DIGBY WELLS
ENVIRONMENTAL

Environmental Impact Assessment for the Blyvoor Gold Mining Project, West Rand, Gauteng

Surface Water Impact Assessment

Project Number:

BVG4880

Prepared for:

Blyvoor Gold Capital (Pty) Ltd

October 2018

Digby Wells and Associates (South Africa) (Pty) Ltd
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This document has been prepared by Digby Wells Environmental.

Report Type:	**Surface Water Impact Assessment**
Project Name:	**Environmental Impact Assessment for the Blyvoor Gold Mining Project, West Rand, Gauteng**
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Name	**Responsibility**	**Signature**	**Date**
Daniel Fundisi	Report Writer		19 October 2018
Mashudu Rafundisani	Technical Review		19 October 2018
Andre Van Coller	OpsCo Review		06 September 2018

EXECUTIVE SUMMARY

Digby Wells Environmental (hereinafter Digby Wells) was appointed by Blyvoor Gold (Pty) Ltd (hereinafter Blyvoor Gold) to undertake a hydrological impact assessment as part of an Environmental Application Process to obtain the required authorisation to recommence operations at the Blyvoor Gold Mine. The Blyvoor Gold Mine project site is located in the West Rand, approximately 6 km from Carletonville within the Gauteng Province of South Africa.

Blyvooruitzicht Gold Mine (Pty) Ltd (BGMC) was placed under provisional liquidation in August 2013. The Mining Right relevant to the former Blyvooruitzicht operation was acquired by Blyvoor Gold Capital (Pty) Ltd through transfer in terms of Section 11 of the Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA).

The purpose of this application is to approve the existing operations at the Blyvoor mine and to align the existing documentation pertaining to the operations to the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and the Environmental Impact Assessment (EIA) Regulations, dated 2014 (as amended in 2017). Furthermore, two metallurgical processing plants are required to be authorised as part of this application, as well as the reclamation of eight Tailings Storage Facilities (TSFs).

Baseline Hydrology

- The Vaal Water Management Area 5 (WMA 5) and quaternary catchment C23E demarcate regional hydrological boundaries in which the Blyvoor Gold Mine project site is located.
- The Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR) and Mean Annual Evaporation (MAE) of the site were calculated to be 634 mm, 7.1 mm and 1675 mm, respectively.
- The MAP indicates moderate to high rainfall for the region of which approximately 1% is redistributed as surface runoff.

Water Quality

- DRD03, DRD07, DRD08, DRD09, DRD10 and DRD12 points show acceptable EC levels with respect to the Upper Vaal Resource Water Quality Objectives (RWQO) for the Mooi River catchment, especially at the beginning of January 2017 to August 2018.
- While the EC levels at the WWS34 point were acceptable up to mid-2016, a fluctuating increase is observed towards the end of 2016 up to August 2018.
- High but declining EC and TDS levels at the BV81L monitoring site were noted.
- Acceptable nitrate levels are indicated for the monitoring period April 2014 to August 2018.

- Generally Lead (Pb) levels are slightly above the RWQO during most of the monitoring period from April 2014 to August 2018.
- Cadmium (Cd) and Uranium (U) monitored at BV81L and WWS34 points generally indicate higher concentrations than the recommended RWQO.
- Selenium levels are acceptable at all monitored points except at WWS34.
- Aluminium (Al) levels fluctuated slightly above the RWQO from 2014 to 2017, then declined to acceptable limits until the August 2018 monitoring period.

Impact Assessment

The following impacts are envisaged from the Blyvoor Gold Mine development:

- Contamination of water in the Mooi River Loop, Wonderfonteinspruit and Greenbelt Streams and subsequent deterioration of water quality for downstream water users.
- In-stream water quality deterioration due to runoff from contaminated areas and any dirty water discharges such as treated sewage effluent into nearby watercourses.
- Contamination of surface water resources from spillages and leakages of hydrocarbons and chemicals from equipment and machinery.
- In-stream water quality deterioration due to sedimentation and siltation of nearby watercourses resulting from demolition of infrastructure and subsequent disturbance of soils.
- Pollution of surface water resources and increase of flow volumes resulting from AMD into proximal watercourses.

Recommendations

The following is recommended to manage the existing and potential impacts at the Blyvoor Gold Mine:

- It is a requirement of the National Water Act 1998 (Act 36 of 1998) that water quality monitoring be undertaken throughout the Life of Mine (LOM) of any mine whether there are discharges or not from mining operations. This ensures that any potential sources of pollution are detected and rectified before severe environmental damage occurs. Blyvoor should, therefore, continue with the current surface water monitoring programme covering the sampling suite as described in the water quality monitoring programme subsection.
- Any infrastructure development which will need excavation and vegetation clearance should be limited to the proposed development footprint.
- Dust suppression measures must be undertaken on the cleared areas during construction to reduce aeolian erosion.
- All fuel and other chemical storage areas should be appropriately bunded and have spill kits in place. Relevant mine workers should be trained in the use of spill kits to

contain and immediately clean up any leakages or spills. All used oils should be disposed of by accredited vendors from the mine site.

- Runoff from dirty areas should be channelled and contained in High Density Polyethylene (HDPE) or concrete lined stormwater infrastructure (drains and Pollution Control Dam (PCD)).
- Any dirty water discharges into the natural environment should be preceded by appropriate Department of Water and Sanitation (DWS) compliance authorisation.
- Vehicles must only be serviced within designated service bays.
- The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites.
- The stormwater management plan for the mine should be optimised to ensure that the clean and dirty water separation systems are updated for the refurbished mine plant. This will include the following:
  - Placement of a perimeter berm and channel around Blyvoor TSFs No. 7 and No. 6;
  - Confirmation of the Return Water Dam (RWD) capacity and sizing of the perimeter berm; and
  - Channelling of polluted runoff from the RWD and associated dirty catchment to a Pollution Control Dam (PCD).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

Digby Wells Environmental (hereinafter Digby Wells) was appointed by Blyvoor Gold Capital (Pty) Ltd (hereinafter Blyvoor Gold) to undertake a hydrological impact assessment as part of an Environmental Application Process to obtain the required authorisation for the Blyvoor Gold mining operation. The Blyvoor Gold Mine project site is located in the West Rand, approximately 6 km from Carletonville within the Gauteng Province of South Africa.

The study was undertaken to comply with the requirements of relevant legislation and guidelines which include:

- The National Water Act, Act 36 of 1998 (NWA);
- The National Environmental Management Act, Act 107 of 1998 (NEMA); and
- The Government Notice Regulation 704 guidelines (GN R 704) of 1999.

1.1 Project Background and Description

Blyvooruitzicht Gold Mine (Pty) Ltd (BGMC) was placed under provisional liquidation in August 2013. The Mining Right relevant to the former Blyvooruitzicht operation was acquired by Blyvoor Gold through transfer in terms of Section 11 of the Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA).

The purpose of this application is to approve the existing operations at the Blyvoor mine and to align the existing documentation pertaining to the operations to the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and the Environmental Impact Assessment (EIA) Regulations, dated 2014 (as amended in 2017). Furthermore, two metallurgical processing plants are required to be authorised as part of this application, as well as the reclamation of eight Tailings Storage Facilities (TSFs).

During the purchase the following assets were acquired:

- The BGMC TSFs Blyvoor No. 1, 4, 5, 6 and 7;
- Doornfontein TSF No. 1, 2 and 3; and
- The BGMC No. 5 Shaft Complex.

The project shall involve the rebuilding and refurbishment of some infrastructure as preparation for effective operations. It is against this background that the current hydrological impact assessment was undertaken to determine the impact on water resources resulting from the construction (rebuilding/refurbishment), operation, decommissioning and closure activities at the Blyvoor Gold Mine.

1.2 Description of Activities

The estimated LOM for the Blyvoor Gold Mine underground operations currently exceeds 30 years and Blyvoor Gold has an operational strategic plan for the first 15 years. Blyvoor Gold intends to recover gold through the existing metallurgical plant constructed at The No. 5 Shaft Complex. Additionally, Blyvoor Gold intends to re-treat the existing TSFs, which will be staggered throughout the LOM.

Much of the Project will be characterised by refurbishment and repair work to return the mine to operation. Wherever possible, the required infrastructure will be installed or constructed within existing footprints.

1.2.1 Underground operations

The underground Project will require the recommissioning of the existing hoists, shaft facilities, ventilation fans, compressors and offices at No. 5 Shaft and the surface complex. No. 5 Shaft provides access to the existing underground network of tunnels and stopes. Ore will be excavated in the stoped areas, beginning in the shallow reaches of the deposit above 29-Level. The current water level occurs at 30-Level. The production levels above 30-Level are accessible and will allow for an estimated nine years of mining. Blyvoor Gold plans to implement a dewatering programme for 30-Level and below from the ninth year of mining.

The waste rock will be deposited at the existing Waste Rock Dump (WRD) and the gold ore will be transported to the surface to be crushed and screened at the No. 5 Shaft metallurgical treatment plant.

The ore will be hoisted up the existing No. 5 Shaft infrastructure, discharged into the existing ore bins in the shaft headgear and then loaded onto the existing Conveyor 1. This conveyor will deposit the ore into Coarse ore Silo. Ore is drawn out of the Silo by an apron feeder and fed into a jaw crusher via a static grizzley. The fines and crushed ore report to a conveyor that delivers it to a screen. Screen oversize reports to a recirculation conveyor that delivers the ore to the cone crusher for secondary crushing. The secondary crushed ore also reports to the screen feed conveyor allowing secondary closed circuit crushing.

Screen undersize reports to the crushed ore silo feed conveyor and is delivered to the shuttle conveyor above the crushed ore silos. The shuttle conveyor is used to deposit ore into one of two silos. Ore is drawn out each crushed ore silo by a light duty Apron feeder and discharged onto the mill feed conveyor that delivers it to the mill. Each mill is therefore fed by its own independent silo, feeder and conveyor system.

The milling circuit includes a 100% mill discharge feed to a Falcon gravity concentrator. Concentrate from the concentrator passes over a magnetic separator to remove magnetics before it is leached in a concentrate leach reactor. The tails from the leach reactor reports back to the milling circuit.

Cyclone overflow from the milling circuit flows over a trash screen before it is thickened and delivered to a leach and Carbon in Pulp (CIP) pump cell circuit. The loaded carbon from the pump cells is acid washed, eluted using a Zadra process and electrowinning, and regenerated before being returned for CIP adsorption. The gold plated onto the electrowinning cathodes is washed off, caked in a filter press, then dried and calcined in a calcine oven before smelting into bullion bars for delivery to a refinery.

The plant tailings will pass through an INCO process[1] detox circuit prior to pumping to the tailings dam. Water recovered from the tailings penstock will be gravity and pump fed to the plant process water dam for reuse in the circuit.

Reagents utilised for the process will be stored and mixed on site. Cyanide will be stored and utilised within strict cyanide control requirements including a separate fenced and locked mixing and storage area within the plant boundary fence. Lime will be bulk delivered to a free standing silo from where it is delivered at a controlled rate for mixing and slaking with water prior to circulation around the plant for PH control. Caustic and Hydrochloric acid will be delivered in concentrated liquid form and stored in separate fenced areas within the plant prior to being diluted with water in storage tanks from which it is pumped for plant use.

Existing infrastructure includes the foundations and the coarse ore silo. The foundations will be modified to suit the designed plant layout. The crushed ore silo will be modified and reused. New plant fencing and a new laboratory, administration and security building will be erected for the plant.

1.2.2 Surface operations

Blyvoor Gold intends to reclaim the Blyvoor No. 7 and Doornfontein 1 and 2 TSFs first and the other TSFs will remain in care and maintenance until they are reclaimed later in the LOM. The approved method of reclamation is hydraulic mining and processing at the No 5 shaft metallurgical plant.

The reclaimed tailings will be pumped to a reception tank via a trash screen on top of the reception tank. The clean slurry is pumped to a cyclone which diverts coarse ore to the milling circuit and size ore to the thickener feed trash screen. The thickened slurry is pumped to a preoxidation tank in which the ore is oxidised by oxygen injection into a leach reactor. The oxidised ore reports to a Carbon in Leach (CIL) circuit that leaches and adsorbs the gold in a preg robbing environment. The gold will then be recovered through the existing plant elution and smelting circuit. The residue from the CIL will be pumped and disposed of, onto TSF 6.

The plant and associated water pipeline servitude (which runs from the plant to Blyvoor No. 6 and No. 7 TSFs) are approved. Should this option be chosen, this will constitute a separate EA process and is not considered in this assessment.

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[1] A process for the destruction of sulphur dioxide cyanide to process tailings patented by INCO Ltd. This is one of two patented processes and this process has been used at over 80 mines globally.

Blyvoor Gold will continue to deposit material on the Blyvoor No. 6 TSF, as this TSF still has sufficient capacity for the LOM. Should more deposition capacity be required, materials will be deposited onto the area of Blyvoor No. 7 TSF after those tailings have been reclaimed. Alternatively, Blyvoor Gold may consider a new site on Blyvoor No. 4 and Blyvoor No. 5 TSF.

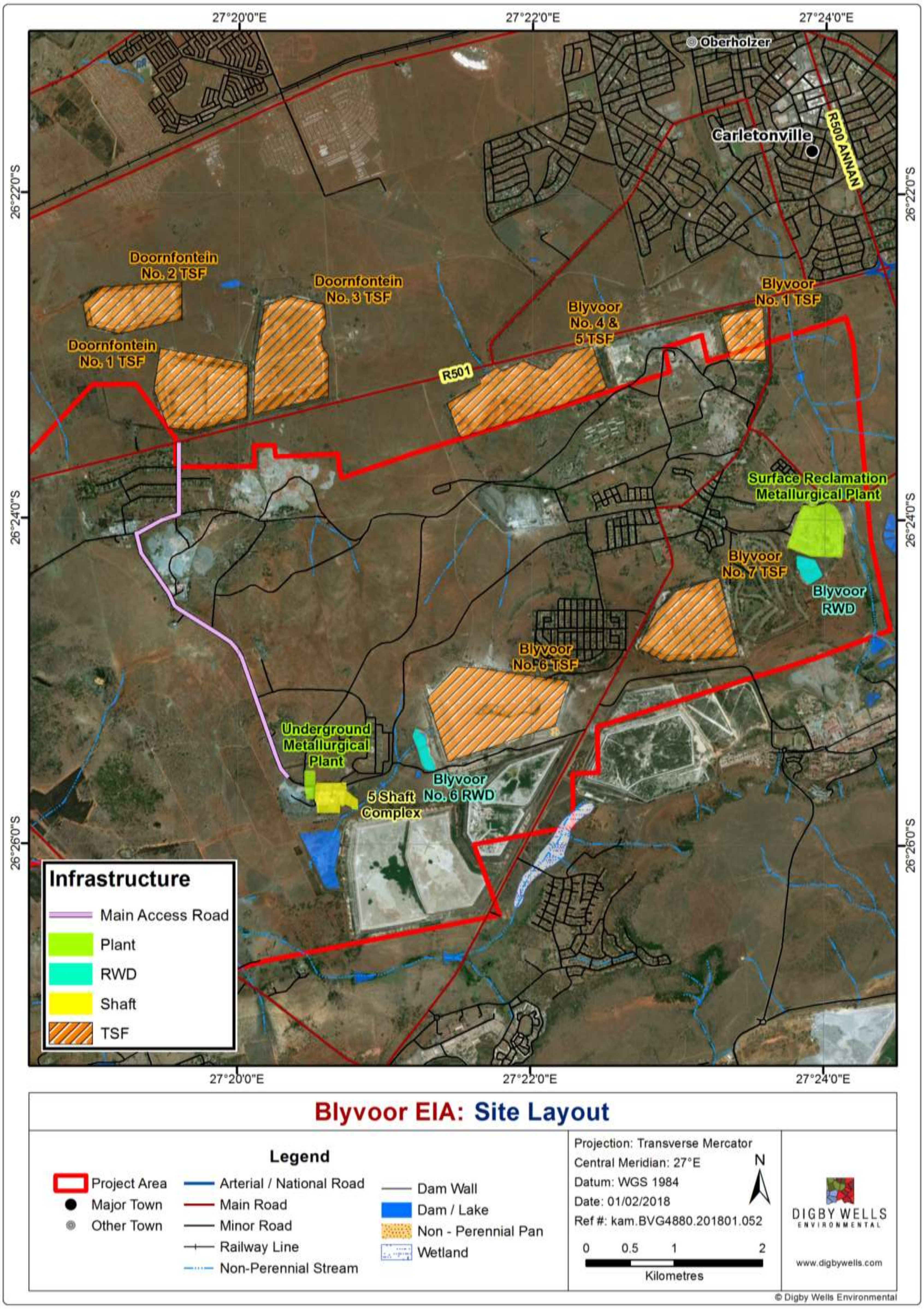

Figure 1-1: Blyvoor Gold infrastructure layout plan

1.2.2.1 Blyvoor TSFs

Five TSFs are associated with the Blyvoor Operation namely; No.1, No. 4 & 5, No.6, and No.7. These are detailed in Table 1-1. As mentioned, deposition will continue onto Blyvoor No.6, Blyvoor No.7 will be reclaimed and then used as a deposition site and the remainder of TSFs associated with the Mining Right will be under care and maintenance until these resources are reclaimed. TSFs number 4 and 5 have mostly been reclaimed and will be considered for future deposition.

Table 1-1: Blyvoor TSFs

TSF	Description	Footprint	Height	Volume	Tonnes
Blyvoor No.1	TSF No. 1 was operated as an emergency dam and because of its relatively small top surface area. Deposition could only take place for a few hours per day. The TSF is a paddock dam and has no under drainage system.	29 ha	20 m	4,633,829	6,797,827
Blyvoor No. 4 & 5	Mostly reclaimed but unlined.	69 ha	N/A	N/A	435, 500
Blyvoor No.6	Blyvoor TSF No. 6 was used for tailings placement during the reclamation of Blyvoor TSFs No.4 and 5 and underground operations. This ended in August 2013. Tailings were placed in a cyclone upstream deposition method. Prior to the reclaiming of TSFs No. 4 & 5. TSF No. 6 was divided into two daywall operated compartments. The cyclone placed material from TSFs No. 4&5 covered the total surface area of TSF No. 6, combining it into a single storage facility. The RWD associated with the TSF is not lined. The total capacity of the existing RWD is 71 500 m^3, this excludes the volume which has been allowed for the regulatory freeboard of 800 mm.	132 ha	26 m	2,9019,056	44,399,155

TSF	Description	Footprint	Height	Volume	Tonnes
Blyvoor No.7	TSF No. 7 dam is a paddock dam with no under drainage system. The dam is the highest TSF and, as indicated in the EMP, dated 2012, the TSF started showing signs of depression on the western flank of the upper compartment.	75 ha	48 m	26,741,680	40,460,161

1.2.2.2 The Doornfontein TSFs

Three Doornfontein TSFs, namely Doornfontein TSFs No. 1, No. 2, and No. 3, formed part of the sale to Blyvoor Gold. All three of these TSFs will remain in Care and Maintenance for the current 15-year LOM. Details of these TSFs are provided in Table 1-2 below. Due to the historic nature of the TSFs, these dumps are not lined. While the waste rock dumps (WRDs) are not owned by Blyvoor Gold, it is also noted that they do not have underdrainage systems.

Table 1-2: Doornfontein TSFs

TSF	Description	Footprint	Height	Volume	Tonnes
Doornfontein No. 1	This TSF was mothballed when it attained its maximum designed height. The dam is characterised by steep side slopes with no step-ins. There is no evident underdrainage system. The dam was rehabilitated by the construction of cross walls and perimeter walls on the top surface. Catchment paddocks have been constructed around the toe of the dam to prevent the migration of eroded material. The dam is situated on gently sloping ground and is not near to any watercourses. The area is fenced. The dam is situated on dolomite; as indicated in the EMP, dated 2012, no sign of instability had been noted.	54 ha	36 m	15,546,000	22,479,516

TSF	Description	Footprint	Height	Volume	Tonnes
Doornfontein No. 2	The TSF is characterised by fairly steep side slopes (1:2) with no step-ins. There is no underdrainage system evident. The dam is situated on gently sloping ground and is not located in proximity to any watercourses. Catchment paddocks have been constructed around the toe of the dam to contain eroded material. Rehabilitation of the dam was implemented by the construction of cross walls and perimeter walls on the top surface. The area is fenced. The dam is situated on dolomite; as indicated in the EMP, dated 2012, no sign of instability had been noted.	37 ha	12 m	6,641,000	9,496,630
Doornfontein No. 3	This TSF is situated on gently sloping ground and consists of a tow paddock construction. There are no underdrains and also no solution trenches around the toe of the dam. Tailings were delivered *via* an in-wall piping system into a day wall operation. Surface water was decanted off the top surfaces of the paddocks *via* a penstock decant system. The penstock decant pipes conveyed the water by gravity to two return water dams approximately 500 m from the tailings dam. Catchment paddocks have been constructed around the toe of the tailings dam to contain eroded material. The area is fenced and there are no structures or services nearby.	73 ha	32 m	11,487,000	17,127,117

1.2.3 Support Infrastructure

Support infrastructure includes power supply, roads, water resources and management, as well as waste management on site.

1.2.4 Stormwater Management

The polluted runoff from the Old Plant/Surface Treatment plant area used to be collected in trenches and directed to a sump and pumped back into the plant. Perimeter berms preventing clean stormwater runoff from entering the site were also in place. Optimisation of the clean and dirty water separation system at the plant area will take place during the refurbishing of the plant.

The stormwater management measures that will be required for the re-mining of Blyvoor TSFs No. 7 and 6 are a berm and channel system around the perimeter of the tailings dams to prevent clean water from entering the re-mining area and polluted runoff from leaving the re-mining area. The stormwater runoff from the re-mining area (for Blyvoor TSF No. 7) will be captured in a pollution control dam and re-used in the re-mining process, or managed in the control dam if not possible to use in re-mining. The stormwater management system will be sized to comply with Regulation 704 of the NWA.

The clean stormwater runoff diversion system constructed around the perimeter of the tailings dams will be sized to convey the flood peak generated from a 50 year 24-hour storm on the clean catchments. The RWD at Blyvoor TSF No. 6 has the capacity to store the runoff from a 50 year 24-hour storm event. The RWD capacity was confirmed by Tailex. Similarly, the perimeter berm will be sized to prevent the flood peak from a 50 year 24-hour storm falling on the re-mining area from entering the clean water system. The polluted runoff will be directed to the pollution control dam. The pollution control dam will be sized so as to spill on average once in 50 years as per Regulation 704. Consideration must also be given to integrating the clean water runoff system with the current diversion channel system preventing runoff from reporting to the Wonderfonteinspruit to reduce the risk of sinkhole formation.

1.2.4.1 Waste Management

General domestic waste (such as paper, plastic, organic matter, building rubble and wood) will be collected in bins and skips on site and transported to the Merafong Municipal landfill site. Hazardous waste, such as used oil and grease, and oil sludges from oil separators, etc., will be temporarily stored in a central collection point (in a bunded area), such as at the on-site salvage yard, for removal by a reputable company for recycling (such as Oilkol) or disposal.

Domestic wastewater (sewage) will be managed using chemical toilets and existing sewage plants (a plant designed to handle 1/Ml/day and using the activated sludge process is located at No.5 Shaft – treated effluent is discharged to the Wonderfonteinspruit or used for irrigation of vegetated areas on TSFs). The No.5 Shaft Surface Treatment Plant (STP) will be refurbished to treat No.5 Shaft flows and flows from the metallurgical treatment plant.

1.3 Aims and Objectives

The aims and objectives of this study are to provide:

- A description of the project area baseline hydrological conditions;
- Predict the long-term impact of TSFs on surface water quality;
- Identify the impact of the existing mine infrastructure on potential receptors;
- Compile an impact assessment; rating the identified potential surface water impacts based on significance scoring before and after mitigation methods are implemented; and
- Recommend management measures to minimise impacts of the mine on the surface water environment.

2 Details of the Specialist

The following specialists compiled this surface water study report:

Responsibility	**Report Writer**
Full Name of Specialist	Daniel Fundisi
Highest Qualification	MSc Hydrology
Years of experience in specialist field	7
Registration(s):	Pr.Sci.Nat. (SACNASP); Reg. Number: 400034/17
Responsibility	**Technical Review**
Full Name of Specialist	Mashudu Rafundisani
Highest Qualification	MSc Hydrology
Years of experience in specialist field	7
Responsibility	**Final Review**
Full Name of Specialist	Andre van Coller
Highest Qualification	MSc Geohydrology
Years of experience in specialist field	10

2.1 Declaration of Specialist

I, Daniel Fundisi, as the appointed specialist, hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent, other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity;

- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Daniel Fundisi (Pr.Sci.Nat)

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

September 2018

Date

3 Methodology

The study was undertaken following relevant methodologies, guidelines and legislative frameworks governing national, regional and local settings. As such, the hydrology of the Vaal Water Management Area 5 (WMA 5), Quaternary Catchment C23E, and the local project site, was assessed.

3.1 Baseline Hydrology

Rainfall and runoff data obtained from the results database of the Water Resources of South Africa 2012 study (WRC, 2015) was analysed to determine the Mean Annual Precipitation (MAP), Mean Annual Evaporation (MAE) and the Mean Annual Runoff (MAR) for the Blyvoor region and site. Time series rainfall-runoff historical data from 1920 to 2009 were adequate to determine mean hydro-meteorological parameters for the project site. These analyses were useful to provide insight into the general rainfall-runoff and evaporation dynamics for the site, which informed the surface water impact assessment for the Blyvoor Mine site.

3.2 Water Quality Analysis

Analysis and interpretation of surface water quality data for the Blyvoor Gold Mine was undertaken for the Mooi River and its Wonderfonteinspruit tributary. Water quality monitoring of samples collected from proximal rivers and various surface water circuits is currently being undertaken on a monthly basis. The most recent water quality time series data provided by the client was analysed for the monitoring period from April 2014 to August 2018. The Department of Water and Sanitation (DWS) Upper Vaal, Mooi River Catchment Resource Water Quality Objectives (RWQO) (DWS, 2016) were used as standard limits for the analysed water chemistry.

3.3 Surface Water Impact Assessment

Potential and existing surface water (quality and quantity) impacts that may result from the proposed project activities, based on the established baseline conditions, were identified. A numerical environmental significance rating methodology that utilises the impact's probability of occurrence and its severity as factors to determine the significance of a particular environmental risk was utilised. Mitigation measures were then determined for implementation to prevent and/or reduce the identified potential and existing surface water impacts. The impact assessment methodology is detailed in Section 5.1 of this report.

3.4 Assumptions and Limitations

The following assumptions and limitations are applicable to this study and report:

- The provided historical water quality monitoring information was assumed to have been correctly sampled and analysed.

- Assuming that the data were correctly sampled and analysed, the findings provide a representative reflection of typical conditions for the Blyvoor Gold Mine as at the year April 2014 to August 2018.

4 Baseline Hydrology

4.1 Catchment Description

South Africa is divided into nine Water Management Areas (WMA) (Revised National Water Resource Strategy, 2012), managed by separate water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A to X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment; A2 for example will represent the secondary catchment; A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the Water Resources of South Africa, 2012 manual. Each of the quaternary catchments has associated hydrological parameters.

The project is located in the Vaal Water Management Area 5 (WMA 5), with the proposed Blyvoor Gold Mine footprint falling within quaternary catchment C23E. This quaternary catchment lies in the Mooi River Loop Catchment, to the north and Loopspruit to the south of the old Blyvoor Gold Mine Plant (Surface Reclamation Plant). The Mooi River has smaller tributaries which include the Wonderfonteinspruit which joins the Mooi at a point adjacent to the Blyvoor Gold Mine. The MAP, MAR and MAE of the region were calculated to be 634 mm, 7.1 mm and 1675 mm, respectively (Table 4-1). The MAP indicates moderate to high rainfall for the region of which approximately 1% is redistributed as surface runoff.

Table 4-1: Mean Annual Rainfall, Runoff and Evaporation for Quaternary C23E

Month	Rainfall (mm)	Runoff (mm)	Evaporation (mm)
Oct	56.6	0.4	183.7
Nov	85.9	0.5	190.8
Dec	101.7	0.7	207.2
Jan	109.2	0.9	204.9
Feb	91.2	1.1	165.2
Mar	84.1	0.9	150.1
Apr	49.4	0.6	109.7
May	18.0	0.5	82.7
Jun	7.8	0.4	63.3
Jul	4.7	0.4	70.7
Aug	7.1	0.4	102.5

Month	Rainfall (mm)	Runoff (mm)	Evaporation (mm)
Sep	18.7	0.4	144.2
Annual	**634**	**7.1**	**1675**

The Köppen-Geiger classification system categorises the West Rand region and the Blyvoor Gold Mine project site in particular, as falling within the Cwb climate, where 'C' represents climate category, 'w' winter conditions and 'b' the summer conditions (Peel et al., 2007). The Cwb classification represents a temperate climate with dry winters and warm, wet summers. Typical hot temperatures for this region usually exceed 10 ˚C while cold temperatures are usually less than 18 ˚C (Cannon, 2011).

The regional and local settings showing quaternary catchments including the C23E and the geographical surroundings are shown in Figure 4-1 and Figure 4-2.

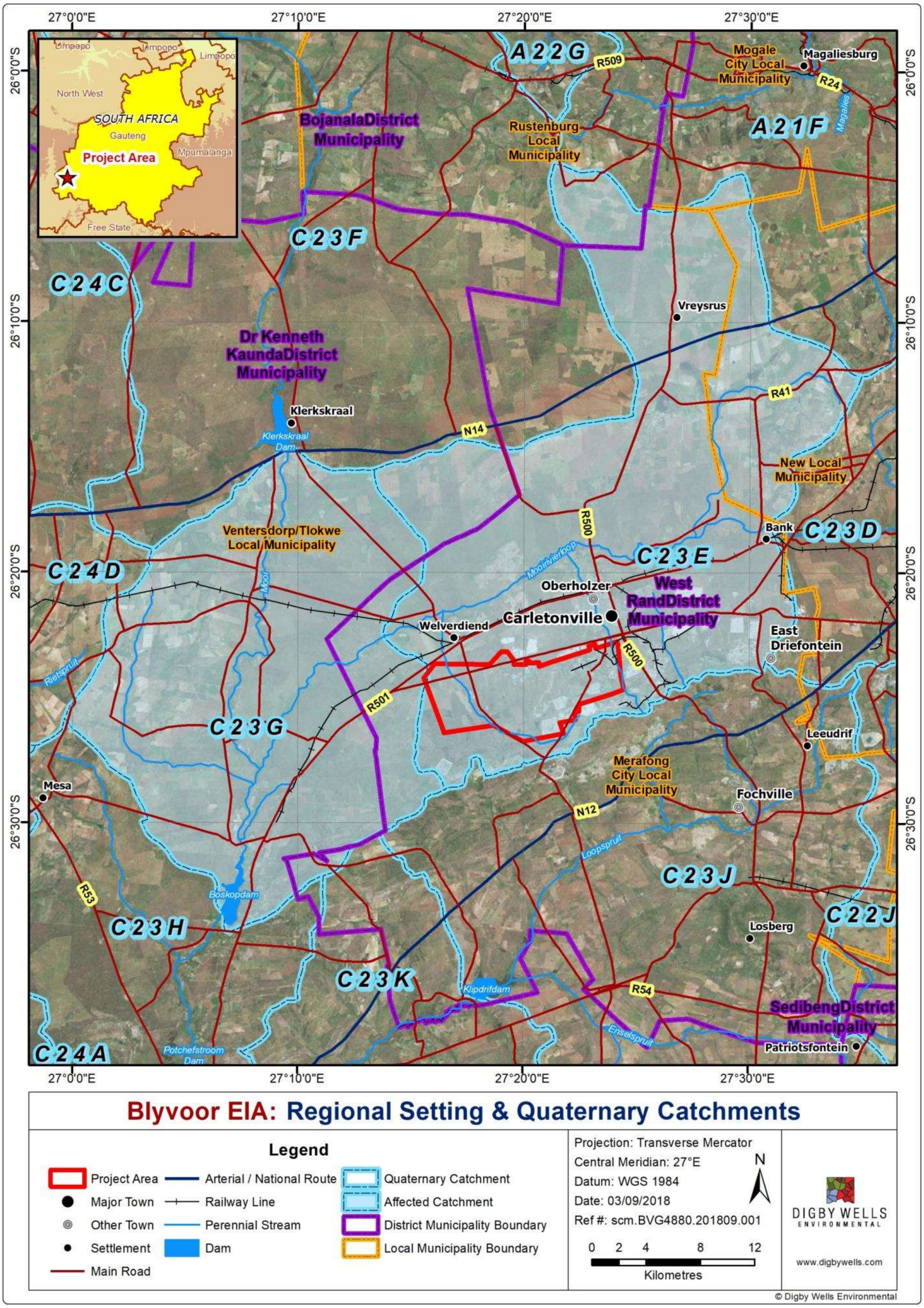

Figure 4-1: Regional setting of the Blyvoor Gold Mine site

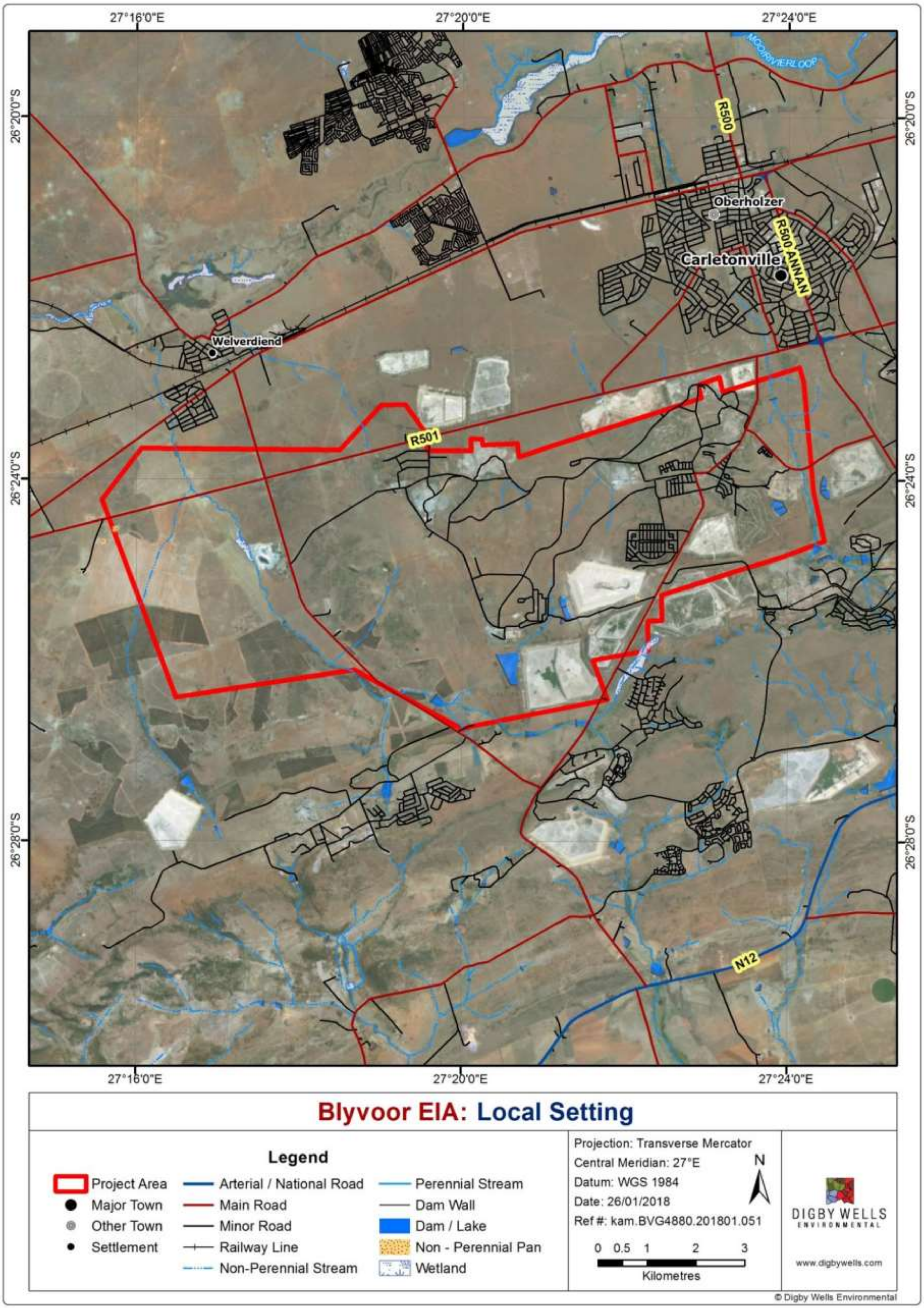

Figure 4-2: Local setting of the Blyvoor Gold Mine project site

4.2 Surface Water Use

From the DWS' water use database, the registered water users within the affected quaternary catchments include mining, irrigation, livestock watering and industry, urban and non-urban. However, the predominant use of surface water is irrigation and livestock watering.

4.3 Water Quality

As mentioned, available surface water quality data was obtained from the client for the period April 2014 to August 2018 for the Blyvoor Gold Mine. Details of the monitoring points and surface water chemistry results are presented in the following subsections.

4.3.1 Monitoring Localities and Historical Record Descriptions

The water quality monitoring is being undertaken at eight sampling points. The location and description of historical, current and proposed monitoring localities for the Blyvoor Gold Mine are presented in Table 4-2 and Figure 4-3.

Table 4-2: Location and description of surface water quality monitoring points at Blyvoor Gold Mine site

Sample Number	Description	Coordinates (Latitude/Longitude)	
DRD 3	Shaft No. 4 Discharge	-26.383882°	27.382833°
DRD 10	Shaft No. 6 Discharge	-26.407145°	27.326735°
DRD 7	Downstream of Shaft 6 in canal between Doornfontein TSF	-26.376051°	27.336066°
DRD 12	End of Doornfontein canal	-26.372292°	27.254210°
DRD 8	Upstream of canal in Wonderfonteinspruit	-26.367098°	27.270639°
DRD 9	Downstream of canal in Wonderfonteinspruit	-26.370242°	27.248049°
WWS34	South of Blyvoor RWD	-26.415862°	27.406061°
BV81L	Southeast of Blyvoor RWD	-26.422499°	27.403025°

The water quality at each monitoring point is analysed for a comprehensive list of parameters which include pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Sulphates (SO_4), Uranium (U), and Cyanide Dissolved (CN) which are the main six parameters.

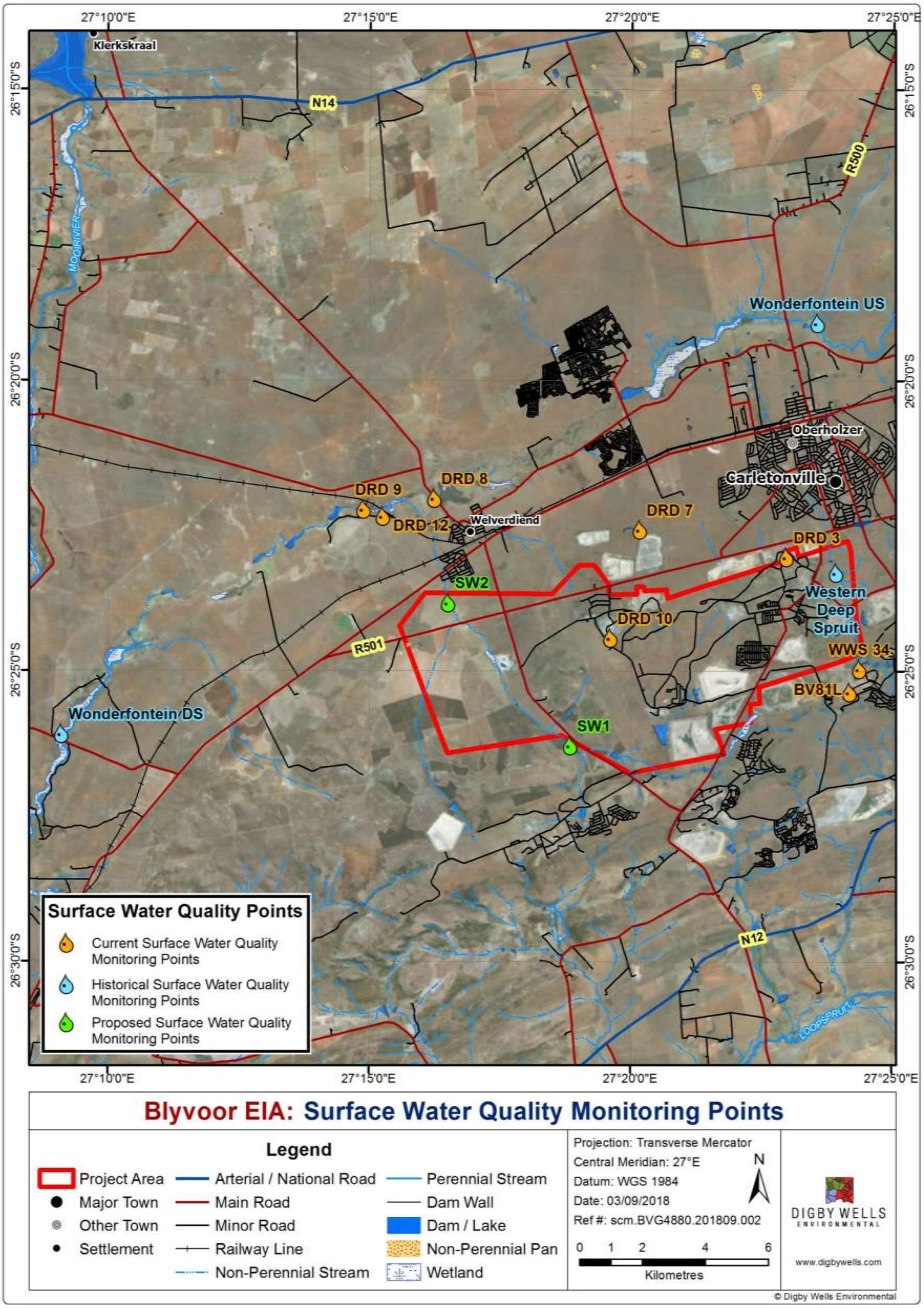

Figure 4-3: Water quality monitoring points at the Blyvoor Gold Mine site

4.3.2 pH Monitoring

Generally, alkaline water quality is indicated at monitored points during the 2014 to 2018 monitoring period (Figure 4-4). The surface water pH of most samples except DRD7 and DRD12, are within acceptable levels with respect to DWS irrigation target values. A considerable drop in pH was noted at point WWS34 at the end of 2016 which indicates temporary acid contamination at this point. This point is upstream of the Blyvoor lease area, therefore, other pollution sources excluding the Blyvoor Gold should be responsible for this drop in pH. Water quality at BV81L also shows acid contamination for the period mid- 2017 to August 2018. Acid contaminated water is not suitable for irrigation (Figure 4-4).

4.3.3 Electrical Conductivity Monitoring

Points DRD08 and DRD09 show acceptable Electrical Conductivity (EC) levels with respect to the RWQO for the Mooi River catchment throughout the 2014 to August 2018 monitoring period. DRD03, DRD07, DRD10 and DRD12 indicate acceptable EC levels beginning January 2017 to August 2018 (Figure 4-5). When compared to the DWS Irrigation standard (540 mg/l), EC levels are within acceptable limits indicating that the water quality in the Wonderfonteinspruit and the Mooi River at these points is suitable for irrigation (DWA, 1996). While the EC levels at the WWS34 point were acceptable up to mid-2016, a fluctuating increase is observed towards the end of 2016 up to August 2018, which might be attributed to a random spill of pollutants from upslope waste water dams. This observation is confirmed by TDS levels which mimic the EC trend. The water quality monitoring which occurred during mid-2017 to August 2018 indicate high but declining EC and TDS levels at the BV81L monitoring site (see Figure 4-8 and Figure 4-6).

4.3.4 Nitrate Monitoring

Acceptable nitrate levels are indicated for the monitoring period April 2014 to August 2018 except for a short period in mid-2014, where only point WWS34 had nitrate levels below the RWQO for the Mooi River catchment (Figure 4-7). This result shows that faecal pollution in the water is absent or minimal which provides a suitable environment for aquatic ecosystems including fish.

4.3.5 Metal Toxins

Generally, Lead (Pb) levels are slightly above the RWQO during most of the monitoring period from April 2014 to August 2018. Cadmium (Cd) and Uranium (U) monitored at BV81L and WWS34 points generally indicate higher concentrations than the recommended RWQO (see Figure 4-9). Selenium levels are acceptable at all monitored points except at WWS34 as indicated in Figure 4-9. Higher metal toxins at BV81L and WWS34 can be attributed to either industrial operations at Western Deep Levels, spillages from waste water dams upslope of BV81L or from operations at Savuka Mine. Aluminium (Al) levels fluctuated slightly above the RWQO from 2014 to 2017, from where a decline to acceptable limits occurred until the August 2018 period (Figure 4-10).

4.3.6 Cyanide

Cyanide is used in the extraction of gold from low-grade ore by converting the gold to a water-soluble coordination complex. It is the most commonly used leaching process for gold extraction. As such, cyanide is one of the major potential pollutants at any gold mine. Monitoring of cyanide at Blyvoor Gold is underway and cyanide levels are acceptable (<0.02 mg/l) being lower than the DWS Aquatic Ecosystem and the World Health Organisation (WHO) target water quality value of 0.1 mg/l (DWA, 1996; WHO, 2016).

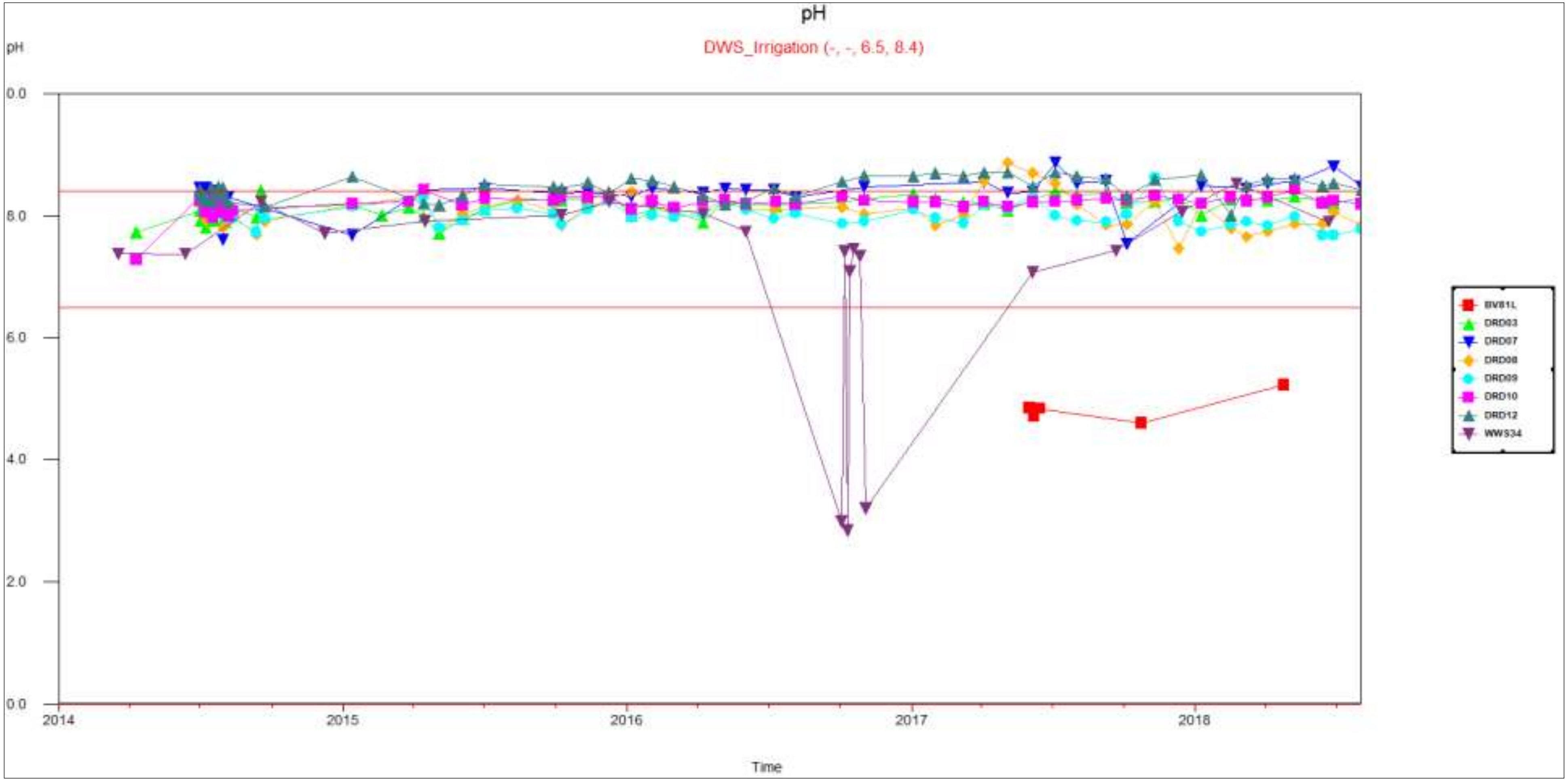

Figure 4-4: pH levels monitored at the Blyvoor Gold Mine

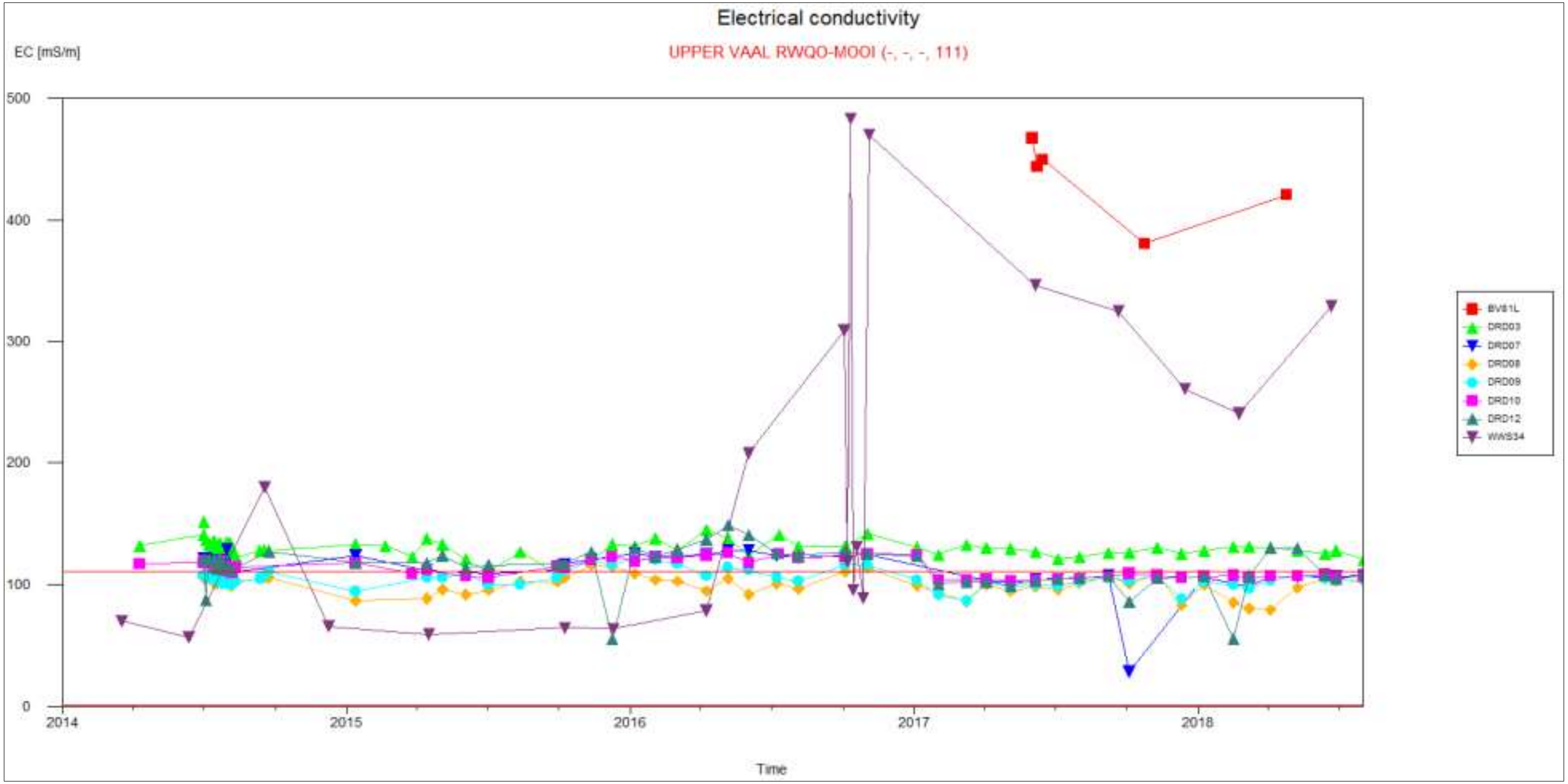

Figure 4-5: Electrical conductivity at the Blyvoor Gold project site

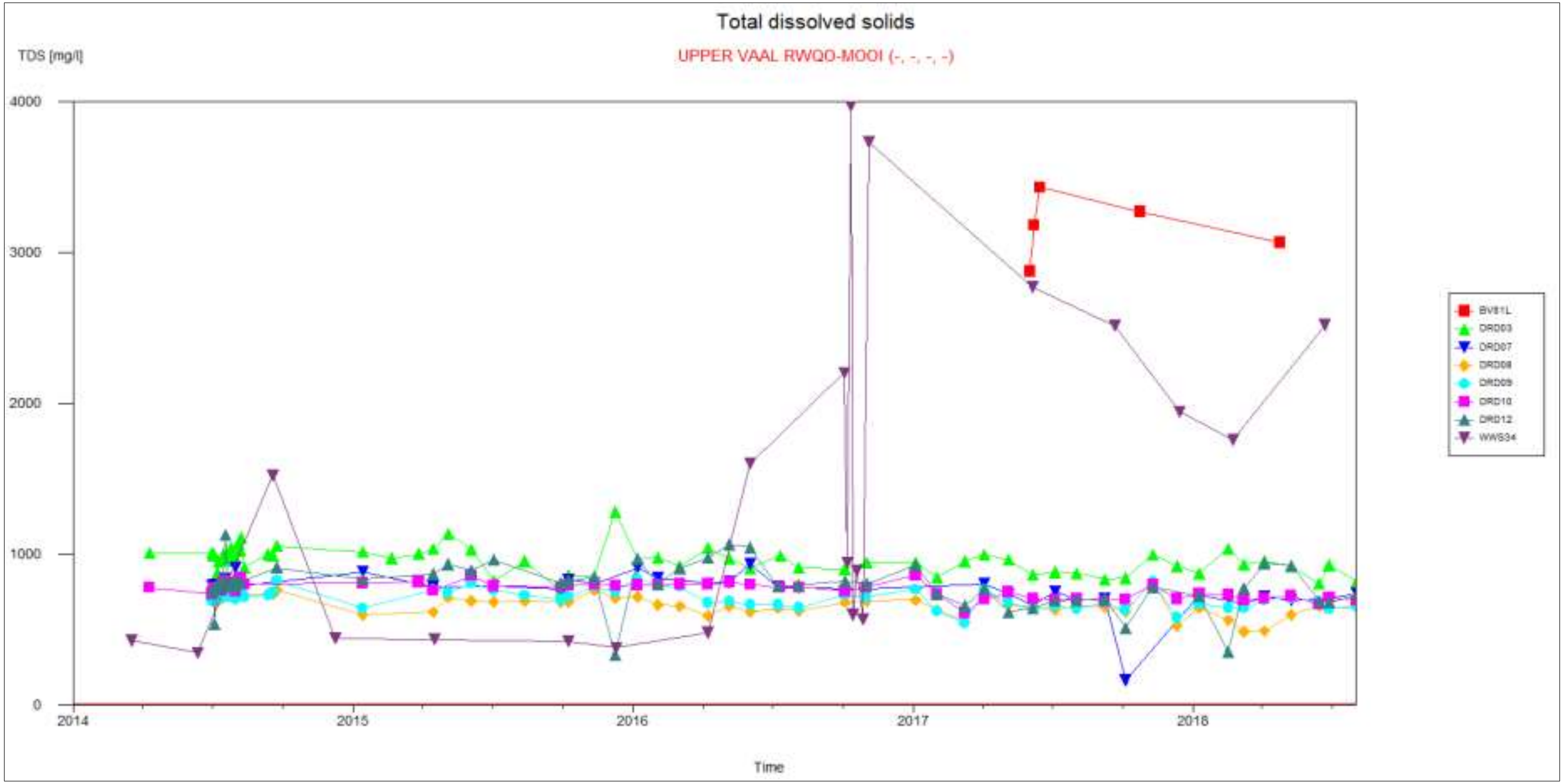

Figure 4-6: Total Dissolved Solids at the Blyvoor Gold project site

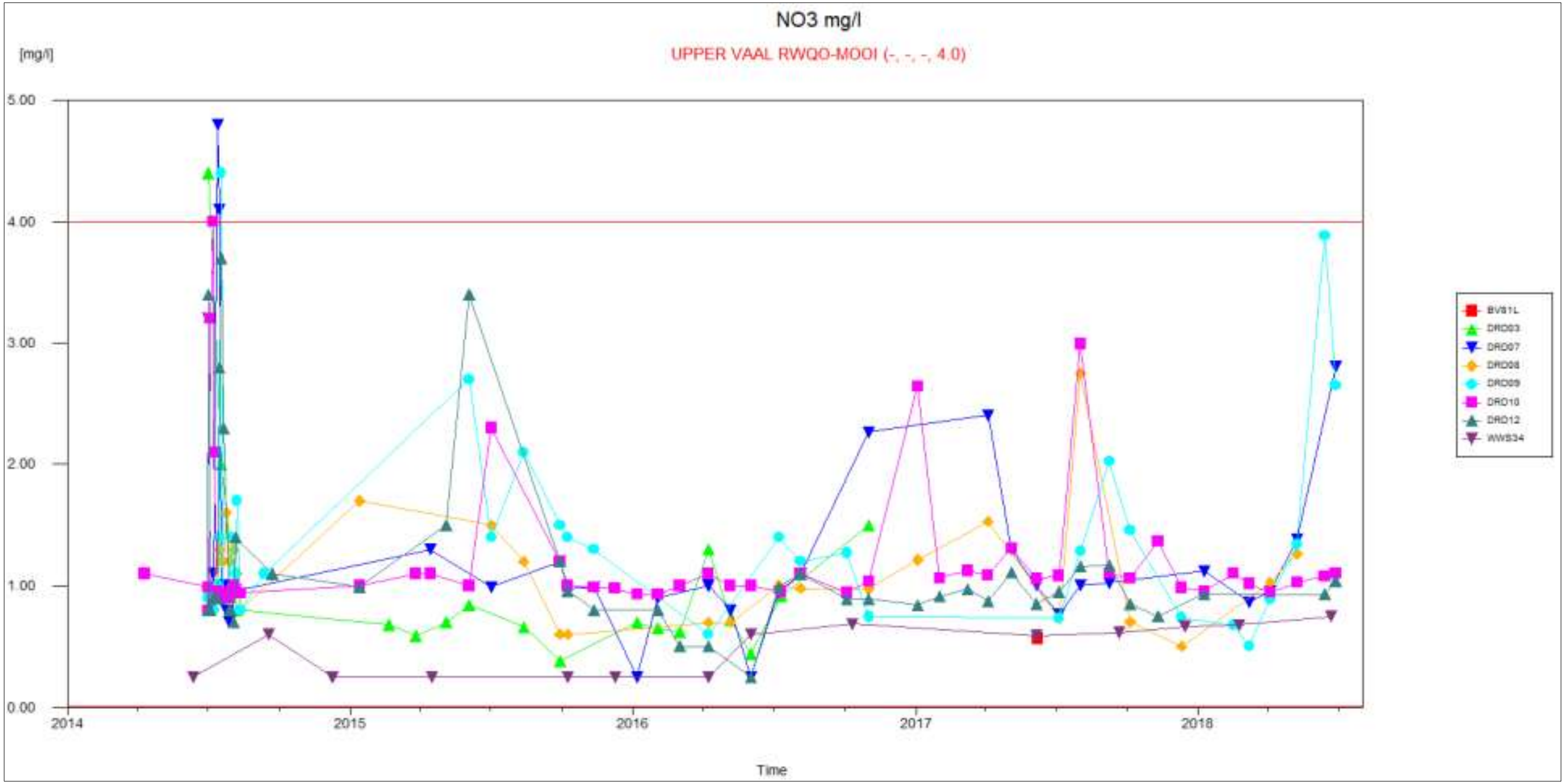

Figure 4-7: Nitrate levels at the Blyvoor Gold project site

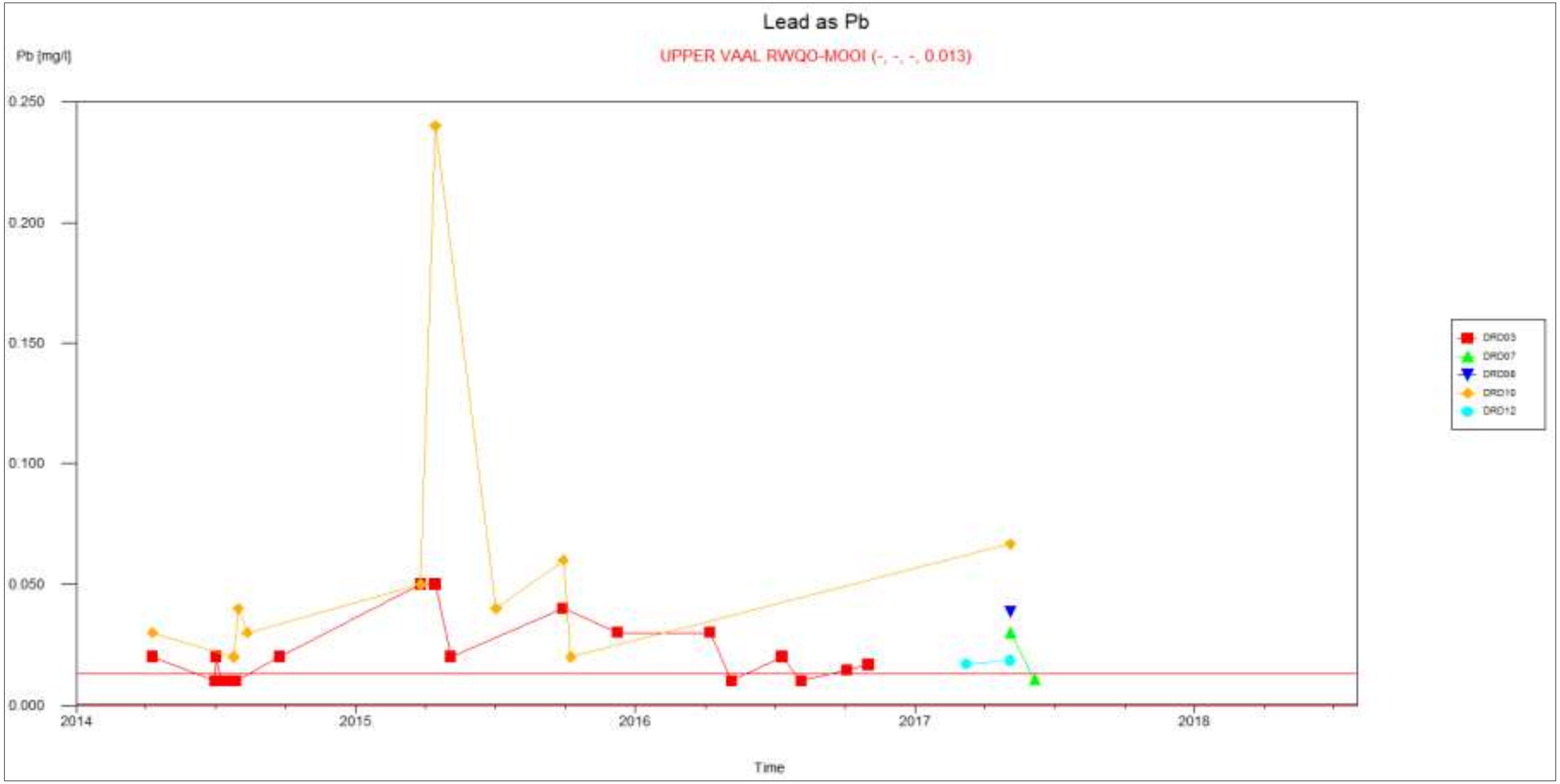

Figure 4-8: Lead concentrations at the Blyvoor Gold project site

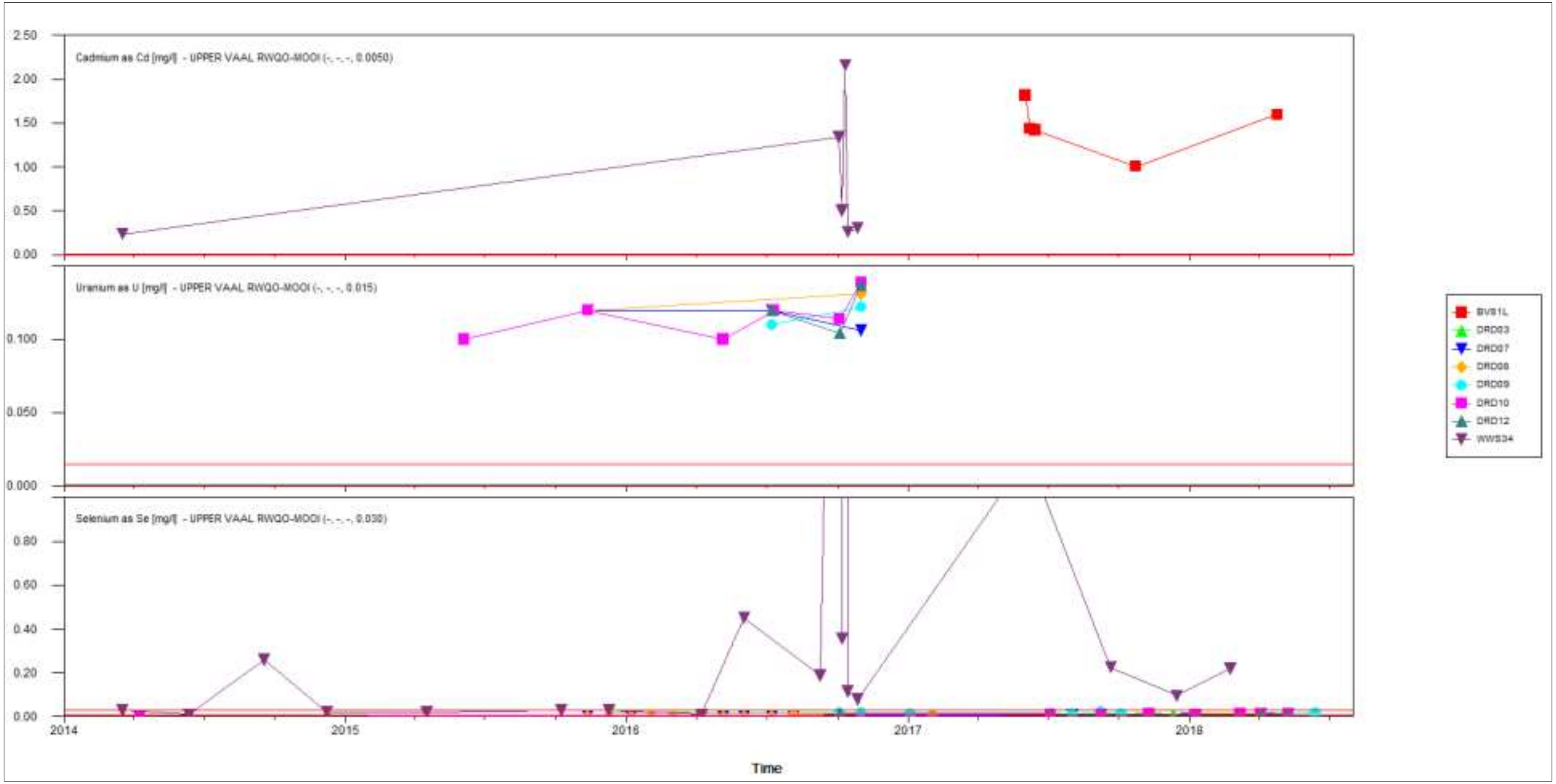

Figure 4-9: Cadmium, Uranium and Selenium concentrations at the Blyvoor Gold project site

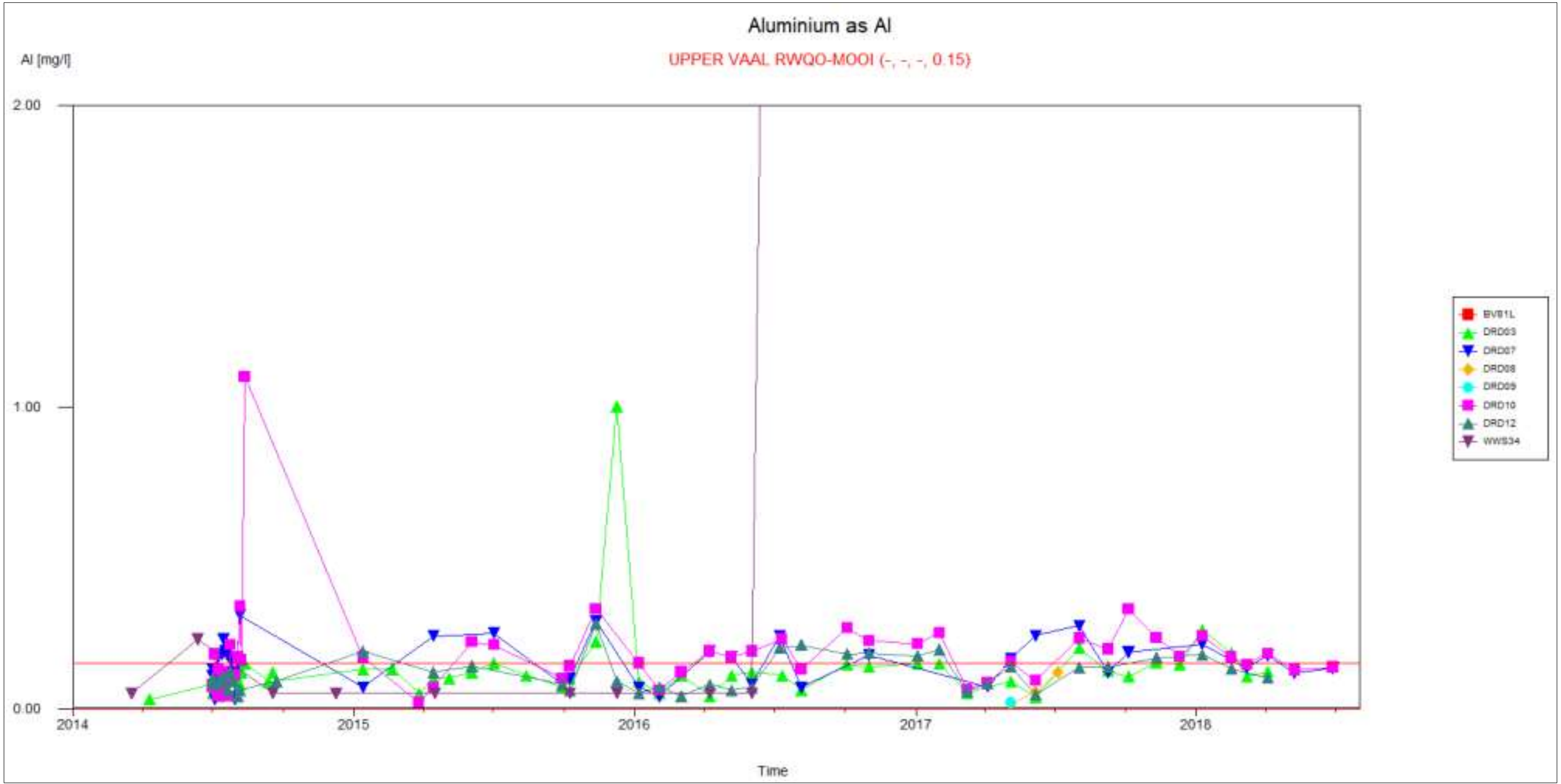

Figure 4-10: Aluminium concentrations at the Blyvoor Gold project site

5 Environmental Impact Assessment

The environmental impact assessment was completed as described in the following subsections.

5.1 Impact Rating Methodology

The methodology utilised to assess the significance of impacts is discussed in detail below. The significance rating formula is as follows:

Significance = Consequence x Probability

Where

Consequence = Type of Impact x (Intensity + Spatial Scale + Duration)

And

Probability = Likelihood of an Impact Occurring

And

Type of Impact = ***+1*** *(Positive Impact) or* ***-1*** *(Negative Impact)*

The weight assigned to the various parameters for positive and negative impacts is provided for in the formula and is presented in Table 5-1. The probability consequence matrix for impacts is displayed in Table 5-2, with the impact significance rating described in Table 5-3.

Table 5-1: Surface Water Impact Assessment Parameter Ratings

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
7	High significant impact on the environment. Irreparable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable damage to highly valued items of great cultural significance or complete breakdown of social order.	Noticeable, on-going social and environmental benefits which have improved the livelihoods and living standards of the local community in general and the environmental features.	International The effect will occur across international borders.	Permanent: No Mitigation The impact will remain long after the life of the Project.	Certain/ Definite. There are sound scientific reasons to expect that the impact will definitely occur.
6	Significant impact on highly valued species, habitat or ecosystem. Irreparable damage to highly valued items of cultural significance or breakdown of social order.	Great improvement to livelihoods and living standards of a large percentage of population, as well as significant increase in the quality of the receiving environment.	National Will affect the entire country.	Beyond Project Life The impact will remain for some time after the life of a Project.	Almost certain/Highly probable It is most likely that the impact will occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment.	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational life span of the Project.	Likely The impact may occur.
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	Municipal Area Will affect the whole municipal area.	Long term 6-15 years.	Probable Has occurred here or elsewhere and could therefore occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
3	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements.	Medium term 1-5 years.	Unlikely Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur.
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by very few of population.	Limited Limited to the site and its immediate surroundings.	Short term Less than 1 year.	Rare/ improbable Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
1	Limited damage to minimal area of low significance that will have no impact on the environment. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level social and environmental benefits felt by very few of the population.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month.	Highly unlikely/None Expected never to happen.

Table 5-2: Probability Consequence Matrix for Impacts

Probability	Significance																																					
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	-21	**-20**	**-19**	**-18**	**-17**	**-16**	**-15**	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
	Consequence																																					

Table 5-3: Significance Threshold Limits

Score	Description	Rating
109 to 147	A very beneficial impact which may be sufficient by itself to justify implementation of the Project. The impact may result in permanent positive change.	**Major (positive)**
73 to 108	A beneficial impact which may help to justify the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and/or social) environment.	Moderate (positive)
36 to 72	An important positive impact. The impact is insufficient by itself to justify the implementation of the Project. These impacts will usually result in positive medium to long-term effect on the social and/or natural environment.	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the social and/or natural environment.	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the social and/or natural environment.	Negligible (negative)
-36 to -72	An important negative impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the Project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the social and/or natural environment.	Minor (negative)
-73 to -108	A serious negative impact which may prevent the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe effects.	Moderate (negative)
-109 to -147	A very serious negative impact which may be sufficient by itself to prevent implementation of the Project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects.	Major (negative)

5.2 Identified Potential Impacts

Although water is an essential requirement in the mine for various purposes, the use of it has the potential to affect the quality of surrounding resources including surface water, groundwater and other aspects of the environment. All mines are, therefore, required to contain, recycle and re-use dirty water within their operational systems, to avoid discharging contaminated water into the natural environment.

If the dirty water contained within the mine exceeds the mine's water needs, transfer to other users or treatment for discharge into proximal natural water resources, can be considered. At the Blyvoor Gold Mine there was discharge of water from the Mine Plant which was channelled through canals/drains to the Mooi River Loop. The water sources for this discharge included treated sewage effluent, water pumped from underground to the surface and storm water from the catchment area of the Western Deep Levels Mine Shaft.

Potential impacts resulting from mining activities during the construction, operation, decommissioning and closure phases of the Blyvoor Gold Mine were assessed. Since the mine already exists, impacts of the construction phase were only limited to those that arise from the development of additional infrastructure such as the access road to the Tailings Storage Facility (TSF). The assessed potential impacts, their descriptions and significance ratings are described below.

5.2.1 Construction Phase

Impacts associated with the construction phase are summarised in Table 5-4 and further described in subsections 5.2.1.1 to 5.2.1.2.

Table 5-4: Interactions and impacts of activity

Interaction	Impact
Fuel or chemical spills from construction vehicles and machinery.	Contamination of water in the Mooi River Loop, Wonderfonteinspruit and Greenbelt Streams and subsequent deterioration of water quality for downstream water users.

5.2.1.1 Impact Description: Water Contamination

Water contamination may occur as a result of fuels and chemical spillages and leakages from construction vehicles and machinery. These leakages and spillages will lead to the deterioration of water quality, affecting aquatic ecosystems and downstream water users.

5.2.1.2 Management/Mitigation Measures

The following mitigation measures are recommended:

- Dust suppression measures must be undertaken on the cleared areas during construction to reduce wind erosion;

- All fuel and other chemical storage areas should be appropriately bunded and have spill kits in place. Construction workers should be trained in the use of spill kits to contain and immediately clean up any leakages or spills. All used oils should be disposed of by accredited vendors from the mine site.

Table 5-5: Impact significance rating for the construction phase

Dimension	Rating	Motivation	Significance
Impact: Water Contamination			
Duration	2	The impact will likely only occur during the construction phase	40- Minor (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	4	The impacts may extend in the greater surrounding area from where the impact occurred	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the construction phase	16-Negligible (negative)
Intensity	3	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	3	The impacts may extend in the greater surrounding area from where the impact occurred	
Probability	2	With the existing measures already in place. It will be rare/improbable for this impact to occur.	

5.2.2 Operational Phase

Activities during the operational phase that may have potential impacts on the surface water resources are summarised in Table 5-6 and further described together with recommended management/mitigation measures in the following subsections.

Table 5-6: Interactions and Impacts of Activity

Interaction	Impact
Runoff from contaminated areas and any dirty water discharges such as treated sewage effluent into nearby watercourses	In-stream water quality deterioration
Hydrocarbon and chemical spillages and leakages from equipment and machinery	In-stream water quality deterioration

5.2.2.1 Impact Description: Water Contamination from runoff from dirty water areas

Water contamination may occur as a result of runoff from contaminated surfaces and from any dirty water discharges such as treated sewage effluent within the mine into the water course in proximity to the site. The dirty water areas at the Blyvoor Gold Mine site include TSFs, Mine area, Plant area and PCDs. Contamination of surface water resources will lead to the deterioration of water quality affecting aquatic ecosystems and downstream water users.

5.2.2.2 Impact Description: Water Contamination from fuels and chemical spillages and leakages from equipment and machinery

Operational machinery at the mine site are potential sources of hydrocarbon and chemical spills and leakages. When not properly managed hydrocarbon and chemical spills and leakages will contaminate surface and groundwater resources in proximity to the Blyvoor Gold Mine site.

5.2.2.3 Management/Mitigation Measures

The following mitigation measures are recommended:

- Runoff from dirty areas should be directed to the existing storm water management infrastructure (PCDs) and should not be allowed to flow into the watercourses, unless DWS discharge authorisation has been granted upon compliance with relevant effluent discharge standards as stipulated in the NWA. The PCDs and dirty water channels should be lined either by concrete or High Density Polyethylene (HDPE) to prevent contamination of groundwater through seepage;
- Water quality monitoring should continue downstream and upstream of the mine site, and within all surface water circuits at the mine to detect any contamination arising from operational activities;
- Vehicles must only be serviced within designated service bays.
- The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites; and

- The hydrocarbon and chemical storage areas and facilities must be located on a hard-standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilisation of leaked hazardous substances.

Table 5-7: Impact significance rating for the operational phase

Dimension	Rating	Motivation	Significance
Impact: Water Contamination from runoff from dirty water areas			
Duration	6	The impact will remain for some time after the life of the gold mining project.	60-Minor (negative)
Intensity	5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate	
Spatial scale	4	The impacts will be localised to the nearby watercourses and to the immediate downstream water users	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	3	The impact will only likely persist in the absence of proper monitoring and maintenance of storm water management plan infrastructure on site.	14-Negligible (negative)
Intensity	2	Proper and continued implementation of storm water management plan and water quality monitoring will lower the intensity of the contaminated runoff impact on proximal water resources.	
Spatial scale	2	The impacts will be localised to the nearby watercourses and to the immediate downstream water users.	
Probability	2	With continued implementation and improvement of existing mitigation measures the impact probability will be low.	

Dimension	Rating	Motivation	Significance
Impact: Water Contamination from hydrocarbon and chemical spillages and leakages			
Duration	2	The impact will only likely occur during the operational phase of the project	36- Negligible (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users.	
Spatial scale	3	The impacts will be localised to the immediate surroundings of the mine site.	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur.	
Post-mitigation			
Duration	2	The impact will only likely occur in the absence of recommended mitigation measures	10-Negligible (negative)
Intensity	1	With proper management of hydrocarbon and chemicals on site the impact will rarely be of significance and water quality in nearby watercourses will be maintained for optimal functionality of ecosystems and downstream	
Spatial scale	2	With proper management, the impact will be localised to relevant operational areas within the mine's footprint.	
Probability	2	With the implementation of recommended mitigation measures the impact's probability of occurrence will be very low.	

5.2.3 Decommissioning and Closure Phase

Activities during the decommissioning and closure phase that are potential impact sources on surface water resources in proximity to the Blyvoor Gold Mine are summarised in Table 5-8 and further described together with recommended management/mitigation measures in the following subsections.

Table 5-8: Interactions and Impacts of Activity

Interaction	Impact
Sedimentation and siltation of nearby watercourses resulting from demolition of infrastructure and subsequent disturbance of soils.	In-stream water quantity and quality deterioration
Acid Mine Drainage (AMD) decant into proximal watercourses.	In-stream water quality deterioration

5.2.3.1 Impact Description: In-stream water quantity and quality deterioration from sedimentation and siltation of nearby watercourses

During the decommissioning phase demolition of infrastructure, which is not planned for third party use, will cause disturbance and subsequent erosion of soils into nearby watercourses. This will result in the sedimentation and siltation of watercourses and dams thereby reducing their flow/storage capacities and their ability to sustain aquatic ecosystems. The quantity and quality of water for downstream water users will thus be compromised.

5.2.3.2 Impact Description: Water contamination from Acid Mine Drainage into nearby watercourses

AMD causes acidification and metal contamination of surface and ground water bodies when mine materials containing metal sulphides are exposed to oxidizing conditions. Heavy-metal contaminated and acidified groundwater discharges into streams at points where the water table is close to the surface. The oxidation of iron sulphide precipitates sulphuric acid which lowers in-stream water pH. Acidic water environments are detrimental to most aquatic life species, and they affect irrigation and livestock watering functions for downstream water users.

5.2.3.3 Management/Mitigation Measures

The following mitigation measures are recommended:

- Disturbance of soils during infrastructure demolition should be restricted to relevant footprint areas;
- Movement of demolition machinery and vehicles should be restricted to designated access roads to minimise the extent of soil disturbance;
- The best option to limit AMD is early avoidance of sulphide oxidation through use of a combination of several techniques which include the following (Sahoo et al., 2013):
  - Electrochemical treatment of the acidified effluent producing re-usable water;
  - Physical barriers using wet or dry covers that retard sulphide oxidation;

- Chemical passivation, which involves encapsulation of sulphide surfaces using organic and/or inorganic coatings such as silica, phosphate, lipids and humic acid; and
- Desulphurization which separates sulphide minerals into a low-volume stream, that mainly results in non-acid-generating waste with low sulphur content.
- Use of accredited contractors for removal or demolition of infrastructure is recommended; this will reduce the risk of waste generation and accidental spillages;
- Should decant occur at a later stage, decant water should be treated to acceptable water quality levels prior to discharge into the natural stream

Table 5-9: Impact significance rating for the decommissioning and closure phase

Dimension	Rating	Motivation	Significance
Impact: In-stream water quantity and quality deterioration			
Duration	2	The impact will only likely occur when there demolition of infrastructure during the decommissioning phase.	24-Negligible (negative)
Intensity	2	This will have minor to medium-term intensity resulting in reduction of proximal watercourse flow capacity and poor water quality for immediate downstream users and the aquatic life	
Spatial scale	2	The impacts will be localised to the nearby watercourses from where the silt is being generated to the immediate downstream	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the decommissioning phase	6-Negligible (negative)
Intensity	2	Should the impact occur, it will have minor medium-term impacts resulting in a reduction in water quality for downstream users and the aquatic life	
Spatial scale	2	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	

Dimension	Rating	Motivation	Significance
Probability	1	With the existing measures already in place. It will be rare/improbable for this impact to occur.	

Dimension	Rating	Motivation	Significance
Impact: Water Contamination from Acid Mine Drainage into surface water resources			
Duration	6	The impact will remain for some time after the life of the project.	90-Moderate (negative)
Intensity	5	High significant impact on the environment. Irreparable damage to highly valued species, habitat or ecosystem.	
Spatial scale	4	The impacts will be localised to the immediate surroundings of the mine site.	
Probability	6	It is most likely that the impact will occur.	
Post-mitigation			
Duration	5	The impact will remain only for the duration of the life of the project.	32-Negligible (negative)
Intensity	1	With effective prevention of the oxidation of iron sulphides the AMD impact will have low to moderate intensity	
Spatial scale	2	Limited to the site and its immediate surroundings.	
Probability	4	It is probable the impact will occur.	

5.1 Unplanned Events and Low Risks

The potential risks or unplanned events involve accidental spillages of hazardous substances from waste storage facilities into adjacent surroundings during the operation phase. This may lead to impacts on water quality in the surrounding streams, should runoff from these contaminated areas enter the system.

There is also a risk of flooding of the proximal watercourses due to discharge of additional treated effluent volumes. Flooding may cause subsequent damage to properties and infrastructure that are placed within the flood prone extent.

Also, flooding may lead to mobilisation of hazardous substances from the mainland and this may impact on the river water quality. A summary of the risks from unplanned events, together with the management measures are presented in Table 5-10.

Table 5-10: Impacts from unplanned events and their management measures

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Hazardous material spillage	Surface water contamination	An emergency spillage response plan and spill kits should be in place and accessible to the responsible monitoring team in case of bursting accidents. The Material Safety Data Sheets (MSDS) should be kept on site for the Life of Mine for anytime reference in terms of best practice guidelines for handling, storage and disposal of materials.
Flooding of the Mooi River Loop	Surface water contamination and subsequent damage to property	The amount of water to be discharged into the Mooi River Loop will not be expected to make a significant change on mean annual runoff for the Blyvoor Gold Mine catchment. Monitoring of discharge volume is, however, recommended to ensure a controlled discharge

6 Surface Water Monitoring Plan

6.1 Monitoring Programme

Although Blyvoor is currently not discharging any waste water into the environment, a monitoring programme is essential as a management tool to detect negative impacts as they arise and to ensure that the necessary mitigation measures are implemented.

Blyvoor Gold Mine does not have an existing monitoring programme in place. Although monitoring has been historically conducted with some of the monitoring points not clearly defined in the previous specialist reports, this report recommends or provide a surface water monitoring programme with clearly defined monitoring points to be implemented by the mine throughout the life of mine. All water quality results should be benchmarked to relevant water quality objectives to determine any impact on the quality of water (positive/negative).

The surface water monitoring plan is summarised as follows:

Table 6-1: Surface Water Monitoring Plan

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Ensure water quality monitoring as per existing monitoring programme. Parameters should include but not limited to; pH, Electrical Conductivity, Cyanide, Aluminium, hydrocarbons, Sulphates, Phosphates, Iron, Manganese, Calcium, Magnesium, Nitrate, Ammonia, Fluoride, Chloride, Total dissolved solids, Suspended Solids; Sodium, Potassium. It is also recommended to monitor water quality within the mine water dams or water containment facilities to determine the concentration levels in case of an overflow or need for discharge.	-Monthly prior to resumption of operations to obtain the baseline water quality; -Monthly during construction and operation (hydrocarbons can be done on a quarterly basis). -Monitoring needs to carry on three years after the project has ceased, as is standard practice to detect residual impacts.	Environmental Officer
Water quantity	Flow monitoring should be carried out downstream of discharge point to ensure a controlled discharge and effectiveness of discharge point energy dissipaters. The discharge pipeline should be equipped with instantaneous or automatic flow meters to ensure real time measurements of discharge water.	In operational areas where automatic flow meters are in place, daily records need to be kept	Environmental Officer
Physical structures and Storm Water Management Plan (SWMP) performance	Personnel should have a walk around facilities to determine the facilities conditions and pick out any anomalies such as leaks or overflows and system malfunctions. Storm water channels, and existing mine dams are inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.	Continuous process and yearly formal report	Environmental Officer

Monitoring Element	Comment	Frequency	Responsibility
Meteorological data	Measure rainfall	Real time system if in place	Environmental Officer

6.2 Proposed Monitoring Points

Blyvoor should undertake surface water quality monitoring before recommencement of mining activities to provide baseline water quality. Monitoring should continue after resumption for the whole of the Blyvoor Gold Mine LOM as per the monitoring programme recommended in section 6.1. The proposed monitoring points are presented in Table 6-2 and in Figure 4-3.

Table 6-2: Proposed monitoring points at the Blyvoor Gold Mine

Monitoring Localities	Description	Coordinates	
		Latitude	Longitude
SW1	Unknown stream upstream of Blyvoor Mine	-26.438707°	27.314957°
SW2	Unknown stream downstream of Blyvoor Mine	-26.397488°	27.275844°
SW3	Mooi River Loop adjacent Blyvoor Mine	-26.372194°	27.239131°
Wonderfonteinspruit	Upstream	-26.316700°	27.392500°
	Downstream	-26.434700°	27.151900°
Blyvooruitzicht 116 IQ	Western Deep Spruit	-26.38833°	27.39861°

7 Conclusions

Based on the preceding discussion, the following conclusions were drawn:

7.1 Baseline Hydrology

- The Vaal WMA 5 and quaternary catchment C23E demarcate regional hydrological boundaries in which the Blyvoor Gold Mine project site is located.
- The MAP, MAR and MAE of the site were calculated to be 634 mm, 7.1 mm and 1675 mm, respectively.
- The MAP indicates moderate to high rainfall for the region of which approximately 1% is redistributed as surface runoff.

7.2 Water Quality

- DRD03, DRD07, DRD08, DRD09, DRD10 and DRD12 points show acceptable EC levels with respect to the RWQO for the Mooi River catchment, especially at the beginning of January 2017 to August 2018.

- While the EC levels at the WWS34 point were acceptable up to mid-2016, a fluctuating increase is observed towards the end of 2016 up to August 2018.
- High but declining EC and TDS levels at the BV81L monitoring site were noted.
- Acceptable nitrate levels are indicated for the monitoring period April 2014 to August 2018.
- Generally, Pb levels are slightly above the RWQO during most of the monitoring period from April 2014 to August 2018.
- Cd and U monitored at BV81L and WWS34 points generally indicate higher concentrations than the recommended RWQO.
- Selenium levels are acceptable at all monitored points except at WWS34.
- Al levels fluctuated slightly above the RWQO from 2014 to 2017, then declined to acceptable limits until the August 2018 monitoring period.

7.3 Surface Water Impact Assessment

The following impacts are envisaged from the Blyvoor Gold Mine joint venture development:

- Contamination of water in the Mooi River Loop, Wonderfonteinspruit and Greenbelt Streams and subsequent deterioration of water quality for downstream water users.
- In-stream water quality deterioration due to runoff from contaminated areas and any dirty water discharges such as treated sewage effluent into nearby watercourses.
- Contamination of surface water resources from spillages and leakages of hydrocarbons and chemicals from equipment and machinery.
- In-stream water quality deterioration due to sedimentation and siltation of nearby watercourses resulting from demolition of infrastructure and subsequent disturbance of soils.
- Pollution of surface water resources and increase of flow volumes resulting from AMD into proximal watercourses.

8 Recommendations

The following is recommended to manage the existing and potential impacts at the Blyvoor Gold Mine:

- Any dirty water discharges into the natural environment should be monitored for compliance to IWUL or RWQO for the Mooi River catchment. It has been noted that Blyvoor is currently not discharging any waste water into the environment.
- It is a requirement of the NWA that water quality monitoring be undertaken throughout the Life of Mine whether regardless of any or no discharges from mining operations. This ensures that any potential sources of pollution are detected and rectified before severe environmental damage occurs. Blyvoor Gold should,

therefore, continue with the current surface water monitoring programme covering the sampling suite as described in the water quality monitoring programme subsection.

- Any infrastructure development which will need excavation and vegetation clearance should be limited to the proposed development footprint;
- Dust suppression measures must be undertaken on the cleared areas during construction to reduce aeolian erosion;
- All fuel and other chemical storage areas should be appropriately bunded and have spill kits in place. Relevant mine workers should be trained in the use of spill kits to contain and immediately clean up any leakages or spills. All used oils should be disposed of by accredited vendors from the mine site.
- Runoff from dirty areas should be channelled and contained in HDPE or concrete lined storm water infrastructure (drains and PCDs).
- Vehicles must only be serviced within designated service bays.
- The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites.
- The stormwater management plan for the mine should be optimised to ensure that the clean and dirty water separation systems are updated for the refurbished mine plant. This will include the following:
  - Placement of a perimeter berm and channel around No. 7 and No. 6 TSFs;
  - Confirmation of the Return Water Dam (RWD) capacity and sizing of the perimeter berm; and
  - Channelling of polluted runoff from the RWD and associated dirty catchment to a Pollution Control Dam (PCD).

9 References

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