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LEADERS IN ENVIRONMENTAL MONITORING

# Anglo American Platinum Rustenburg Process Division

## Annual Integrated Surface and Groundwater Quality, Biomonitoring and Toxicity Testing Assessment Report, Vol I

September 2018 to August 2019

**Anglo American Platinum**
**Rustenburg Process Division**

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|---|---|
| **REFERENCE** | APPD/AR1.1/2019/WR |
| **REPORT TITLE** | Annual Integrated Surface and Groundwater Quality, Biomonitoring and Toxicity Testing Assessment Report. September 2018 to August 2019 |
| **DATE SUBMITTED** | 14 January 2020 |
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| **STATUS** | Final |
| **REPORTING SCOPE** | This is an extensive report and includes a full evaluation of all the results obtained during the annual monitoring period. The report includes a statistical summary (temporal & spatial) of all the chemical variables for all the monitoring localities, time-series graphs (for the entire database period), linear trend determinations, performance analyses and compliance assessments, water quality thematic maps indicating pollution sources and impacts on the receiving water body as well as a discussion and recommendation section. This report is composed of three volumes. |

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**APPENDIX A: Annual Report on Groundwater Monitoring**

**APPENDIX B: Biomonitoring Report**

**APPENDIX C: Toxicity Test Report**

# 1. INTRODUCTION

Globally, water is one of the prime environmental resources that are affected by anthropogenic activities. Activities associated with mining can pose a risk for adverse environmental impacts. Mining and mineral beneficiation can affect water quality; alter the hydrological and topographical characteristics on a local scale and subsequently surface runoff, soil moisture, evapo-transpiration and groundwater behaviour. Mining activities can pose a significant risk to South Africa's water resource security. Failure to manage the impacts on water resources in an acceptable manner throughout life-of-mine and post-closure will result in the mining industry finding it increasingly difficult to obtain community and government support for existing and future projects.

In South Africa, environmental impacts associated with mining are managed under the Minerals and Petroleum Resources Development Act, 2002 (MPRDA, Act 28 of 2002) which is administrated by the Department of Mineral Resources (DMR). The Department of Water and Sanitation (DWS) acts as primary agent for water related issues in the mining sector. As custodian of the natural water resources, it is an integral function of the Department of Water and Sanitation's (DWS) regulatory system to manage the effects of any anthropogenic activities on the country's water resources. The National Water Act provides the legal framework for the effective and sustainable management of our water resources. The protection of water resources is fundamentally related to their use, development, conservation, management and control.

The National Water Act, 1998 (Act 36 of 1998) (NWA) introduced the concept of Integrated Water Resource Management (IWRM), comprising all aspects of the water resource, including water quality, water quantity and the aquatic ecosystem quality (quality of the aquatic biota and in-stream and riparian habitat) (DWAF, 2007). The mentioned IWRM approach also calls for both resource and source directed measures. Resource directed actions include the formulation of resource quality objectives and catchment management strategies while source directed measures focus on impacts at source. The resource directed measures must also give effect to the Class, Reserve and Resource Quality Objectives of the water resources and associated protection measures (DWAF, 2008).

The promulgation of the NWA thus lead to a paradigm shift resulting in the natural environment being regarded as an integral part of the water resource itself, as well as one of the competing water users. Hence the biota, the physical and chemical in-stream habitats and the processes which link biota and habitat are all considered being inseparably part of the water resource itself.

Section 19 of Chapter 3 in the NWA deals with pollution prevention, and in particular the situation where pollution of a water resource occurs or might occur as a result of activities on land, such as mining, and states that: *"The person who owns, controls, occupies or uses the land in question is responsible for taking measures to prevent pollution of water resources. If these measures are not taken, the catchment management agency concerned may itself do whatever is necessary to prevent* *pollution or to remedy its effects, and to recover all reasonable costs from the persons responsible for the pollution."*

In Section 22 of Chapter 4 of the Act, the general principles for regulating the use of water are set out. Water use is defined broadly and includes the taking and storing of water, activities which reduce stream flow or alters a water course, waste discharges and disposal, removing water from underground and controlled activities which may impact detrimentally on a water resource. In general, a water use must be licensed under the Act.

Section 26 of the National Water Act, 1998 (Act 36 of 1998) also provides for the development of regulations to, amongst others:

- Require that the use of water from a water resource be monitored, measured and recorded.
- Regulate or prohibit any activity in order to protect a water resource or in-stream or riparian habitat.
- Prescribe the outcome or effect, which must be achieved through management practices for the treatment of waste, or any class of waste before it is discharged into or allowed to enter a water resource.
- Require that waste discharged or deposited into or allowed to enter a water resource be monitored and analysed, and prescribing methods for such monitoring and analysis.

Prior to issuing of the WUL the Rustenburg operations operated according to the expired Exemption Permit issued in terms of the now repealed Water Act, 1956 (Act 54 of 1956). Both the WUL and the expired Permit stipulated that a surface- and ground water quality, biomonitoring and toxicity testing program should be designed, implemented and maintained.

Rustenburg Platinum Mines: Rustenburg Section (RPM-RS) was issued with a Water Use License (WUL; License No 03/A22H/ACGIJ/926) in terms of Chapter 4 of the National Water Act, 1998 (Act No 36 of 1998) in March 2012. Due to several alsubstantial errors observed in the approved WUL and after consultation with DWA, an amendment WULA was submitted on 12 July 2012; A the new WUL (WUL; License No A22H/GIAC/6501) was issued in January 2018 and will henceforth be referenced as WUL, 2018.

The Anglo Platinum Environmental Department decided to take a pro-active approach towards auditing requirements, as well as the latest development in national water management policy. Aquatico Scientific was commissioned by Anglo Platinum to conduct the surface water and groundwater monitoring programme and to evaluate the physical, chemical and biological properties of the receiving water environment subject to potential impact.

This annual report presents the data from the Anglo Platinum monitoring programme while effectively indicating compliance with the applicable policy of regulating authorities, such as contained in ethe mentioned WUL. It is thus the intention of this annual monitoring report to indicate the implementation of a well-designed and maintained monitoring programme which is considered essential within any mine water management strategy on the basis that "one cannot manage what one cannot measure" (DWAF, 2008).

Additional information can be found in the comprehensive annual water management report "Anglo Platinum Process Division – Annual DWA Compliance Report" *No.* ***APPD/ACR1/2019/WR*** submitted to DWA and compiled by Aquatico Scientific. Additional information referenced in above-mentioned report includes:

- Operations and permit information;

- Production figures and water usage;
- Rainfall and evaporation data; and
- Flow data.

## 2. WATER USE LICENCE

**Note on compliance towards license conditions as set out in the WUL (2018)**

A new water use license in terms of Chapter 4 of the National Water Act, 1998 (Act No. 36 of 1998) (The Act) was issued by the Department of Water and Sanitation (DWS) in 2018: Licence no. A22H/GIAC/6501. The license was issued for water uses relating to the following:

i. Section 21(a) of the Act: Taking water from a water resource
ii. Section 21(g) of the Act: Disposing of waste in a manner which may detrimentally impact on a water resource

The uses applicable to the water monitoring programme and the current document are Section 21(g) of the Act relating to the disposing of waste which may detrimentally impact on a water resource.

As mentioned, the NWA introduced the concept of Integrated Water Resource Management (IWRM), comprising all aspects of the water resource, including water quality, water quantity and the aquatic ecosystem quality. The IWRM approach provides for both resources directed and source directed measures. Resource directed measures aim to protect and manage the receiving environment. Examples of resource directed actions are the formulation of resource quality objectives and the development of associated strategies to ensure on-going attainment of these objectives; catchment management strategies and the establishment of catchment management agencies (CMAs) to implement these strategies.

On the other hand, source directed measures aim to control the impacts at source through the identification and implementation of pollution prevention, water reuse and water treatment mechanisms.

The integration of resource and source directed measures forms the basis of the ***hierarchy of decision-taking*** aimed at protecting the resource from waste impacts (Figure 1). This hierarchy is based on a *precautionary approach* and the following order of priority for mine water and waste management decisions and/or actions is applicable:

**RESOURCE PROTECTION AND WASTE MANAGEMENT HIERARCHY**

**Step 1: Pollution Prevention**

↓

**Step 2: Minimisation of impacts**
Water reuse and reclamation
Water treatment

↓

**Step 3: Discharge or disposal of waste and/or waste water**
Site Specific risk-based approach
Polluter pays principle

**Figure 1: Resource Protection and Waste Management Hierarchy**

Appendix III of the WUL (2018) stipulates that the Licensee shall monitor the water resources at surface water monitoring points, groundwater monitoring points, biomonitoring points and toxicity monitoring points to determine the impact of the facilities and other activities on the water quality. The WUL has two main water quality objectives; (1) limits for the impact of the activities on groundwater (in Table 8 of the WUL), and (2) water quality limits stipulated for the impact of the activities on the surface water quality of the area (in Table 9 of the WUL), i.e. the resource water quality objectives.

Presented in Table 1 below are the guidelines which were issued by the DWA to serve as protection of the resource and to monitor the quality of of the source. Also shown are the SANS241:2015 Drinking water standard, the South African Water Quality Guidelines' Target water quality guideline ranges for Domestic Use (DWAF, 1996) and the quality typical of the wastewater dams (Return Water Dams) of the RPM-RS operations.

The table shows stringent WUL limits as oppose to the presented drinking water quality guidelines and also greater compared to typical upstream and wastewater quality for the RPM-RS lease area. It is therefore recommended that the WUL limits be revised which should be created using the background 'in-coming' quality as reference and not pristine groundwater quality of the region or catchment.

**Table 1: Quality limits for water monitoring programme**

| VARIABLE | Units | Groundwater Quality Limits (WUL 2018) | Surface Water Quality Limits (WUL 2018) | SANS 241-1:2015 Drinking water standards | General Limit [Section 21 (f) and (h)] | DWA SAWQG Ideal (Class 0) Domestic Water |
|---|---|---|---|---|---|---|
| pH | pH units | 6.0 - 9.5 | 6.0 - 9.0 | 5.0 - 9.7 | 5.5 - 9.5 | 6.0 - 9.0 |
| Electrical Conductivity (EC) | mS/m | 150 | 85.00 | 170 | 150 | 0 - 70 |
| Total Dissolved Solids (TDS) | mg/l | - | - | < 1200 | - | 0 - 450 |
| Dissolved Oxygen (DO) | mg/l | - | 43654.00 | - | - | - |
| Total Alkalinity ($CaCO_3$) | mg/l | - | - | - | - | - |
| Hardness (CaCO3) | mg/l | - | 50 | - | - | 0 - 200 |
| Calcium (Ca) | mg/l | 150 | - | - | - | 0 - 80 |
| Magnesium (Mg) | mg/l | 100 | - | - | - | 0 - 70 |
| Sodium (Na) | mg/l | 200 | - | 200 | - | <100 |
| Potassium (K) | mg/l | - | - | - | - | <25 |
| Chloride (Cl) | mg/l | 200 | - | 300 | - | < 100 |
| Sulphate ($SO_4$) | mg/l | 200 | - | 250 | - | 0 - 200 |
| Nitrate ($NO_3$) as N | mg/l | 10 | - | 11 - (Acute Health) | 15 | <6 |
| Ammonia ($NH_4$) as N | mg/l | - | 1.00 | 1.5 | 6 | 0 - 1.0 |
| Phosphate ($PO_4$) as P | mg/l | - | 0.125 | - | 10 | - |
| Fluoride (F) | mg/l | 1 | 0.75 | < 1.5 - (Chronic Health) | 1 | <0.7 |
| Aluminium (Al) | mg/l | - | 5 | 0.3 (Operational) | - | 0 - 0.15 |
| Iron (Fe) | mg/l | - | 0.5 | 0.3 - (Aesthetic)<br>2.0 - (Chronic Health) | 0.3 | 0 - 0.5 |
| Manganese (Mn) | mg/l | - | 0.18 | 0.1 - (Aesthetic)<br>0.4 - (Chronic Health) | 0.1 | 0 - 0.1 |
| Cadmium (Cd) | mg/l | - | - | 0.003 | 0.005 | <0.003 |
| Trivalent chromium ($Cr^{3+}$) | mg/l | - | - | 0.05 | - | - |
| Hexavalent chromium ($Cr^{6+}$) | mg/l | 0.0049 | 0.0049 | 0.1 | 0.05 | 0 - 0.05 |
| Copper (Cu) | mg/l | - | 0.3 | 2 | - | 0 - 1.0 |
| Nickel (Ni) | mg/l | - | - | 0.07 | - | - |
| Lead (Pb) | mg/l | - | - | 0.01 | 0.01 | 0 - 0.01 |
| Zinc (Zn) | mg/l | - | - | 5 | 0.1 | 0 - 20 |
| Arsenic (As) | mg/l | - | - | 0.01 | 0.02 | <0.01 |
| Cyanide (CN) | mg/l | - | - | 0.2 | 0.02 | - |
| Mercury (Hg) | mg/l | - | - | 0.006 | 0.005 | - |
| Seleniun (Se) | mg/l | - | - | 0.04 | 0.02 | - |
| Vanadium (V) | mg/l | - | - | - | - | - |
| Barium (Ba) | mg/l | - | - | 0.7 | - | - |
| Boron (B) | mg/l | - | - | 2.4 | 0.5 | - |
| SAR | mg/l | - | - | - | - | - |
| Free Chlorine (residual) $Cl_2$ | mg/l | - | - | 5 | 0.25 | 0.3-0.6 |
| E Coli counts / 100 ml | mg/l | - | - | 0 | 1000 | 0 |
| Total coliforms counts / 100 ml | mg/l | - | - | 10 | - | 0 |
| Het. Plate count / TVC | mg/l | - | - | 1000* | - | - |
| Faecal coliforms counts / 100 ml | mg/l | - | - | 0 | 1000 | 0 |
| Turbidity (NTU) | mg/l | - | - | 1 (Operational)<br>5 (Aesthetic) | - | < 0.1 |
| Total Suspended Solids | mg/l | - | - | - | 25 | - |
| Soap, Oil, Grease | mg/l | - | - | - | 2.5 | - |
| Chemical Oxygen Demand | mg/l | - | - | - | 75 | - |
| Hydrocarbons | mg/l | - | - | - | - | - |
| Polycyclic aromatics | mg/l | - | - | - | - | - |

## 3. LEGAL PERSPECTIVE AND MONITORING REQUIREMENTS

Mining operations are anticipated to pose a high risk for adverse environmental impacts. These impacts may occur slowly and unnoticed during the operational life cycle phase of the mine as mining activities progresses and/or during adverse weather conditions, or only emerge long after mining ceased. Possible impacts need to be prioritised in terms of a number of influencing factors such as the actual impact quantification, industry standards, applicable legislation, mitigation requirements, and mine management requirements (DWAF, 2006a).

The development of a site-specific efficient monitoring programme that complies with the requirements of mine management as well as regulatory requirements is of utmost importance. Water monitoring should be objective driven and purposefully utilised to achieve goals such as compliance auditing and reporting as summarised in the Figure 2.

Various environmentally related legislation require either directly or indirectly the monitoring of water resources, such as the Environment Conservation Act (Act 73 of 1989), the National Environmental Management Act (Act 107 of 1998), the Minerals and Petroleum Resources Development Act (Act 28 of 2002) (including Environmental Management Programme Reports (Section 39), Regulations relating to performance assessments (auditing) of EMPR's (Government Notice (GN) R801 of 25 June 1999) and Closure requirements (Section 12), as well as the National Water Act, 1998 (Act 36 of 1998).

Special emphasis should be placed on the National Water Act, 1998 regarding water resource monitoring. Subsequent to the implementation of the mentioned Act, the focus changed from concentrating on controlling pollution at source by means of regulatory standards, to a water resource management philosophy that concentrate also on resource management through maintaining the fitness for agreed or specified uses including the protection of aquatic ecosystems. The mentioned Act recognises that ecosystems form the resource base on which sustainable utilisation of water resources depend.

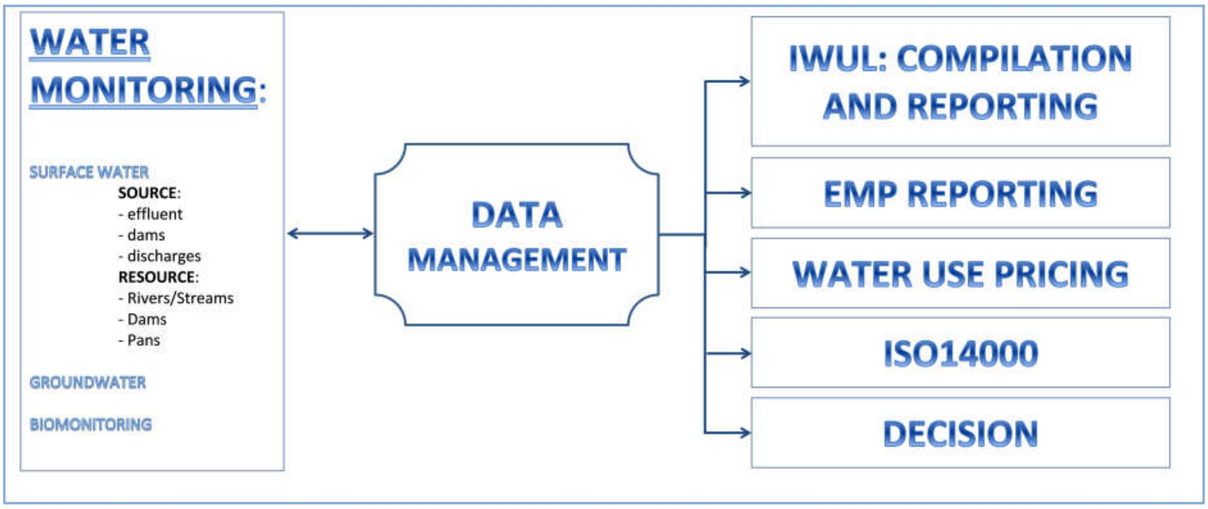



**Figure 2: Diagrammatic presentation of the importance of environmental monitoring in Integrated Environmental Management, as adopted from BPG G3**

Since the Department of Water Affairs (DWA) is the public trustee of South Africa's water resources it is the DWA's responsibility to ensure that water resources remain fit for use on a sustainable basis. DWA exercises the responsibility through the implementation of Regulations such as the regulations on use of water for mining and related activities aimed at the protection of water resources (GN 704 dated June 1999), the Water use licensing process, including the determination of the “reserve” for the various water resources. Verification of the mining operation’s compliance with the applicable legislation (including the water use licences and requirements of the regulations) can only be illustrated through the implementation of a water resource monitoring plan.

The importance of a monitoring system can be emphasised through the following: “It is essential that any management system incorporate clearly defined monitoring systems to be implemented to measure the effectiveness of management strategies and mitigating actions and compliance with agreed targets and objectives. The responsibilities, reporting formats and frequencies must be defined, together with an auditing plan for both technical and compliance audits” (DWAF, 2008).

The DWA developed a series of Best Practice Guidelines (BPG’s) for water quality management in the South African mining industry. This series of BPG’s forms a component of the overall source directed water policy for mining and related activities implemented by the DWA. The following Best Practice Guideline are of importance to surface water monitoring; Integrated Mine Water Management (BPG G1; DWAF, 2006a), Water and salt balances (BPG G2; DWAF, 2006b) and Water Monitoring Systems (BPG G3; DWAF, 2007) make specific references to water monitoring requirements and was thus used as a guiding tool in this study and the subsequent development of a surface water monitoring programme for Anglo Platinum.

The BPG G3 guideline emphasise that the development and maintenance of a well-designed and effective monitoring programme is essential within any mine water management strategy. It deals with the following aspects of a monitoring strategy:

- Definition of the objectives of a monitoring strategy,
- Design of a monitoring strategy,
- Monitoring and sampling equipment and procedures,
- Procedures for implementation of monitoring programmes,
- Data management systems, and
- Audit and quality assurance of monitoring programmes.

It is stated in BPG G3, that accurate and reliable data forms a key component of many environmental management actions. Some of these actions may receive more focus from government officials, whilst others may be more important for the mine personnel or mine management. Water monitoring is a legal requirement and can be used in negotiations with authorities for licence applications. The most common environmental management actions that require data and thus the objectives of a water monitoring programme include, though not limited to the following (DWAF, 2007):

- Development of environmental and integrated mine water management plans based on impact and incident monitoring.
- Generation of baseline / background data before new project implementation.
- Identification of sources of pollution and extent of pollution.
- Monitoring of water usage by different users and thus maximising on water reuse.
- Calibration and verification of various prediction and assessment models.
- Identification and evaluation of appropriate water treatment technology.
- Control of unit processes such as water treatment plants or process plants.
- Evaluation and auditing of the success of implemented management actions (ISO14000, compliance monitoring).
- Assessment of compliance with set standards and legislation (EMPR’s, water use licences).

- Assessment of impact on receiving water environment.

Without reliable measurement of water resource quality and quantity, the above functions cannot be undertaken and hence the saying that "one cannot manage that which one cannot measure".

A typical monitoring process is summarised in Figure 3 and was added in order to describe the process where it states that it “must be recognised and understood that the successful development and implementation of an appropriate, accurate and reliable monitoring programme requires that a defined structured procedure be followed. Furthermore, it is important that this is done by a suitably qualified person. The requirements for the use of suitably qualified persons during various activities undertaken in the monitoring process as well as the definition of a suitably qualified person are also prescribed in the above-mentioned guideline. A suitably qualified person is defined as a person having a level of training, experience and the recognised skills in the type of work to be done.

The detailed features of monitoring programmes are required to be very site-specific. No single uniform procedure that can be followed when defining and implementing a monitoring programme was thus provided in BPG G3. The following procedural requirements that should however be considered are also indicated in BPG G3:

- Interested and affected parties should be consulted at the appropriate time during the development, implementation and operation of the monitoring programme. The monitoring programme should be able to address their concerns and provide answers to their questions.
- The objectives of the management actions that drive the monitoring programme must be clearly defined, together with the data and information requirements that support these objectives.
- A detailed design of the monitoring programme must be undertaken. This should define the location of all monitoring points (indicated on a map), the type of data to be collected, as well as the data collection (protocol/procedure/methodology, frequency of monitoring and parameters determined, quality control and assurance), management (database and assessment) and reporting procedures. The implemented programme should be able to deliver the data and information that are required to achieve the objectives of the programme.
- Linked to the company SHE policies.
- The results from the monitoring programme should be representative of the actual situation. This requires that the monitoring programme should cover the relevant area in sufficient detail with a sufficient amount of appropriate monitoring points. It also requires that the sampling and monitoring should be undertaken according to procedures that will ensure representative samples and data.
- To ensure that the monitoring programme functions properly, an operating and maintenance programme should be developed and implemented.
- A well-defined data management system is required to ensure that data is secure, used optimally and is accessible to all the relevant users.
- The monitoring programme must include quality control (QC) measures and audits to ensure that the collected data are meeting the defined objectives (DWAF, 2007).

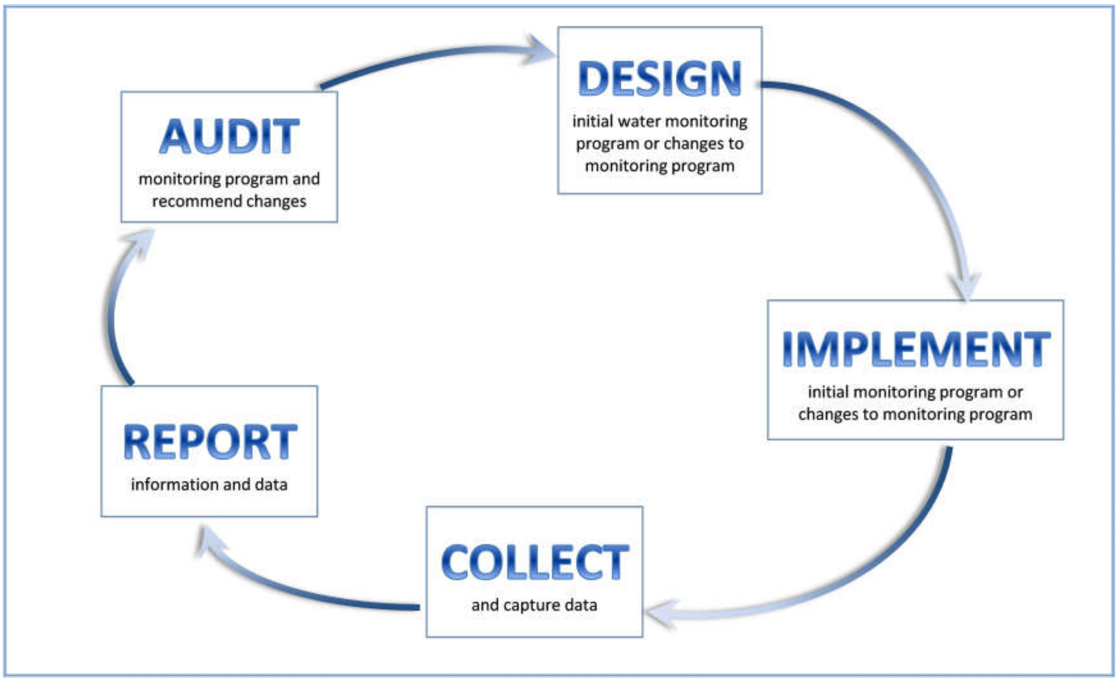



**Figure 3: Water monitoring process as adopted from BPG G3**

A water monitoring system on a mine should therefore consist of the following components:

- Surface and groundwater quality monitoring system.
- Surface and groundwater flow monitoring system.
- Bio-monitoring.
- Data and information management system.

Risk assessment needs to be built into any monitoring programme and it is important to determine the risk of water being polluted from different sources and its associated impact. The diversity of climates, ecosystems, land uses and topography are some Impacts that need to be considered in the design of a monitoring programme. Social factors have also become important elements in environmental management based on the Constitution of South Africa. The monitoring programme designed will thus be very site-specific and will need to consider regional physical and social factors.

The proposed procedure to develop a monitoring programme from the regulatory requirement point of view is described in detail in BPG G3 and summarised in Figure 4.

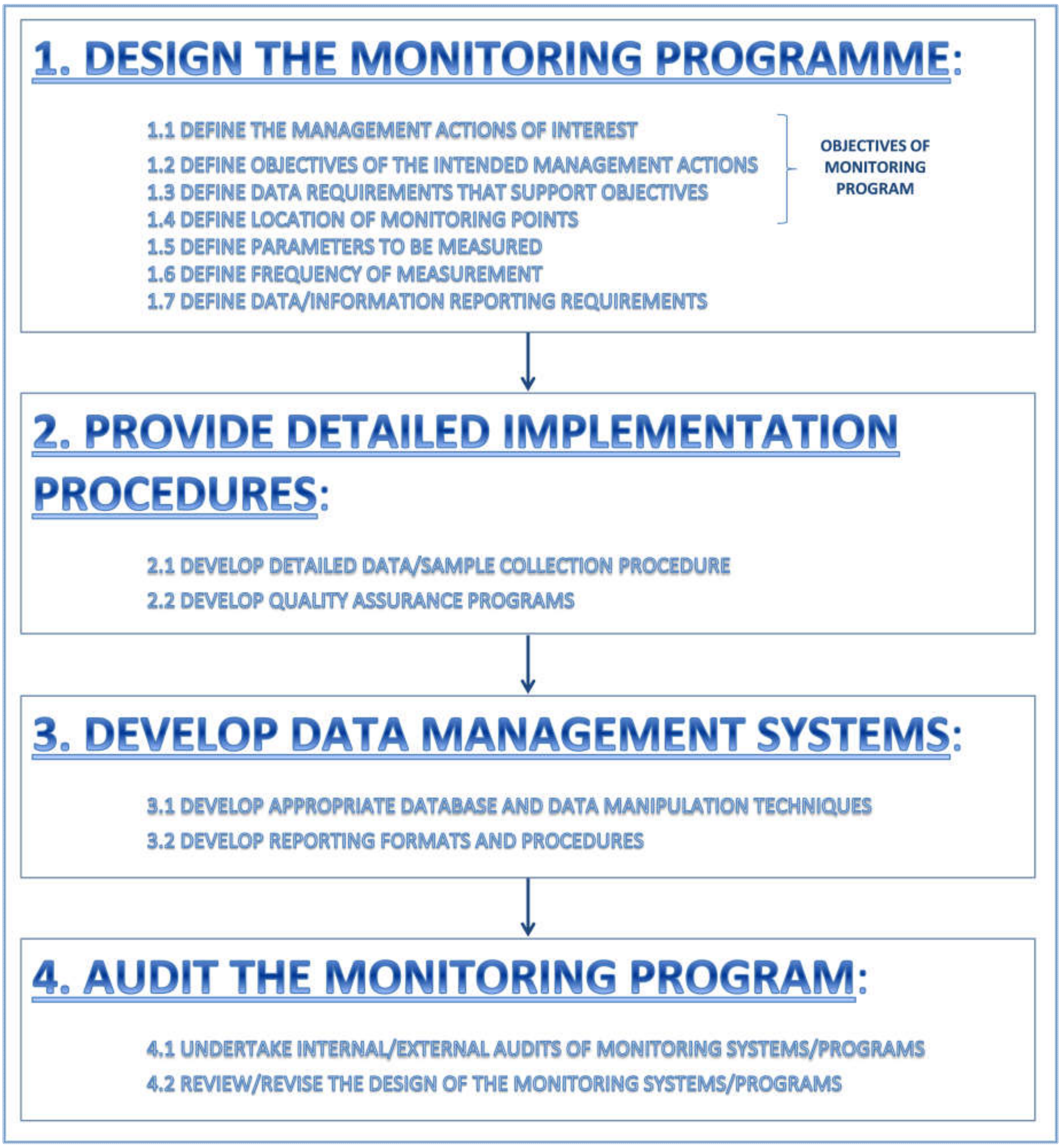



**Figure 4: Procedure to develop a monitoring programme as adopted from BPG G3**

The importance of data collection and implementation of a monitoring programme is also emphasised BPG G2. In the description and summary diagrams of the processes to develop water and salt balances, specific emphasis is given to “data collection and monitoring programme” as a specific and separate step in the development of such a water balance. This includes labelling of streams, collection and evaluation of existing data, identification of areas with insufficient data, development of a site-specific sufficient monitoring programme and the collection and assessment of new data.

It is stated in the above-mentioned guideline that to develop a water and salt balance, it is necessary to collect data of flow rates, dam volumes and water quality relevant to the identified water circuits. Existing data needs to be evaluated in order to determine where flow and quality data are not available, or where the data is out-dated, not reliable or insufficient. The areas in the water reticulation system where there are insufficient data must then be identified and a monitoring programme must be adapted or developed to collect sufficient data at these identified locations. The level of monitoring needs to take into consideration the significance of the point relative to the overall water and salt balance, and the accuracy required at the point. The monitoring programme should also take into consideration whether the water and salt balance are to assess missing flows or for compliance monitoring, which may have different requirements for location and accuracy. It must be noted at this stage that the current water monitoring program implemented at Anglo Platinum was not designed to cater sufficiently for the development of a water and salt balance.

# 4. SITE DESCRIPTION AND BACKGROUND INFORMATION

## 4.1. Background

Anglo American Platinum sold its Rustenburg mining operations to Sibanye Platinum, effective 1 November 2016. The mining operations were located north and east of the town Rustenburg in the Critical Zone of the western lobe of the Bushveld Complex. In the centre of these mining operations remained the Anglo American Platinum Process Division (henceforth referred to as the Rustenburg Process Division), including the Precious Metal Refiners, Rustenburg Base Metal Refiners, Waterval Smelter, Anglo Converting Process (ACP) and the Waterval East Tailings Storing Facility.

The Process Division is situated within the Hex River catchment just upstream from the Bospoort Dam (Quaternary catchment A22H). Various continuous, seasonal or event-linked discharges of affected process water takes place into seasonal tributaries of the Hex River, which drains the processing areas. The tributaries affected by the process division that drain into the Hex River are the Klipfonteinspruit and Klipgatspruit.

Activities in a catchment affect both the physical attributes and the chemical constituents of the water body and therefore also affect the biotic community. The Target Water Quality Guideline Ranges (TWQGR) as developed by the then Department of Water Affairs and Forestry and published in 1996, aim to ensure that water quality variables are maintained within the “no effect” range, i.e. such that the aquatic environment is not detrimentally affected by the additions of effluents.

## 4.2. Operational Overview

The Rustenburg Process Division is owned and operated by Anglo American Platinum Limited. Processing (smelting and refining) operations include mainly the Platinum and Platinum Group Metals (PGMs). Anglo American Platinum Limited is the world’s leading primary producer of Platinum and other PGMs including palladium, rhodium, ruthenium, iridium and osmium. Nickel, copper, other base metals and gold are also produced.

The process division is concerned with the beneficiation of ore into economical products and consists of the following operations:

*Waterval Smelter:*

> The Smelter uses electric furnaces to smelt concentrate to produce a sulphur-rich matte with gangue impurities removed as slag. The slag is cleaned and converter slag is reduced in an electric furnace to recover PGMs and base metals for recycling back to the converter. Oxygen-enriched air is blown through a top-submerged lance converter to oxidise sulphur and iron contained in furnace matte to $SO_2$ gas and slag respectively.

*Anglo Converting Process (ACP) and Acid Plant:*

The ACP plant is designed to reduce sulphur dioxide emissions and increase converting capacity. The resulting converter matte is slow-cooled to concentrate PGMs into a metallic fraction. At the acid plant $SO_2$ gas is converted to $SO_3$ by passing it over catalytic beds and the subsequent addition of water produces 98% sulphuric acid which is sold to fertiliser manufacturers.

*Rustenburg Base Metal Refiners (RBMR):*

At the Magnetic Concentration Plant (MCP) crushed converter matte is milled and the PGM fraction is separated magnetically. This is pressure leached to yield a solid final concentrate that is sent to PMR. Base metal-rich non-magnetic solids and leach solution are processed further in the base metal refinery. The base metal-rich solids are leached in high pressure autoclaves and contacted with MCP leach solution to yield separate nickel and copper streams. The separate nickel and copper streams are purified. During this process cobalt sulphate is recovered. Nickel and copper metal cathodes are produced by passing an electrical current through the separate purified streams in a process called electro-winning. Excess sulphur in solution is neutralised with sodium hydroxide and crystallised to form a sodium sulphate product. The final economical products of the RBMR are cobalt sulphate, nickel, copper and sodium sulphate.

*Precious Metal Refiners (PMR):*

From the MCP Plant at the RBMR, final concentrate is dissolved using hydrochloric acid and chlorine gas. PGMs are sequentially separated and purified to yield platinum, palladium, iridium, ruthenium and gold. Osmium is precipitated as a salt.

## 5. WATER MONITORING PROGRAM

The Rustenburg Process DivisionRustenburg Process Division water monitoring program in its current format, barring the addition or decommissioning of certain localities over time as operations change, has been running consistently since 1995. The monitoring programme was developed to include the following objectives:

- To document the determination and assessment of the impacts of the Rustenburg platinum operations on the receiving river systems. This includes monitoring of process water, discharges and effluents and receiving water up- and downstream from potential impacts to ultimately quantify and highlight impacts caused by the Rustenburg Process Division business units as well as other non-mining related impacts.
- To determine the usefulness of water for potential downstream users.
- The implementation of a well-designed and maintained monitoring programme and database which is considered essential within any mine water management strategy.
- Measuring of compliance towards the Water User License (WUL, 2018) under Chapter 4 of the National Water Act, 1998 (Act 36 of 1998).
- Aligning with the programs and guidelines of the Department of Water Affairs.

It is indicated as part of this annual monitoring report that:

- A detailed design of the monitoring programme was undertaken and that monitoring was undertaken in accordance with the monitoring programme.
- The monitoring programme is site specific as reflected in this annual monitoring report.
- The implemented programme delivered the data and information required to achieve the objectives of the programme.
- The results of the monitoring programme represent the actual situation on site.
- The data management system was used to ensure that data is optimally utilised.
- The monitoring programme is a dynamic system that changes as the mine and the mine water management system change. Recommendations are made as part of this annual report pertaining to such changes.

The current Rustenburg Process Division monitoring program’s locality names, coordinates, relevant catchment descriptions and sampling frequencies are illustrated in Table 2 and Table 3. A total of 47 surface water monitoring localities and 33 groundwater monitoring localities are currently active in the Rustenburg Process Division water monitoring programme.

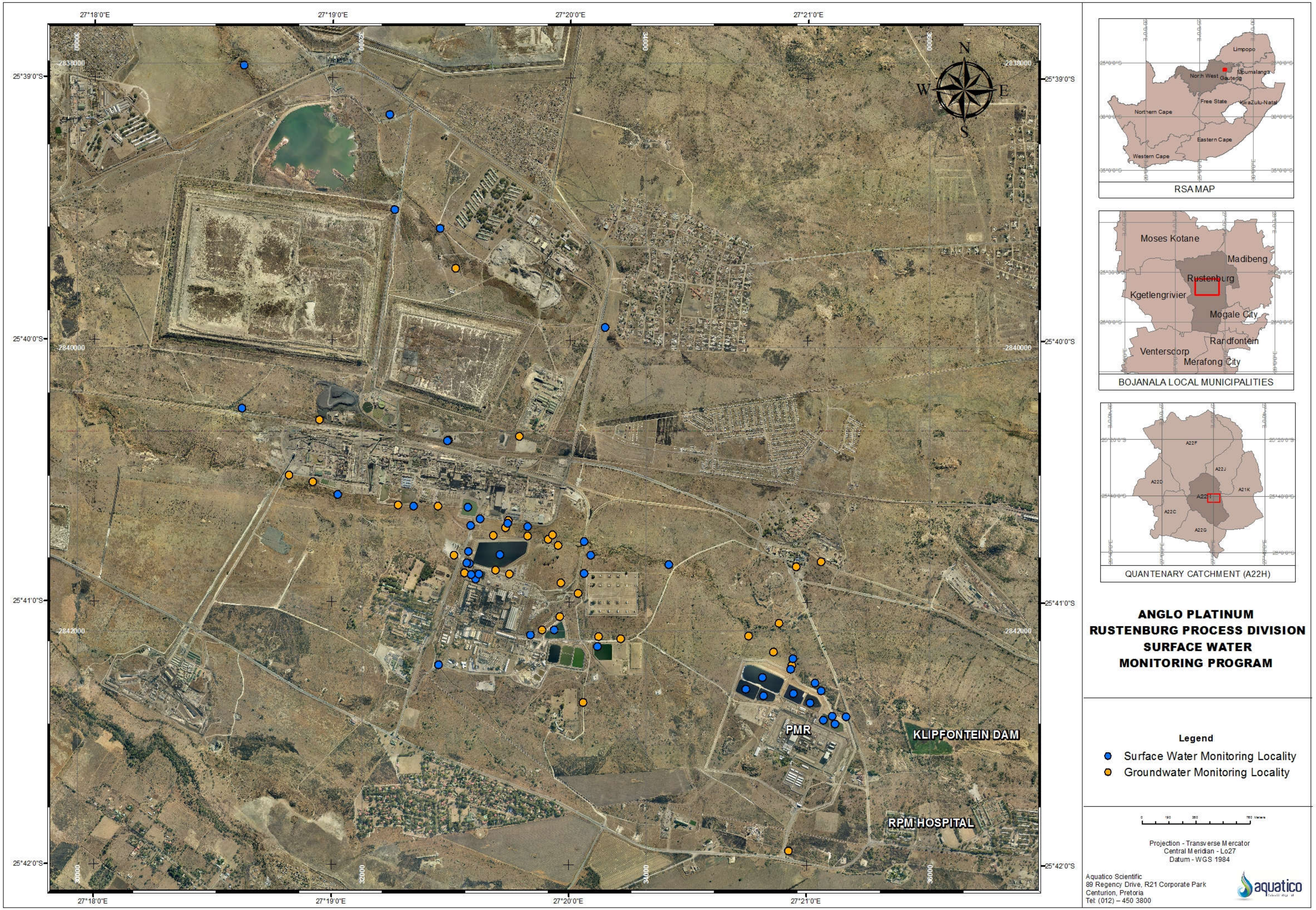



**Figure 5: Anglo Platinum monitoring area**

**Table 2: Rustenburg Process Division surface water monitoring locality names and descriptions**

| Site Name | Site description | Y-coordinates | X-coordinates | Monitoring Frequency |
|---|---|---|---|---|
| K008 | Klipfonteinspruit at PMR Bridge | -25.69061 | 27.35275 | M |
| K009 | PMR East rain water dam overflow | -25.68893 | 27.35098 | M |
| K010 | Klipfonteinspruit, downstream of K009 | -25.68844 | 27.35057 | M |
| K011 | Discharge at PMR culvert at PMR bridge | -25.69056 | 27.35177 | M |
| K012 | Klipfonteinspruit between PMR and RBMR on old road to magazine | -25.68096 | 27.34029 | M |
| K013 | Culvert ditch going to Klipfonteinspruit halfway between PMR bridge and Waterval bridge parallel to old railway | -25.68152 | 27.33435 | M |
| K014 | Intersection of Klipfonteinspruit and rail line bridge (south side) | -25.6795 | 27.33434 | M |
| K015 | 150 metres up from intersection of Klipfonteinspruit and rail line | -25.68036 | 27.33484 | M |
| K023 | Klipfonteinspruit at base of RBMR dump | -25.67855 | 27.33039 | M |
| K024 | Outflow of RBMR Dam 3 stormwater dam | -25.68091 | 27.32634 | M |
| K025 | Intersection between electric pylons & compressor air pipe between RBMR and lab. Storm water canal from ACP. | -25.67806 | 27.32706 | M |
| K028 | Klipfonteinspruit after confluence of RBMR west ditch system at Waterval smelter bridge | -25.67849 | 27.32638 | M |
| K032 | Klipfonteinspruit downstream of Waterval Smelter | -25.67655 | 27.31709 | M |
| K035 | Klipgat Return Water Dam of Waterval Tailings | -25.65237 | 27.32067 | M |
| K036 | Inflow into Klipgat return water dam from Waterval tailings dam 7-stream and Khomanani I Shaft sump canal | -25.65843 | 27.32103 | M |
| K044 | Trench to the west of the RBMR dam 3B | -25.68087 | 27.32612 | M |
| K059 | Culvert at railway entry to RBMR | -25.68543 | 27.3306 | Q |
| K062 | Spillway overflow RBMR stormwater dam 3B | -25.68015 | 27.32625 | M |
| K063 | Klipfonteinspruit at stormwater discharge from Waterval smelter and concentrator | -25.67728 | 27.3224 | M |
| K080 | Effluent and stormwater discharge west of PMR | -25.68759 | 27.34887 | M |
| K098 | ACP Pollution Control Dam | -25.677331 | 27.326189 | M |
| K099 | Klipfonteinspruit downstream of PMR | -25.68691 | 27.34901 | M |
| K136 | Klipgatspruit, downstream of Entabeni Hostel at Khomanani I Shaft (Frank I Shaft) | -25.65959 | 27.3242 | M |
| K158 | RBMR Dam1 | -25.68188 | 27.32676 | Q |
| K159 | RBMR Dam2 | -25.68163 | 27.32644 | Q |
| K160 | RBMR Dam3A | -25.68157 | 27.32700 | Q |
| K161 | RBMR Dam3B | -25.68034 | 27.32847 | Q |
| K162 | RBMR Triangular Dam | -25.68511 | 27.33229 | Q |
| K163 | RBMR SSSS Dam | -25.68618 | 27.33532 | Q |
| K167 | Cut-off trench north of Waterval concentrator just before discharge towards Klipfonteinspruit | -25.67106 | 27.31033 | Q |
| K168 | Cut off trench north of Waterval Smelter reverts area | -25.67312 | 27.32476 | M |
| K169 | Trench from PF Retief laboratory towards Klipfonteinspruit | -25.67835 | 27.32898 | M |
| K187 | Trench upstream of RBMR at culvert on access road to South gate | -25.68735 | 27.32416 | M |
| K188 | Klipgatspruit, downstream of Mfidikoe village, upstream of Khomanani I Shaft (Frank I Shaft), Frank Concentrator and Waterval Complex | -25.66587 | 27.33577 | M |
| K190 | Klipgatspruit, downstream of Klipgat Return Water Dam and Waterval Tailings | -25.64926 | 27.31044 | M |
| K208 | PMR Dam 1 | -25.68972 | 27.350228 | Q |
| K209 | PMR Dam 2 | -25.689142 | 27.349065 | Q |
| K210 | PMR Dam 3a | -25.690796 | 27.351136 | Q |
| K211 | PMR Dam 3b | -25.691052 | 27.35198 | Q |
| K212 | PMR Dam 4/5 | -25.6881 | 27.346858 | Q |
| K213 | PMR Dam 6E | -25.689256 | 27.346964 | Q |
| K214 | PMR Dam 6W | -25.688854 | 27.345702 | Q |
| K220 | RBMR Effluent dam 1 | -25.685799 | 27.331835 | Q |
| K221 | RBMR Effluent dam 2 | -25.685799 | 27.331835 | Q |
| K222 | RBMR Effluent dam 3 | -25.685799 | 27.331835 | Q |
| K223 | RBMR E&S feed dam 1 | -25.687804 | 27.330812 | Q |
| K224 | RBMR E&S feed dam 2 | -25.687661 | 27.330610 | Q |

***M – Monthly frequency**
**Q – Quarterly frequency**

**Table 3: Rustenburg Process Division groundwater monitoring locality names and descriptions**

| Site Name | Site description | Y-coordinates | X-coordinates | Monitoring Frequency |
|---|---|---|---|---|
| BMRWWTW | Downgradient of Waterval treatment works | -25.680378 | 27.325227 | Q |
| EM01 | UG2 complex downgradient south borehole | -25.675743 | 27.315343 | Q |
| EM11 | Central Deep borehole downgradient south-east of rock dump | -25.684665 | 27.348047 | Q |
| EM16 | Klipgatspruit borehole downgradient of Khomanani I Mine | -25.662122 | 27.325315 | Q |
| NB01 | UG2 complex upgradient north borehole | -25.671792 | 27.315785 | Q |
| NB02 | UG2 complex downgradient south-west borehole | -25.675300 | 27.313652 | Q |
| NB03 | Downstream South of ACP | -25.678150 | 27.329030 | Q |
| NB04 | PMR upgradient borehole | -25.699105 | 27.348748 | Q |
| NB48 | Waterval Tailings upgradient of Frank concentrator | -25.672808 | 27.329792 | Q |
| NB52 | BMR upgradient of SSS effluent dams | -25.689740 | 27.334303 | Q |
| NB56 | Central Deep borehole downgradient south of salvage yard | -25.680740 | 27.350972 | Q |
| NB57 | Central Deep borehole downgradient south of shaft | -25.681065 | 27.349220 | Q |
| NBH07 | Downgradient from PMR | -25.687347 | 27.348928 | Q |
| S011 | BMR downgradient west towards Klipfonteinspruit | -25.681508 | 27.325960 | Q |
| S051 | ACP downgradient south towards Klipfonteinspruit | -25.678628 | 27.328833 | Q |
| S102 | BMR downgradient north of north dump towards Klipfonteinspruit | -25.679347 | 27.331812 | Q |
| S104 | ACP downgradient south-east borehole | -25.679068 | 27.332142 | Q |
| S120 | BMR downgradient north of SSS effluent dams | -25.684282 | 27.332675 | Q |
| S140 | Downgradient south of Waterval Tailings - control towards WV Smelter | -25.673088 | 27.324837 | Q |
| S160 | BMR downgradient north-east of north dump towards Klipfonteinspruit | -25.679735 | 27.332518 | Q |
| S230 | BMR downgradient of SSS effluent dams | -25.685518 | 27.335377 | Q |
| S373 | PMR downgradient northwest borehole | -25.685472 | 27.345885 | Q |
| S374 | PMR downgradient north borehole | -25.686502 | 27.347647 | Q |
| S386 | BMR upgradient east of BMR rainwater dam | -25.681567 | 27.329112 | Q |
| S388 | Borehole west of BMR magazines | -25.682787 | 27.333922 | Q |
| S389 | BMR upgradient south of north dump | -25.682130 | 27.332737 | Q |
| S400 | Waterval Smelter downgradient borehole towards Klipfonteinspruit | -25.677258 | 27.324082 | Q |
| S403 | BMR downgradient east of SSS effluent dams | -25.685688 | 27.336937 | Q |
| S405 | BMR upgradient south of BMR rainwater dam | -25.681318 | 27.328167 | Q |
| S407 | Retrofit downgradient borehole towards Klipfonteinspruit | -25.677188 | 27.321320 | Q |
| S409 | BMR downgradient north towards Klipfonteinspruit | -25.679103 | 27.328003 | Q |
| S410 | BMR downgradient north-east towards Klipfonteinspruit | -25.679132 | 27.330390 | Q |
| S418 | BMR downgradient northwest of SSS effluent dams | -25.685108 | 27.331415 | Q |

***M – Monthly frequency**
**Q – Quarterly frequency**

# 6. SAMPLING AND MONITORING PROCEDURES

## 6.1. Fieldwork

The Aquatico Fieldwork Division uses acknowledged methods for sampling as per Rustenburg Process DivisionRustenburgProcess Division WUL conditions.

Sampling is conducted by qualified Aquatico Field Technicians in order to obtain a representative sample as well as the highest possible scientific integrity. Incorrect sampling procedures and methods will affect the accuracy. reliability and credibility of analytical results and can lead to misleading information and conclusions. A representative water sample can be described as:

"A sample taken in the correct manner at a point that truly represents the water body at the time, at the specific locality of concern"

All fieldwork conducted are based on the protocols and specifications, and code of practice contained in the SABS ISO 5667:1-15. These international standards address all aspects from the monitoring programme design, sampling methods as well as sample preservation and many other aspects. Applicable standards include:

- ISO 5667-1: 2006 Part 1: Guidance on the design of sampling programmes and sampling techniques
- ISO 5667-3: 2003 Part 3: Guidance on preservation and handling of samples
- ISO 5667-5: 2006 Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems
- ISO 5667-6: 2005 Part 6: Guidance on sampling of rivers and streams
- ISO 5667-11: 1993 Part 11: Guidance on sampling of groundwater
- DWAF Best Practice Guidelines Series G3: General Guidelines for Water Monitoring Systems

In certain cases, adhering to the norms as set out in the above SABS ISO standards is not possible due to certain practicalities. Two such cases, applicable to Anglo Platinum, are given below:

- Due to field conditions, no pH, EC, or temperature readings are taken *in situ*. As sampling takes place over different time periods in the field, temperature will vary from samples taken in the early morning to samples taken at midday, and late afternoon. These temperature variations will induce pH and EC fluctuations, and will ultimately make the data incomparable. Thus, pH and EC readings are taken under controlled laboratory conditions to ensure that data sets are more comparable and reliable. The Anglo Platinum water samples are delivered to the laboratory within a sufficient time period (less than 48 hours) to ensure freshness of the water samples for analysis.
- Boreholes at the Anglo Platinum are not purged before sampling. Purging is the practice of pumping a borehole up to a point of stable EC or when three volumes of water are removed from the borehole before collecting a sample for analysis. The ISO SABS 5667-11 guideline recommends that purging only be applied to boreholes being pumped, such as abstraction boreholes or water supply boreholes. The majority of the monitoring boreholes at Anglo Platinum are for observation/monitoring purposes. The ISO SABS 5667-11 stipulates "Depth sampling consists of lowering a sampling devise (bailer) into the borehole, allowing it to fill with water at a known depth, and retrieving the sample for transfer to an appropriate sampling container. This method of sampling is normally suitable for use in observation boreholes that are not being pumped". For observation boreholes that are equipped with pumps, which limit accessibility of the

sampling device, a sample is collected from a tap installed on the line (where available). A second reason for deviating from the practice of purging boreholes before sampling is the high cost involved at the level of monitoring employed at Anglo Platinum (i.e. purging 100+ boreholes on a quarterly frequency will have a dramatic effect on monitoring cost.

Aquatico developed a custom-made data input system in accordance with SABS ISO guidelines 5667-1 to 5667-3, to assist the field technician in recording the physical and environmental information of the sampling locality. This information is needed to interpret water quality especially if the water quality results obtained by the laboratory indicate sudden changes at a specific locality.

The field data typically include the following information:

- Location, name and details of the sample site
- Method of collection
- Name of collector
- Nature of pre-treatment, if any
- Preservative or stabilizer added, if any
- Flow status or dam level
- GPS Co-ordinates
- Photographic evidence
- Water level of boreholes
- Other data gathered at this point

All of the above information is recorded on a handheld PDA device deployed to the field complete with GPS, bar-code scanner, camera and database-linked MONLIMS software. The water quality database is electronically updated with this information when the field technician returns from the field trip.

*Sample collection and transport to the laboratory*

- Prior to going to the field, all project info required for the successful monitoring is downloaded onto an electronic handheld field unit (Figure 6A). The field technician thus works solely on the orders given by the field unit. As soon as he arrives at a certain sample point, he is prompted to complete a set of pre-set observations – these can be customised by the programme manager, for example, flow of stream, water-level of borehole, meter reading on flow meter, odour/colour of water etc. The software will not allow the technician to continue to a next step without successfully entering the required information.

- Prior to taking any sample, the software will also require that a photo of the sampling point be taken. The photo is automatically named and filed, together with a time and date of sample and GPS coordinate as reference to the sample taken. This acts as conclusive proof that the technician actually visited the correct sampling point, providing an audit trail for field work.

- The GPS coordinates are also verified against a pre-programmed XY coordinate for that specific sampling point. As soon as the technician is not within a 30m radius (customisable parameter) of the programmed position for the specific monitoring locality, the software immediately prompts a warning on the screen that it is not the correct location. This warning can be ignored by the technician but a new GPS coordinate will be taken in the background and stored with the site info to keep log of any deviation from the sampling set-up. A full audit report can be generated showing actual sampling localities, date and time of sampling and deviations from programme.

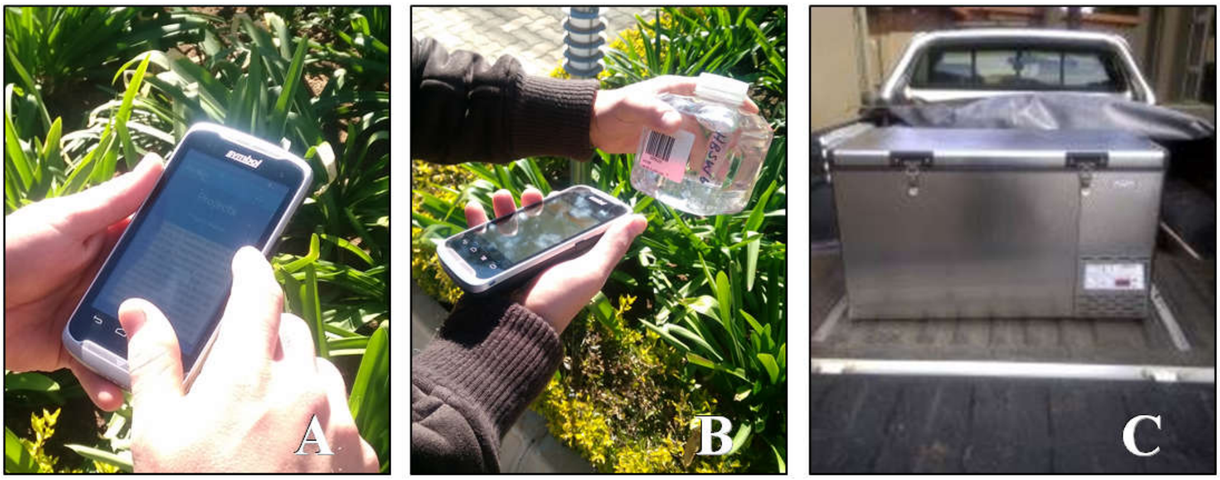



**Figure 6: A –The field PDA units that are being used during sampling. B – Field technician scanning a bar-coded sampling container after the sample has been taken. C – National Luna cooling units fitted on all field vehicles to ensure proper sample transport to the laboratory (at 4C)**

- At this point the technician will be prompted to take a specific sample type.
- All containers are pre-bar coded and the technician must scan the sampling container prior to taking the sample (Figure 6B); the reason for this step is twofold. Firstly, to ensure that it is the right sampling point and secondly to ensure that the correct sampling container type is used (i.e. organic samples in amber glass containers, microbiological samples in sterile containers etc.).
- Only at the point where all the requested tasks are completed will the software acknowledge that the function is completed and prompt the technician to proceed to the following locality.
- Once the field technician arrives back at the laboratory, all the samples are delivered to sample reception and the handheld unit is connected to the mainframe system via a docking station. All sampling info is downloaded into a SQL database.
- With the project set-up being completed and programmed at the start of the project (before fieldwork), all analytical requests are already in the database. As soon as the sample barcode is scanned at sample reception, the laboratory immediately knows what analyses need to be conducted on which samples.
- The fieldwork efficiency is also checked at this point to ensure that all samples taken in the field are actually being delivered to the laboratory; i.e. sample names and counts from field unit matches the laboratories submission worksheet or the system alarms should there be discrepancies in this regard. As example, a sample container may have been leaking in transit and although the sample container arrived at the laboratory, there is not sufficient volume of sample to be analysed, this will then be rectified immediately and the technician tasked for re-sampling.

*Samples and sampling containers applicable to Anglo Platinum*

Water samples for hydro-chemical or inorganic analysis are collected in new clean polyethylene bottles and stored in dust free thermo-isolated container. Samples for bacteriological analyses are sampled in sterile containers and kept cool (at around 4°C) in on-board fridge units (Figure 6C). Samples for hydrocarbon or organic analysis are sampled in clean, amber glass containers. Samples are not being preserved after sampling. As new and clean sampling bottles are used, cross-contamination is minimal. Water samples, which are not properly filtered, should never be preserved (acidified). This would lead to the re-suspension and remobilization of substances and could lead to “false–positive” results.

*Water-level measurements of boreholes at Anglo Platinum*

Accurate water-level measurements are critical in geo-hydrological studies and standard procedure when sampling a borehole/well. Depth to water measurements is conducted using the manual OTT KL010 Contact Gauge depth meter.

## 6.2. Laboratory Analysis

Approved laboratory analysing techniques are followed. Aquatico performs the hydro-chemical analyses as well as the bacteriological analyses.

Aquatico Laboratories is a state-of-the-art water testing laboratory in Irene, Centurion. This analytical laboratory is operational since July 2006. Aquatico Laboratories take part in the SANAS accredited SABS Proficiency Testing Scheme (PTS0003) for hydro-chemical analyses as well as the National Laboratory Association - South Africa Water Microbiology Proficiency Test Scheme. The Laboratory also took part in the non-accredited Anglo American Laboratory Proficiency Testing Programme (administrated by Thistle) and achieved an overall third place out of nine competing laboratories, based on z-score statistical results across the analytical suites. Further, Aquatico is an SANAS Accredited Testing Laboratory, No T0685. The SANAS accreditation certificate and schedule is provided in the Appendices.

Wherever current, analyses are carried out in accordance with methods prescribed by and obtainable from the South African Bureau of Standards, in terms of the Standards Act, Act 30 of 1982 as prescribed in the WUL. The routine laboratory analyses conducted on the Anglo Platinum samples is presented in Table 4 below.

**Table 4: Analytical packages associated with the Anglo Platinum water monitoring localities**

| Anglo suite | Suite description | Analysis description |
|---|---|---|
| Anglo Salts and Nutrients (Suite A) | Chemical salts and nutrients | pH, EC, Alk, TDS, Hardness, Ca, Na, Mg, K, Cl, $SO_4$, F, $NO_3$, $NH_4$, $PO_4$ , $PO_4$ as $PO_4$, TIN, DO, $Cr^{6+}$ |
| Anglo Comprehensive metals (Suite B) | Selected comprehensive metals | Al, Fe, Mn, Cr, Cu, Ni |
| Anglo env. bacteriological suite (Suite C) | Bacteriological variables | *E. coli*, Total coliforms |
| Anglo metal scan (suite D) | Selected broad metal scan | Ag, B, Ba, Be, Bi, Cd, Co, Ga, Li, Mo, Pb, Rb, Sr, Te, Tl, V, Zn |
| Anglo SOG (Suite E) | Total oil and grease (SOG) | SOG |
| Anglo Resource (Additional WUL Suite) | Anglo additional WUL requirements | DO, Pb, Zn, B, Phenol, Cr6+, As, Cd, Hg, Se, PO4 Calculated, TIN |
| Toxicity analysis | Toxicity analysis | Trophic level toxicity test |

Different analytical suites are applied to different water monitoring locality types at different frequencies. Table 5 below presents an overview of the suites applied to the locality types.

**Table 5: Analytical suites applied to the different types of surface water monitoring localities**

| Description | Anglo Salts and Nutrients (Suite A) | Anglo Comprehensive metals (Suite B) | Anglo env. bacteriological suite (Suite C) | Anglo metal scan (suite D) | Anglo SOG (Suite E) | Anglo Resource (WUL Suite) | Toxicity analysis |
|---|---|---|---|---|---|---|---|
| Applicable Bio-icon | | | | | | | |
| Rivers/streams | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Stormwater dams | ✓ | ✓ | | ✓ | | ✓ | |
| Pollution Control Dams | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| Effluents, discharges | ✓ | ✓ | | ✓ | ✓ | ✓ | |
| Groundwater boreholes | ✓ | ✓ | | ✓ | | ✓ | |

*Laboratory set-up and workflow*

The sample enters the laboratory in a stream-lined workflow with various elements enhancing the analyses process as well as turn-around time. After being logged on the Laboratory information management system, the samples are firstly being filtered through a 0.45µm membrane filter as prescribed by ISO17025. The filtrate is transferred to new clean bar-coded sampling tubes and now ready for chemical analysis. pH and EC is determined on unfiltered samples and fed into the management software to act as an initial QC process in providing information to the other instrumentation in the Laboratory in terms of the expected quality of water (clean/dirty), the necessity for dilutions, etc. A further QC measure is minimising sample transfer between tubes to a single bar-coded sample tube that is introduced to the various instruments for analyses. The bar-coding system drastically minimises the possibility of sample-swop and result mis-feed into the information management system.

All results from the automated analytical instruments are automatically populated into the database minimising human error with data capturing. In terms of QC procedures, being an ISO17025 laboratory, quality is one of the main drivers in the laboratory. With each sample batch various Certified Reference Materials (CRMs) and quality standards and/or duplicate samples are analysed. Should one of the QC values fail the pre-set criteria, the entire batch of samples are automatically rejected and re-run. All QC samples are tabled and graphically plotted on a daily basis to ensure continuous monitoring and improvement.

When all requested variables are analysed, the data is ready for verification. During this step a technical signatory (Analyst) will evaluate the results provided by the software interface. All analytical checks and balances are calculated by the system and must comply with strict pre-set criteria and conditions. Samples/Variables that fail this step are prompted for re-analyses. As a further QC point, whenever possible, a historical water quality profile for that specific sampling locality is presented onscreen to enable the Analyst to evaluate temporal variance. Should the new results not comply with the history profile of the sample the technical signatory is notified and prompted to investigate further to assess the possibility of environmental factor or spill event.

As soon as all the results for the batch are available and verified by the technical signatories, the results are released and made available on the SQL software database for reporting purposes by the Scientific Reporting Division.

*Audit trail*

All actions or samples can be tracked on the software platform indicating the precise stage of completion for each task or sample. Various reports are generated providing valuable management information, for example.

- Number samples collected for project or field trip.
- All samples not collected in project or field trip.
- Reasons why samples not collected.
- Deviation distance from sampling point (by GPS).
- Days in holding.
- Turnaround days in Laboratory.
- Distance travelled.
- Number of samples per variable.

The software application was designed in such a way that all the info is stored within the SQL database. Any report or query could thus be executed to provide the desired management report. The software is also compatible with Microsoft Excel and can therefore interact with any other database system (such as Pivot).

### 6.3. Water Quality Reporting

Water Quality Reporting is conducted by the Aquatico Scientific Reporting Division consisting of qualified scientists and water quality specialists. All final evaluations are conducted by experienced and SACNASP registered (*Pri.Sci.Nat*) scientists.

The fieldwork information and water quality data, following laboratory analysis and verification, are entered into the Aquatico water quality management programme from where various custom-made reports are produced.

*Monthly Reporting:*

On a monthly basis, the Anglo Platinum Environmental Department is provided with the monitoring field data and water quality results in a PDF report as well as a Microsoft Excel format (WDAT) that is fully compatible with the Anglo American Platinum Integrated Data Display System (IDDS).

*Quarterly Reporting:*

On a quarterly basis, a concise quarterly report is produced that includes time-series graphs and maps of the most relevant information. The report also highlights water quality results that may require urgent management actions from the mine. This report is considered to be a short information report and will include a brief evaluation of the monthly surface water results over the quarterly period. This report can also be submitted to the Department of Water Affairs in-line with the WUL requirements for quarterly reporting of water results to the Chief Director.

*Annual Reporting:*

The Annual Integrated Surface and Groundwater Quality, Biomonitoring and Toxicity report (this report) is extensive and includes a full evaluation of all the results obtained during the annual monitoring period. The report includes a statistical summary (temporal & spatial) of all the chemical variables for all the monitoring localities, time-series graphs (for the entire database period), linear trend determinations, performance analyses and compliance assessments, water quality thematic maps indicating pollution sources and impacts on the receiving water body as well as a discussion and recommendation section. This report is composed of three volumes as discussed in further details in the next section.

Additional information can be found in the Comprehensive Annual Water Management Report "Anglo Platinum Rustenburg Process Division: Annual DWA Compliance Report" submitted to DWA and compiled by Aquatico Scientific. Additional information referenced in this report includes:

- Operations and permit information;
- Production figures and water usage;
- Rainfall and evaporation data; and
- Flow data.

## 6.4. Data Presentation

### 6.4.1. Volume 1

Anglo American Platinum Water Quality Assessment Report

The main report of the Anglo Platinum water quality assessment (Volume 1, "Annual Integrated Surface and Groundwater Quality, Biomonitoring and Toxicity Testing Assessment Report", No. ***APPD/AR1.1/2018/WR***) is a detailed and descriptive report with an introduction outlining the purpose of water quality monitoring, a locality map with names and descriptions (surface water), a background and objectives section including interpretation of the results obtained for the specific annual period, which will include:

- Surface Water Quality Discussion;
- Anglo Platinum impact quantifications on the main catchment area of the Hex River;
    - Impact quantification (mg/l) = Average downstream value from an Anglo Platinum business unit (mg/l) – Average upstream value from an Anglo Platinum business unit (mg/l)
- Surface water quality risk assessment;

- Appendix A – Detailed Biomonitoring Report;
- Appendix B – Detailed Toxicity Report;

Appendix C – Detailed Groundwater Report6.4.2. Volume 2

Volume 2 contains data collected for review purposes (Report Number: *APPD/AR1.2/2018/WR).*

This will include:

*Locality Assessment Reports*

The Locality Assessment Report aims to give the reader a short water quality evaluation and interpretation of a specific Anglo Platinum monitoring locality during a specific period and also provide relevant information regarding a given monitoring locality. A locality assessment report consists of the following:

- Locality
  - Reference ID, type, locality photograph and coordinates
- Locality description
  - Type of monitoring locality and description
  - Applicable Target Water Quality Guideline Ranges (TWQGR) and or Permit Conditions (DWAF)
- Locality status
- Scheduled sampled month, sampling status (yes/no), observations
  - Average Water Quality Description
    - Average quarterly/yearly water quality description
    - Exceedance of applicable TWQGR/Permit Conditions (DWAF)
    - Additional notes
- Additional Analyses
  - Additional scheduled analyses which may include – bacteriological, soap, oil and grease, chemical oxygen demand (COD), chromium (VI) ($Cr^{6+}$), and/or full metal analysis.

*Site Reports*

A comprehensive format (Site Report) has been designed for data evaluation at Anglo Platinum surface water monitoring localities. The Site Report aids in the interpretation process of data, as well as giving more relevant information regarding a given monitoring locality during a specific period and are arranged according to catchment. A site report consists of the following:

- General description
  - (Site name, description, and type)
- Data table
  - Variables
  - Guideline/Permit Condition value
  - Results
  - Statistical presentation: (average, previous average and graph average)
- Time–series graphs & long-term trends
- Selected variables plot on the graph to give an indication of the range and linear movement for the variable over the database period. Also indicated are long-term trends for a specific variable at a monitoring locality.
- STIFF diagram

- The STIFF diagram exhibits a quick visual indication of the major anions / cations recorded (based on the meq/l and does not indicate mg/l concentration of a variable). This diagram plots the equivalent concentrations of the major anions and cations on a horizontal scale on opposite sides of a vertical axis. The plot point on each parameter is linked to the adjacent one until a polygon is created around the y-axis. The result is a small figure of which the geometry typifies the water composition at that point. Water with similar major ion ratios will show the same geometry.

*Locality Tables*

Time-series data and statistical analysis for the monitoring period are presented in tabular format according to catchment. Statistical evaluation of monitoring results and recommendations regarding the suitability for the identified uses are based only on variables being analysed. The summary tables include the following statistics for each monitoring locality:

- number of records in database period (September 2017 to August 2018);
- average value and standard deviation for database period;
- minimum, maximum and median values;
- 5$^{th}$, 50$^{th}$ and 95$^{th}$ percentile for the entire database period;

A percentile is the value of a variable below which a certain percentage of observations fall, so for example, the 50$^{th}$ percentile is the value below which 50 percent of the observations may be found.

6.4.3. Volume 3

Anglo Platinum Water Quality Executive Summary

The Executive Summary (Refer to Volume 3, “Annual Integrated Surface and Groundwater Quality, Biomonitoring and Toxicity Executive Summary”, No. ***APPD/AR1.3/2018/WR***) aims to give the reader a short and basic summarization of the current status of water quality at the respective business units, to highlight environmental and human risks associated thereof and to raise awareness specifically developed for department heads (HOD’s).

## 6.5. Data evaluation

### 6.5.1. Water quality evaluation against applicable guidelines

The South African Water Quality Guidelines are used by the Department of Water Affairs as its primary source of information and decision-support to judge the fitness of water for use and for other water quality management purposes. Five broad categories of water use are recognised in the South African Water Act, namely the use of water for **domestic purposes, industrial purposes, agricultural purposes, aquatic ecosystems** and **recreational purposes**. Added to that is the DWA’s mandate to protect the health and integrity of the aquatic ecosystem, which is therefore also seen as a major water user. Given its regional setting and for the purposes of the Rustenburg Process Division water monitoring programme, focus is placed on three of the above water users, namely Aquatic Ecosystems, Domestic Use and Agricultural Use, specifically, water used as livestock watering. The target water quality guideline range (TWQGR) is defined as those values or concentrations where no impact is expected on the specific user group, i.e. it is the ‘No Effect Range’. These values and concentrations are used within the water quality database evaluation and are presented in Table 5

Another guideline that will be used in these discussions is the General Limit (Table 7). The General Limit Guideline refers to the wastewater limit values as contained in Schedule 3 of the General Authorisations (General Authorisations in terms of Section 39 of the National Water Act, as documented in the Government Gazette No 26187, Notice No 399, dated 26 March 2004) and applies to the discharge of waste or water containing waste into a water resource through a pipe, canal, sewer or other conduit and the disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process. It should however be noted that the General Authorisation is not applied to any category A mine (defined as any gold or coal mine, any mine with an extractive metallurgical process, or any mine where sulphate producing or acid generating material occurs) and it is thus used with caution. The General Limit is only applied as a comparative guideline and should not be interpreted for compliance purposes.

**Table 6: SAWQG Target water quality guidelines**

| Variable | South African Water Quality Guidelines (DWAF, 1996) | | |
|---|---|---|---|
| | Dom[1] | Aqua[2] | Live[3] |
| pH | 6.0 –9.0 | <5% variation | - |
| Electrical Conductivity (mS/m) | 70 | - | 500 |
| Sulphate (mg/l $SO_4$) | <200 | - | <1 000 |
| Nitrate (mg/l $NO_3$) | <6 | - | <22 |
| Chloride (mg/l Cl) | <100 | - | <3 000 |
| Fluoride (mg/l F) | <0.7 | <0.75 | <2 |
| Ammonia (mg/l $NH_3$) | <1 | <0.007 | - |
| Calcium (mg/l Ca) | <80 | - | <1 000 |
| Magnesium (mg/l Mg) | <70 | - | <500 |
| Sodium (mg/l Na) | <100 | - | <2000 |
| Aluminium (mg/l Al) | <0.15 | <0.005 | <5 |
| Iron (mg/l Fe) | <0.5 | - | <10 |
| Manganese (mg/l Mn) | <0.1 | <0.18 | <10 |

[1] *DWAF SAWQG TWQGR for Domestic use*
[2] *DWAF SAWQG TWQGR for Aquatic Ecosystems*
[3] *DWAF SAWQG TWQGR for Agricultural Use - Livestock watering*

**Table 7: DWAF General Limit Guideline**

| Variable / Parameter | Unit | DWAF General Limit |
|---|---|---|
| pH | - | 5.5 - 9.5 |
| EC | mS/m | 150 |
| TDS | mg/l | (1000)* |
| TH | mg/l | - |
| M_Alk | mg/l | - |
| Cl | mg/l | - |
| $SO_4$ | mg/l | - |
| F | mg/l | 1 |
| $NO_3$_N | mg/l | 15 |
| $NH_4$_N | mg/l | 6 |
| $PO_4$ | mg/l | 10 |
| Ca | mg/l | - |
| Mg | mg/l | - |
| Na | mg/l | - |
| K | mg/l | - |
| Fe | mg/l | 0.3 |
| Al | mg/l | - |
| Mn | mg/l | 0.1 |
| SAR | - | - |
| SOG | mg/l | 2.5 |

As mentioned previously in this report, Anglo American Platinum is also a registered water user in terms of Chapter 4 of the National Water Act, 1998 (Act No. 36 of 1998) with a Water Use Licence issued to the mining operation in January 2018. In terms of this WUL the water quality limits presented in Table 8 should be adhered to; but do refer to Section 2 above for a detailed discussion on the WUL limits.

**Table 8: WUL Resource and Groundwater Quality Limits**

| VARIABLE | Units | Groundwater Quality Limits (WUL 2018) | Surface Water Quality Limits (WUL 2018) |
|---|---|---|---|
| pH | pH units | 6.0 - 9.5 | 6.0 - 9.0 |
| Electrical Conductivity (EC) | mS/m | 150 | 85.00 |
| Hardness (CaCO3) | mg/l | - | 50 |
| Calcium (Ca) | mg/l | 150 | - |
| Magnesium (Mg) | mg/l | 100 | - |
| Sodium (Na) | mg/l | 200 | - |
| Chloride (Cl) | mg/l | 200 | - |
| Sulphate ($SO_4$) | mg/l | 200 | - |
| Nitrate ($NO_3$) as N | mg/l | 10 | - |
| Ammonia ($NH_4$) as N | mg/l | - | 1.00 |
| Phosphate ($PO_4$) as P | mg/l | - | 0.125 |
| Fluoride (F) | mg/l | 1 | 0.75 |
| Aluminium (Al) | mg/l | - | 5 |
| Iron (Fe) | mg/l | - | 0.5 |
| Manganese (Mn) | mg/l | - | 0.18 |
| Hexavalent chromium ($Cr^{6+}$) | mg/l | 0.0049 | 0.0049 |
| Copper (Cu) | mg/l | - | 0.3 |
| Dissolved oxygen | mg/l | - | 7-8 |

### *6.5.2. Water quality classification*

In 1998, the Department of Water Affairs and Forestry (DWAF), in association with the Water Research Commission (WRC) and the Department of Health (DOH) published a useful colour coding system for evaluating the prevailing water quality of water used for domestic use. The system is based on the principle of assigning a colour to a specific concentration range of variables commonly found in water and that has a major effect on the suitability of water for domestic use.

Due to significance of using water for domestic purposes and the importance of effective water quality evaluation for the use, efficient data for a wide variety of variables are available. The colour coding system will specifically be used to assess the water quality of the identified monitoring localities sampled. When comparing data with the guidelines for domestic use, the worst substance class will determine the overall class of the water supply. Data can be interpreted as in Table 9:

- Water testing within the Blue or Green colour class may be used without reservation and is considered safe for all users.
- Water testing within the Yellow colour class is generally regarded as safe, however sensitive users should be identified and warned to take personal consumption precautions.
- Water testing within the Red colour class can be used as a short-term emergency supply, approximately seven days only, when other sources are unavailable.
- When water tests within the Purple colour class the public must be warned not to use the water, or to use emergency home treatment where possible. If this is not possible, alternative water supplies must be considered and made available

**Table 9: Structure of the classification system describing the effects of the different classes of water on the various domestic uses of water (DWAF *et al*, 1998)**

| CLASS / COLOUR | DESCRIPTION | EFFECTS |
|---|---|---|
| **Class 0 (Blue)** | Ideal water quality | **Drinking health**: No effects, suitable for many generations |
| | | **Drinking aesthetic**: Water is pleasing |
| | | **Food preparation**: No effects |
| | | **Bathing**: No effects |
| | | **Laundry**: No effects |
| **Class 1 (Green)** | Good water quality | **Drinking health**: Suitable for lifetime use. Rare instances of sub-clinical effects |
| | | **Drinking aesthetic**: Some aesthetic effects may be present |
| | | **Food preparation**: Suitable for lifetime use |
| | | **Bathing**: Minor effects on bathing or on bath fixtures |
| | | **Laundry**: Minor effects on laundry or on fixtures |
| **Class 2 (Yellow)** | Marginal water quality | **Drinking health**: May be used without health effects by majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use. |
| | | **Drinking aesthetic**: Poor taste and appearance are noticeable |
| | | **Food preparation**: May be used without health or aesthetic effects by the majority of individuals. |
| | | **Bathing**: Slight effects on bathing or on bath fixtures |
| | | **Laundry**: Slight effects on laundry or on fixtures |
| **Class 3 (Red)** | Poor water quality | **Drinking health**: Poses a risk of chronic health effects, especially in babies, children and the elderly |
| | | **Drinking aesthetic**: Bad taste and appearance may lead to rejection of water |
| | | **Food preparation**: Poses a risk of chronic health effects, especially in babies, children and the elderly |
| | | **Bathing**: Significant effects on bathing or on bath fixtures |
| | | **Laundry**: Significant effects on laundry or on fixtures |
| **Class 4 (Purple)** | Unacceptable water quality | **Drinking health**: Severe acute health effects, even with short-term use |
| | | **Drinking aesthetic**: Taste and appearance will lead to rejection of water |
| | | **Food preparation**: Severe acute health effects, even with short-term use |
| | | **Bathing**: Serious effects on bathing or on bath fixtures |
| | | **Laundry**: Serious effects on laundry or on fixtures |

### *6.5.3. Water quality parameters*

Physical Water Quality

This refers to the water quality properties such as temperature, electrical conductivity, pH and oxygen content that may be determined by physical methods. When referring to the physical quality of water at Anglo Platinum we refer to the three parameters namely pH, EC or TDS. The physical quality affects the aesthetic as well as chemical quality of the water.

**Table 10: Physical Quality of Water Parameters**

| Physical quality |
|---|

| Parameter | Relevance |
|---|---|
| pH | Affects the corrosivity and taste of water |
| EC / TDS | Serves as a general indicator of change in water quality and affects the “freshness” taste of the water. Indicates the salinity and quantity of dissolved substances. |

Chemical Water Quality

The chemical quality of the water refers to the nature and concentrations of dissolved substances such as organic or inorganic compounds, including metals, in the water body. Many chemicals in water are essential for the biotic community and may form an integral part of the nutritional requirements. However, elevated levels may be limiting for some of the downstream water users.

**Table 11: Chemical Quality of Water**

| Chemical quality | |
|---|---|
| Parameter | Relevance |
| Alkalinity | Indicative of intrinsic buffering capacity against acidification. |
| Major anions | Typically, chloride, sulphate, fluoride and the nitrogen compounds, Impacts the salinity levels |
| Hardness | Mainly affected by Calcium and Magnesium and affects the scaling and foaming quality of the water |
| Major cations | Typically, Calcium, Magnesium and Sodium - Elevated levels could affect the taste of water |
| Heavy metals | Toxic at low concentrations |

Bacteriological Water Quality

Generally, the microbiological quality of water refers to the presence of organisms that cannot be individually seen with the naked eye, such as protozoa, bacteria and viruses. Many of these microbes are associated with the transmission of infectious water-borne diseases such as gastro-enteritis and cholera. In order to determine the bacteriological status and safety of Anglo Platinum water, Aquatico specifically focuses on total coliforms and *E. coli* (indicator of faecal coliforms) bacteria.

**Table 12: Bacteriological Quality of Water**

| Bacteriological quality | |
|---|---|
| Parameter | Relevance |
| Faecal coliforms | Indicates recent faecal pollution and the potential risk of contracting infectious diseases |
| Total coliforms | Indicates the general hygienic quality of the water |

Parameters such as pH, hardness and salinity are used to describe the general quality of water. These are tabulated below (Table 13) and are based on the descriptions as proposed by DWA:

**Table 13: General water quality description parameters**

| Acidity | |
|---|---|
| pH: > 8.5 | Alkaline/Basic |
| pH: 6.0- 8.5 | Neutral |
| pH: < 6 | Acidic |
| Hardness | |
| Hardness < 50 mg/l | Soft |
| Hardness 50 - 100 mg/l | Moderately soft |
| Hardness 100 -150 mg/l | Slightly hard |
| Hardness 150 – 200 mg/l | Moderately hard |
| Hardness 200 – 300 mg/l | Hard |
| Hardness 300 – 600 mg/l | Very Hard |
| Salinity | |
| TDS < 450 mg/l | Non saline |
| TDS 450 – 1 000 mg/l | Saline |
| TDS 1 000 – 2 400 mg/l | Very saline |
| TDS 2 400 – 3 400 mg/l | Extremely saline |

## 7. SURFACE WATER MONITORING SUMMARY PER BUSINESS UNIT

The data summary aims to give the reader a short and basic summarisation of the current water quality status of the relevant process areas at Anglo American Platinum Rustenburg. Each business unit will be discussed separately focusing on qualities of process and pollution dams, effluents and up- and downstream qualities of adjacent streams and rivers. Each section will include a map illustrating the relative positions of monitoring localities situated in a specific catchment, and the general quality thereof (physical, chemical, bacteriological and organic where applicable). Localities discussed include:

- Process water (including return water dams and pollution control dams);
- Discharges, effluents and seepages of mining and non-mining sources;
- Receiving environment (including natural streams and rivers).

An impact evaluation is ultimately discussed using a simplified diagram for the river catchments showing the relative positions of possible pollutant contributors on a particular system. Only localities upstream and downstream from potential impacts are included in the diagrams. Averages for a specific period of selected variables are plotted on histograms while estimated impacts are presented in tabular format. The impacts are discussed broadly as combined impacts observed between upstream and downstream localities and calculated using the following:

*Impact quantification (mg/l) = annual average downstream value (mg/l) – annual average upstream value (mg/l)*

Where a specific business unit has impacted negatively on a specific river or spruit the impact quantified is in red font and where a positive impact has been quantified the impact is in green.

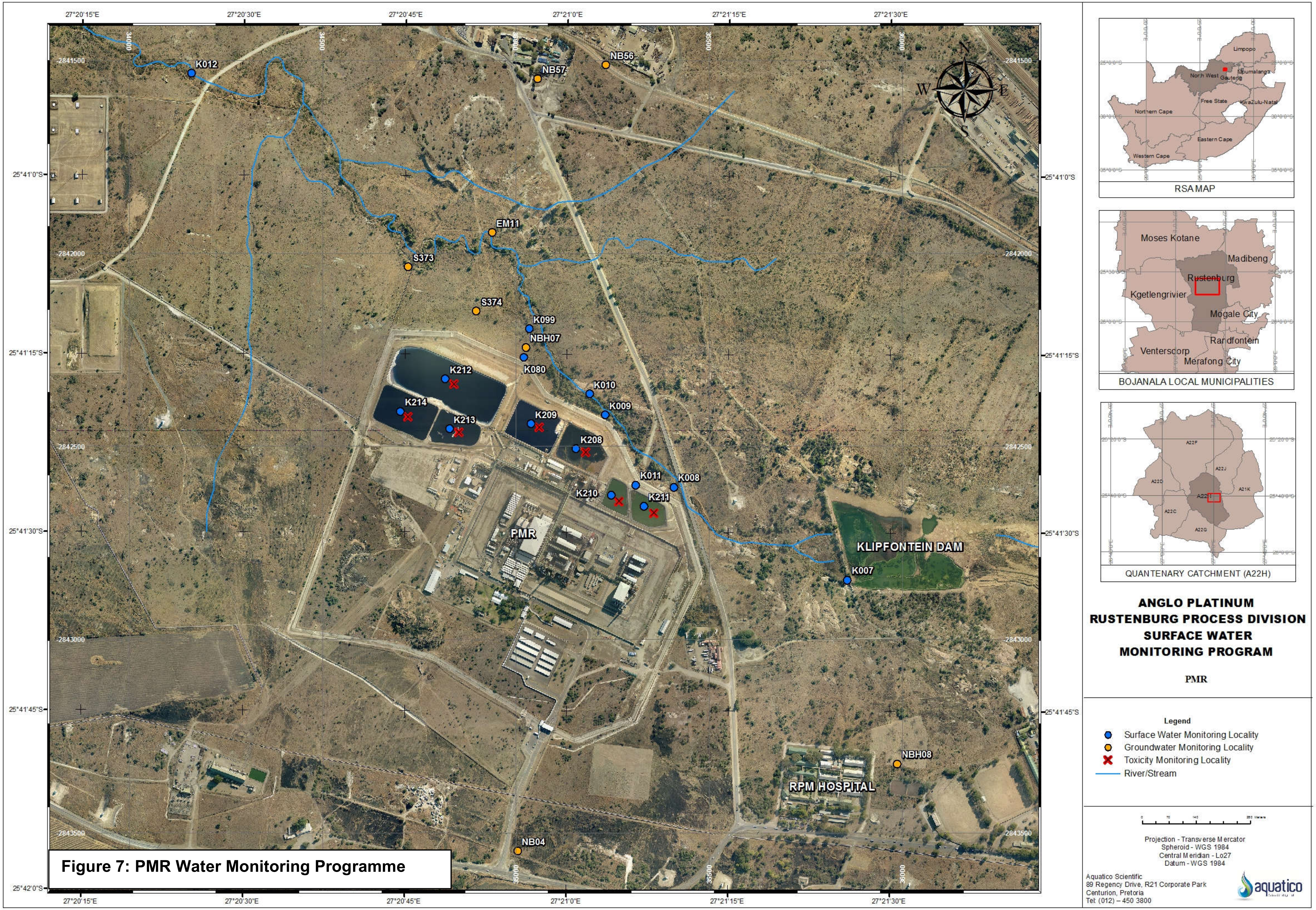



**Figure 7: PMR Water Monitoring Programme**

**Table 14: PMR sampling register of the surface water monitoring conducted during the annual period**

| Anglo Rustenburg Surface water monitoring | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effluent | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K009 | PMR East rain water dam overflow | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K011 | Discharge at PMR culvert at PMR bridge | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K080 | Effluent and stormwater discharge west of PMR | Dry | Dry | Stagnant | Stagnant | Dry | Dry | Dry | Dry | Stagnant | Stagnant | ● | Dry |
| Pollution control dam | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K208 | PMR Dam 1 | - | NS | - | - | NS | - | - | NS | - | - | NS | - |
| K209 | PMR Dam 2 | - | ● | - | - | ● | - | - | ● | - | - | ● | - |
| K210 | PMR Dam 3A | - | NS | - | - | ● | - | - | ● | - | - | ● | - |
| K211 | PMR Dam 3B | - | ● | - | - | ● | - | - | ● | - | - | ● | - |
| K212 | PMR Dam 4+5 | - | ● | - | - | ● | - | - | ● | - | - | ● | - |
| K213 | PMR Dam 6 East | - | ● | - | - | ● | - | - | ● | - | - | ● | - |
| K214 | PMR Dam 6 West | - | ● | - | - | ● | - | - | ● | - | - | ● | - |
| River or stream | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K007 | Klipfontein Dam | - | - | - | - | - | - | - | ● | Dry | Dry | ● | ● |
| K008 | Klipfonteinspruit at PMR Bridge | Dry | Dry | Dry | Dry | ● | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K010 | Klipfonteinspruit, downstream of K009 | ● | ● | ● | Stagnant | ● | ● | Dry | ● | ● | ● | ● | ● |
| K012 | Klipfonteinspruit between PMR and RBMR on old road to magazine | Dry | Dry | Dry | Dry | ● | ● | Dry | ● | Dry | Dry | Dry | Dry |
| K099 | Klipfonteinspruit downstream of PMR | Dry | Dry | ● | Dry | Dry | ● | Dry | ● | ● | Dry | ● | Dry |

*● – Sampled

NS – Not submitted

\- – Not scheduled for sampling (quarterly sampling frequency in the case of pollution control dam localities)

## 7.1. PRECIOUS METAL REFINERS (PMR)

Presented in Table 14 is the frequency of sampling at each PMR monitoring locality during the annual period. Additionally, the average data tables are illustrated within Table 15 and Table 16, results are discussed separately according to the relevant sections below.

### 7.1.1. Process water

The PMR Pollution Control Dams (**K209**, **K211, K212**, **K213** and **K214**) were sampled on a quarterly basis throughout the annual period; **K210** was not submitted on one occasion. Locality **K208** was however not sampled and is currently under construction. Due to the high security area in PMR, these dams are sampled by PMR staff and samples are samples are submitted to Aquatico for analysis. pH levels fluctuated quarterly, with average TDS concentrations of all the localities being recorded as extremely saline (average TDS concentrations exceeding 60000 to 100000 mg/l). The average hardness concentration of the water also indicated very hard water with high concentrations of salts, nutrients and metals. Chloride and sodium concentrations are dominant in the PMR dams and may be used as indicator variables.

Water quality profiles (STIFF diagrams) for each dam remained stable throughout the annum. The major contributing cation was sodium. Chloride was the major contributing anion for all these localities (STIFF diagram, Figure 8). A hazard is posed towards the integrity of the Klipfonteinspruit in the event of uncontrolled discharges and effluents from the PMR complex. Furthermore, a high risk also remains towards groundwater contamination if seepages or dam-liner failure occurs.

Compared with the General Authorisation limit guidelines, analysed variables from all five dams exceeded in terms of average EC, fluoride, ammonium, iron, manganese and copper concentrations (amongst others). Water quality limits are not stipulated in the WUL for process water storage localities.

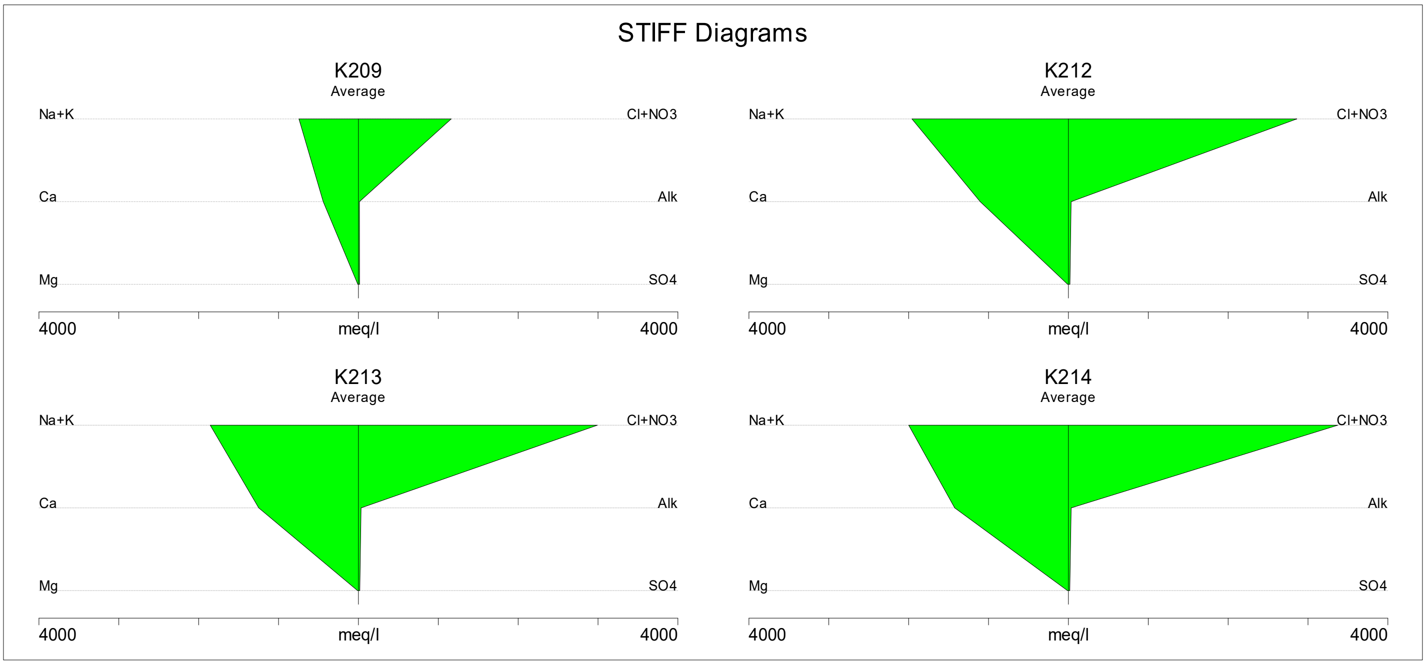



**Figure 8: STIFF diagrams representing the water quality profile of the PMR Pollution control dams (K209, K212, K213 and K214)**

Average water quality at the PMR stormwater dam localities **K210** and **K211** was alkaline, non-saline (average TDS concentrations of 320 mg/l and 357 mg/l respectively) and moderately soft with low salt concentrations and heavy metals mostly below detection limits. The major contributing cation for K210 and K211 was sodium while the major contributing anion was bicarbonate alkalinity ($HCO_3$) (STIFF diagram, Figure 9). Discharges from K210 and K211 in high rainfall situations should not cause significant deteriorating impacts on the Klipfonteinspruit.

K210 exceeded the General Authorisation limit guidelines in terms of average pH and copper concentrations while K211 exceeded in terms of average copper concentrations.

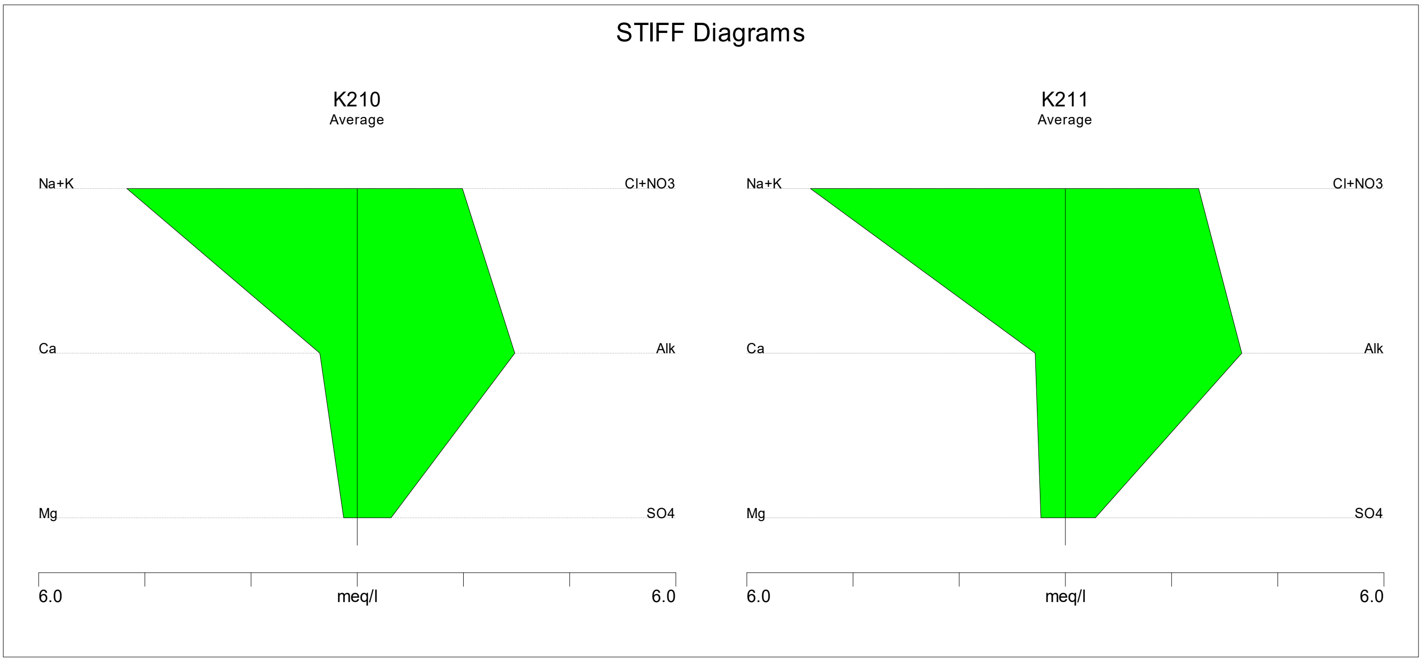
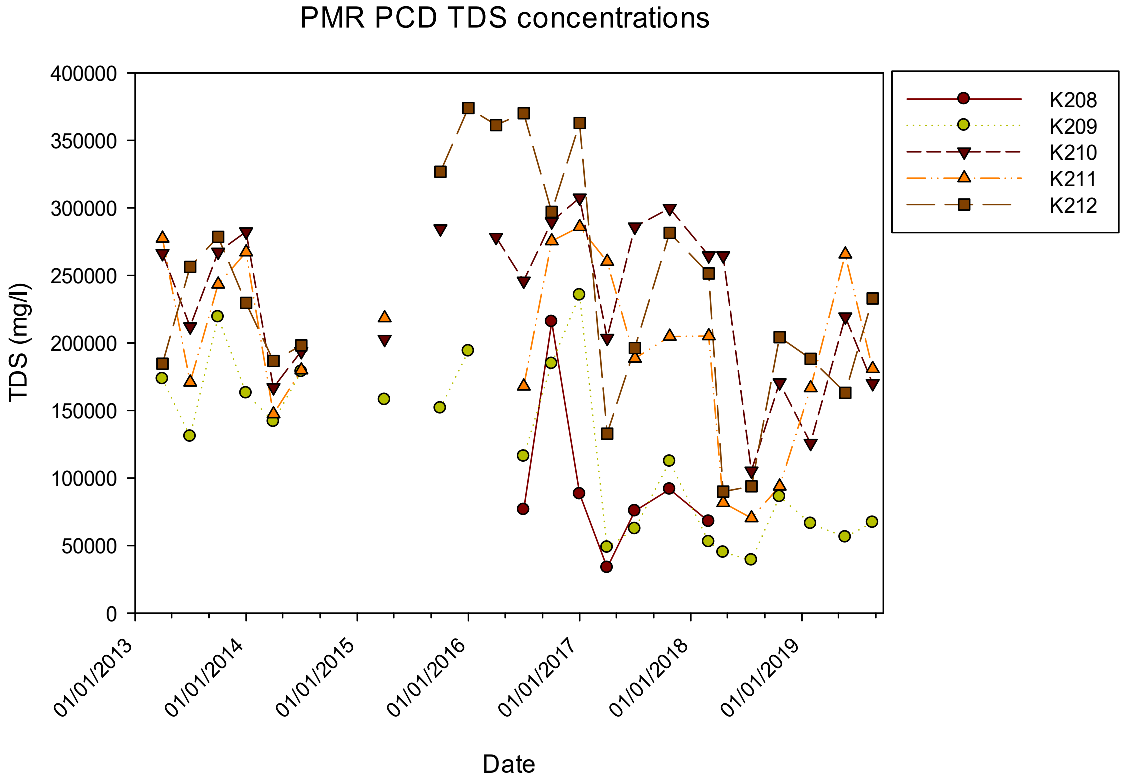



**Figure 9: STIFF diagrams representing the water quality profile of the PMR Pollution control dams (K210 and K211)**

The time-line graph Figure 10 indicates quarterly variances in terms of TDS (salinity) concentrations. A decrease over the indicated time period was noted at the pollution control dams and stormwater dams in relation to overall salinity concentrations. That being said, the average salinity of the pollution control dams remained high.



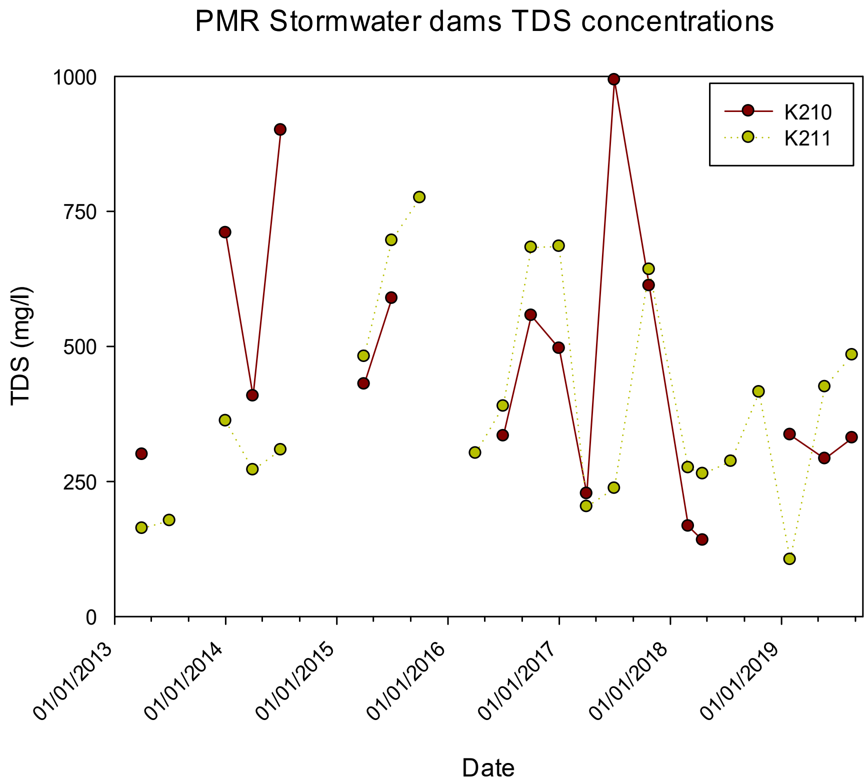




**Figure 10: PMR pollution control dams and stormwater dams timeline graph**

**Table 15: Average PMR process dams data table for the annual monitoring period**

| AVERAGE DATA TABLE: | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PROJECT NAME | | | Anglo Rustenburg Surface water monitoring | | | | | | | |
| ASSESSMENT SET 1 | | | General Authorisation Limit, Section 21f and h, 2013 | | | | | | | |
| ASSESSMENT SET 2 | | | AAP Rustenburg - Surface water WUL | | | | | | | |
| | | | | | | | | | | Value exceeds the assessment set 1 |
| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES | | | | | | |
| | | | | K208 | K209 | K210 | K211 | K212 | K213 | K214 |
| pH @ 25°C | pH | 5.5/9.5 | 6.0/9.0 | - | 3.75 | 9.86 | 9.5 | 6.06 | 6.07 | 5.59 |
| Electrical conductivity (EC) @ 25°C | mS/m | 150 | 85 | - | 10895 | 49.7 | 56.6 | 18888 | 18363 | 19470 |
| Total dissolved solids (TDS) | mg/l | - | - | - | 68868 | 320 | 357 | 171498 | 176689 | 197144 |
| Total hardness | mg CaCO3/l | - | 50 | - | 22449 | 48 | 51 | 55762 | 63046 | 71870 |
| Calcium (Ca) | mg/l | - | - | - | 8843 | 14.1 | 11.4 | 22142 | 25019 | 28542 |
| Magnesium (Mg) | mg/l | - | - | - | 89.5 | 3.13 | 5.61 | 115 | 139 | 146 |
| Sodium (Na) | mg/l | - | - | - | 16924 | 97.5 | 108 | 44375 | 41966 | 45211 |
| Potassium (K) | mg/l | - | - | - | 343 | 3.71 | 3.93 | 1138 | 1182 | 1296 |
| Total alkalinity | mg CaCO3/l | - | - | - | *668* | 148 | 166 | 1725 | 1688 | 1748 |
| Chloride (Cl) | mg/l | - | - | - | 41180 | 69.1 | 84.7 | 101324 | 106083 | 119582 |
| Sulphate ($SO_4$) | mg/l | - | - | - | 708 | 30.6 | 27.1 | 941 | 857 | 841 |
| Fluoride (F) | mg/l | 1 | 0.75 | - | *103* | 0.697 | *0.645* | 96.3 | 117 | 130 |
| Nitrate ($NO_3$) as N | mg/l | 15 | - | - | 8.98 | 0.334 | 1.66 | 19.2 | 14.2 | 18 |
| Ammonium ($NH_4$) as N | mg/l | 6 | 1 | - | *175* | 4.65 | 4.64 | *175* | 176 | 189 |
| Orthophosphate ($PO_4$) as P | mg/l | 10 | 0.125 | - | *0.797* | *0.033* | *0.003* | *1* | *2.63* | *2.82* |
| Aluminium (Al) | mg/l | - | 5 | - | *9.2* | *0.032* | *0.058* | *1.12* | *0.951* | *0.851* |
| Iron (Fe) | mg/l | 0.3 | 0.5 | - | 192 | *0.002* | *0.002* | 2.62 | 2.29 | 1.43 |
| Manganese (Mn) | mg/l | 0.1 | 0.18 | - | 40.3 | *0.001* | *0.001* | 23.9 | 25 | 30.1 |
| Chromium (Cr) | mg/l | - | - | - | *0.989* | *0.002* | *0.002* | *0.221* | *0.201* | *0.44* |
| Copper (Cu) | mg/l | 0.01 | 0.3 | - | 44 | *0.004* | *0.005* | 47.5 | 49.4 | 50.1 |
| Nickel (Ni) | mg/l | - | - | - | 188 | *0.059* | 0.121 | 160 | 169 | 183 |

### 7.1.2. Discharges, effluents and seepages

The Klipfontein dam (**K007**) was added to the monitoring programme to be used as an additional upstream locality. Three samples were collected between April and August 2019; average water quality depicted neutral, very saline and very hard water quality. Very high concentrations of nitrates were also detected.

**K009** (PMR East rain water dam overflow) and **K011** (Discharge at PMR culvert at PMR Bridge) were recorded as dry throughout the annual period.

**K080** (Effluent and stormwater discharge west of PMR) was sampled once during the annual period and was recorded as dry or stagnant throughout the rest of the annual period. Water quality was alkaline, very saline and moderately soft and may be indicative of stormwater run-off with moderate to high salinity.

### 7.1.3. Receiving environment

**K012** is used as the downstream locality of PMR in the Klipfonteinspruit with **K008** as the upstream locality. An increase, especially in TDS, chloride and sodium was observed downstream of PMR with a significant reduction in sulphate concentrations.

The Klipfonteinspruit is discussed in greater detail under section 8.1.

**Table 16: Average spatial assessment for PMR impacts on the Klipfonteinspruit**

| VARIABLE | UNIT | AAP Rustenburg - Surface water WUL | Locality | | CALCULATED CHANGE |
|---|---|---|---|---|---|
| | | | Upstream | Downstream | |
| | | | K008 | K012 | |
| pH @ 25°C | pH | 6.0/9.0 | 8.53 | 8.19 | -0.34 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 67.8 | 162 | 94.2 |
| Total dissolved solids (TDS) | mg/l | - | 525 | 1007 | 482 |
| Total hardness | mg CaCO3/l | 50 | 370 | 432 | 62 |
| Total alkalinity | mg CaCO3/l | - | 369 | 142 | -227 |
| Chloride (Cl) | mg/l | - | 25.2 | 523 | 498 |
| Sulphate ($SO_4$) | mg/l | - | 73.3 | 29.3 | -44 |
| Fluoride (F) | mg/l | 0.75 | *0.132* | *0.132* | 0 |
| Nitrate ($NO_3$) as N | mg/l | - | 0.253 | 0.244 | -0.009 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 0.089 | 0.099 | 0.01 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | *0.003* | *0.007* | 0.004 |
| Calcium (Ca) | mg/l | - | 94.7 | 113 | 18.3 |
| Magnesium (Mg) | mg/l | - | 32.5 | 36 | 3.5 |
| Sodium (Na) | mg/l | - | 50 | 199 | 149 |
| Potassium (K) | mg/l | - | 12.8 | 6.43 | -6.37 |
| Aluminium (Al) | mg/l | 5 | *0.001* | *0.001* | 0 |
| Iron (Fe) | mg/l | 0.5 | *0.002* | *0.002* | 0 |
| Manganese (Mn) | mg/l | 0.18 | *0.001* | *0.001* | 0 |
| Chromium (Cr) | mg/l | - | *0.002* | *0.002* | 0 |
| Copper (Cu) | mg/l | 0.3 | *0.001* | 0.017 | 0.016 |

| | | | | | |
|---|---|---|---|---|---|
| Nickel (Ni) | mg/l | - | 0.012 | *0.013* | 0.001 |

**Table 17: Average PMR receiving environment data table for the annual monitoring period**

| AVERAGE DATA TABLE: | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PROJECT NAME | | | Anglo Rustenburg Surface water monitoring | | | | | | | |
| ASSESSMENT SET 1 | | | AAP Rustenburg - Surface water WUL | | | | | | | |
| ASSESSMENT SET 2 | | | SANS 241-1:2015 Drinking Water Standard (SABS, 2015) | | | | | | | |
| | | | | | | | | | | Value exceeds the assessment set 1 |
| VARIABLE | UNITS | AAP Rustenburg - Surface water WUL | SANS 241-1:2015 Drinking Water Standard (SABS, 2015) | MONITORING LOCALITIES | | | | | | |
| | | | | K007 | K008 | K010 | K012 | K099 | K080 | |
| pH @ 25°C | pH | 6.0/9.0 | 5.0/9.7 | 8.02 | 8.53 | 7.89 | 8.19 | 9.31 | 9.61 | |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 170 | 199 | 67.8 | 2490 | 162 | 1072 | 286 | |
| Total dissolved solids (TDS) | mg/l | - | 1200 | 1380 | 525 | 15548 | 1007 | 5341 | 1542 | |
| Total hardness | mg CaCO3/l | 50 | - | 830 | 370 | 6857 | 432 | 426 | 82 | |
| Calcium (Ca) | mg/l | - | - | 191 | 94.7 | 1752 | 113 | 111 | 26.1 | |
| Magnesium (Mg) | mg/l | - | - | 85.7 | 32.5 | 603 | 36 | *36.4* | 4.1 | |
| Sodium (Na) | mg/l | - | 200 | 73.8 | 50 | 3380 | 199 | 1755 | 551 | |
| Potassium (K) | mg/l | - | - | 13.9 | 12.8 | 25.7 | 6.43 | 179 | 24.7 | |
| Chloride (Cl) | mg/l | - | 300 | 185 | 25.2 | 9375 | 523 | 2702 | 544 | |
| Sulphate ($SO_4$) | mg/l | - | 500 | 363 | 73.3 | 338 | 29.3 | 71.4 | 59 | |
| Fluoride (F) | mg/l | 0.75 | 1.5 | *0.207* | *0.132* | *0.237* | *0.132* | 0.893 | 0.721 | |
| Nitrate ($NO_3$) as N | mg/l | - | 11 | 95.7 | 0.253 | *0.311* | 0.244 | 9.34 | 7.48 | |
| Ammonium ($NH_4$) as N | mg/l | 1 | 1.5 | 2.79 | 0.089 | 0.552 | 0.099 | 0.301 | 0.476 | |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | - | *0.069* | *0.003* | *0.064* | *0.007* | *0.385* | 0.444 | |
| Ortophosphate as $PO_4$ | mg/l | 0.234 | - | *0.211* | *0.008* | *0.196* | *0.02* | *1.18* | 1.36 | |
| Aluminium (Al) | mg/l | 5 | 0.3 | 0.028 | *0.001* | *0.338* | *0.001* | *0.387* | 0.139 | |
| Iron (Fe) | mg/l | 0.5 | 0.3 | *0.002* | *0.002* | *0.499* | *0.002* | *0.079* | *0.002* | |
| Manganese (Mn) | mg/l | 0.18 | 0.1 | *0.024* | *0.001* | *2.86* | *0.001* | *0.018* | *0.001* | |
| Chromium (Cr) | mg/l | - | 0.05 | *0.002* | *0.002* | *0.012* | *0.002* | *0.019* | 0.011 | |
| Copper (Cu) | mg/l | 0.3 | 2 | *0.005* | *0.001* | *0.068* | 0.017 | 0.173 | 0.3 | |
| Nickel (Ni) | mg/l | - | 0.07 | *0.011* | 0.012 | *0.053* | *0.013* | 0.112 | 0.078 | |
| Dissolved oxygen (DO) | mg/l | 7.0/8.0 | - | - | 1.31 | 3.59 | 2.4 | 3.29 | 2.91 | |
| Lead (Pb) | mg/l | - | 0.01 | *0.002* | *0.002* | *0.042* | *0.002* | *0.01* | *0.002* | |
| Zinc (Zn) | mg/l | - | 5 | 0.155 | *0.001* | *1.11* | *0.001* | *0.004* | *0.001* | |
| Boron (B) | mg/l | - | 2.4 | - | 0.644 | *0.098* | 0.026 | 0.059 | 0.035 | |
| Phenol | mg/l | - | 0.01 | - | *0.005* | *0.032* | *0.008* | *0.007* | *0.005* | |
| Hexavalent chromium ($Cr^{6+}$) | mg/l | 0.0049 | - | *0.001* | *0.001* | *0.001* | *0.001* | *0.008* | 0.004 | |
| Arsenic (As) | mg/l | - | 0.01 | - | *0.003* | *0.003* | *0.003* | *0.028* | 0.03 | |
| Cadmium (Cd) | mg/l | - | 0.003 | *0.001* | *0.001* | *0.022* | *0.001* | *0.001* | *0.001* | |
| Mercury (Hg) | mg/l | - | 0.006 | - | *0.002* | *0.002* | *0.002* | *0.002* | *0.002* | |
| Selenium (Se) | mg/l | - | 0.04 | - | *0.001* | *0.001* | *0.001* | *0.014* | 0.029 | |
| E.coli | CFU/100ml | - | 0 | 450 | 10 | - | - | - | - | |
| Total coliform | CFU/100ml | - | 10 | 695 | 14 | - | - | - | - | |

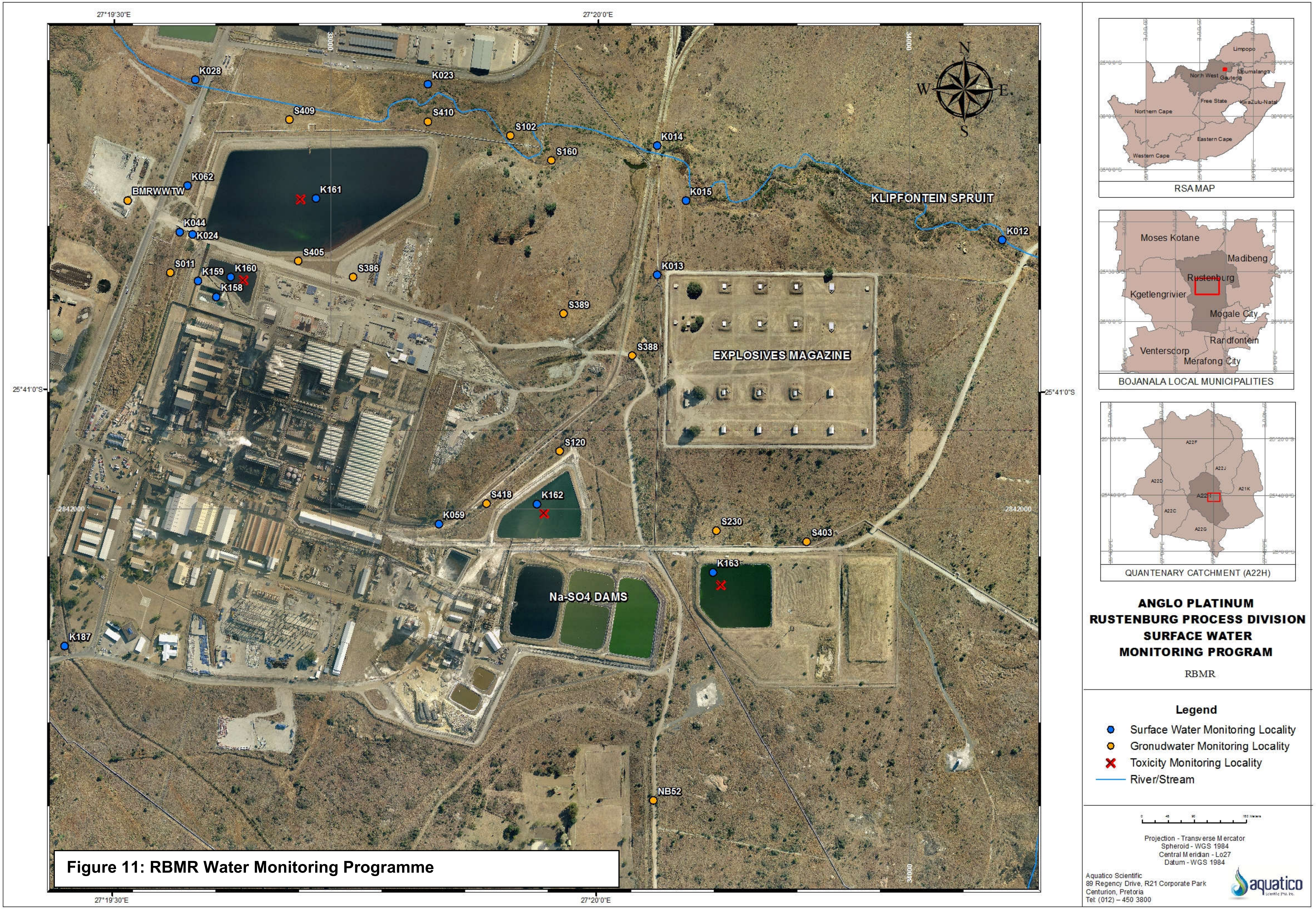



**Figure 11: RBMR Water Monitoring Programme**

**Table 18: RBMR sampling register of the surface water monitoring conducted during the annual period**

| Anglo Rustenburg Surface w ater monitoring | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effluent | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K013 | Culvert ditch going to Klipfonteinspruit halfw ay betw een PMR bridge and Waterval bridge parallel to old railw ay | Dry | Dry | Dry | Dry | Dry | Dry | Dry | ● | ● | Dry | Dry | Dry |
| K024 | Outflow of RBMR dam 3 rain catchment. RBMR rain w ater collection dam | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K044 | Trench to the w est of the RBMR dam 3B | Dry | Dry | Dry | Dry | Dry | Dry | Dry | ● | Dry | Dry | Dry | Dry |
| K062 | Spillw ay overflow RBMR stormw ater dam 3B | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K187 | Trench upstream of RBMR at culvert on access road to South gate | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K059 | Culvert at railw ay entry to RBMR | - | Dry | - | - | ● | - | - | Dry | - | - | Dry | - |
| Pollution Control Dam | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K158 | RBMR Dam 1 | - | NS | - | - | - | NS | - | - | NS | - | - | NS |
| K159 | RBMR Dam 2 | - | NS | - | - | - | NS | - | - | NS | - | - | NS |
| K160 | RBMR Dam 3A | - | NS | - | - | - | ● | - | - | ● | - | - | NS |
| K161 | RBMR Dam 3B | - | ● | - | - | - | ● | - | - | ● | - | - | NS |
| K162 | RBMR Triangular Dam - West section | - | ● | - | - | - | ● | - | - | ● | - | - | ● |
| K162 Duplicate | RBMR Triangular Dam - East section | - | - | - | - | - | - | - | - | - | - | - | ● |
| K163 | RBMR SSSS dams | - | Stagnant | - | - | - | NS | - | - | NS | - | - | NS |
| K220 | RBMR Effluent dam 1 | - | ● | - | - | - | ● | - | - | ● | - | - | ● |
| K221 | RBMR Effluent dam 2 | - | ● | - | - | - | ● | - | - | ● | - | - | ● |
| K222 | RBMR Effluent dam 3 | - | ● | - | - | - | ● | - | - | ● | - | - | ● |
| K223 | RBMR E&S feed dam 1 | - | ● | - | - | - | ● | - | - | ● | - | - | ● |
| K224 | RBMR E&S feed dam 2 | - | ● | - | - | - | ● | - | - | ● | - | - | ● |
| River or Stream | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K012 | Klipfonteinspruit betw een PMR and RBMR on old road to magazine | Dry | Dry | Dry | Dry | ● | ● | Dry | ● | Dry | Dry | Dry | Dry |
| K014 | Intersection of Klipfonteinspruit and rail line bridge (south side) | Dry | Dry | ● | Dry | ● | ● | Dry | ● | ● | Too low | ● | Dry |
| K015 | 150 metres up from intersection of Klipfonteinspruit and rail line | Dry | Dry | Dry | Dry | ● | ● | Dry | ● | ● | ● | ● | Dry |
| K023 | Klipfonteinspruit at base of RBMR dump | Dry | Dry | Dry | Dry | ● | ● | ● | ● | ● | ● | ● | ● |
| K028 | Klipfonteinspruit after confluence of RBMR w est ditch system at Waterval smelter bridge | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

*● – Sampled

NS – Not submitted

- – Not scheduled for sampling (quarterly sampling frequency in the case of pollution control dam localities)

## 7.2. RUSTENBURG BASE METAL REFINERS (RBMR)

Presented in Table 18 is the frequency of sampling at each RBMR monitoring locality during the annual period. Additionally, the average data tables are illustrated within Table 19 and Table 20 below, results are discussed separately according to the relevant sections below.

### 7.2.1. Process water

The Process water dams at RBMR are sampled by RBMR staff and samples are then submitted to Aquatico for analysis. Most RBMR pollution control dam samples were submitted throughout the annual period on a quarterly basis; RBMR dams 1 and 2 have been demolished and were thus not sampled for the annual period. RBMR dam 3A was submitted on two occasions while the RBMR SSSS dam was not sampled on any occasion during the annual period. The effluent dams (**K220**, **K221** and **K222**) and the E&S feed dams (**K223** and **K224**) were submitted throughout the annum.

Water quality profiles (STIFF diagrams) for most of the sampled dams at RBMR are similar with Na+K as the main contributing cation and sulphate as the main contributing anion. The meq/l concentrations were however noted to differed between the dams. On average, acidic water quality was found at K160 and K161, while most other analysed dam samples had alkaline water quality. RBMR dams 3A and 3B (K160 and K161) recorded significantly high metal concentrations (copper, nickel, etc.).

Fluctuating concentrations of TDS and metals were recorded in all samples; Figure 13 displays the TDS trends from 2013. Dam operation water levels should be maintained at these dams to prevent discharge which will cause deteriorating conditions to the receiving natural environment.

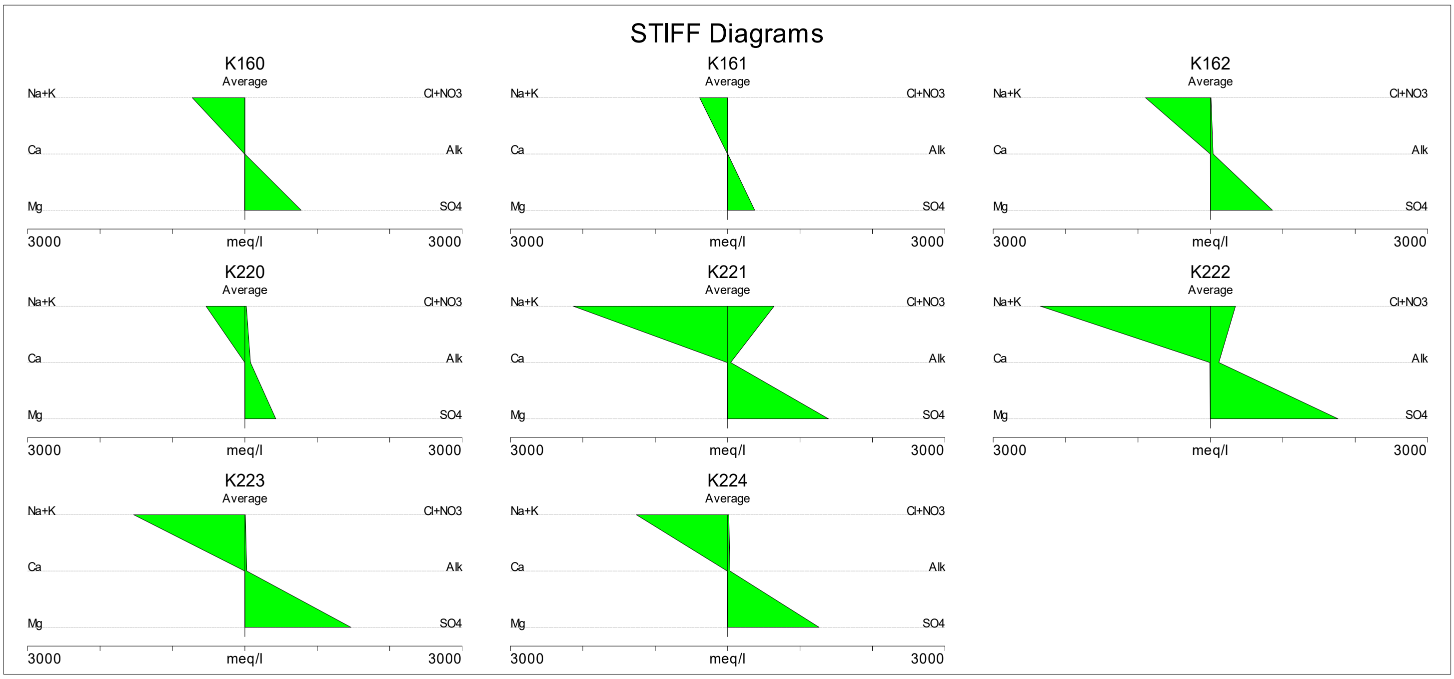
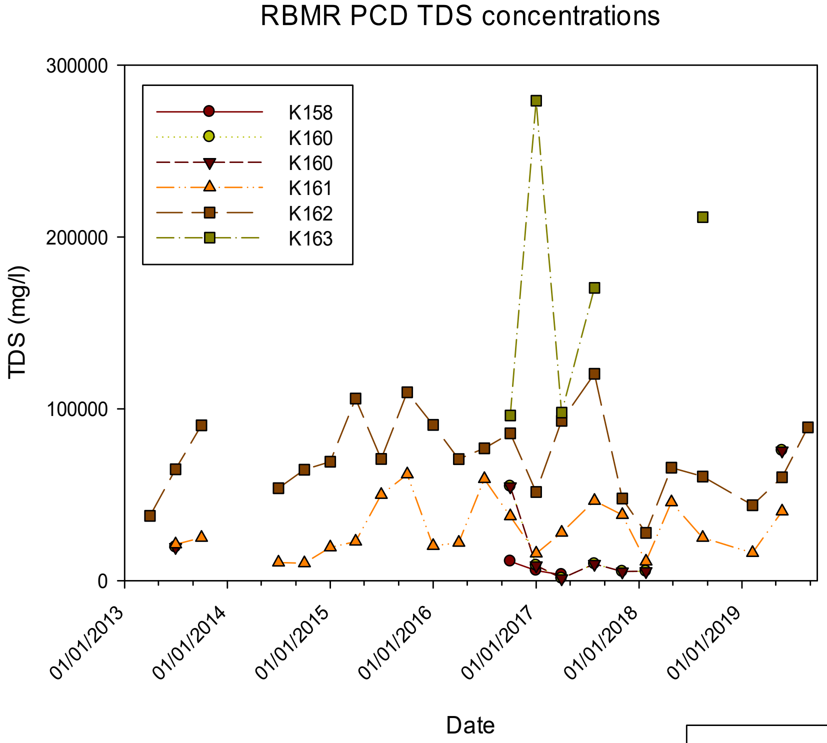



**Figure 12: STIFF diagrams showing the water quality profiles of the RBMR pollution control dams**

The new WUL (2018) does not include any guidelines for water to be stored in a process water dam. The general authorisation limit guidelines and the WUL limits for surface water are therefore used for comparative purposes; many of the analysed variables exceeded these guidelines due to the extreme salinity of these process water dams and concentrations of fluoride, base metals and heavy metals. A hazard is posed towards the integrity of the Klipfonteinspruit; a high risk also remains towards polluting groundwater if seepages and / or effluents are not controlled.



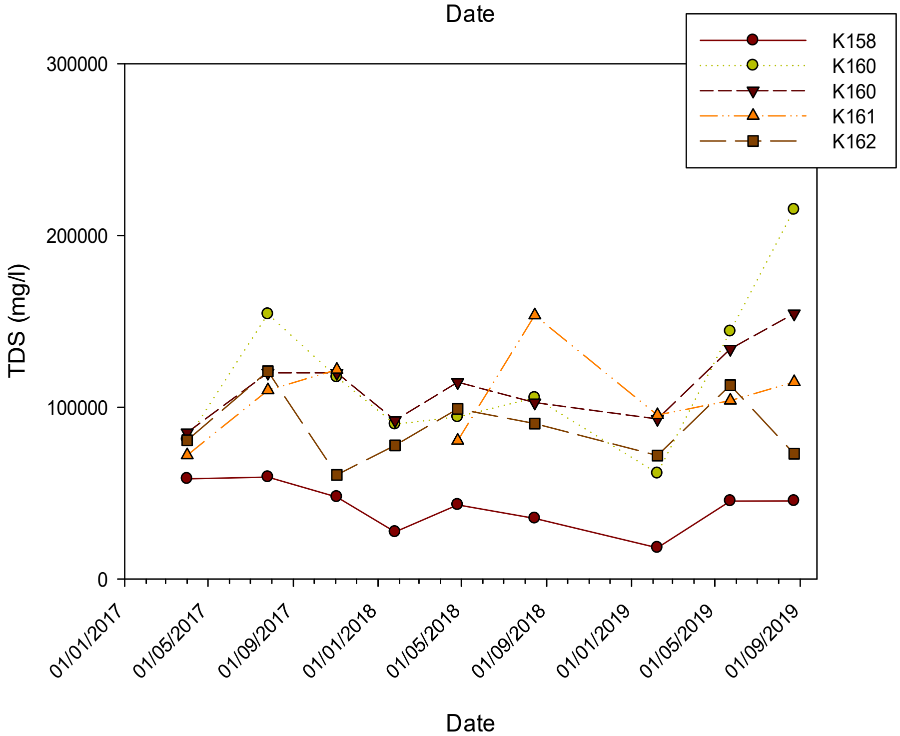




**Figure 13: RBMR PCD TDS concentration trend line graph**

**Table 19: Average RBMR process dams data table for the annual monitoring period**

| | |
|---|---|
| PROJECT NAME | Anglo Rustenburg Surface water monitoring |
| ASSESSMENT SET 1 | General Authorisation Limit, Section 21f and h, 2013 |
| ASSESSMENT SET 2 | AAP Rustenburg - Surface water WUL |

Value exceeds the assessment set 1

| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | K160 | K161 | K162 | K162 duplicate | K220 | K221 | K222 | K223 | K224 |
| pH @ 25°C | pH | 5.5/9.5 | 6.0/9.0 | 2.91 | 5.73 | 10.3 | 10.2 | 10.2 | 9.68 | 9.72 | 8.7 | 9.14 |
| Electrical conductivity (EC) @ 25°C | mS/m | 150 | 85 | 5280 | 2759 | 6503 | 8550 | 3428 | 10098 | 10163 | 8695 | 7143 |
| Total dissolved solids (TDS) | mg/l | - | - | 54355 | 27115 | 63452 | 102629 | 36059 | 141017 | 155586 | 107064 | 92011 |
| Total hardness | mg CaCO3/l | - | 50 | 548 | 167 | 105 | 111 | 113 | 434 | 555 | 123 | 325 |
| Calcium (Ca) | mg/l | - | - | 89.5 | 50.9 | 39.7 | 44.6 | 35.8 | 135 | 185 | 42.3 | 116 |
| Magnesium (Mg) | mg/l | - | - | 78.9 | 9.59 | 1.42 | 0.039 | 5.88 | 23.7 | 22.6 | 4.26 | 8.48 |
| Sodium (Na) | mg/l | - | - | 16715 | 8884 | 20552 | 35287 | 12322 | 47851 | 53000 | 35023 | 28346 |
| Potassium (K) | mg/l | - | - | 33.7 | 34.4 | 112 | 114 | 36.7 | 1999 | 1633 | 502 | 1125 |
| Total alkalinity | mg CaCO3/l | - | - | 0.995 | 126 | 1896 | 1669 | 3883 | 2088 | 5831 | 1326 | 1627 |
| Chloride (Cl) | mg/l | - | - | 8.27 | 69 | 320 | 88 | 723 | 22734 | 12287 | 234 | 600 |
| Sulphate ($SO_4$) | mg/l | - | - | 37378 | 17971 | 41214 | 66050 | 20516 | 66896 | 84701 | 70397 | 60735 |
| Fluoride (F) | mg/l | 1 | 0.75 | 0.653 | 3.96 | 36.2 | 22.8 | 35.9 | 97.7 | 188 | 11.2 | 29 |
| Nitrate ($NO_3$) as N | mg/l | 15 | - | 0.68 | 1.02 | 2.46 | 0.665 | 1.05 | 0.45 | 0.553 | 5.67 | 2.08 |
| Ammonium ($NH_4$) as N | mg/l | 6 | 1 | 1.1 | 3.21 | 0.957 | 0.718 | 2.61 | 0.066 | 0.027 | 1.03 | 0.175 |
| Orthophosphate ($PO_4$) as P | mg/l | 10 | 0.125 | 1.61 | 0.045 | 13 | 8.84 | 17.2 | 21.1 | 15.6 | 4.69 | 3.7 |
| Aluminium (Al) | mg/l | - | 5 | 17.2 | 1.77 | 0.62 | 0.061 | 0.35 | 0.017 | 0.018 | 0.013 | 0.03 |
| Iron (Fe) | mg/l | 0.3 | 0.5 | 176 | 2.86 | 0.456 | 2.86 | 0.194 | 0.894 | 0.854 | 0.52 | 0.407 |
| Manganese (Mn) | mg/l | 0.1 | 0.18 | 10.7 | 1 | 0.001 | 0.001 | 0.001 | 0.005 | 0.001 | 0.001 | 0.001 |
| Chromium (Cr) | mg/l | - | - | 8.36 | 1.27 | 0.021 | 0.002 | 0.004 | 0.032 | 0.095 | 0.061 | 0.101 |
| Copper (Cu) | mg/l | 0.01 | 0.3 | 3139 | 186 | 1.07 | 0.237 | 0.046 | 0.257 | 0.177 | 0.146 | 0.155 |
| Nickel (Ni) | mg/l | - | - | 12591 | 2150 | 6.76 | 0.492 | 0.388 | 0.77 | 0.87 | 0.195 | 0.175 |

In August 2019, two samples were taken from the RBMR triangular dam (K162 west section and K162 duplicate east section). Slight differences in water quality may be seen between the two samples.

### 7.2.2. Discharges, effluents and seepages

Dry conditions persisted at **K013** (Culvert ditch going to Klipfonteinspruit halfway between PMR bridge and Waterval bridge parallel to old railway), **K024** (Outflow of RBMR rain water collection dam), **K062** (Spillway overflow RBMR storm water dam 3B) and **K187** (Trench upstream of RBMR at culvert on access road to South gate) throughout the annual period.

**K044** (Trench to the west of the RBMR dam 3B) was sampled in April 2019. Water quality was neutral, saline and hard with moderate salts and nutrients. High concentrations of fluoride, copper and nickel were detected which would impact the Klipfonteinspruit.

**K059** (Culvert at railway entry to RBMR) was sampled in January 2019, recording water quality that was alkaline, extremely saline and very hard with high concentrations of sodium and sulphate as well as fluoride.

### 7.2.3. Receiving environment

The upstream locality of RBMR, **K012** (Klipfonteinspruit between PMR and RBMR on old road to magazine) was sampled in January, February and April 2019, recording dry conditions throughout the rest of the annual period. **K028** is used as the downstream locality of RBMR and was sampled throughout the annum. The average water quality revealed significant deteriorating conditions from the upstream to the downstream locality at RBMR. Sulphate, fluoride and nickel concentrations revealed the most significant increases and may be as a direct result of process water from the RBMR dams which are dominated by these constituents.

Figure 14 shows the average water quality profiles of localities upstream (K012), midstream (K014 and K023) and downstream (K028) of RBMR in the Klipfonteinspruit. These water quality profiles may be compared with those in Figure 12 for the RBMR process water dams.

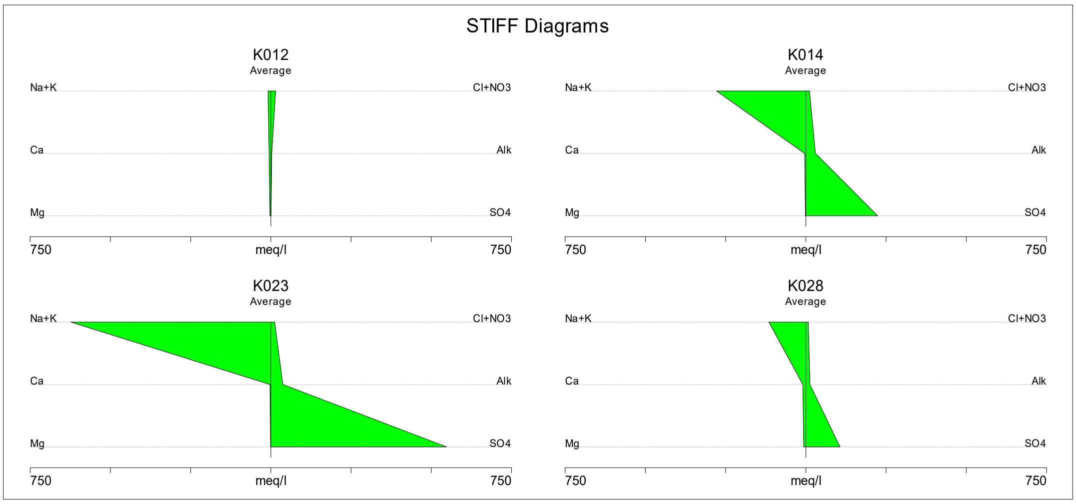



**Figure 14: STIFF diagrams showing the water quality profiles of the Klipfonteinspruit, up-, mid- and downstream of RBMR.**

The Klipfonteinspruit is discussed in greater detail under section 8.1.

**Table 20: Average spatial assessment for the BMR impacts on the Klipfonteinspruit**

| VARIABLE | UNIT | AAP Rustenburg - Surface water WUL | Locality | | CALCULATED CHANGE |
|---|---|---|---|---|---|
| | | | Upstream | Downstream | |
| | | | K012 | K028 | |
| pH @ 25°C | pH | 6.0/9.0 | 8.19 | 8.74 | 0.55 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 162 | 1318 | 1156 |
| Total dissolved solids (TDS) | mg/l | - | 1007 | 8749 | 7742 |
| Total hardness | mg CaCO3/l | 50 | 432 | 822 | 390 |
| Total alkalinity | mg CaCO3/l | - | 142 | 637 | 495 |
| Chloride (Cl) | mg/l | - | 523 | 267 | -256 |
| Sulphate ($SO_4$) | mg/l | - | 29.3 | 5113 | 5084 |
| Fluoride (F) | mg/l | 0.75 | *0.132* | 11.3 | 11.2 |
| Nitrate ($NO_3$) as N | mg/l | - | 0.244 | 0.692 | 0.448 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 0.099 | 0.235 | 0.136 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | *0.007* | *1.95* | 1.94 |
| Calcium (Ca) | mg/l | - | 113 | 189 | 76 |
| Magnesium (Mg) | mg/l | - | 36 | 84.7 | 48.7 |
| Sodium (Na) | mg/l | - | 199 | 2631 | 2432 |
| Potassium (K) | mg/l | - | 6.43 | 41.3 | 34.9 |
| Aluminium (Al) | mg/l | 5 | *0.001* | *0.005* | 0.004 |
| Iron (Fe) | mg/l | 0.5 | *0.002* | *0.1* | 0.098 |
| Manganese (Mn) | mg/l | 0.18 | *0.001* | *0.48* | 0.479 |
| Chromium (Cr) | mg/l | - | *0.002* | *0.011* | 0.009 |
| Copper (Cu) | mg/l | 0.3 | 0.017 | 0.369 | 0.352 |
| Nickel (Ni) | mg/l | - | *0.013* | 11.4 | 11.4 |

**Table 21: Average RBMR receiving environment data table for the annual monitoring period**

| AVERAGE DATA TABLE: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PROJECT NAME | | | | Anglo Rustenburg Surface w ater monitoring | | | | | | | |
| ASSESSMENT SET 1 | | | | AAP Rustenburg - Surface w ater WUL | | | | | | | |
| ASSESSMENT SET 2 | | | | SANS 241-1:2015 Drinking Water Standard (SABS, 2015) | | | | | | | |
| | | | | | | | | | | | Value exceeds the assessment set 1 |
| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES | | | | | | | |
| | | | | K012 | K014 | K015 | K023 | K028 | K013 | K044 | K059 |
| pH @ 25°C | pH | 6.0/9.0 | 5.0/9.7 | 8.19 | 9.95 | 10.1 | 10.1 | 8.74 | 10.5 | 8.14 | 8.94 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 170 | 162 | 3421 | 4690 | 4840 | 1318 | 5025 | 225 | 509 |
| Total dissolved solids (TDS) | mg/l | - | 1200 | 1007 | 18619 | 33947 | 42350 | 8749 | 36903 | 1415 | 4358 |
| Total hardness | mg CaCO3/l | 50 | - | 432 | 267 | 229 | 187 | 822 | 109 | 281 | 381 |
| Calcium (Ca) | mg/l | - | - | 113 | 76.8 | 67.3 | 56.5 | 189 | 34 | 82.2 | 114 |
| Magnesium (Mg) | mg/l | - | - | 36 | 18.3 | 14.8 | 11.1 | 84.7 | 5.76 | 18.3 | 23.2 |
| Sodium (Na) | mg/l | - | 200 | 199 | 6350 | 11205 | 14267 | 2631 | 12104 | 372 | 1177 |
| Potassium (K) | mg/l | - | - | 6.43 | 79.4 | 123 | 105 | 41.3 | 145 | 12.9 | 13.3 |
| Chloride (Cl) | mg/l | - | 300 | 523 | 393 | 438 | 416 | 267 | 320 | 146 | 38.3 |
| Sulphate ($SO_4$) | mg/l | - | 500 | 29.3 | 10738 | 20877 | 26305 | 5113 | 22913 | 620 | 2807 |
| Fluoride (F) | mg/l | 0.75 | 1.5 | 0.132 | 23.1 | 36.4 | 31 | 11.3 | 25.5 | 15.3 | 1.32 |
| Nitrate ($NO_3$) as N | mg/l | - | 11 | 0.244 | 1.63 | 0.919 | 1.15 | 0.692 | 1.23 | 1.47 | 0.437 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 1.5 | 0.099 | 0.378 | 0.185 | 0.099 | 0.235 | 0.066 | 1.74 | 0.223 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | - | 0.007 | 6.73 | 11.7 | 15 | 1.95 | 11 | 0.08 | 0.589 |
| Ortophosphate as $PO_4$ | mg/l | 0.234 | - | 0.02 | 20.6 | 35.9 | 46 | 5.97 | 33.8 | 0.245 | 1.81 |
| Aluminium (Al) | mg/l | 5 | 0.3 | 0.001 | 0.445 | 0.638 | 0.301 | 0.005 | 0.531 | 0.077 | 0.001 |
| Iron (Fe) | mg/l | 0.5 | 0.3 | 0.002 | 0.171 | 0.262 | 0.472 | 0.1 | 0.403 | 0.13 | 0.002 |
| Manganese (Mn) | mg/l | 0.18 | 0.1 | 0.001 | 0.539 | 0.113 | 0.061 | 0.48 | 0.001 | 0.183 | 0.023 |
| Chromium (Cr) | mg/l | - | 0.05 | 0.002 | 0.037 | 0.038 | 0.07 | 0.011 | 0.054 | 0.002 | 0.033 |
| Copper (Cu) | mg/l | 0.3 | 2 | 0.017 | 0.192 | 0.195 | 0.2 | 0.369 | 0.543 | 1.85 | 0.037 |
| Nickel (Ni) | mg/l | - | 0.07 | 0.013 | 0.082 | 0.057 | 0.063 | 11.4 | 0.002 | 32.2 | 0.074 |
| Dissolved oxygen (DO) | mg/l | 7.0/8.0 | - | 2.4 | 3.05 | 1.92 | 1.95 | 3.58 | 3.07 | 1.79 | - |
| Lead (Pb) | mg/l | - | 0.01 | 0.002 | 0.019 | 0.033 | 0.043 | 0.018 | 0.064 | 0.076 | 0.002 |
| Zinc (Zn) | mg/l | - | 5 | 0.001 | 0.028 | 0.061 | 0.081 | 0.108 | 0.091 | 0.217 | 0.031 |
| Boron (B) | mg/l | - | 2.4 | 0.026 | 23.2 | 39.8 | 29.7 | 10.3 | 42.7 | 3.12 | 4.8 |
| Phenol | mg/l | - | 0.01 | 0.008 | 0.005 | 0.005 | 0.005 | 0.006 | 0.005 | 0.005 | - |
| Hexavalent chromium ($Cr^{6+}$) | mg/l | 0.0049 | - | 0.001 | 0.011 | 0.009 | 0.009 | 0.001 | 0.001 | 0.001 | 0.001 |
| Arsenic (As) | mg/l | - | 0.01 | 0.003 | 0.03 | 0.043 | 0.042 | 0.009 | 0.037 | 0.003 | - |
| Cadmium (Cd) | mg/l | - | 0.003 | 0.001 | 0.007 | 0.007 | 0.004 | 0.004 | 0.001 | 0.001 | 0.001 |
| Mercury (Hg) | mg/l | - | 0.006 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | - |
| Selenium (Se) | mg/l | - | 0.04 | 0.001 | 0.021 | 0.027 | 0.024 | 0.013 | 0.032 | 0.001 | - |
| E.coli | CFU/100ml | - | 0 | - | - | - | - | 8.96 | - | - | - |
| Total coliform | CFU/100ml | - | 10 | - | - | - | - | 72.38 | - | - | - |

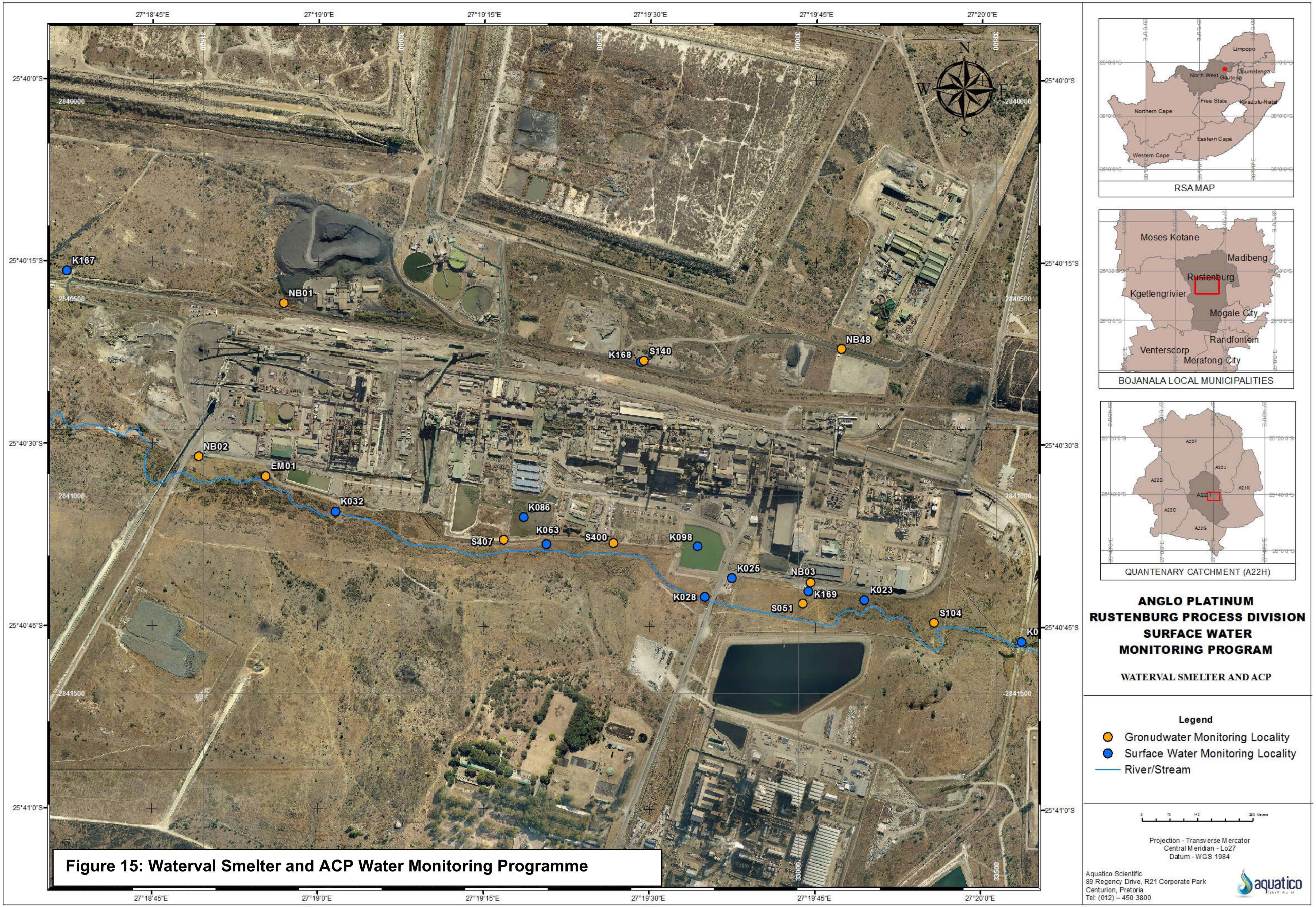



**Figure 15: Waterval Smelter and ACP Water Monitoring Programme**

**Table 22: Waterval Smelter and ACP sampling register of the surface water monitoring conducted during the annual period**

| Anglo Rustenburg Surface water monitoring | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canal or trench | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K025 | Intersection between electric pylons & compressor air pipe between RBMR and lab. Storm water canal from ACP | Dry | Dry | Dry | Dry | ● | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K167 | Cut-off trench north of Waterval concentrator just before discharge towards Klipfonteinspruit | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | Dry | Dry |
| K168 | Cut off trench north of Waterval Smelter reverts area | Dry | Dry | Dry | Dry | ● | ● | ● | ● | ● | Dry | Dry | Dry |
| K169 | Trench from PF Retief laboratory towards Klipfonteinspruit | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | Not sampled | ● |
| Pollution control dam | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K098 | ACP Pollution Control Dam | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| River or stream | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K014 | Intersection of Klipfonteinspruit and rail line bridge (south side) | Dry | Dry | ● | Dry | ● | ● | Dry | ● | ● | Too low | ● | Dry |
| K023 | Klipfonteinspruit at base of RBMR dump | Dry | Dry | Dry | Dry | ● | ● | ● | ● | ● | ● | ● | ● |
| K028 | Klipfonteinspruit after confluence of RBMR west ditch system at Waterval smelter bridge | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| K063 | Klipfonteinspruit at stormwater discharge from Waterval smelter and concentrator | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

*● – Sampled

## 7.3. WATERVAL SMELTER AND ACP

Presented in Table 22 is the frequency of sampling at each Waterval Smelter and ACP monitoring locality during the annual period. Additionally, the average data tables are illustrated in Table 23 and Table 25, which are discussed separately according to the relevant sections below.

### 7.3.1. Process water

The ACP Pollution Control Dam (**K098**) was sampled throughout the annual period. Values of pH alternated between acidic to alkaline throughout the annum. The physical and chemical water quality fluctuated significantly throughout the annual period. Water quality was recorded as saline to extremely saline and very hard with moderate to high concentrations of inorganic salts and nutrients on average. Concentrations of fluoride and heavy metals (aluminium, iron, manganese, copper and nickel) were recorded when the pH was acidic. Increasing acidity (lowering op pH value) results in the mobilisation of suspended metals into solution, often resulting in an increase in recorded metal concentrations (if present in suspension). A graph showing increased EC and Ni concentrations when the pH decreases is shown in Figure 17. WUL, Domestic, irrigation and livestock watering guidelines are exceeded and freeboard should be managed to prevent overflows.

The new WUL (2018) does not include any guidelines for water to be stored in a process water dam or wastewater to be disposed of into a waste water facility. The general authorisation limit guidelines and the WUL limits for surface water are therefore used for comparative purposes in Table 23. The Stiff diagrams below also show how the physical and chemical water quality is altered over the annual period.

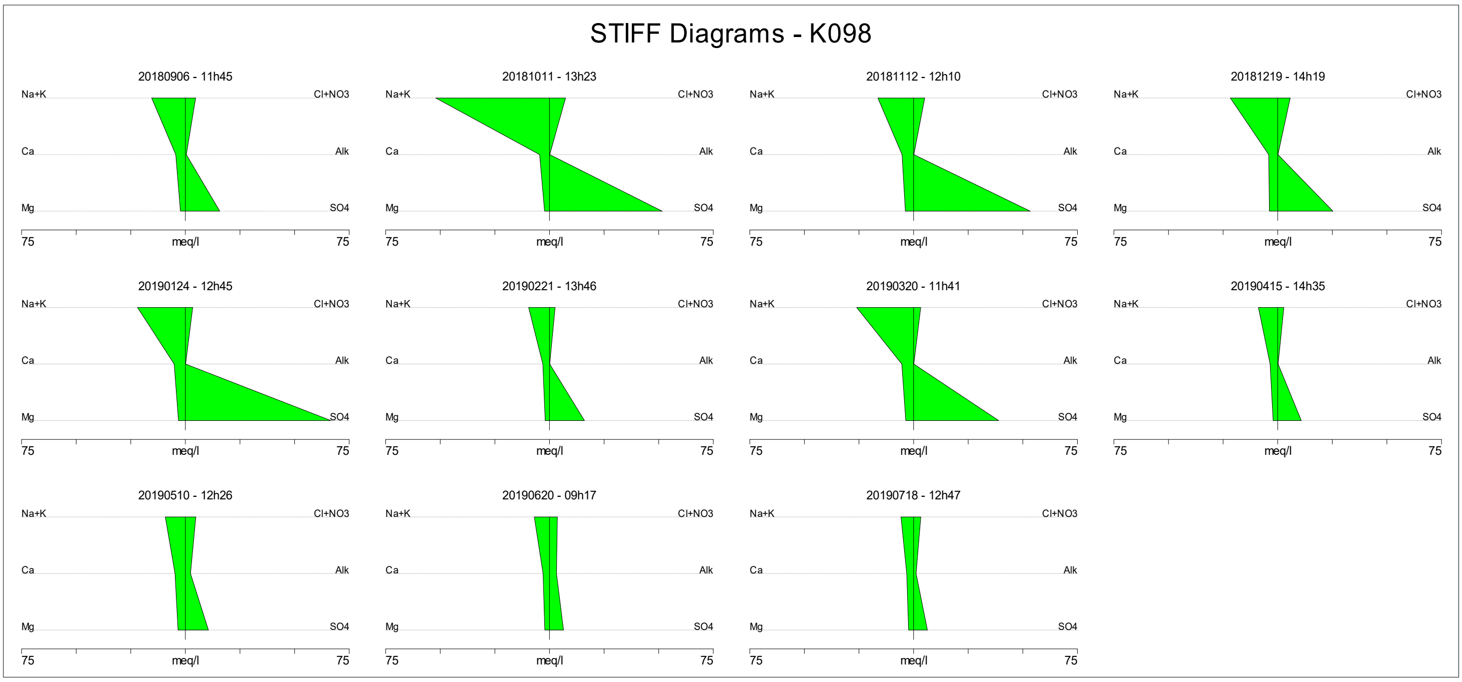



**Figure 16: Time-series STIFF diagrams of the ACP Pollution Control Dam.**

**Table 23: Average Waterval Smelter and ACP process dam data table for the annual monitoring period**

| AVERAGE DATA TABLE: | | | | |
|---|---|---|---|---|
| PROJECT NAME | | | Anglo Rustenburg Surface water monitoring | |
| ASSESSMENT SET 1 | | | General Authorisation Limit, Section 21f and h, 2013 | |
| ASSESSMENT SET 2 | | | AAP Rustenburg - Surface water WUL | |
| | | | | Value exceeds the assessment set 1 |
| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES |
| | | | | K098 |
| pH @ 25°C | pH | 5.5/9.5 | 6.0/9.0 | 4.62 |
| Electrical conductivity (EC) @ 25°C | mS/m | 150 | 85 | 432 |
| Total dissolved solids (TDS) | mg/l | - | - | 2068 |
| Total hardness | mg CaCO3/l | - | 50 | 350 |
| Calcium (Ca) | mg/l | - | - | 84.3 |
| Magnesium (Mg) | mg/l | - | - | 33.9 |
| Sodium (Na) | mg/l | - | - | 391 |
| Potassium (K) | mg/l | - | - | 24 |
| Chloride (Cl) | mg/l | - | - | 134 |
| Sulphate ($SO_4$) | mg/l | - | - | 1318 |
| Fluoride (F) | mg/l | 1 | 0.75 | *1.27* |
| Nitrate ($NO_3$) as N | mg/l | 15 | - | 6.51 |
| Ammonium ($NH_4$) as N | mg/l | 6 | 1 | 1.09 |
| Orthophosphate ($PO_4$) as P | mg/l | 10 | 0.125 | *0.758* |
| Aluminium (Al) | mg/l | - | 5 | *5.59* |
| Iron (Fe) | mg/l | 0.3 | 0.5 | *47.2* |
| Manganese (Mn) | mg/l | 0.1 | 0.18 | *0.407* |
| Chromium (Cr) | mg/l | - | - | *0.166* |
| Copper (Cu) | mg/l | 0.01 | 0.3 | 4.6 |
| Nickel (Ni) | mg/l | - | - | 10.1 |

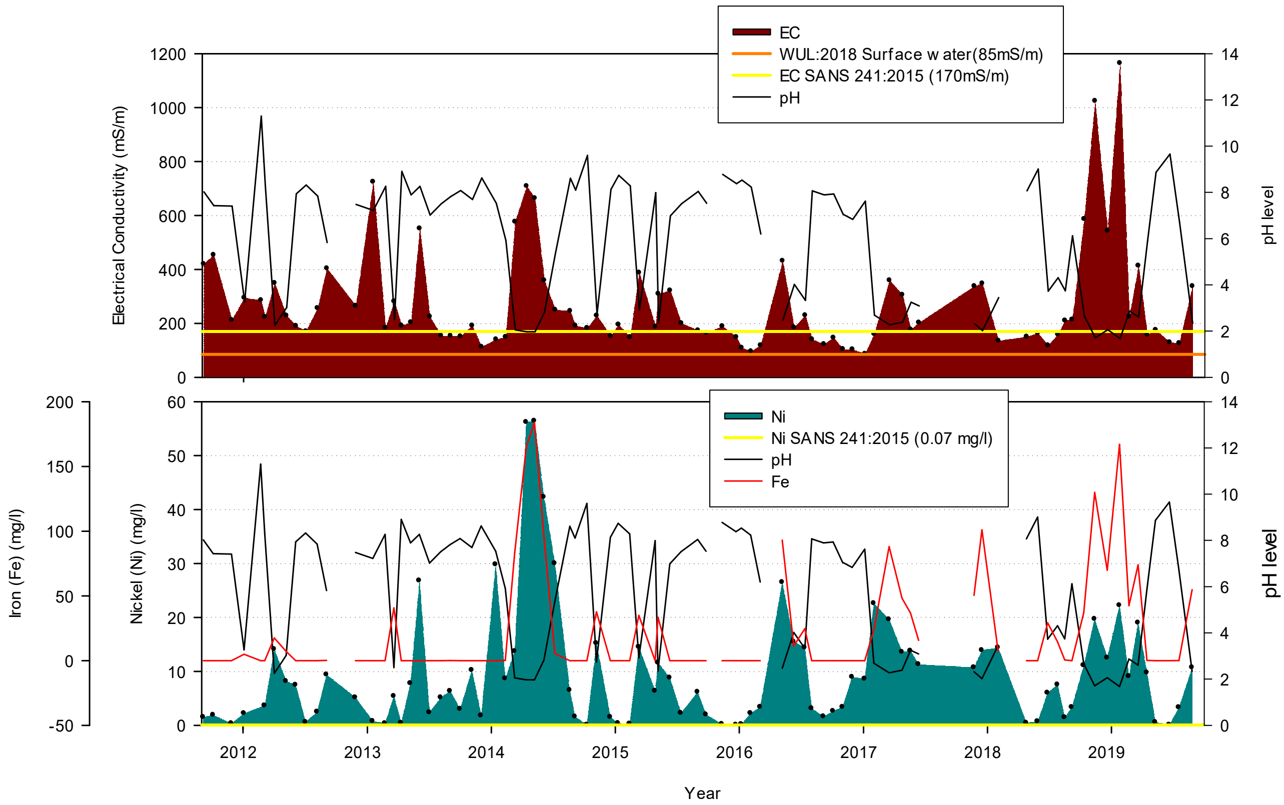



**Figure 17: ACP pollution control dam (K098) time-series data for pH, EC, iron and nickel**

### 7.3.2. Discharges, effluents and seepages

**K025** (Stormwater from ACP into Klipfonteinspruit between K014 and K028) was sampled once throughout the annual period and recorded neutral, very saline and very hard water quality. High concentrations of fluoride and nickel was detected in the water sample.

**K168** (Cut off trench north of Waterval Smelter into Klipfonteinspruit) will flow towards the Klipfonteinspruit during high flow events. This locality was sampled on five occasions during the annual period. The average water quality was recorded as neutral, extremely saline and very hard with high concentrations of inorganic salts. High average concentrations of fluoride, manganese, nickel, nitrate and ammonium were detected. This source is seen to be an important contributor to the water quality of the Klipfonteinspruit.

**K167** (Cut off trench north of Waterval Smelter into Klipfonteinspruit) was sampled mostly throughout the annual period. Average water quality was similar to K168 with high salinity and hardness and concentrations of fluoride, manganese and nickel. Water discharged from this locality into the Klipfonteinspruit will contribute to negative effects on the water quality of the Klipfonteinspruit.

In the PF Retief culvert (**K169**) the average water quality may be described as neutral, very saline and very hard. Moderate inorganic salt concentrations and sporadic high nutrient and low heavy metal concentrations were detected.

### 7.3.3. Receiving environment

**K023** and **K063** are used as the up- and downstream localities for the Waterval complex on the Klipfonteinspruit. The only significant increases in analysed variables detected were nitrate and nickel. The majority of the analysed variables revealed a noteworthy decrease in concentration which may be explained by the reed bed that the Klipfonteinspruit flows through next to the Waterval complex. The naturally growing reed bed creates an ecological water-filtration system that takes up inorganic salts, nutrients and metals from the water. The presence of the reed bed helps improve water quality in the Klipfonteinspruit. The Klipfonteinspruit as a whole is discussed in greater detail under section 8.1.

**Table 24: Average smelter and ACP impacts on the Klipfonteinspruit**

| VARIABLE | UNIT | AAP Rustenburg - Surface water WUL | Locality | | CALCULATED CHANGE |
|---|---|---|---|---|---|
| | | | Upstream | Downstream | |
| | | | K023 | K063 | |
| pH @ 25°C | pH | 6.0/9.0 | 10.1 | 7.89 | -2.21 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 4840 | 200 | -4640 |
| Total dissolved solids (TDS) | mg/l | - | 42350 | 1382 | -40968 |
| Total hardness | mg CaCO3/l | 50 | 187 | 291 | 104 |
| Total alkalinity | mg CaCO3/l | - | 1867 | 152 | -1715 |
| Chloride (Cl) | mg/l | - | 416 | 138 | -278 |
| Sulphate ($SO_4$) | mg/l | - | 26305 | 636 | -25669 |
| Fluoride (F) | mg/l | 0.75 | 31 | 0.997 | -30 |
| Nitrate ($NO_3$) as N | mg/l | - | 1.15 | 12.5 | 11.4 |
| Ammonium ($NH_4$) as N | mg/l | 1 | *0.099* | 0.162 | 0.063 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | 15 | 2.65 | -12.4 |
| Calcium (Ca) | mg/l | - | 56.5 | 81.3 | 24.8 |
| Magnesium (Mg) | mg/l | - | *11.1* | 21.3 | 10.2 |
| Sodium (Na) | mg/l | - | 14267 | 325 | -13942 |
| Potassium (K) | mg/l | - | 105 | 15.5 | -89.5 |
| Aluminium (Al) | mg/l | 5 | *0.301* | *0.017* | -0.284 |
| Iron (Fe) | mg/l | 0.5 | 0.472 | *0.002* | -0.47 |
| Manganese (Mn) | mg/l | 0.18 | *0.061* | *0.095* | 0.034 |
| Chromium (Cr) | mg/l | - | 0.07 | *0.002* | -0.068 |
| Copper (Cu) | mg/l | 0.3 | *0.2* | 0.114 | -0.086 |
| Nickel (Ni) | mg/l | - | *0.063* | 1.24 | 1.18 |

**Table 25: Average Waterval Smelter and ACP receiving environment data table for the annual monitoring period**

| AVERAGE DATA TABLE: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PROJECT NAME | | | | Anglo Rustenburg Surface w ater monitoring | | | | | | | |
| ASSESSMENT SET 1 | | | | AAP Rustenburg - Surface w ater WUL | | | | | | | |
| ASSESSMENT SET 2 | | | | SANS 241-1:2015 Drinking Water Standard (SABS, 2015) | | | | | | | |
| | | | | | | | | | | | Value exceeds the assessment set 1 |
| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES | | | | | | | |
| | | | | K025 | K167 | K168 | K169 | K014 | K023 | K028 | K063 |
| pH @ 25°C | pH | 6.0/9.0 | 5.0/9.7 | 8.44 | 7.6 | 7.71 | 8.03 | 9.95 | 10.1 | 8.74 | 7.89 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 170 | 234 | 542 | 415 | 155 | 3421 | 4840 | 1318 | 200 |
| Total dissolved solids (TDS) | mg/l | - | 1200 | 1996 | 4222 | 3431 | 1203 | 18619 | 42350 | 8749 | 1382 |
| Total hardness | mg CaCO3/l | 50 | - | 1256 | 1572 | 1481 | 771 | 267 | 187 | 822 | 291 |
| Calcium (Ca) | mg/l | - | - | 305 | 478 | 390 | 166 | 76.8 | 56.5 | 189 | 81.3 |
| Magnesium (Mg) | mg/l | - | - | 120 | 91.7 | 123 | 86.8 | 18.3 | 11.1 | 84.7 | 21.3 |
| Sodium (Na) | mg/l | - | 200 | 139 | 733 | 493 | 105 | 6350 | 14267 | 2631 | 325 |
| Potassium (K) | mg/l | - | - | 17 | 54.7 | 44.1 | 7.12 | 79.4 | 105 | 41.3 | 15.5 |
| Chloride (Cl) | mg/l | - | 300 | 239 | 820 | 607 | 156 | 393 | 416 | 267 | 138 |
| Sulphate ($SO_4$) | mg/l | - | 500 | 1000 | 1969 | 1631 | 506 | 10738 | 26305 | 5113 | 636 |
| Fluoride (F) | mg/l | 0.75 | 1.5 | 21.6 | 1.07 | 3.72 | 0.415 | 23.1 | 31 | 11.3 | 0.997 |
| Nitrate ($NO_3$) as N | mg/l | - | 11 | 2.8 | 4.57 | 11.1 | 1.55 | 1.63 | 1.15 | 0.692 | 12.5 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 1.5 | 0.054 | 0.402 | 6.68 | 4.85 | 0.378 | 0.099 | 0.235 | 0.162 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | - | 0.088 | 0.014 | 0.003 | 0.801 | 6.73 | 15 | 1.95 | 2.65 |
| Ortophosphate as $PO_4$ | mg/l | 0.234 | - | 0.27 | 0.043 | 0.008 | 2.46 | 20.6 | 46 | 5.97 | 8.13 |
| Aluminium (Al) | mg/l | 5 | 0.3 | 0.001 | 0.003 | 0.005 | 0.002 | 0.445 | 0.301 | 0.005 | 0.017 |
| Iron (Fe) | mg/l | 0.5 | 0.3 | 0.002 | 0.069 | 0.002 | 0.002 | 0.171 | 0.472 | 0.1 | 0.002 |
| Manganese (Mn) | mg/l | 0.18 | 0.1 | 0.418 | 0.208 | 1.12 | 0.097 | 0.539 | 0.061 | 0.48 | 0.095 |
| Chromium (Cr) | mg/l | - | 0.05 | 0.013 | 0.002 | 0.004 | 0.002 | 0.037 | 0.07 | 0.011 | 0.002 |
| Copper (Cu) | mg/l | 0.3 | 2 | 0.761 | 0.029 | 0.199 | 0.007 | 0.192 | 0.2 | 0.369 | 0.114 |
| Nickel (Ni) | mg/l | - | 0.07 | 40.1 | 1.27 | 19.8 | 0.487 | 0.082 | 0.063 | 11.4 | 1.24 |
| Dissolved oxygen (DO) | mg/l | 7.0/8.0 | - | 3.22 | 3.28 | 2.54 | 1.38 | 3.05 | 1.95 | 3.58 | 3.33 |
| Lead (Pb) | mg/l | - | 0.01 | 0.002 | 0.002 | 0.002 | 0.004 | 0.019 | 0.043 | 0.018 | 0.003 |
| Zinc (Zn) | mg/l | - | 5 | 0.27 | 0.045 | 0.11 | 0.089 | 0.028 | 0.081 | 0.108 | 0.01 |
| Boron (B) | mg/l | - | 2.4 | 0.16 | 0.852 | 0.619 | 0.18 | 23.2 | 29.7 | 10.3 | 0.868 |
| Phenol | mg/l | - | 0.01 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.006 | 0.005 |
| Hexavalent chromium ($Cr^{6+}$) | mg/l | 0.0049 | - | 0.001 | 0.001 | 0.001 | 0.001 | 0.011 | 0.009 | 0.001 | 0.001 |
| Arsenic (As) | mg/l | - | 0.01 | 0.003 | 0.003 | 0.003 | 0.003 | 0.03 | 0.042 | 0.009 | 0.003 |
| Cadmium (Cd) | mg/l | - | 0.003 | 0.001 | 0.003 | 0.002 | 0.001 | 0.007 | 0.004 | 0.004 | 0.001 |
| Mercury (Hg) | mg/l | - | 0.006 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| Selenium (Se) | mg/l | - | 0.04 | 0.001 | 0.001 | 0.001 | 0.001 | 0.021 | 0.024 | 0.013 | 0.001 |
| Oil and grease (SOG) | mg/l | - | - | - | 405 | 0.899 | 2.81 | - | - | - | - |
| E.coli | CFU/100ml | - | 0 | - | - | - | - | - | - | 8.96 | 659.67 |
| Total coliform | CFU/100ml | - | 10 | - | - | - | - | - | - | 72.38 | 2771.67 |

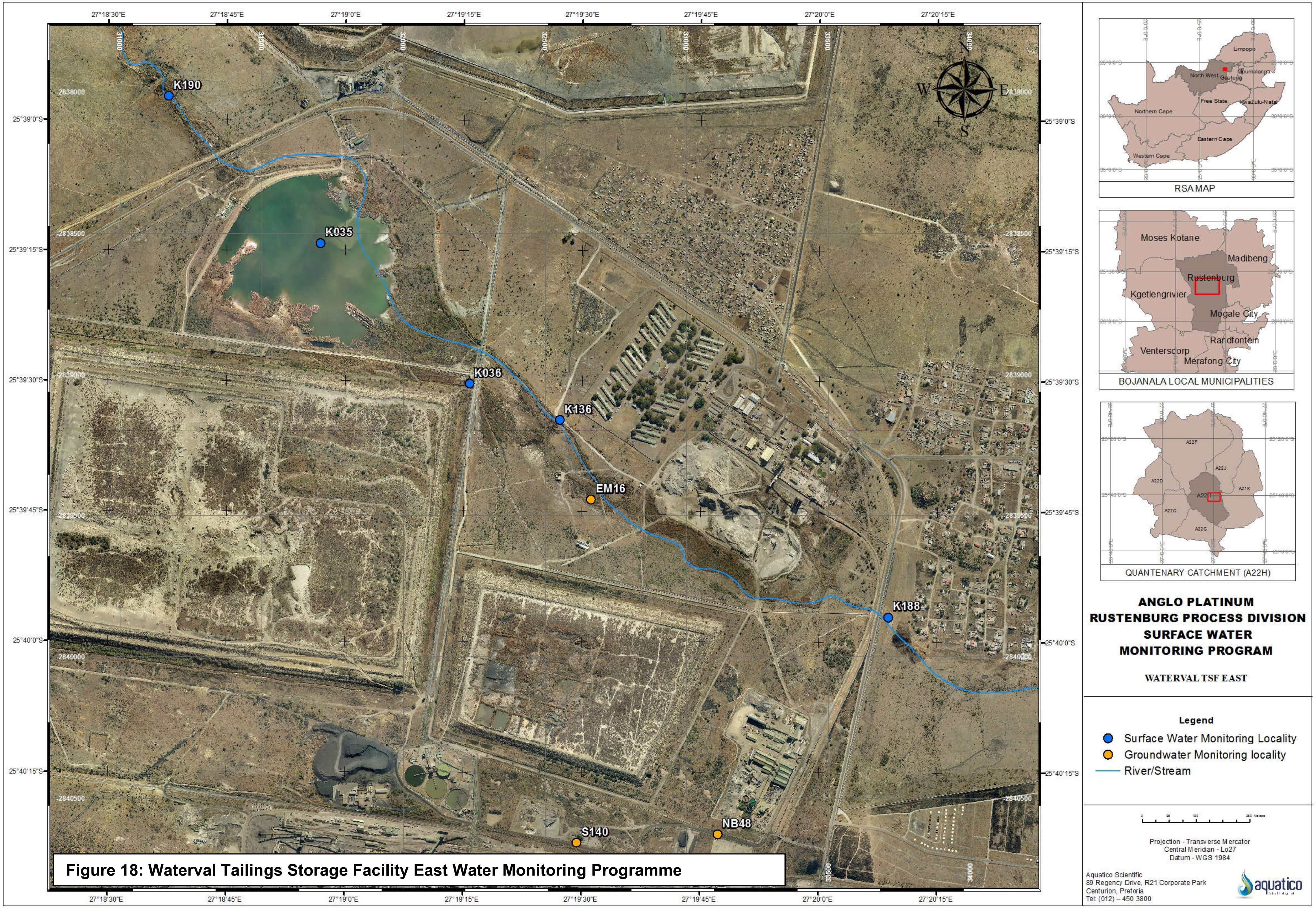



Figure 18: Waterval Tailings Storage Facility East Water Monitoring Programme

**Table 26: WVE TSF sampling register of the surface water monitoring conducted during the annual period**

| Anglo Rustenburg Surface water monitoring | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effluent | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K036 | Inflow into Klipgat return water dam from Waterval tailings dam 7-stream and Khomanani I Shaft sump canal | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| K034 | Spillway overflow of Klipgat Return Water Dam | Dry | Dry | Dry | Dry | Dry | Dry | Dry | ● | Dry | Dry | ● | Dry |
| River or stream | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K188 | Klipgatspruit, downstream of Mfidikoe village, upstream of Khomanani I Shaft (Frank I Shaft), Frank Concentrator and Waterval Complex | Dry | Dry | Dry | Dry | Dry | Dry | Dry | ● | Dry | Dry | ● | ● |
| K136 | Klipgatspruit, downstream of Entabeni Hostel at Khomanani I Shaft (Frank I Shaft) | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| K190 | Klipgatspruit, downstream of Klipgat Return Water Dam and Waterval Tailings | ● | ● | ● | ● | Dry | ● | ● | ● | ● | ● | ● | ● |
| Return water dam | | | | | | | | | | | | | |
| Monitoring Localities | | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 |
| K035 | Klipgat Return Water Dam of Waterval Tailings | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

*● – Sampled

## 7.4. WATERVAL-EAST TAILINGS STORAGE FACILITY

Presented in Table 26 is the frequency of sampling at each Waterval East TSF monitoring locality during the annual period. Additionally the average data tables are illustrated within Table 27 and Table 29, results are discussed separately according to the relevant sections below.

### 7.4.1. Process water

Klipgat RWD (**K035**), part of the Waterval Tailings Storage Facility, is characterised by elevated TDS/EC and total hardness dominated by the sulphate anion and sodium cation. Average TDS for the current annum measured 4420 mg/l, with an average total hardness of 1560 mg/l. Inorganic salt concentrations and nutrients in the form of nitrate and ammonium were high throughout the annum. Most metals were below detection limits while sporadic high concentrations of manganese, chrome and nickel were detected during the annual period. *E.coli* and total coliforms recorded high counts throughout the monitoring period. The water quality is classified as *Unacceptable (class 04)* for Domestic Use. Domestic, irrigation, aquatic ecosystems and livestock watering guidelines at the Klipgat Dam were exceeded. There are no WUL conditions for wastewater disposed of into the dams for the new 2018 WUL. The general authorisation limits and WUL for surface water limits were exceeded for multiple variables, including EC, nitrate, ammonium and SOG. The water quality profile remained stable throughout the annum, as indicated by the STIFF diagrams (Figure 19).

Water quality for the inflow into Klipgat dam (**K036**) also had elevated average TDS (4395 mg/l) and inorganic salt concentrations. This locality revealed similar STIFF diagrams (water quality) as compared to **K035**. Average nutrient concentrations (nitrate, ammonium and phosphate) were lower than those found at **K035**. **K036** also recorded high concentrations of manganese, copper and nickel which fluctuated throughout the annum.

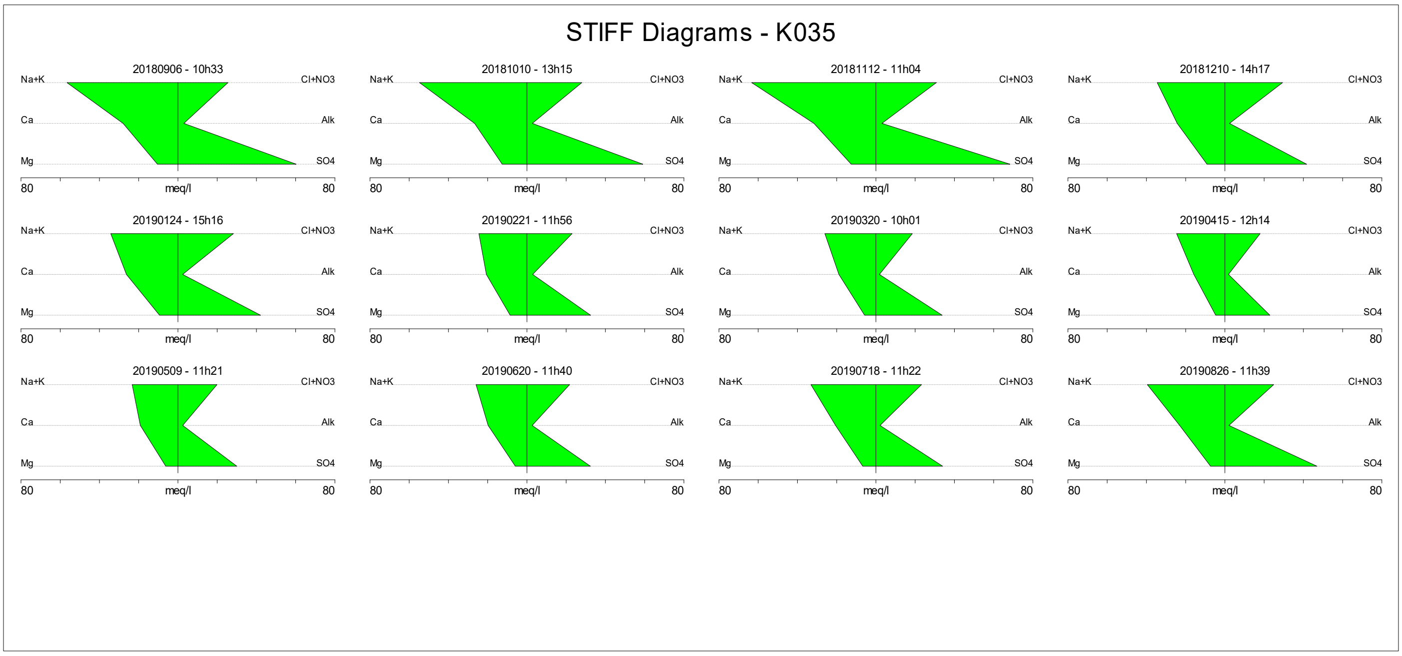



**Figure 19: Time series STIFF diagrams representing the Klipgat RWD water quality for the past annual period**

**Table 27: Average WVE TSF process dams data table for the annual monitoring period**

| AVERAGE DATA TABLE: | | | | | | |
|---|---|---|---|---|---|---|
| PROJECT NAME | | | Anglo Rustenburg Surface water monitoring | | | |
| ASSESSMENT SET 1 | | | General Authorisation Limit, Section 21f and h, 2013 | | | |
| ASSESSMENT SET 2 | | | AAP Rustenburg - Surface water WUL | | | |
| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES | | |
| | | | | K034 | K035 | K036 |
| pH @ 25°C | pH | 5.5/9.5 | 6.0/9.0 | 8.01 | 7.98 | 7.95 |
| Electrical conductivity (EC) @ 25°C | mS/m | 150 | 85 | 639 | 571 | 584 |
| Total dissolved solids (TDS) | mg/l | - | - | 4437 | 4420 | 4395 |
| Total hardness | mg CaCO3/l | - | 50 | 1443 | 1560 | 1713 |
| Calcium (Ca) | mg/l | - | - | 418 | 459 | 491 |
| Magnesium (Mg) | mg/l | - | - | 97.1 | 101 | 118 |
| Sodium (Na) | mg/l | - | - | 869 | 809 | 786 |
| Potassium (K) | mg/l | - | - | 56 | 58.7 | 53.7 |
| Chloride (Cl) | mg/l | - | - | 785 | 829 | 893 |
| Sulphate ($SO_4$) | mg/l | - | - | 2063 | 2016 | 1916 |
| Fluoride (F) | mg/l | 1 | 0.75 | 0.621 | *0.524* | *0.416* |
| Nitrate ($NO_3$) as N | mg/l | 15 | - | 4.9 | 12.6 | *2.48* |
| Ammonium ($NH_4$) as N | mg/l | 6 | 1 | 6.32 | 6 | 0.68 |
| Orthophosphate ($PO_4$) as P | mg/l | 10 | 0.125 | *0.011* | *0.062* | *0.081* |
| Aluminium (Al) | mg/l | - | 5 | *0.008* | *0.007* | *0.046* |
| Iron (Fe) | mg/l | 0.3 | 0.5 | *0.002* | *0.005* | *0.024* |
| Manganese (Mn) | mg/l | 0.1 | 0.18 | 1.1 | *0.046* | 0.305 |
| Chromium (Cr) | mg/l | - | - | *0.002* | *0.002* | *0.003* |
| Copper (Cu) | mg/l | 0.01 | 0.3 | *0.021* | *0.016* | *0.016* |
| Nickel (Ni) | mg/l | - | - | 1.2 | 0.953 | 0.793 |
| Zinc (Zn) | mg/l | 0.1 | - | *0.008* | *0.033* | *0.038* |
| Hexavalent chromium ($Cr^{6+}$ ) | mg/l | 0.05 | 0.0049 | *0.001* | *0.001* | *0.001* |
| Oil and grease (SOG) | mg/l | 2.5 | - | - | *6.65* | - |
| E.coli | CFU/100ml | 1000 | - | - | *18.21* | - |
| Total coliform | CFU/100ml | - | - | - | 52.67 | - |

### 7.4.2. Receiving environment

**K188** (Klipgatspruit, downstream of Mfidikoe village, upstream of Waterval TSF) was sampled in April, July and August 2019, recording neutral, non-saline and hard water quality based on the average data with low salts, nutrients and metals. Water quality is typical of stormwater run-off.

**K136** (Klipgatspruit downstream from the Entabeni Hostel) was recorded as dry throughout the annual period.

**K190** (Klipgatspruit downstream of Klipgat Dam) was sampled for most of the annum; samples were however taken from pooled-up water and not necessarily from the flowing Klipgatspruit. Average water quality can be described as neutral, extremely saline and very hard, resembling process water from Klipgat dam. Inorganic salt concentrations were high, with sporadic high nitrate concentrations. Trace metals were detected on some occasions at low concentrations.

Water quality from the upstream locality **K188** to the downstream locality **K190** revealed an overall deterioration in water quality as may be seen in the table below; this is due to the tailings storage facilities and Klipgat dam situated between these two monitoring sites.

**Table 28: Average Waterval TSF-East impacts on the Klipfonteinspruit**

| VARIABLE | UNIT | AAP Rustenburg - Surface water WUL | Locality | | CALCULATED CHANGE |
|---|---|---|---|---|---|
| | | | Upstream | Downstream | |
| | | | K188 | K190 | |
| pH @ 25°C | pH | 6.0/9.0 | 8.24 | 8.29 | 0.05 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 63.9 | 629 | 565 |
| Total dissolved solids (TDS) | mg/l | - | 371 | 4854 | 4483 |
| Total hardness | mg CaCO3/l | 50 | 201 | 2359 | 2158 |
| Total alkalinity | mg CaCO3/l | - | 218 | 269 | 51 |
| Chloride (Cl) | mg/l | - | 46.8 | 1334 | 1287 |
| Sulphate ($SO_4$) | mg/l | - | 35.8 | 1733 | 1697 |
| Fluoride (F) | mg/l | 0.75 | *0.181* | *0.146* | -0.035 |
| Nitrate ($NO_3$) as N | mg/l | - | 1.74 | 10 | 8.26 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 5.59 | 0.993 | -4.6 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | 1.16 | *0.023* | -1.14 |
| Calcium (Ca) | mg/l | - | 51.6 | 530 | 478 |
| Magnesium (Mg) | mg/l | - | 17.4 | 251 | 234 |
| Sodium (Na) | mg/l | - | 42.2 | 748 | 706 |
| Potassium (K) | mg/l | - | 11.8 | 20.2 | 8.4 |
| Aluminium (Al) | mg/l | 5 | 0.117 | *0.002* | -0.115 |
| Iron (Fe) | mg/l | 0.5 | *0.018* | *0.002* | -0.016 |
| Manganese (Mn) | mg/l | 0.18 | *0.006* | *0.201* | 0.195 |
| Chromium (Cr) | mg/l | - | *0.002* | *0.002* | 0 |
| Copper (Cu) | mg/l | 0.3 | 0.012 | *0.054* | 0.042 |
| Nickel (Ni) | mg/l | - | 0.027 | *0.087* | 0.06 |

**Table 29: Average WVE TSF receiving environment data table for the annual monitoring period**

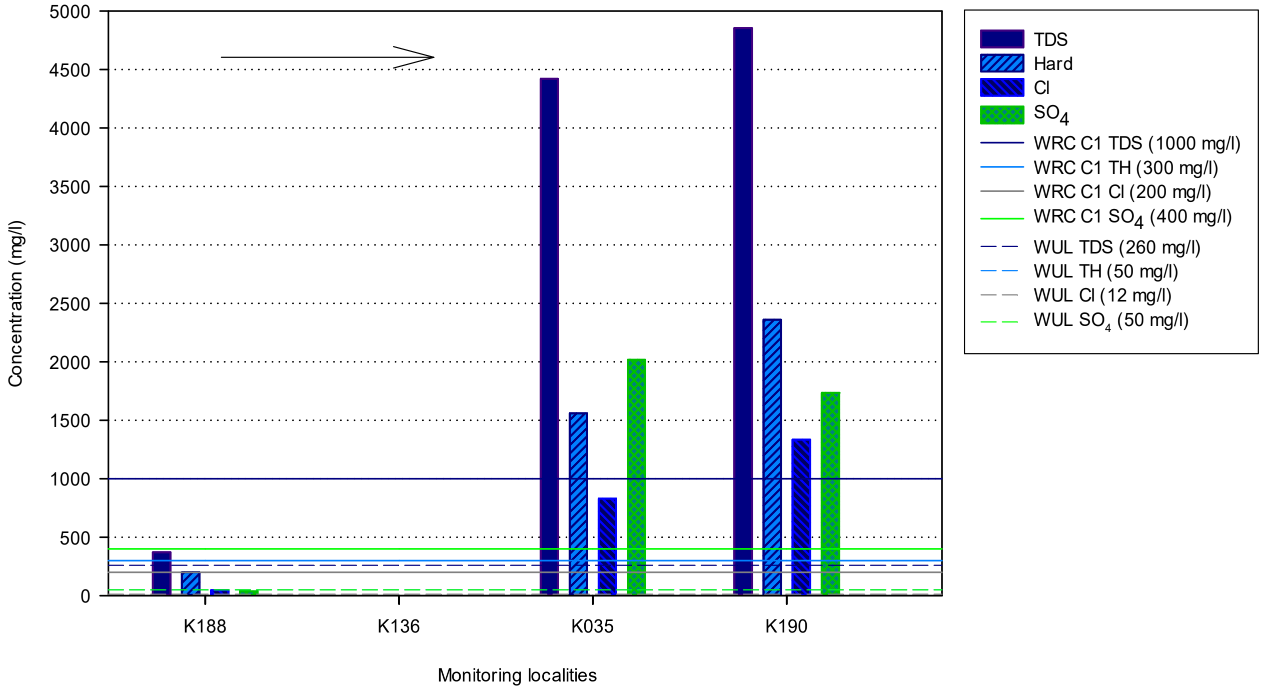
| AVERAGE DATA TABLE: | | | | | | |
|---|---|---|---|---|---|---|
| PROJECT NAME | | | | Anglo Rustenburg Surface water monitoring | | |
| ASSESSMENT SET 1 | | | | AAP Rustenburg - Surface water WUL | | |
| ASSESSMENT SET 2 | | | | SANS 241-1:2015 Drinking Water Standard (SABS, 2015) | | |
| | | | | Value exceeds the assessment set 1 | | |
| VARIABLE | UNITS | ASSESSMENT 1 | ASSESSMENT 2 | MONITORING LOCALITIES | | |
| | | | | K188 | K136 | K190 |
| pH @ 25°C | pH | 6.0/9.0 | 5.0/9.7 | 8.24 | - | 8.29 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 170 | 63.9 | - | 629 |
| Total dissolved solids (TDS) | mg/l | - | 1200 | 371 | - | 4854 |
| Total hardness | mg CaCO3/l | 50 | - | 201 | - | 2359 |
| Calcium (Ca) | mg/l | - | - | 51.6 | - | 530 |
| Magnesium (Mg) | mg/l | - | - | 17.4 | - | 251 |
| Sodium (Na) | mg/l | - | 200 | 42.2 | - | 748 |
| Potassium (K) | mg/l | - | - | 11.8 | - | 20.2 |
| Chloride (Cl) | mg/l | - | 300 | 46.8 | - | 1334 |
| Sulphate ($SO_4$) | mg/l | - | 500 | 35.8 | - | 1733 |
| Fluoride (F) | mg/l | 0.75 | 1.5 | *0.181* | - | *0.146* |
| Nitrate ($NO_3$) as N | mg/l | - | 11 | 1.74 | - | 10 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 1.5 | 5.59 | - | 0.993 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | - | 1.16 | - | *0.023* |
| Ortophosphate as $PO_4$ | mg/l | 0.234 | - | 3.56 | - | *0.069* |
| Aluminium (Al) | mg/l | 5 | 0.3 | 0.117 | - | *0.002* |
| Iron (Fe) | mg/l | 0.5 | 0.3 | *0.018* | - | *0.002* |
| Manganese (Mn) | mg/l | 0.18 | 0.1 | *0.006* | - | *0.201* |
| Chromium (Cr) | mg/l | - | 0.05 | *0.002* | - | *0.002* |
| Copper (Cu) | mg/l | 0.3 | 2 | 0.012 | - | *0.054* |
| Nickel (Ni) | mg/l | - | 0.07 | 0.027 | - | *0.087* |
| Dissolved oxygen (DO) | mg/l | 7.0/8.0 | - | 2.53 | - | 4.2 |
| Lead (Pb) | mg/l | - | 0.01 | *0.002* | - | *0.003* |
| Zinc (Zn) | mg/l | - | 5 | *0.008* | - | *0.125* |
| Boron (B) | mg/l | - | 2.4 | 0.026 | - | 0.672 |
| Phenol | mg/l | - | 0.01 | *0.007* | - | *0.006* |
| Hexavalent chromium ($Cr^{6+}$ ) | mg/l | 0.0049 | - | *0.001* | - | *0.001* |
| Arsenic (As) | mg/l | - | 0.01 | *0.003* | - | *0.003* |
| Cadmium (Cd) | mg/l | - | 0.003 | *0.001* | - | *0.001* |
| Mercury (Hg) | mg/l | - | 0.006 | *0.002* | - | *0.002* |
| Selenium (Se) | mg/l | - | 0.04 | *0.001* | - | *0.001* |

# 8. RECEIVING ENVIRONMENT SUMMARY

## 8.1. Klipgatspruit

A schematic diagram showing selected sampling localities and relevant Rustenburg Process Division facilities relative to the Klipgatspruit is shown in Figure 21. The direction of flow of the Klipgatspruit towards the Hex river is also show. Please note that the diagram is not to scale and all other non-Rustenburg Process Division contributors are not indicated in the diagram.

Upstream from the Waterval tailings storage facilities, the Klipgatspruit water quality is seen to be fairly un-impacted; samples were also indicative of stormwater run-off. Downstream from the Waterval tailings storage facilities (including the Klipgat dam) water quality is seen to change significantly. As may be seen from Figure 20 water quality from Klipgat dam is the main contributor to the noted change. During high-flow events water flowing in the Klipgatspruit will eventually end up in the Hex River. Although no overflow was recorded at the Klipgat dam, it is evident that some seepage occurs, either from Klipgat dam or the tailings storage facility.



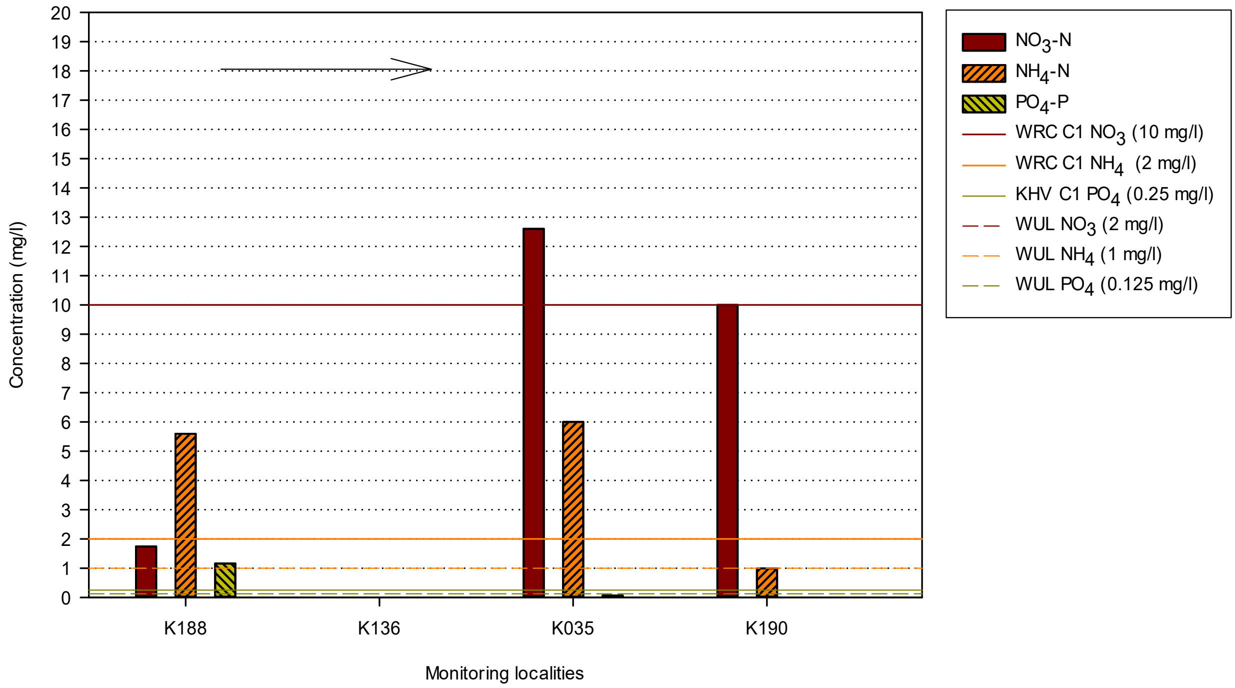




**Figure 20: Average data for in-stream localities in the Klipgatspruit for the annual period September 2018 to August 2019**

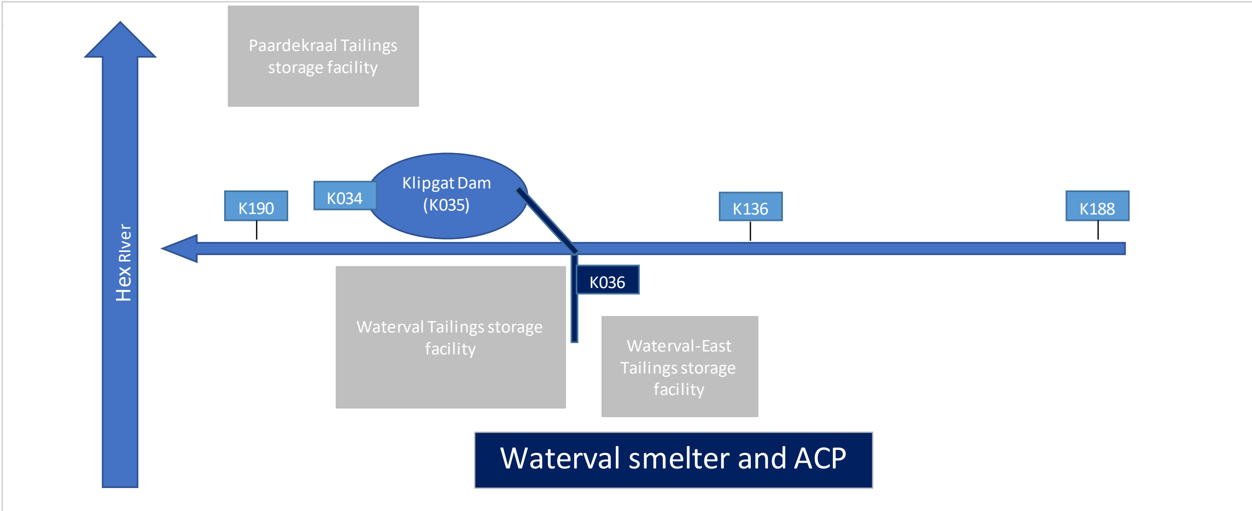



**Figure 21: Schematic diagram of the Klipgatspruit relative to Rustenburg Process Division localities**

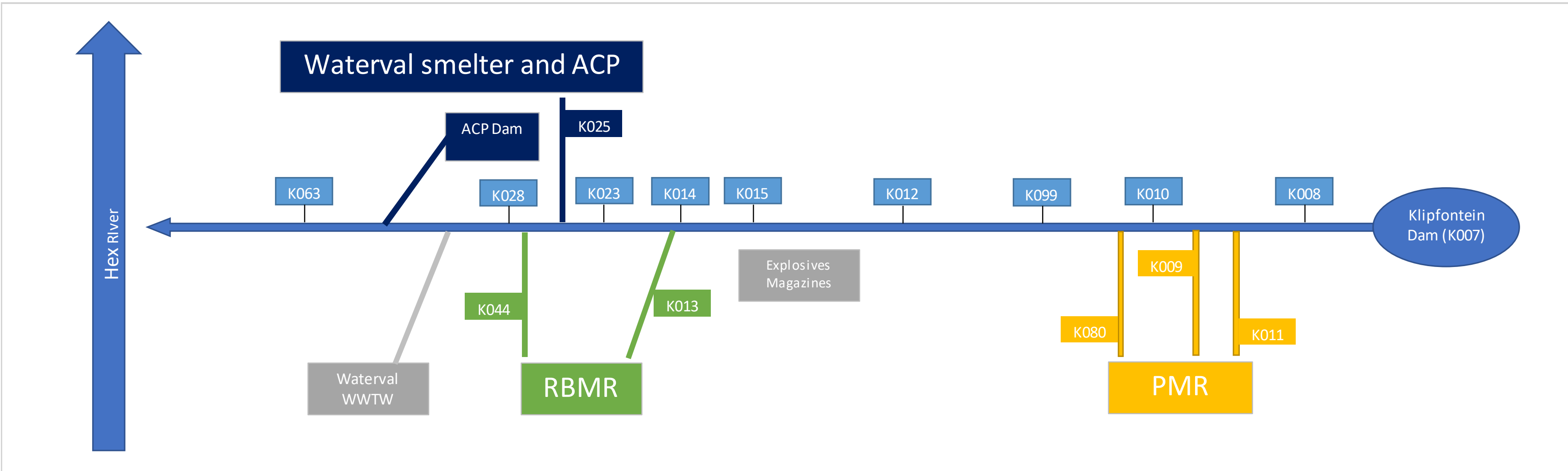



**Figure 22: Schematic diagram of the Klipfonteinspruit relative to Rustenburg Process Division localities**

## 8.2. Klipfonteinspruit

Various mining shafts, concentrators, smelters and waste rock dumps are situated within the Klipfontein catchment and have been identified as possible stressors on the Klipfonteinspruit. These include various Anglo process plants as well as other mining shafts and facilities (selected contributors are shown in Figure 22).

The Klipfontein dam (**K007**) was added to the monitoring programme to be used as an additional upstream locality at PMR, and therefore the whole Rustenburg Process Division. Three samples were collected between April and August 2019; average water quality being neutral, very saline and very hard. Very high concentrations of nitrates were also detected.

Locality **K008** (Klipfonteinspruit at PMR bridge) is an upstream locality in the Klipfonteinspruit for monitoring at PMR and was recorded as dry for most of the year. One sample was taken in January 2019 where physical water quality was neutral, saline and very hard with low nutrients and trace amounts of nickel detected.

**K010** (downstream from K008 and K009) was sampled during most of the annual period. It must be noted however that this locality is thought to represent stagnant water as the upstream K008 was recorded as dry. This locality is seen to have fluctuating water qualities; a significant increase in salinity concentrations was seen from June 2019 where nutrient and metal concentrations also increased. On average sodium and chloride concentrations dominate this locality; water quality profiles resemble that of the PMR PCDs.

Further downstream at **K099** samples were taken a few times during the annual period; annual average water quality was recorded as extremely saline and very hard. Sporadic high concentrations of fluoride, nitrate and metals were detected.

Locality **K012** (downstream from PMR and upstream from RBMR) was sampled on three occasions and was recorded as dry during the remainder of the annual period. Moderate fluctuating salinity was noted at this locality.

**K015** was sampled between January 2019 and July 2019, with the exception of March 2019. Water quality was alkaline, extremely saline and hard, dominated by sodium and sulphate concentrations. Very high concentrations of fluoride, phosphate and various metals were also detected. Water quality of this nature is indicative of process water seen at RBMR.

**K014** was sampled on various occasions during the annual period. Water quality was similar to K015 and representative of RBMR process water.

Locality **K023** (upstream of the Waterval complex) was sampled between January 2019 and August 2019. Water quality was alkaline, extremely saline and hard, dominated by sodium and sulphate concentrations. Again, very high concentrations of fluoride, phosphate and various metals were detected, indicating seepage or discharge from RBMR process water.

Locality **K028** (mid-Waterval complex and downstream of RBMR) was sampled throughout the annum with water quality fluctuating constantly; this may be caused by several discharges entering the Klipfonteinspruit before K028. High concentrations of sulphate, fluoride and nickel reveal the impact of the RBMR dams (either by discharge or seepage) on the

Klipfonteinspruit. Long term data is presented in Figure 23. Water quality profiles (STIFF diagrams, Vol. II site reports) show that water quality remained relatively constant, a significant increase in salinity was however noted in May 2019.

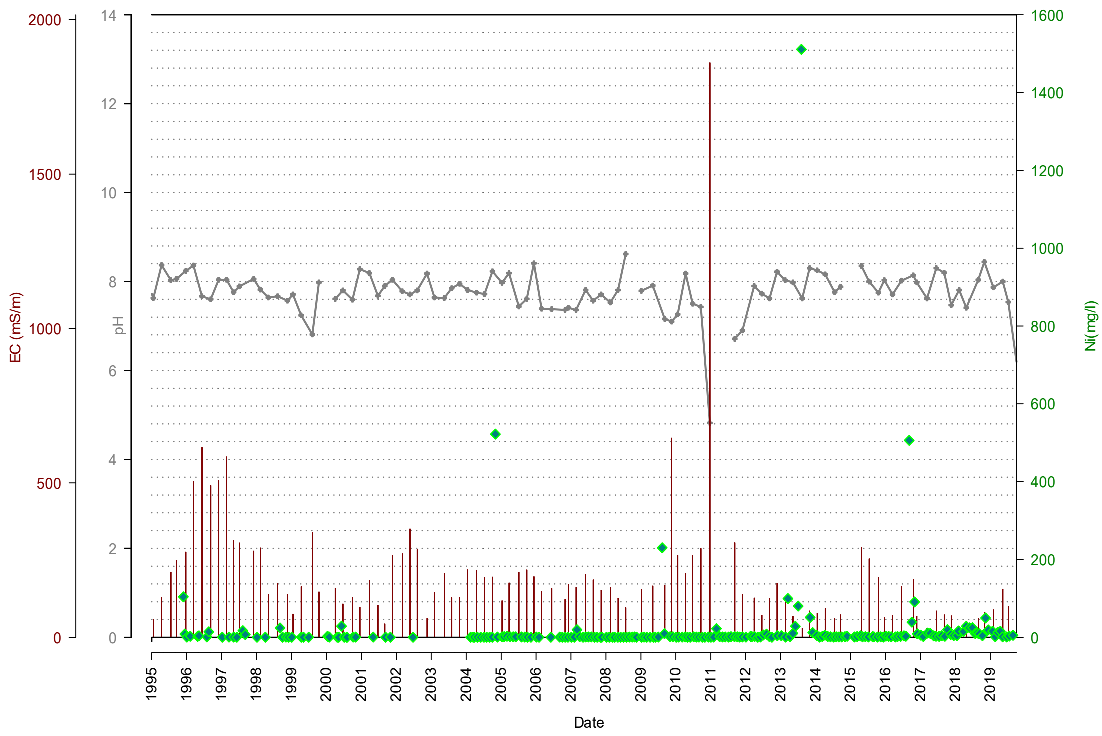



**Figure 23: Time series data for pH, EC and Ni concentrations at K028 from 1995 to August 2019**

**K063** was sampled throughout the annual period and recorded an average water quality that could be described as neutral, saline and hard with moderate inorganic salt concentrations and high nutrients (nitrates and phosphates). Nickel concentrations remained high due to discharges or seepages from RBMR dams. Effluent from Waterval Sewage entering the Klipfonteinspruit between localities K028 and K063 explains the sudden increase in nitrate concentrations, as seen in Figure 24. High phosphate was already present upstream.

Water quality of the Klipfonteinspruit, relevant to the Rustenburg Process Division, is shown in Figure 24. The in-stream Klipfontein Dam is situated upstream from the Rustenburg Process Division and receives impacts from multiple sources (mining and settlements) before it reaches Anglo Platinum facilities. An increase in TDS and hardness concentrations was noted at K010, where after the concentration decreased in a downstream direction toward K012 and downstream from PMR. From K015 (after impacts from RBMR) TDS and sulphates increase significantly towards K028. Decreased salinity concentrations are seen at K063.

Nutrients fluctuated in the Klipfonteinspruit with a significant increase in nitrate concentration noted at K099. Nitrate decreased at K015 where phosphate concentrations increased significantly; this nitrate-phosphate ratio remains stable towards K063 where nitrate is increases and phosphate decreased. This nitrate increase is caused by the inflow of sewage-effluent from the nearby Waterval water treatment works flowing directly into the Klipfonteinspruit.

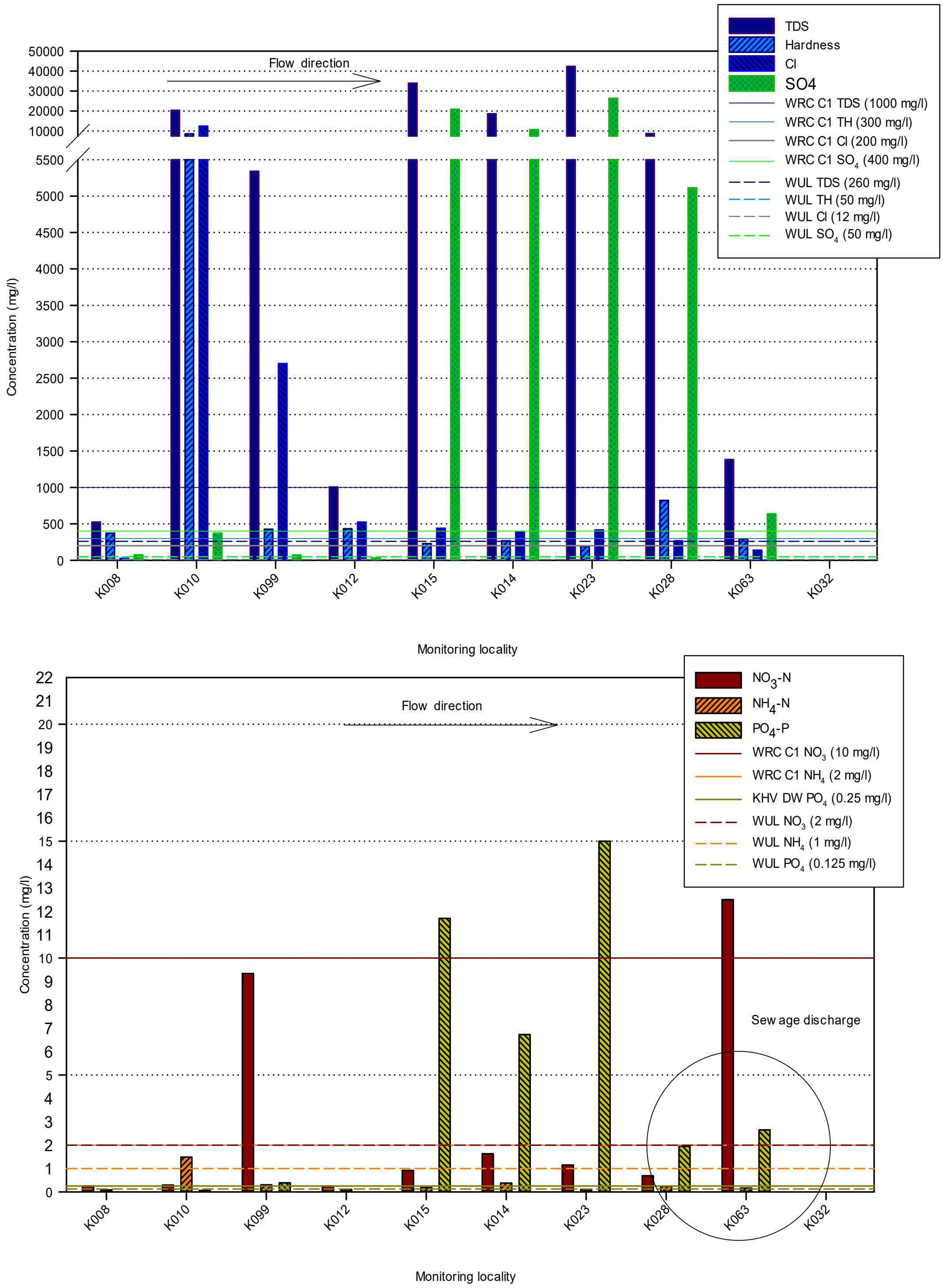



**Figure 24: Average data for in-stream localities in the Klipfonteinspruit for the annual period September 2018 to August 2019**

Nickel concentrations reached a maximum at locality K028 (11.4 mg/l annual average concentration) and remained in the Klipfonteinspruit further downstream (Figure 25). Various pollution control dams at PMR, RBMR and the Waterval complex contribute to the high nickel concentration.

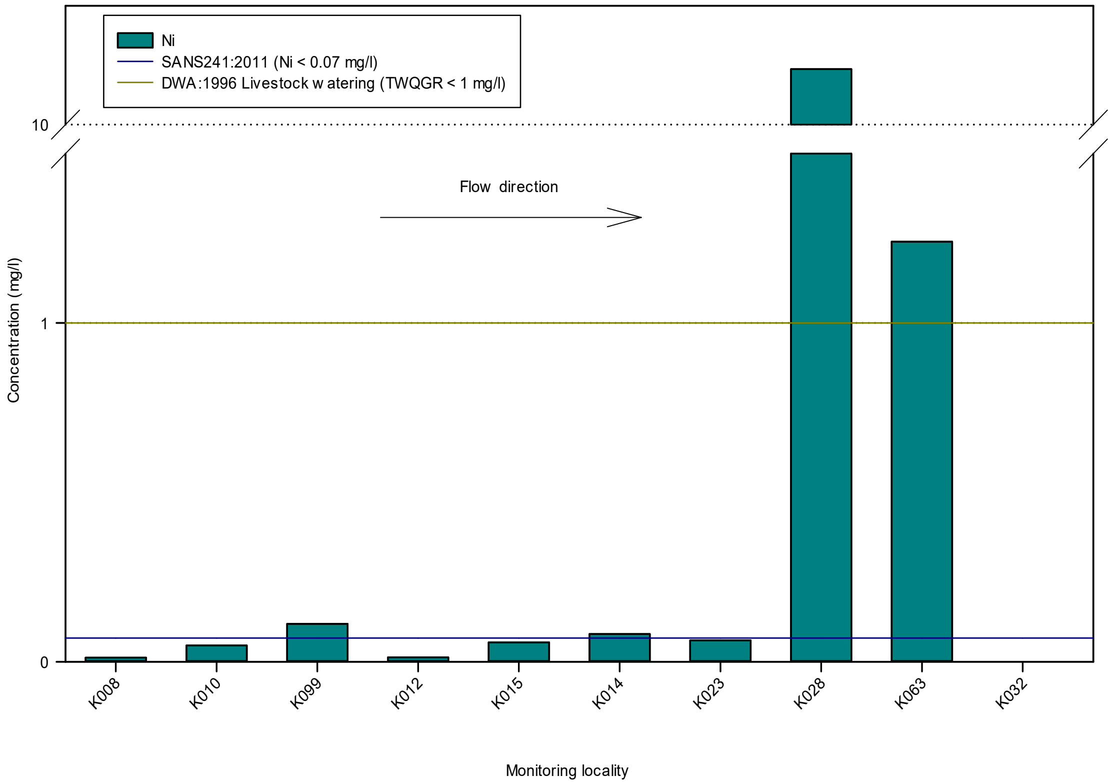



**Figure 25: Annual average Nickel concentrations in the Klipfonteinspruit**

Figure 25 indicates that nickel concentrations detected at most Klipfonteinspruit localities remained relatively stable throughout the monitoring period. Only locality K028 revealed a significant variating concentration of nickel (Figure 26). Nickel concentrations at K028 are seen to be strongly influenced by the nickel concentrations of the ACP dam (K098). The nickel content in the ACP dam is further seen to be a function of its pH value (also see Figure 17). Nickel concentrations further downstream at K063 follows the same trend as at K028, albeit at a much lower concentration, due to the absorption action of the natural reeds as well as possible oxidation and settling out.

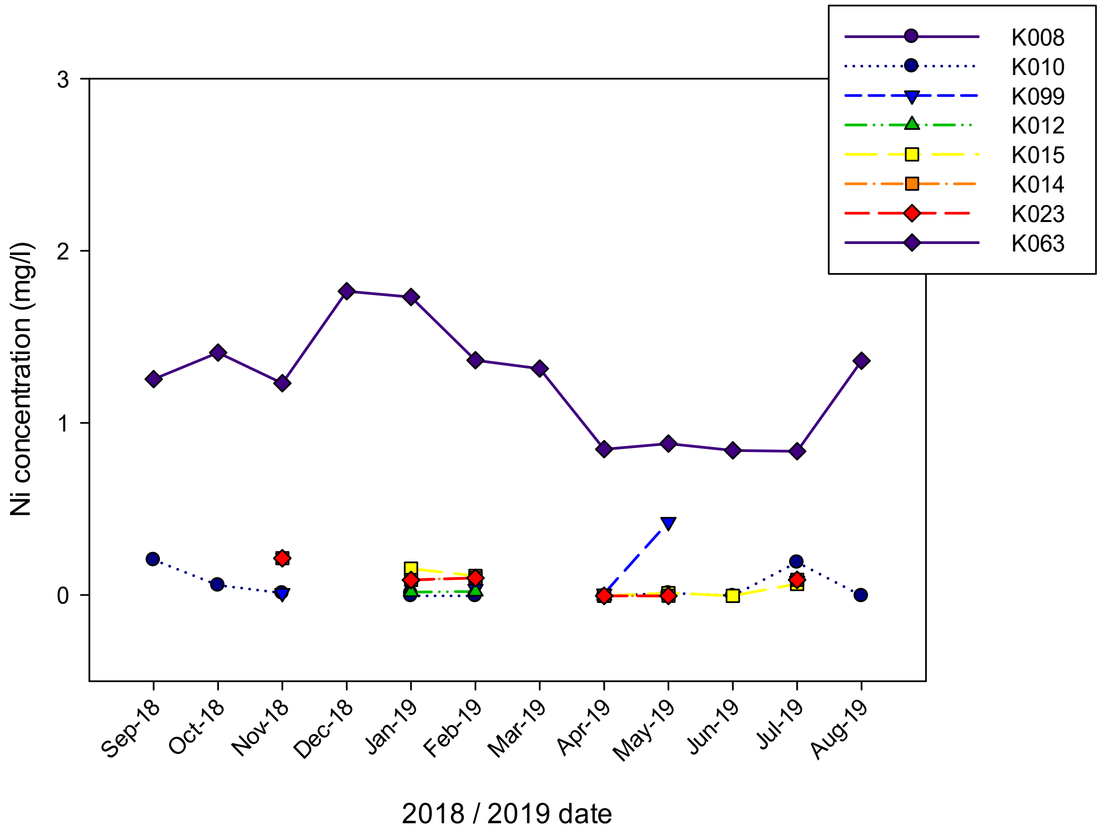



**Figure 26: Nickel concentrations per selected localities over the monitoring period**

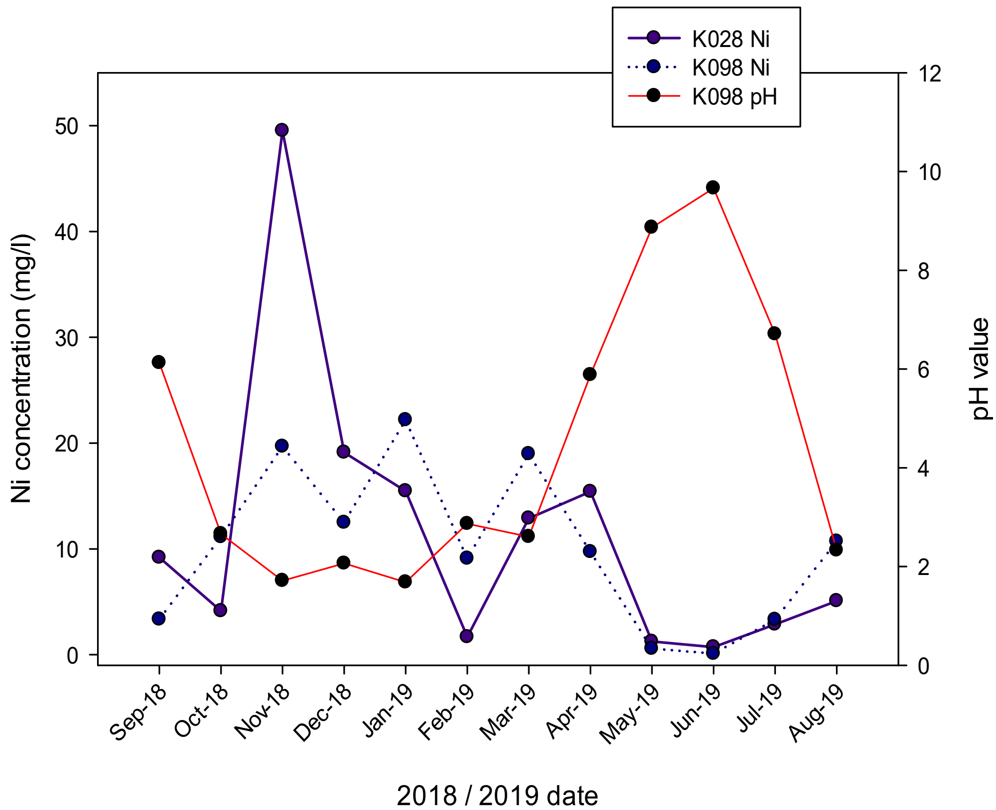
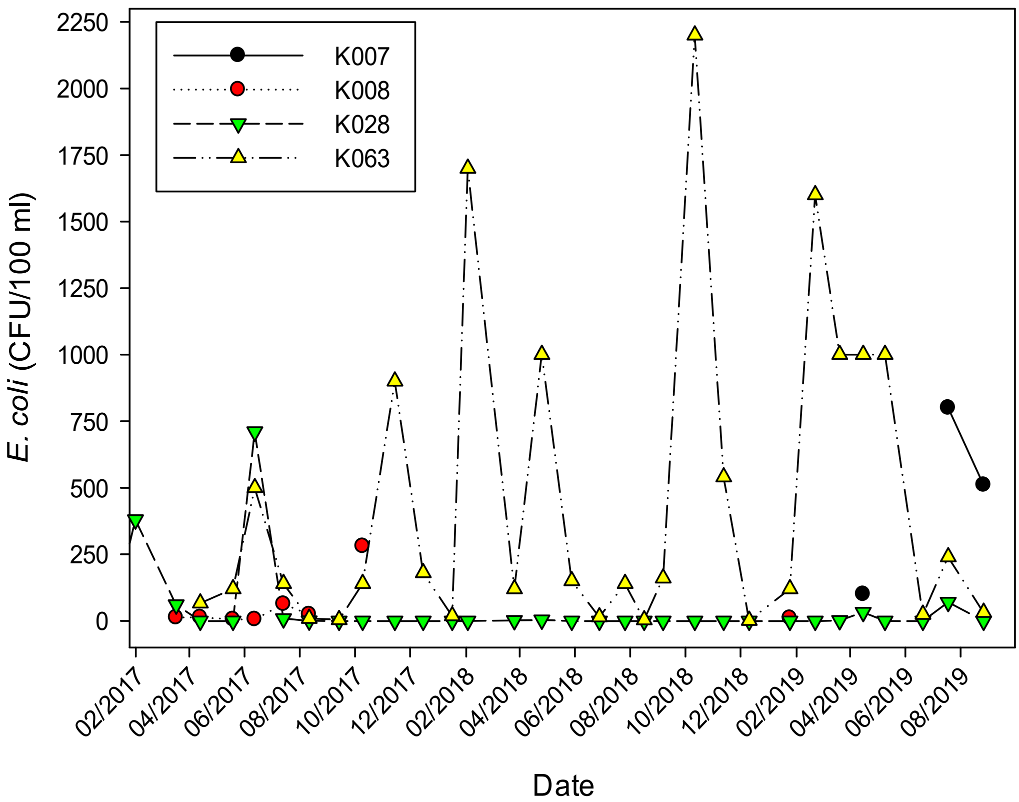



**Figure 27: Nickel concentrations over time at localities K028 and K098**

*E. coli* counts in the Klipfonteinspruit (relevant to the Anglo process division) are seen to vary over the time-frame and indicate an increasing trend (Figure 28). A spatial increase in counts is also noted at K063 in accordance with the nutrient load seen in Figure 24. This increase in bacterial count is due to the sewage effluent from the nearby Waterval sewage works




K007: Klipfontein dam
K008: Klipfonteinspruit at PMR Bridge
K028: Klipfonteinspruit d/s Waterval sewage & RBMR at bridge
K063: Klipfonteinspruit at stormwater discharge from Waterval smelter

**Figure 28: *E.coli* counts detected in the Klipfonteinspruit catchment for the annual period**

The exceedance graphs below indicate the number of times the Klipfonteinspruit localities (average data) exceeded the Anglo surface water WUL limits and SANS 241-1:2015 drinking water standards respectively. The most prominent variables to exceed the Anglo surface water WUL limits were EC and hardness. Other variable that regularly exceeded were pH, fluoride, phosphate, manganese and copper concentrations.

The SANS 241-1:2015 drinking water standards were exceeded by variables including EC, sodium, chloride and nickel. The SANS241-1 :2015 standard is only for comparative purposes and should not be interpreted for compliance.

**Table 30: Exceedance table for the Klipfonteinspruit measuring percentage non-compliance to the Anglo surface water WUL conditions**

| EXCEEDANCE TABLE: | | | |
|---|---|---|---|
| PROJECT NAME | Anglo Rustenburg Surface w ater monitoring | DATE COMPILED | 17 September 2019 |
| LOCALITY GROUP | Monitoring Localities | COMPILED BY | Werner Rossouw |
| DATE RANGE | September 2018 to August 2019 | | |
| ASSESSMENT SET | AAP Rustenburg - Surface w ater WUL | Non-compliance | 0% - 25% / 25% - 75% / 75% - 100% |

| VARIABLE | UNIT | ASSESMENT VALUE | MONITORING LOCALITIES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | K008 | K010 | K099 | K012 | K015 | K014 | K023 | K028 | K063 | K188 | K190 |
| NUMBER OF RECORDS | | | 1 | 10 | 5 | 3 | 6 | 6 | 8 | 12 | 12 | 3 | 11 |
| pH @ 25°C | pH | 6.0/9.0 | 0 | 0 | 40 | 0 | 100 | 83 | 100 | 33 | 0 | 0 | 0 |
| Electrical conductivity (EC) @ 25°C | mS/m | 85 | 0 | 90 | 100 | 100 | 100 | 100 | 100 | 100 | 75 | 0 | 100 |
| Total dissolved solids (TDS) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total hardness | mg CaCO3/l | 50 | 100 | 100 | 80 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Calcium (Ca) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Magnesium (Mg) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sodium (Na) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potassium (K) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total alkalinity | mg CaCO3/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chloride (Cl) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sulphate ($SO_4$) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fluoride (F) | mg/l | 0.75 | 0 | 0 | 60 | 0 | 100 | 83 | 100 | 100 | 25 | 0 | 0 |
| Nitrate ($NO_3$) as N | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitrite ($NO_2$) as N | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium ($NH_4$) as N | mg/l | 1 | 0 | 30 | 0 | 0 | 0 | 17 | 0 | 8 | 0 | 33 | 18 |
| Orthophosphate ($PO_4$) as P | mg/l | 0.125 | 0 | 10 | 40 | 0 | 100 | 83 | 100 | 58 | 100 | 100 | 9 |
| Aluminium (Al) | mg/l | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Iron (Fe) | mg/l | 0.5 | 0 | 30 | 0 | 0 | 17 | 0 | 12 | 8 | 0 | 0 | 0 |
| Manganese (Mn) | mg/l | 0.18 | 0 | 60 | 0 | 0 | 17 | 17 | 12 | 58 | 8 | 0 | 18 |
| Chromium (Cr) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper (Cu) | mg/l | 0.3 | 0 | 0 | 20 | 0 | 17 | 33 | 38 | 50 | 0 | 0 | 0 |
| Nickel (Ni) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 31: Exceedance table for the Klipfonteinspruit measuring percentage non-compliance to the SANS 241-1:2015 Drinking Water Standard**

| EXCEEDANCE TABLE: | | | |
|---|---|---|---|
| PROJECT NAME | Anglo Rustenburg Surface w ater monitoring | DATE COMPILED | 17 September 2019 |
| LOCALITY GROUP | Monitoring Localities | COMPILED BY | Werner Rossouw |
| DATE RANGE | September 2018 to August 2019 | | |
| ASSESSMENT SET | SANS 241-1:2015 Drinking Water Standard (SABS, 2015) | **Non-compliance** | 0% - 25% / 25% - 75% / 75% - 100% |

| VARIABLE | UNIT | ASSESMENT VALUE | MONITORING LOCALITIES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | K008 | K010 | K099 | K012 | K015 | K014 | K023 | K028 | K063 | K188 | K190 |
| NUMBER OF RECORDS | | | 1 | 10 | 5 | 3 | 6 | 6 | 8 | 12 | 12 | 3 | 11 |
| pH @ 25°C | pH | 5.0/9.7 | 0 | 0 | 20 | 0 | 67 | 50 | 62 | 25 | 0 | 0 | 0 |
| Electrical conductivity (EC) @ 25°C | mS/m | 170 | 0 | 70 | 100 | 67 | 100 | 100 | 100 | 100 | 17 | 0 | 100 |
| Total dissolved solids (TDS) | mg/l | 1200 | 0 | 60 | 100 | 33 | 100 | 100 | 100 | 100 | 17 | 0 | 91 |
| Total hardness | mg CaCO3/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium (Ca) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Magnesium (Mg) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sodium (Na) | mg/l | 200 | 0 | 60 | 100 | 67 | 100 | 100 | 100 | 100 | 25 | 0 | 91 |
| Potassium (K) | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total alkalinity | mg CaCO3/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chloride (Cl) | mg/l | 300 | 0 | 70 | 100 | 100 | 67 | 33 | 75 | 42 | 0 | 0 | 100 |
| Sulphate ($SO_4$) | mg/l | 500 | 0 | 30 | 0 | 0 | 100 | 100 | 100 | 100 | 17 | 0 | 91 |
| Fluoride (F) | mg/l | 1.5 | 0 | 0 | 20 | 0 | 100 | 83 | 100 | 100 | 17 | 0 | 0 |
| Nitrate ($NO_3$) as N | mg/l | 11 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 67 | 0 | 27 |
| Nitrite ($NO_2$) as N | mg/l | 0.9 | 0 | 0 | 40 | 0 | 17 | 33 | 25 | 0 | 0 | 0 | 9 |
| Ammonium ($NH_4$) as N | mg/l | 1.5 | 0 | 10 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 33 | 18 |
| Orthophosphate ($PO_4$) as P | mg/l | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aluminium (Al) | mg/l | 0.3 | 0 | 30 | 40 | 0 | 17 | 50 | 25 | 0 | 0 | 0 | 0 |
| Iron (Fe) | mg/l | 0.3 | 0 | 40 | 0 | 0 | 17 | 17 | 25 | 8 | 0 | 0 | 0 |
| Manganese (Mn) | mg/l | 0.1 | 0 | 60 | 0 | 0 | 17 | 17 | 25 | 67 | 17 | 0 | 27 |
| Chromium (Cr) | mg/l | 0.05 | 0 | 10 | 20 | 0 | 17 | 50 | 50 | 8 | 0 | 0 | 0 |
| Copper (Cu) | mg/l | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nickel (Ni) | mg/l | 0.07 | 0 | 20 | 40 | 0 | 33 | 67 | 62 | 100 | 100 | 0 | 45 |

## 9. STANDARD ANGLO RISK RATING

Remediation is necessary where risks exist towards human health or health to the environment. These risks are assessed with relation to the current or intended use of the land and the wider environmental setting and the risk of contaminant spreading. Risk is commonly defined as the probability that a substance will produce harm (for example adverse health effects) under specified conditions. When dealing with contaminated land management, risks occur when the following three components are present: i) source, ii) receptor, and iii) pathway. Generally, remediation is carried out due to the following reasons:

- To protect human health or the environment;
- To enable redevelopment;
- To limit potential liabilities; and
- To repair or enhance previous remediation efforts.

Table 32 below tabulates the potential risks and quantified risks on the surface water regime resulting from Anglo Platinum process activities. The risks given are based on the ANGLO AMERICAN 5×5 RISK RATING MATRIX and the probability of the unwanted event occurring as shown on the next page.

**Table 32: Anglo American Risk Matrix**

| ANGLO AMERICAN Plc RISK MATRIX | | **Hazard Effect/Consequence** (Where an event has more than one Loss Type , choose the Consequence with the highest rating) | | | | |
|---|---|---|---|---|---|---|
| **Loss Type** (Additional 'Loss Types' may exist for an event: identify and rate accordingly) | | 1. INSIGNIFICANT | 2. MINOR | 3. MODERATE | 4. MAJOR | 5. CATASTROPHIC |
| **(EI) Environmental Impact** | | Minimal environmental harm L1 incident | Material environmental harm L2 incident remediable short term | Serious environmental harm L2 incident remediable within LOM | Major environmental harm L2 incident remediable with post LOM | Extreme environmental harm L3 incident irreversible |
| **Likelihood** | Examples (Consider near hits as well as actual events) | RISK RATING | | | | |
| **5 (Almost Certain)** | The unwanted event has occurred frequently; occurs in order of one or more times per year and is likely to reoccur within 1 year | 11 (M) | 16 (H) | 20 (H) | 23 (EX) | 25 (EX) |
| **4 (Likely)** | The unwanted event has occurred infrequently; occurs in order of less than once per year and is likely to reoccur within 5 years. | 7 (M) | 12 (M) | 17 (H) | 21 (EX) | 24 (EX) |
| **3 (Possible)** | The unwanted event has happened in the business at some time; or could happen within 10 years | 4 (L) | 8 (M) | 13(H) | 18 (H) | 22 (EX) |
| **2 (Unlikely)** | The unwanted event has happened in the business at some time; or could happen within 20 years | 2 (L) | 5 (L) | 9 (M) | 14 (H) | 19 (H) |
| **1 (Rare)** | The unwanted event has never been known to occur in the business; or it is highly unlikely it will occur within 20 years | 1 (L) | 3 (L) | 6 (M) | 10 (M) | 15 (H) |

| RISK RATING | RISK LEVEL | GUIDELINES FOR RISK MATRIX | PRIORITY |
|---|---|---|---|
| 21 to 25 | (Ex) Extreme | Eliminate, avoid, implement specific actions plans/procedures to manage and monitor | 1 |
| 13 to 20 | (H) High | Proactively manage | 2 |
| 6 to 12 | (M) Medium | Actively manage | 3 |
| 1 to 5 | (L) Low | Monitor and manage as appropriate | 4 |

**Table 33: Environmental risk table for surface water regime at Anglo Platinum Process Division**

| Name of Facility | Potential Impact (pre-control) | | | | |
|---|---|---|---|---|---|
| | Nature of Environmental Impact/Risk | Point sources of pollution | Distance from community | Potential Impact Ranking | Management plan |
| **Tailings facilities** | | | | | |
| Waterval Tailings | Waterval Tailings solution trench (K107N) and water from Waterval Tailings K036 discharges into Klipgat Dam which regularly overflows. Quality of these localities is of poor quality with high salinity, nitrate and nickel. | K034 (Klipgat Dam overflow) records irregular overflow | 1000 m | High | Remediate TSF seepage. Prevent RWD discharge – closed circuit management. |
| **Processing Units** | | | | | |
| Waterval Smelter + Acid Plant | Klipfonteinspruit downstream from Waterval Complex is of Marginal to Poor quality with TDS, Ni, $NO_3$ and *E.coli* exceeding acceptable domestic use guidelines. | K025 (ACP), K167 (Conc.), K168 (Conc.), K169 (PF Lab) & Waterval WWTW | 2200 m | High | Closed circuit management, effective separation of clean and dirty water, prevent discharge of substandard water |
| RBMR | Impact in terms of salinity, nickel and nitrate on Klipfonteinspruit downstream from RBMR. Significant increases in Ni concentration in Klipfonteinspruit exceeding acceptable domestic standards | K015, K024, K044, K062 | 2000 m | High | Contain in dirty water circuit, prevention of discharge or dam overflows of substandard quality. Delineate groundwater pollution plume |
| PMR | Effluent and stormwater discharge E of PMR K080 is of Poor quality with elevated TDS, inorganic nitrogen, Ni and Cu. TDS and $NO_3$ impacts on already impacted Klipfonteinspruit. | K010, K080 | 1000 m | High | Prevention of discharge, separate clean and dirty water, prevention of dam overflows |

## 10. SURFACE WATER CONCLUSION

- Raised salinity (TDS and EC), total hardness, inorganic salts and heavy metals are indicative of the water type associated with the refining processes at the Rustenburg Process Division.

- The pollution control dams at PMR had (on average) significant concentrations of calcium, chloride and sodium while the dams at RBMR had significant concentrations of sodium and sulphate. PCD localities sampled at PMR, RBMR and the Waterval complex recorded very high concentrations of metals, these included iron, cobalt, copper, manganese and nickel. Spills at the dams should be prevented and precautions must be taken in times of heavy rains.

- Impact in the Klipfonteinspruit was seen from discharge or spillage from RBMR. The exact point source or sources should be established to prevent such occurrences.

- It is of utmost importance that impacted water and seepages at the Anglo process division's business units be contained within the mine's dirty water circuit to minimize the pollution potential towards the different streams and therefore ultimately to the Hex River.

- Discharge localities that may introduce process water to receiving environments (K044, K168, K169, etc.) recorded water qualities with high salinity and metals that may prove to be detrimental to the environment.

- Organic pollution probably deriving from sewage (introducing harmful bacteria, oils and greases and $NH_4$ and $PO_4$) is also a hazard, and enters the Klipfonteinspruit from the Waterval WWTW.

- Process and refinery complexes remain a high risk to the environment especially in terms of salt load, nutrient load and metals to the surrounding receiving environment, including the groundwater resources.

- Most localities had variables that exceeded the WUL conditions for surface water localities. These WUL conditions are however very stringent for the typical expected water qualities.

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# Anglo American Platinum
# Rustenburg Process Division

## Annual Integrated Surface and Groundwater Quality, Biomonitoring and Toxicity Testing Assessment Report, Vol I (Continued)

**September 2018 to August 2019**

# Appendix A

*Annual report on groundwater monitoring*

Anglo American Platinum – Rustenburg Operations

Annual integrated water monitoring report

Volume I