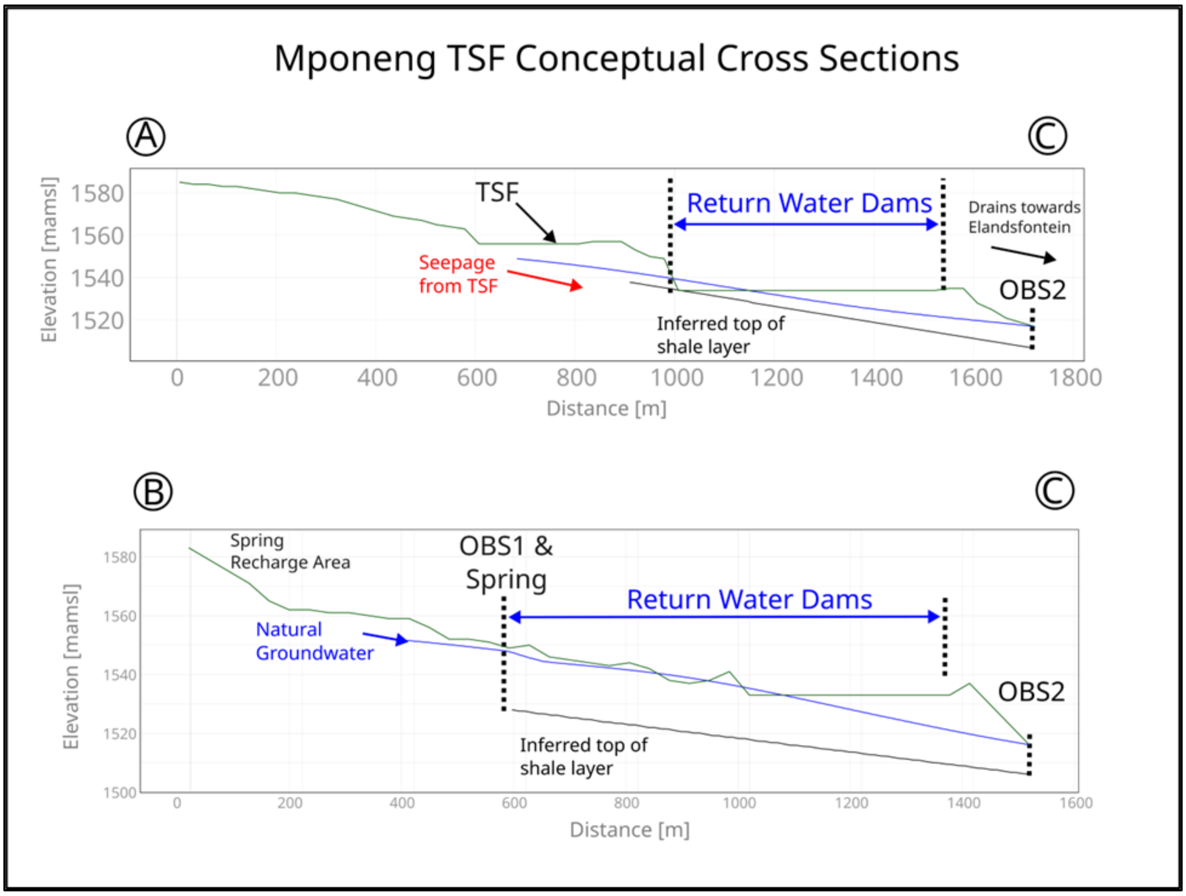


Figure 6-7: Cross Sections as indicated on Figure 6-6
Green = Topography, Black = Top of Shale Layer, Blue = Groundwater level

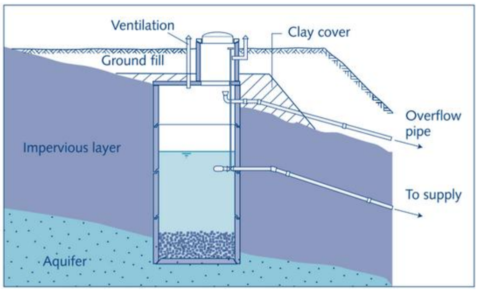
6.3 Mitigation Strategy

Mitigating these environmental impacts will require a multifaceted approach. Addressing the spring at the northeast side of the TSF will help reduce the volume of water exposed to potential contamination, this alone will not resolve the broader issue of rainwater infiltration interacting with contaminants from the TSF before moving into the local aquifer system. Recommendations for mitigation include the following:

1. **Management of the Spring**: GCS recommends that a spring capture system be implemented north of the TSF. Several techniques can be considered
   a. Spring Boxes: Concrete or steel structures built around the spring to collect water. Water is then transferred via a network of pipes connected to the collection structure (refer to Figure 6-8).
   b. Horizontal Drains: Pipes or drains installed into the hillside upgradient of the Mponeng TSF to intercept groundwater before it daylights at the spring, redirecting it safely (refer to Figure 6-9).
   c. Gravel Packs and French Drains: Used to enhance water collection while minimizing sediment entry (refer to Figure 6-10).

2. **Management of Stormwater Runoff:** To more effectively reduce the amount of rainwater interacting with the TSF, and thereby decrease the volume of contaminated rainwater seepage, it is proposed that the stormwater management plan and associated infrastructure north of the TSF be assessed and updated. The existing storm water diversion trench will need to be extended to fully intercept all runoff north of the TSF

3. **TSF Seepage Mitigation**: To address the expected contaminant plume emanating from the unlined TSF, scavenger boreholes can be used to intercept and abstract groundwater from the aquifer for treatment before it impacts downgradient water sources. This will help protect vital resources like the nearby spruit and other downgradient ecosystems. It is envisaged that these boreholes are to remain operational until rehabilitation of the TSF is complete and the TSF rainwater seepage quality improves.



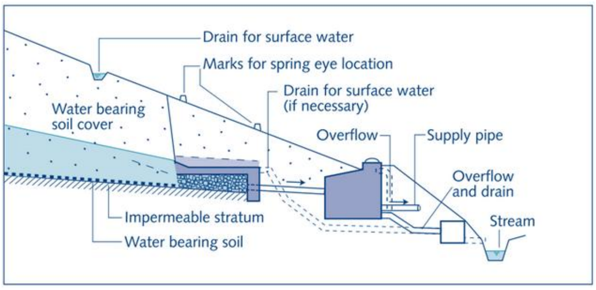
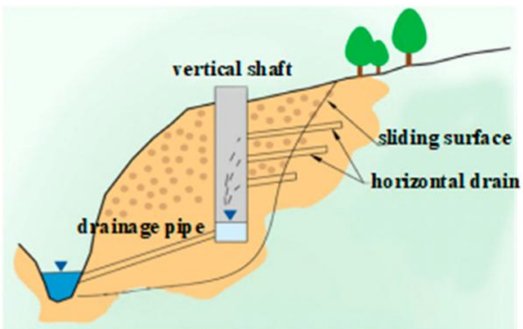


Figure 6-8: Example of Spring Boxes for confined (left) and unconfined (right) systems (Smet & van Wijk, 2002)



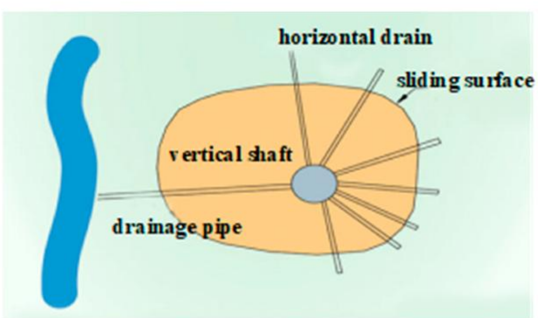


Figure 6-9: A side view (left) and top view (right) of a horizontal drain system (Soil and Water Conservation Bureau, 2003)

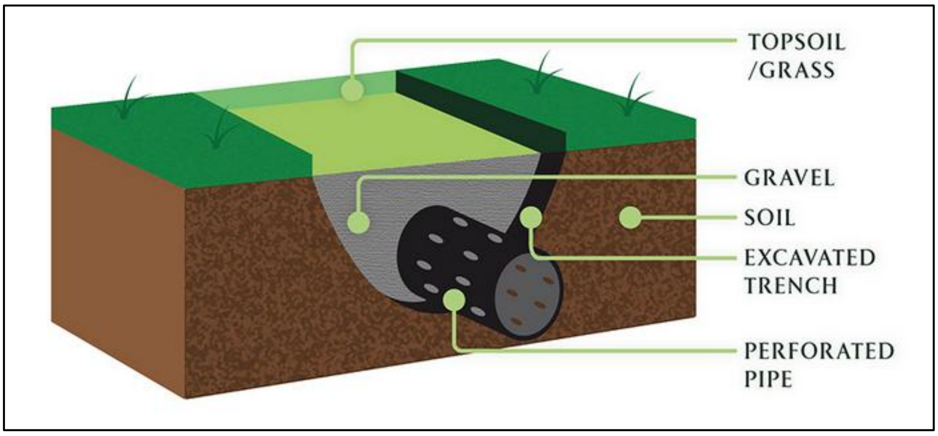


Figure 6-10: French Drain System (Grade Solutions, 2025)

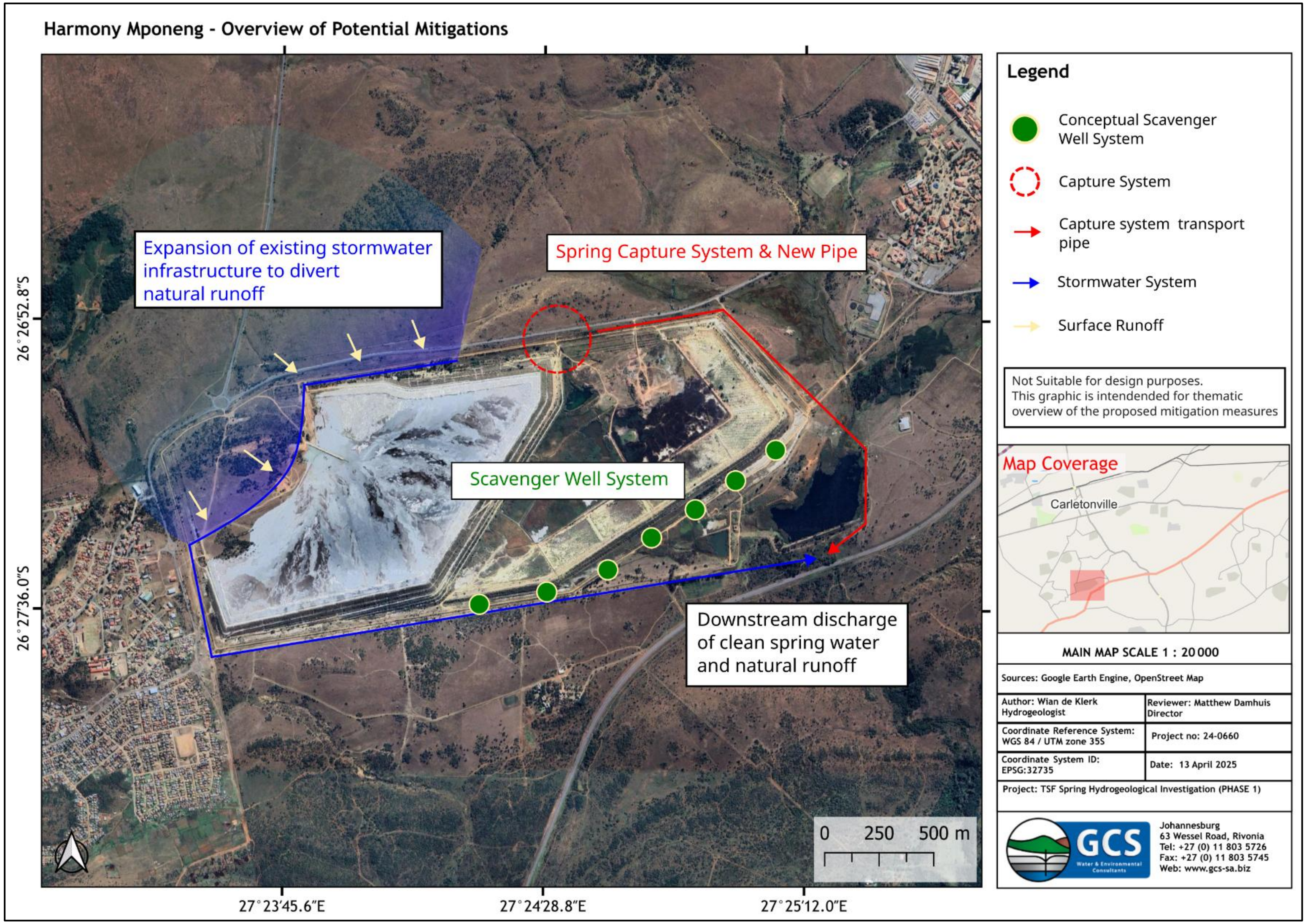


Figure 6-11: Conceptual Overview of each respective mitigation strategy proposed.

7 CONCLUSION

The investigation conducted on the Mponeng Tailings Storage Facility (TSF) and its surrounding areas has resulted in the following findings:

- **The Spring**: Elevated hydraulic conductivities (Section 3.5) and low EC values (Section 5.1.1) in borehole OBS1 confirm the existence of a spring near the return water dam north of the TSF. This is a natural spring, resulting from a geological fault or lineament, and is contributing clean groundwater (sourced from the north of the TSF) to the area. The spring is at risk of contamination due to its interaction with contaminated rainwater seepage from the TSF.
- **Contaminated Groundwater Recharge**: The southern side of the TSF exhibits artesian conditions and increased solute load (OBS2 discussed in Section 5.1.2). Rainwater interacts with the unlined Mponeng TSF and results in undesirable migration of contaminated rainwater seepage into the subsurface, posing a risk to local groundwater quality and downstream receptors such as the Elandsfonteinspruit. The artesian conditions observed during the investigation are the result of groundwater mounding caused by the TSF. Elevated water levels in the TSF increase the piezometric pressure exerted on the groundwater south of the TSF, when a pressure release pathway is opened through drilling through competent geology into a fractured section of the shale formation
- **Mitigation Strategy Recommendations**: The report outlines a multifaceted approach to mitigate the identified environmental impacts, emphasizing the need for:
  - Spring Capture Systems
  - an updated Stormwater Management Plan and infrastructure north of the TSF
  - the strategic use of scavenger boreholes to intercept and treat contaminated groundwater before it impacts downgradient water systems.

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APPENDIX A - SLUG TEST ANALYSIS FITS

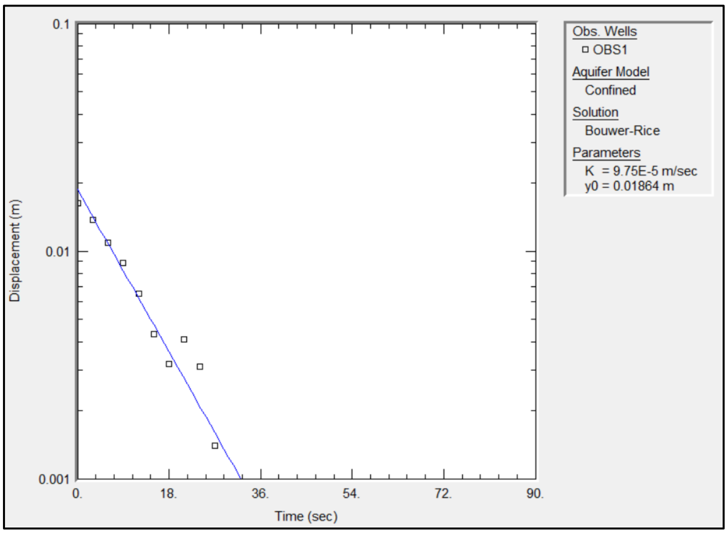

Figure 8-1: Slug test for OBS1

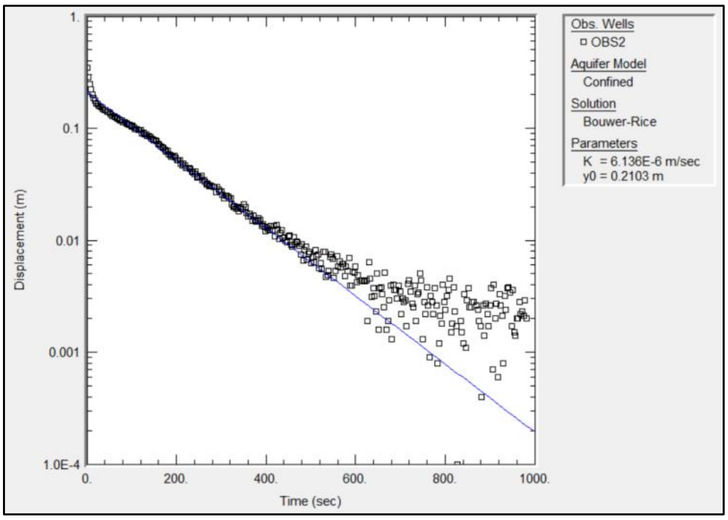

Figure 8-2: Slug test for OBS2

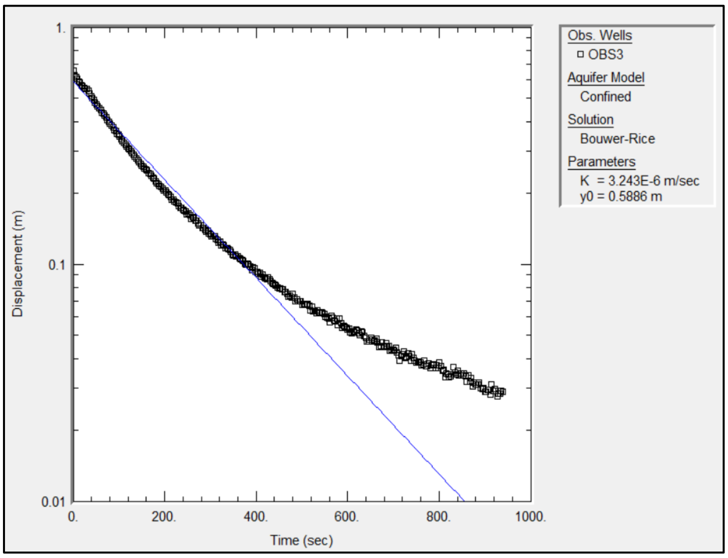

Figure 8-3: Slug test for OBS3

APPENDIX B – MONITORING DATA USED TO CREATE AREAL COVERAGE DATASETS (WATER LEVEL & EC MAPS)

ID	Coordinates (WGS84)		Avg Water Level 2023 [mbgl]	Avg EC 2023 [mS/m]
	x	y		
MB11	27.42225	-26.45713	4.43	401.74
MB13	27.40414	-26.44882	4.15	20.25
MB20	27.40892	-26.45003	4.59	39.77
MB21	27.41634	-26.45831	6.69	347.12
MB22	27.41514	-26.45803	2.19	394.68
MB25	27.40631	-26.44854	4.45	23.69
MB32	27.41762	-26.45712	4.43	1622.31
MB33	27.40996	-26.45904	11.73	583.54
MB35	27.41967	-26.45083	2.01	1365.52
MB62	27.41193	-26.45119	1.89	52.87
MB58	27.42203	-26.44856	N/A	18.57
OBS1	27.40884	-26.44948	1.08	300.00
OBS3	27.41641	-26.44795	3.40	180.00
NBH2	27.40346	-26.45974	-1.50	N/A
OBS2	27.41359	-26.45675	-0.15	417.00