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CHIEF DIRECTORATE WATER ECOSYSTEMS

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**APPLY RELEVANT METHODS FOR
GROUNDWATER AND SURFACE
WATER INTERACTION FOR
PROTECTION OF THE WATER
RESOURCES IN THE UPPER VAAL**

HYDROCENSUS REPORT

April 2016

Final



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Directorate: Reserve Determination

**APPLY RELEVANT METHODS FOR GROUNDWATER AND
SURFACE WATER INTERACTION FOR PROTECTION OF THE
WATER RESOURCES IN THE UPPER VAAL**

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LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
CD: WE	Chief Directorate: Water Ecosystems
DWS	Department of Water and Sanitation
DWA	Department of Water Affairs (former DWS)
DWAF	Department of Water Affairs and Forestry (former DWS)
EC	Electrical Conductivity
IUA	Integrated Unit of analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
MC	Management Class
NFEPA	National Freshwater Ecosystem priority areas
NWA	National Water Act
RDM	Resource Directed Measures
RHP	River Health Programme
RQOs	Resource Quality Objectives
RQS	Resource Quality Services
Swater	Surface Water
Gwater	Groundwater
ST-CB	Skills Transfer & Capacity Building
LoP	Life of Project
LHTS	Lesotho Highlands Transfer Scheme.

EXECUTIVE SUMMARY

Project WP10491 deals with the application of relevant methods for assessing groundwater and surface water interaction for protection of water resources in the Ash and Liebenbergsvlei Rivers and major tributaries in nine (9) of the C83 quaternary catchments in the Upper Vaal Water Management Area.

Originally the Ash and Liebenbergsvlei Rivers were natural, low flowing drainage systems draining a portion of the Eastern Free States Highlands in the Clarens-Bethlehem area (~2200 mamsl). Three small dams were built to capture a portion of the natural floods that occurs during the wet season, viz. October to March. The Liebenbergsvlei and Ash Rivers joins at Bethlehem (at the Sol Plaatje Dam) and the main stem (viz. the Liebenbergsvlei River) flows virtually north for ~220 km's and join the Wilge River at Frankfort (~1500 mamsl).

The main tributary in the C83 Catchment is the Tierkloof River, draining the eastern quaternary catchments (C83D and -E) joining the Liebenbergsvlei River in the centre plains area (~1600 mamsl). The Langspruit drains the central eastern C83G quaternary catchment and joins the Liebenbergsvlei River further downstream (~1550 mamsl) in the low land area. On the western side of the C83 catchment, drainages such as the Rietpanspruit, Klipspruit and Kaloemspruit (all draining the C83F quaternary catchment) represents the major tributaries.

The Ash and Liebenbergsvlei River's drainage channels are used since 1996 as the main water conduct from the Lesotho Highlands Transfer Scheme between the Katse Dam in Lesotho and the Upper Vaal River (Vaal Dam). The volume of water in these river channels has increased significantly and flows between 17 and 34 m³/s.

The climate is typically of the Eastern Free State region, wet summers and dry winters with the possibility of heavy snowfalls in the winter period which will generate important snowmelt – especially in the upper headwater areas of the C83 catchment, i.e. the Jordaan River (C83B-western highlands area south-west of Bethlehem), Ash River (C83A-central highlands area north of Clarens) and the Liebenbergsvlei River (C83A-eastern highlands area).

The main towns in the area are Bethlehem in the south (C83C at ~1700 mamsl) and Frankfort in the north (~1500 mamsl) – ~7km downstream from the Liebenbergsvlei-Wilge Rivers confluence. Other smaller towns in the area between Bethlehem and Frankfort are: Reitz and Tweeling and a few smaller settlements such as Daniëlsrus – all servicing the local agricultural activities in the area.

Agricultural activities are confined to dryland cash crops (maize and wheat) and stock farming. Although the water from the Lesotho Highlands Transfer Scheme is to augment the water supplies in the Gauteng Region, some allocations have been allowed for agricultural use; thus several centre pivot irrigation systems occur. The use of groundwater resources for bulk water supplies to irrigation systems in the study is likely very low due to the nature of the local aquifer systems.

The Ash and Liebenbergsvlei Rivers represent the main stem of the surface flow system in the study area; although the water quality status and flow dynamics off the major tributaries such as the Langspruit, Tierkloof River and western C83F quaternary catchment are regarded as important as well.

Phase II of the study continued with a thorough search for hydrological data/information covering surface water flow and hydrochemistry data – given the fact that there are SEVEN DWS gauging stations on the main stem, surface water hydrochemistry and flow dynamic data are available.

Groundwater data collated from the Dept. Water and Sanitation's National Groundwater Archive comprises of basic borehole information, but a lack of “modern” time series hydrochemistry and water level data, i.e. post 1996 data when the Lesotho Highlands Transfer Scheme became operational.

A water resources data gap analyses was conducted during the Phase I (viz. Inception Report) and groundwater quality and water levels in a zone ~1 km from the main stem and major tributaries were identified as a gap in the groundwater dataset. In Phase II (Hydrocensus Survey), this gap has been addressed. In addition, surface water flow measurements in the upper reaches of the main stem were also identified as an information gap due to fact that flow measurements were not available for the Jordaan River (C83B at Bethlehem) and at the confluence of the Ash and Liebenbergsvlei Rivers at the Sol Plaatje Dam (C83A at Bethlehem).

Using the “best practise” methodology in this study required a search for what methodologies have been applied and developed in South Africa. The difference in this study's case is that the main stem of the system is in a permanent “flood condition” due to the high flows induced by the Lesotho Highlands Transfer Scheme.

Several methodologies have been developed internationally and nationally to study surface water – groundwater interactions, however, the study areas cover only a few km². Due to the spatial coverage of study area (5052 km²) and the dimension of the main stem river (~220 km), the focus are on surface water hydrochemistry changes and flow dynamics along the flow path. Unfortunately, no such data were available for the tributaries and an intervening project-specific monitoring network was planned and implemented.

The 27-Bridges Monitoring Network covers the whole study area (eight of the nine quaternary catchments) – 13 monitoring sites on the main stem and 15 monitoring sites on the tributaries; in total 28 Monitoring Sites, including the LHTS tunnel outlet.

Right from the start of the project in July 2015, it was realised that the surface water monitoring programme should cover the dry and wet seasons of the hydrological cycle and therefore monitoring already started in the first week of July 2015; followed by a second “dry-cycle” monitoring run around mid-August 2015. The rationale is that the base flows in the tributaries would provide a direct indication of the groundwater hydrochemistry signature which differs significantly from the LHTS “mountain-type” fresh water.

The surface water quality in the main stem of the study area contains water from the Lesotho mountain land which is regarded as a pristine water quality and the first sample run of the 27 Bridges Monitoring Network indicated a measurable different groundwater hydrochemical signature, i.e. <10 mS/m for the LHTS water and >50 mS/m for the overall groundwater based on the base flows sampled in the tributaries.

The surface water quality measurements collated during the first two “dry cycle” monitoring runs, indicated that the water quality all along the main stem are showing very small variations and in fact, the difference between the water quality at the tunnel outfall (near Clarens) and just above the Wilge River confluence at Frankfort, is probably just higher than the detection limits of the measuring instruments. To verify the validity of these small water quality variations, two Diurnal Monitoring surveys (viz. a 24 hours period) was conducted at one of the 27 Bridges Monitoring Sites.

The surface water qualities of the tributaries in some cases reported elevated water quality signatures, especially the Langspruit (draining the C83G Quaternary Catchment).

The geology of the study area consists of sedimentary rocks of the upper Karoo Supergroup sequence, i.e. the Beaufort Group, consisting of the lower Adelaide Subgroup (Normandien Formation consisting of lenticular sandstones in a mudrock package), overlain by the Tarkastad Subgroup, consisting of two formations, viz. the upper Driekoppen Formation (mudstone) underlain by coarse grained sandstones of the Verkykerskop Formation.

The Beaufort Group sediments are overlain by the Molteno (predominantly sandstone and mudrock with thin coal seams), Elliot (predominantly mudrock and sandstone) and the Clarens (siltstone with thick aeolian sandstone beds) Formations.

Several Jurassic Karoo dolerite intrusions (vertical dykes and sub-horizontal sills) occur throughout the study area.

The hydrogeological classification of the primary rocks in the study area is “Intergranular and fractured”, with borehole yield class varying 0.1 to 0.5 (low) to 0.5 to 2.0 (moderate).

The actual borehole yields reported in the National Groundwater Archive indicated yields in the order of 5 to 8 l/s which are correlated with secondary intrusive features, i.e. Karoo Dolerite sills and dykes. These yields were confirmed by the local land occupiers noted during the November 2015 hydrocensus.

The hydrological dataset collated during the water resource information and data gathering activities (Task 2) covered the following components:

- Borehole Information (basic, lithology, discharge, owner, water levels and water strikes);
- Water resources quality signatures (a modern, post 1996 dataset showing time series trends);
- WARMS data (surface and groundwater, updated to 2014);
- Groundwater levels (mostly historic);
- General hydrogeological conditions (groundwater occurrence and borehole yield classification) and
- Surface water flow data (at five gauging stations on the main stem, including the tunnel outfall);

Data/information gaps were identified during the inception phase (Phase I) and the following hydrological data were collated during the hydrocensus phase (Phase II):

- A study area (quaternary catchment) surface water monitoring network, that include the water quality and flow status of the main stem and main tributaries;
- Surface water quality data (hydrochemical analyses) during the “dry season”, i.e. July-August period from the main stem and main tributaries;
- Diurnal surface water quality monitoring/analysis to observe the impact caused by day-night biological activity on the hydrochemistry signatures of the main stem water body;
- Modern (i.e. 2015) groundwater levels within a zone 1500 m from the main stem of the Liebenbergsvlei River;
- Specific boreholes to be used for calculation of piezometric gradients in the main stem area (specifically boreholes situated within a 1500 m zone from the main stem); and
- Surface water flows monitored at the Loch Athlone and Sol Plaatje Dams in the headwaters region of the study area, viz. Quaternary Catchments C83A and C83B.

All the data/information gaps were addressed during Phase II of the project, except the actual surface water flows at the Loch Athlone and Sol Plaatje Dams. Both sites were initially part of the DWS gauging station network, but deterioration of the gauging infrastructure at Loch Athlone Dam and diversion of the dam spillage at the Sol Plaatje Dam for power generation (hydro-electric scheme) unfortunately mothballed these gauging stations. Water quality is still monitored at these sites on a weekly interval.

One of the deliverables of Phase II of the study is the development of the analytical/numerical model based on a simplified conceptual model of the upper weathered and fractured upper Beaufort Group sediments. The upper weathered aquifer system contains fresh water quality due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments. The unconfined nature makes the aquifer also vulnerable to pollution.

To support the surface water modelling work a large amount of flow and water quality monitoring data was collected and processed. The data sources, as well as the summaries of the data retrieved, have been included in this document. Initial analyses of the data have been completed and were done to address the initial gaps and assist in the interpretation of the raw data. Sufficient data currently exists for both flow and water quality modelling, however the water quality data suggests little seasonal or geographical changes along the river reach and will not be analysed further. The flow monitoring data suggests some inconsistencies along the river reach that will be further analyses during the modelling phase of the project.

In terms of the numerical modelling, 107 measured groundwater levels obtained from the National Groundwater Archive were assumed to be representative of the more recent, average aquifer conditions and used as the primary calibration targets. Baseflow estimates were used as broad secondary calibration targets to enable the calibration of leakage coefficients and the derivation of reasonable baseflow values.

The original model was run with the initial conditions and the hydraulic conductivities and leakage coefficients of the river courses adjusted using sensible boundaries until a best fit between measured and computed values was achieved. The hydraulic conductivity values vary according to the underlying geology and within different aquifers, and the leakage coefficients according to the order of the river stretch.

The important conclusions of the Quarter 2 (Hydrocensus) Phase are as follows:

- The hydrological datasets are useful; however, it required significant assessment to isolate valuable time series related data. The best applicable surface water dataset in terms of flows, is that from 1999 to 2009;
- Surface water quality assessment: Water quality data from the DWS monitoring stations suggest minimal changes along the river reach as well as insignificant seasonal changes;
- The surface water monitor dataset collated from two monitoring runs on the 27 Bridges Monitoring indicated fresh mountain water all along the Ash and Liebenbergsvlei Rivers (electrical conductivity, EC, values <10 mS.m);
- Discharge from the Sol Plaatje Dam seems to have been producing inaccurate data from approximately October 2008, thus data for the last year should be excluded.
- No surface water flow or quality from the tributaries drainages is monitored. The 27 Bridges Monitoring Network were designed/implemented to overcome this shortfall, however the “dry cycle” flow contributions were insignificant and ceased after August 2015;
- The EC values between the Tunnel Outfall (Start Point) and just above the Wilgeriver Confluence (End Point at Monitoring Site C83CA) is small and falls within the diurnal water quality variation/limits of measurement tolerance of water quality equipment, i.e. 1.0 mS/m;
- The surface water quality (EC values) of the tributaries is in the range of 45 to 55 mS/m which correlates with the historical and November 2015 groundwater quality characteristics;
- Surface water quality in the Langspruit is a concern (>90 mS/m, with several elevated constituents noted in the laboratory analyses) and has been indicated by the local landowners as well. The reason for this anomaly has not been investigated; and
- Application of a simple analytical model to calculate the contributions of other than the Ash and Liebenbergsvlei River channel, based on the EC-values is not sensitive enough to conclusively indicate a permanent, significant (or measurable) groundwater contribution to the main stem, however, this could change during the annual “wet cycles”.

To conclude, flow-monitoring data from five stations on the Liebenbergsvlei and Wilge rivers will be used to calibrate the surface water model. This will be used to support different scenario simulations with the calibrated numerical model. It is foreseen that a typical “wet cycle” scenario will develop during the main wet season (January to March) in the study area, to allow a “wet cycle” monitor run and observe the input from the tributaries.

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1. INTRODUCTION

The aim of the study is to determine surface-groundwater interaction along the Ash River main channel from the Boston-A Dam to the confluence with the Wilge River, upstream of the Vaal Dam. This comprises of the main stem drainage channel of the Ash and Liebenbergsvlei Rivers in the C83 Tertiary Catchment of the Upper Vaal Water Management Area (WMA). In addition, and probably the most important objective of the study, is to support and establish efforts to identify sensitive areas where protection zoning of the surface water and groundwater resources are required.

The study will be supported by team members who have been involved in a variety of studies for the DWS over the past 20 years in groundwater and surface water related assessment and investigations.

Extensive experience and a proven track record in integrated water (surface and groundwater) resource management, resource protection, ecological baseline assessment, water resources planning and catchment management in South Africa and neighbouring countries are relevant to the study objectives.

Numerical 3D groundwater flow and transport modelling on catchment scale will be applied as an aid for understanding regional flows through aquifer systems, simulation of linkages to the surface water component and test hydraulic and water quality protection zoning criteria between the groundwater and surface water resources.

Regarding the size of the study area, nine (9) quaternary catchments (5052 km²), the success of appropriate scientific applications in the above-mentioned disciplines are, however, a factor of the coverage and integrity of the available hydrological information.

1.1 BACKGROUND AND CONTEXT

The Department of Water and Sanitation (DWS) as custodian of the nation's water resources is mandated to protect, use, develop, conserve, manage and control the nation's water resources in a sustainable and equitable manner for the benefit of all South Africans. Sustainability encompasses both the long- and short-term protection of the quality and quantity of the water resources to ensure that they can be developed and used effectively into the future.

Interaction between surface and groundwater resources has not been studied at a regional level as envisaged in this study in South Africa. One of the difficulties of surface water – groundwater interaction is the diffuse nature of groundwater resources in terms of the different aquifer characteristics. There are, however, evidence that groundwater contributions to the baseflow water balance occurs in most drainage channels, especially in the headwaters regions of large drainage systems such as the Vaal River – a phenomenon observed by scientists of the Department of Water and Sanitation during a field visit in the study area in 2012.

The aquifer systems in the area consist of Karoo Supergroup formations; horizontally layered but intruded with various dimensions of dolerite magma (sub-vertical dykes and undulating horizontal sills). Although the hydraulic characteristics of these formations do not indicate high yielding primary aquifers, interstratified high permeable horizons and secondary fracture zones may represent preferential flow paths for groundwater which may intersects deeply incised surface water drainage channels.

Due to the lack of surface water gauging structures in the tributaries feeding into the main stem system, the discerning approach will be based on the hydrochemical characteristics of the main stem flux and whether changes in the water quality (e.g. total dissolved solids) downstream could indicate groundwater influx (viz, an influent stream system) through a special designed monitoring network/programme for the LoP.

The contrary (i.e. an effluent or losing stream system) may also apply due to the significant flow volume increase in the main stem system coming from the Lesotho Highland Transfer Scheme (LHTS) releases above the Boston A-Dam in the Ash River.

1.2 PURPOSE OF THE STUDY

The purpose of this study is to quantify potential effluent/influent conditions along the Ash and Liebenbergsvlei Rivers between the Lesotho Highlands Transfer Scheme, from the Tunnel Outfall, along the main stem to the confluence with the Wilge River., as indicated in Figure 1 below.

Secondly, to establish and quantify water resources protection zoning which is regarded as an important management protocol to sustain the water resources in a manner protecting downstream water users.

The objectives/deliverables of the study is to:

- Assess/identify the interaction between surface and groundwater sources along the Ash and Liebenbergsvlei Rivers, supported by hydrodynamic assessment of the main stem and tributaries;
- Obtain 'modern' groundwater and surface water quality signatures in the study area and compared to available long-term historical datasets; and
- Delineate groundwater protection zones along the main stem and tributaries through establish/qualify hydraulic protection zoning based on a 3D flow/transport modelling approach.

This study leads on from the recently completed surface/groundwater interaction studies in South Africa, i.e. the Dr MC Moseki Surface water – Groundwater methodology development.

This study will focus on:

- Hydrochemical signatures of the surface and groundwater water bodies obtained from recent (2013) and historical data to establish possible seasonal trends and possible long-term trends. Water quality datasets from national water resources monitoring programmes and specific investigations in the study area;
- Hydrodynamics of the main river channel and the timing of the flow contributions from the major secondary tributaries using the Hec-Ras model;
- Conduct an indirect (not on site) land use assessment along the main river channel of the study area (it has been observed that high-level agricultural activities are practised in the study area and correlations with the WARMS database will be conducted);
- Design a surface water quality monitoring network/programme along the main stem and tributaries to assess the surface water quality characteristics and timely changes thereof.
- Implement a surface water sampling programme based on the above-mentioned monitoring network and collate physical data and hydrochemical analyses on a prescribed interval (i.e. bi-monthly)
- Establish a surface water quality profile along the main channel of the study area based on the natural hydrochemical signatures (i.e. electrical conductance, total dissolved solids and natural, conservative tracers). This will be followed by a spot hydrocensus of the groundwater quality and potential gradients at selected zones along the main stem of the Liebenbergsvlei River;

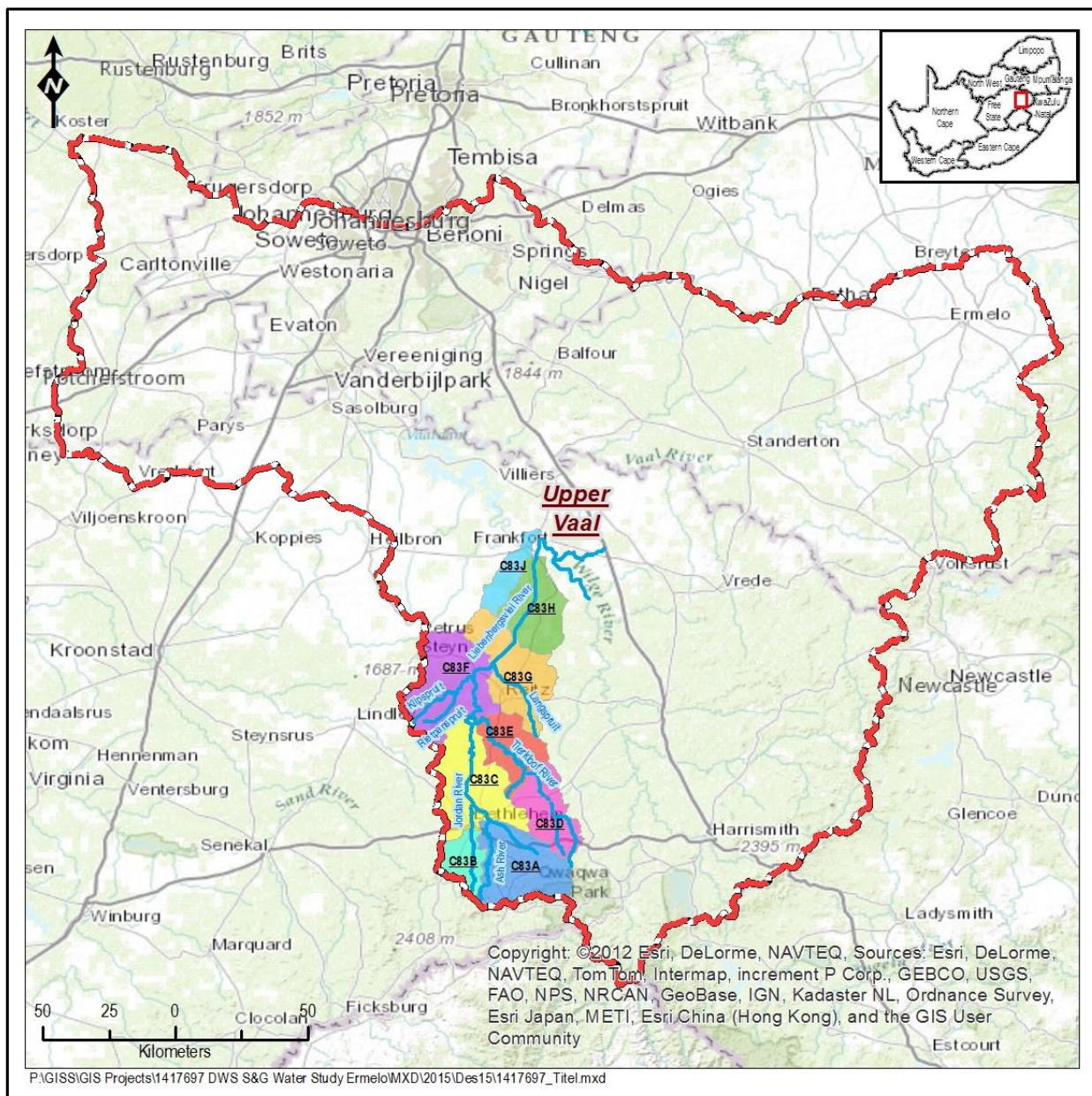


Figure 1 Showing study area in relation with Upper Vaal WMA

- Development of a concept hydrogeological model describing groundwater-surface water interactions for both scenarios, i.e. groundwater feeding into the drainage channel under natural gradients and the reversal where due to local over abstraction, surface water may be drawn in from the river channel;
- The conceptual hydrogeological model for the study area will be converted into a numerical groundwater flow model, which is a mathematical approximation of the real world aquifer channel and its interaction with surface waters. The numerical model will be developed to assess the spatial and seasonal likelihood and extent of surface-groundwater interaction and to inform management decisions such as annual water balance variations and water quality changes;
- Based on the numerical flow model, demarcation of hydraulic and water quality protection zones will be based on the classical borehole protection zone concept, but not exclude other considerations for delineation if requested by the client; and
- To conclude, skills development and capacity building is a major part of this study. Officials from

DWS have been nominated and participate in desktop and field activities of the investigation.

1.3 PURPOSE OF THIS REPORT

This is the second report submitted for the study and deals with the status and value of the available hydrological data/information required to perform a logical assessment on the surface water – groundwater interaction in the Upper Vaal, Ash and Liebenbergsvlei Rivers. The purpose of this report is therefore as follows:

- Provide an summary of the available hydrological data/information that is available – a Desktop Hydrocensus;
- Identify and implement a process to augment the Desktop Hydrocensus Dataset as required to conduct and complete the study objectives;
- Initiate a physical hydrocensus programme to augment the hydrological dataset;
- Provide a summary of the value of the data/information set;
- Perform a first round of data/information assessment (hydrogeology and hydrology); and
- Initiate the conceptual/ analytical/numerical modelling phases with preliminary reporting on the hydrogeological conditions in the study main stem area.

The hydrological and hydrogeological datasets that were collated during the Quarter 1 (Inception) Phase and this phase, Quarter 2 (Hydrocensus) Phase) are packed a set of appendixes added to this report.

1.4 STUDY AREA

1.4.1 The General Hydrology

The area is drained by several northerly flowing drainages; all contributing to the headwaters input of the Vaal River channel via the Vaal Dam; ~44 km downstream from the outlet of C83J QC. The elevation difference between the LHTS Tunnel-Outlet, just upstream of the Boston-A Dam, is ~250 m over a distance of ~220 km's, thus a fall of 0.12 m/100 m river stretch along the main stem.

Several tributaries join the main stem along the flow path and the Liebenbergsvlei River joins the Wilge River just upstream of Frankfort on its way to the Vaal River. The Wilge River which is fed from the Sterkfontein Dam system at Jagersrust, that represents the other main tributary to the Vaal River channel upstream of the Vaal Dam. The main tributaries are shown in Figure 2

There are four small dams in the study area; the Boston A Dam (just downstream of the Tunnel-Outfall, the Sol Plaatje Dam at Bethlehem (where the Ash River joins the Liebenbergsvlei River, C83A QC). The Jordan River drains the western C83B QC and two dams (viz. the Loch Athlone and the Loch Lomond Dams – are situated in the upstream section of the river before it joins the Liebenbergsvlei River.

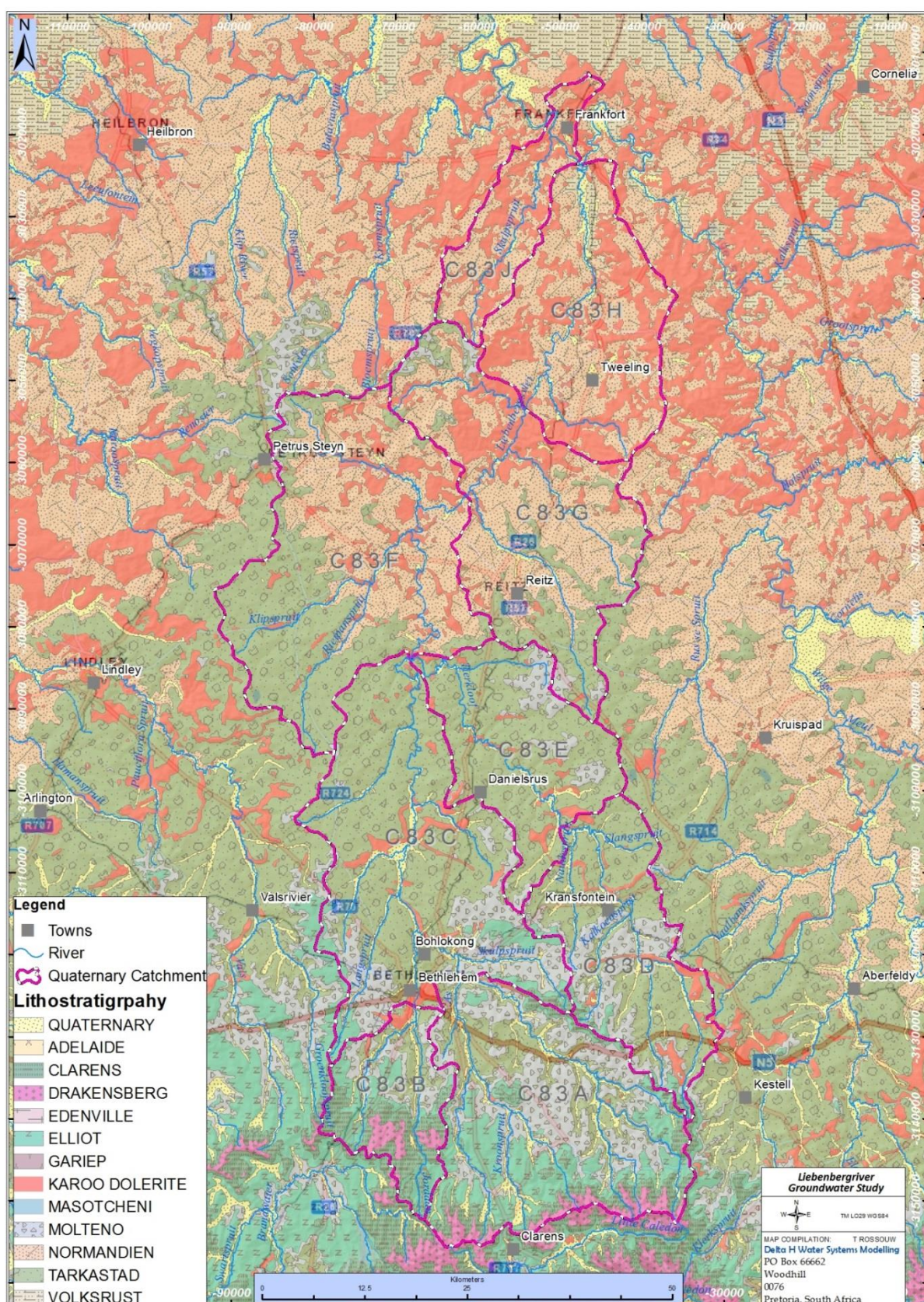


Figure 2: Regional geology of the Liebenbergsvlei River project (after Delta H WSM, November 2015)

1.4.2 The General Hydrogeology

The main Karoo basin, in which most of the study area is located as illustrate in Figure 1, was controlled by the geodynamic events of the deposition of Karoo sediments, the intrusion of Karoo dolerites and extrusion of Karoo basalts associated with the break-up of Gondwanaland and modern geologic and geomorphologic processes such as erosion and deposition of recent sediments. The main Karoo basin is in-filled with sedimentary strata of up to 12 km thickness and capped by a 1.4 km thick layer of basaltic lava (Woodford and Chevallier, 2002). These sediments were deposited during the late Carboniferous through to Mid Jurassic times. The Jurassic age Karoo basalt(s) extruded onto the surface of the Karoo sediments during a period of extensive magmatic activity. The same magmatic event has generated large volumes of hypabyssal dolerite dykes and sills that control the geomorphology and drainage system of the Karoo basin.

The Karoo sediments and intruded dolerite dykes and sills are overlain in places by quaternary sediments and underlain by the pre-Karoo Msikaba Formation.

The northern part of the study area is associated with the rocks of the Normandien Formation, which shows a significantly higher density of dolerite intrusions (especially dolerite sill structures) in comparison to the southern part (mostly sub-vertical dolerite dykes) of the study area associated with younger Karoo Supergroup rocks, see Figure 2.

The Karoo sediments and overlying Drakensburg basaltic lava that covers the southwestern part of the basin and the dolerite intrusions are grouped together into what is called the Karoo Supergroup. The Karoo sediments in the study area consist of shales, mudstones and sandstones, which are extensively intruded by dolerite dykes and sills. Lateral facies changes have given rise to inter-fingering of formations. The intrusion of dolerite dykes and sills has created in many places fractures within the older sediments, enhancing the hydrogeologic characteristics of these rocks. The main Karoo Supergroup geologic units occurring within the study area from the oldest to the youngest are (Figure 3):

- **Ecca Group:** The main Formation within the Ecca Group characterizing the study area is the Volksrus Formation. The lithological units are mainly argillaceous, comprising of shale, carbonaceous shale, clay-, mud- and siltstone.
- **Beaufort Group:** It comprises of the lower Adelaide Subgroup and upper Tarkastad Subgroup as well as the Normandien Formation. These rocks are mainly sandstones and mudstones.
 - The Adelaide Subgroup consists of variable proportions of alternating bluish-grey, greenish-grey or greenish-red mudrock, and grey, fine to medium-grained sandstone; and
 - The Tarkastad Subgroup occurs as two distinct Formations; a lower sandstone-rich (up to 90% sandstone) Katberg Formation and an upper, mudstone-rich Burgersdorp Formation. The Katberg Formation sandstones are light brownish grey to greenish grey, fine to medium-grained and contain scattered pebbles, whereas the Burgersdorp Formation sandstones are greenish grey to light brownish grey and are fine grained.
- **Molteno Formation:** Rocks of this Formation comprise of alternating medium to coarse grained sandstones and grey mudstones. Its thickness varies considerably, but decreases northwards.

- Elliot Formation: This Formation comprises of an alternating sequences of mudrock and subordinate, fine to medium grained sandstones (Johanson et al., 2006).
- Clarens Formation: This discontinuous outcrop of aeolian sandstone marks the final phase of Karoo sedimentation. Interlayered basaltic lava flows signal the commencement of the magmatic activity that led to the termination of sedimentation in the main Karoo Basin (Woodford and Chevallier, 2002).
- Drakensberg Formation and Karoo dolerites: The Drakensberg Formation occurs in the southernmost part of the study area. The study area is intruded by dolerite dykes and sills which have important implications in modifying the hydrogeological properties of an otherwise impermeable rock mass. The dolerite intrusions become less prominent towards the upper Karoo Drakenberg volcanics. This is evident in the study area as rocks from the Ecca and lower Beaufort Group, located towards the north of the study area, are more intruded by dolerite dykes and sills compared to the rocks from the upper Beaufort and Stormberg Groups located towards the south of the study area.

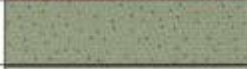
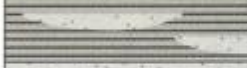
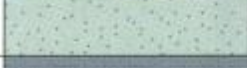
Drakensberg Volcanics			Basalt	Jurassic
Stormberg Group	Clarens		Cross-bedded sandstone	Triassic
	Elliott		Red mudstone and sandstone	
	Molteno		Sandstone, conglomerate and mudstone	
Beaufort Group	Tarkastad Subgroup		Burgersdorp Formation	Permian
			Katberg Sandstone	
	Adelaide Subgroup		Green, grey and purple mudstones	
Ecca Group			Sandstone	Carboniferous
Dwyka Group			Shale and sandstone	
			Tillite and diamictite	

Figure 3: Karoo Supergroup Stratigraphy (Woodford and Chevallier, 2002)

Alluvial deposits occur in most valleys associated with surface water courses, but their regional coverage is small. These unconsolidated alluvial sediments comprise of clay, sand, gravel and courser sized grains.

A more detailed description of the hydrogeological characteristics of the different rock formations follows later in this document.

2. HYDROCENSUS PHASE

Collation and verification of hydrogeological data/information for the study area is the main objective of the Quarter 2 (Hydrocensus) Phase of the study. Various meta data/information sources have been identified during the Quarter 1 (Inception) Phase. A data/information gap analysis was conducted during the Inception Phase. These meta datasets have been evaluated and additional work has been planned/implemented during Quarter 2 (Hydrocensus) Phase which included limited scientific assessments of the datasets and implementing field activities where required.

Quarter 2 (Hydrocensus) Report, thus describes the fieldwork conducted, as well as preliminary hydrological and hydrogeological evaluations done on the datasets collated during the Hydrocensus Phase which ran from October 2015 to December 2015.

2.1 WATER RESOURCE DATA/INFORMATION COLLATION

Surface and groundwater data have been collated from the Dept. of Water and Sanitation. These datasets are listed below. In addition all data collated during the Quarter 2 (Hydrocensus) Phase, which covers the surface water monitoring programme specifically designed for the study and important sections prepared for the flow and water quality analyses are included in the following Appendixes:

- Appendix A: Daily and Monthly surface flows for DWS Gauging Stations on the Liebenbergsvlei River.
- Appendix B: Surface water quality monitoring stations DWS – Hydrochemical variables analysed for each station;
- Appendix C: Long-term statistical assessment of surface water quality at DWS Gauging Stations;
- Appendix D: Attributes for boreholes included in the National Groundwater Archive (only a specific section is illustrated);
- Appendix E: November 2015 Groundwater Hydrocensus Survey – Field Observations;
- Appendix F: November 2015 Groundwater Hydrocensus Survey – Hydrochemical Analyses from Jones Laboratories, U.K.
- Appendix G: Long-term groundwater hydrochemistry dataset (all boreholes and National Groundwater Quality Monitoring Programme, Station ZQMBTM1);
- Appendix H1 & H2: Field parameters observed for “dry cycle” surface water monitoring on the 08072015 and 22082015 – 27-Bridges Monitoring Network;
- Appendix I1 & I2: Hydrochemical analyses for 08072015 and 22082015 from UIS and Jones Laboratories respectively for 27-Bridges Monitoring Network;
- Appendix J: Field observations (water quality measurements) during First Diurnal Monitoring Run on Liebenbergsvlei River at Monitoring Site C83C-A (13/14 October 2015);
- Appendix K: Multi-parameter water quality logging during First Diurnal Monitoring Run on Liebenbergsvlei River at Monitoring Site C83C-A (13/14 October 2015);
- Appendix L: Surface water field alkalinity titrations during First Diurnal Monitoring Run on Liebenbergsvlei River at Monitoring Site C83C-A (13/14 October 2015);
- Appendix M: Hydrochemical analyses from the DWS’s Roodeplaat Laboratory for samples taken during the First Diurnal Monitoring Run at Monitoring Site C83C-A (13/14 October 2015);

- Appendix N: Surface water EC, TDS (analysed) and alkalinity titration of water samples submitted to the IGS Water Quality Laboratory, Univ. of the Free State, Bloemfontein – during the First Diurnal Monitoring Run at Monitoring Site C83C-A (13/14 October 2015);
- Appendix O: Field observations (water quality measurements) during Second Diurnal Monitoring Run on Liebenbergsvlei River at Monitoring Site C83C-A (17/18 November 2015);
- Appendix P: Water quality analytical results for samples taken during the Second Diurnal Monitoring Run on Liebenbergsvlei River at Monitoring Site C83C-A (17/18 November 2015), DWS Roodeplaat Laboratory;
- Appendix Q: Surface water field alkalinity titrations during Second Diurnal Monitoring Run on Liebenbergsvlei River at Monitoring Site C83C-A (17/18 November 2015);
- Appendix R: Attendance List of DWS Officials that has joined the First Skills Development and Capacity Building Session at Golder's Hatfield Offices on the 18th of September 2015;
- Appendix S: Attendance List of DWS Officials that has joined the Second Skills Development and Capacity Building Session at Golder's Hatfield Offices from the 23rd to the 24th of November 2015; and
- Appendix T: Attendance list of Stakeholder Information and Project Steering Committee meeting at Daniëlsrus on the 19th of November 2015.

2.2 INFORMATION GAP SOLVER

The following information gaps identified during the Quarter 1(Inception) Phase desk study were addressed during the hydrocensus phase and solved where possible:

- Groundwater Levels: Preferably along a few profiles across the main stem in selected areas, supported with local groundwater quality information (to collect groundwater samples from local boreholes):
 - *Seven (7) "Site Areas" were identified during the Hydrocensus Phase and a field hydrocensus were conducted in these priority areas during November 2015. Water levels were measurable in nineteen (19) boreholes.*
- Piezometric gradients in the main stem area: Based on the hydrocensus information, this input is important to classify whether the main stem drainage system is influent (losing to groundwater) or effluent (gaining from groundwater):
 - *Twenty-four (24) boreholes were identified of which eight (8) were located in a zone <500 m from the Liebenbergsvlei River, five (5) boreholes were located in a zone <500 from the Langspruit (2 boreholes) and three (3) boreholes were located in a zone <500 m from the Tierkloof River. Nine (9) boreholes were located in a zone >500 m from the Liebenbergsvlei/Langspruit/Tierkloof Rivers.*
 - *This data gap has been addressed and three (3) boreholes were located in a zone <50 m from a river drainage channel and as close as 13 m from the Liebenbergsvlei.*

- Groundwater/borehole information along the main stem of the Liebenbergsvlei River is unfortunately limited and a special hydrocensus of private boreholes in this area was conducted, i.e.:
 - *Water levels (19 boreholes), physical water quality measurements (22 boreholes) macro/micro element analyses (16 boreholes).*
 - *The physical borehole and water quality information is included in Appendix F.*
- Diurnal (24 Hour) surface water quality variations: A monitoring exercise to assess the short-term (hourly) water quality variation due to day/night biological activity in the main stem channel. This was recommended after the 27-Bridges surface water-monitoring programme indicated very small changes in the overall EC-values of the flowing water body between the LHTS tunnel outfall and the Liebenbergsvlei confluence with the Wilge River at Frankfort.
 - *Two individual 24-Hour monitoring runs were conducted on the Liebenbergsvlei River at Monitoring Site C83C-A on the 13th -14th October and the 17th-18th November 2015.*
 - *Several hydrological datasets were generated during these monitoring runs, i.e. continuous multi-probe water quality monitoring (pH, EC, TDS, DO and ORP) and three-hourly physical Total Alkalinity titrations.*
 - *Water quality samples for laboratory analysis (EC, TAL, Cl, NO₃-N, SO₄ and TDS_{Analysed}) for 11 samples running over a 30-hour time slot (Institute for Groundwater Studies Laboratory, Univ. of free State);*
 - *Water quality analysis from nine (9) samples from the DWS Roodeplaat Laboratory was received.*
- Flow releases from Loch Athlone and Sol Plaatje Dams: The DWS surface water gauging station list indicates that flow measurements are available at five (5) surface water-monitoring sites only, viz. the gauging weirs only. It seems therefore that no flow measurements are recorded at these two dams.
 - *It was possible to calculate flow measurements from the Sol Plaatje Dam between the period October 1999 to September 2009. Unfortunately, due to the diversion of the flow at the Sol Plaatje Dam, these measurements are significantly influenced and do not report the total outflow from the dam.*

2.3 SURFACE WATER DATA COLLATION

To support the surface water modelling work required for the surface-groundwater interaction study along the Liebenbergsvlei a large amount of data has been collated. This document summarises the data sources as well as the summaries of the data retrieved. Initial analysis of the data has also been completed to identify any gaps or improve the understanding of the raw data.

The DWS flow data from the gauging stations is included in Appendix A.

2.4 DATA SOURCES

The primary source of data is the DWS Hydrological Services Website) as well as the Google Earth files generated by DWS to identify monitoring station locations and data records.

Additional data related to the expected natural runoff within the catchment was sourced from the WR2012 datasets (<http://waterresourceswr2012.co.za>).

Irrigation data was sourced from the March 2013 Water Authorisation and Registration Management System (WARMS) database.

3. SURFACE WATER FLOWS

3.1 FLOW MONITORING STATIONS

A number of active and inactive flow monitoring stations within the catchment were identified and the raw data sourced from the DWS Hydrology website (DWS, 2015). The metadata for these stations are provided in Table 1 below and the locations are indicated in Figure 4.

Table 1: Flow Monitoring Stations

Station ID	Name	Start Date	End Data	Updates of Rating Table
C8H036	Ash River (Tunnel @ Outlet from Katse)	Dec 1997	Active	Sept 1997
C8R005	Jordaan River @ Loch Athlone	Dec 1971	May 2015	Jun 1971
C8R004	Liebenbergsvlei @ Sol Plaatje Dam	Jun 1971	Nov 2009*	June 1971, Nov 2009
C8H007	Liebenbergsvlei @ Vogelfontein	Dec 1964	Mar 1978	Dec 1964
C8H037	Liebenbergsvlei @ Reward	Jun 1998	Active	Jun 1998
C8H004	Liebenbergsvlei @ De Molen	Mar 1957	Jan 1996	Mar 1957, Oct 1965
C8H020	Liebenbergsvlei @ Roodekraal	Oct 1974	Active	Oct 1974, Jul 1987
C8H026	Liebenbergsvlei @ Frederiksdal	Mar 1985	Active	Mar 1985, April 1998
C8H001	Wilge River @ Frankfort	Oct 1913	Active	Jun 1962 (last update)

*Rating unreliable thereafter

Discharge from the Katse Dam Tunnel started in January 1998. It was decided to analyse the data after this change thus the period analysed starts in October 1998 (beginning of the next hydrological year) and runs through to September 2009, where after the data for the Sol Plaatje Dam discharge becomes unreliable. Photos of the weirs used were sourced from the DWS website and are provided in Figure 5.

The stations at the Tunnel outlet, Reward and Frederiksdal all have fairly recent rating curves that should ensure relative accurate measurements over the time period analysed. Sol Plaatje dam, Roodekraal and the Wilge River station should have their rating curves re-assessed; for the purpose of this analysis the measurements are assumed to be sufficiently accurate.

3.2 FLOW DATA ANALYSIS

3.2.1 Flow Statistics

Monthly averages for each station were sourced from the DWS Hydrology website (<https://www.dwa.gov.za/Hydrology>) for the period October 1999 to September 2009. These average flow rates are shown in Table 2 and presented graphically in Figure 6. As expected the flow rates in the Wilge River follow a season pattern with increased run-off being generated during the wet season and reduction of flow taking place over the dry season.

The flow rates in the Ash River and Liebenbergsvlei do not follow this pattern due to the significant discharge from the tunnel outlet. It is interesting to note the increase in flow rate as you move downstream during the wet season compared to the fairly constant flow rate along the river during the dry season. The discharge via the tunnel increases during the dry season as the need for additional water at the Vaal Dam increases.

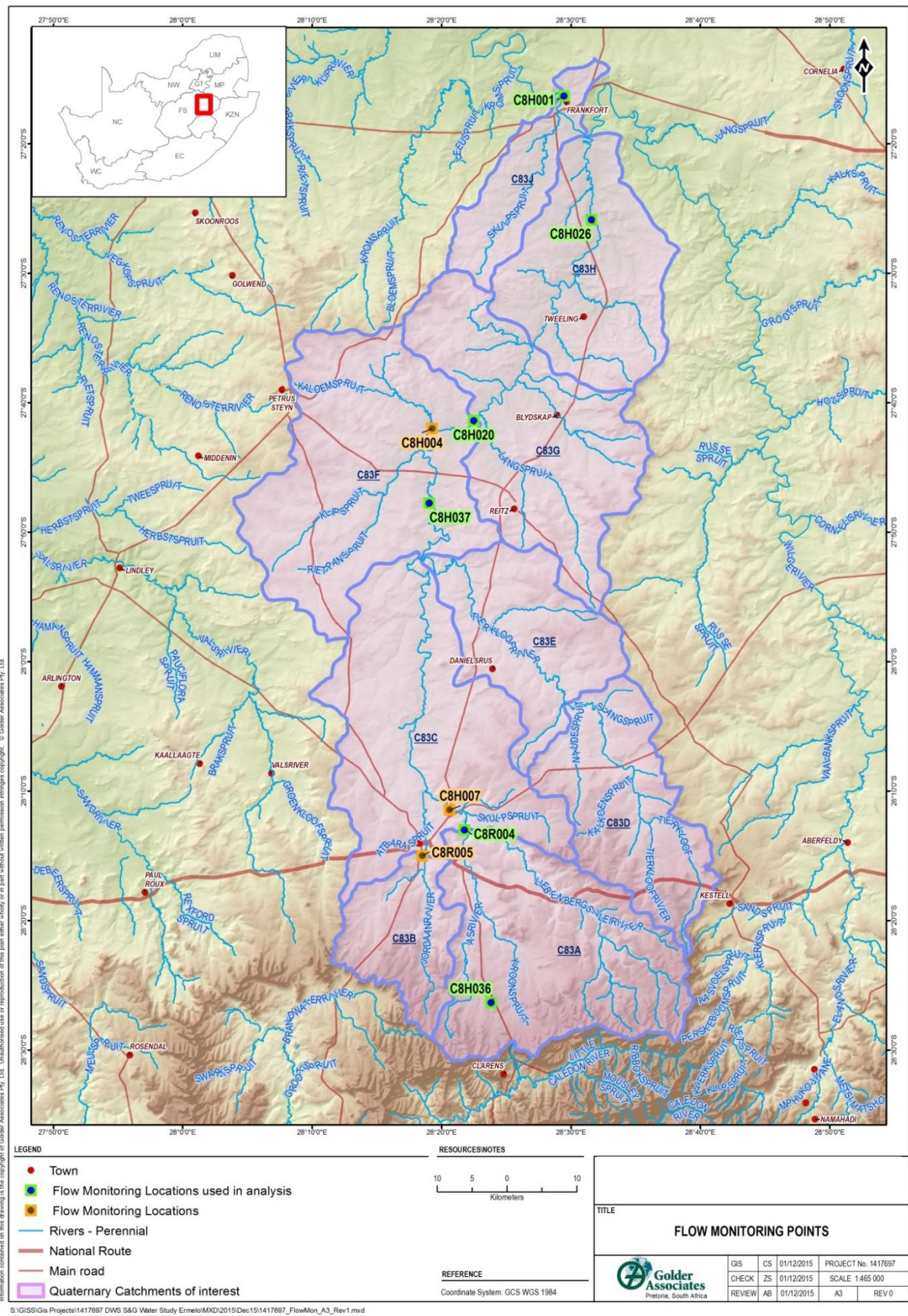


Figure 4: Flow Monitoring Locations

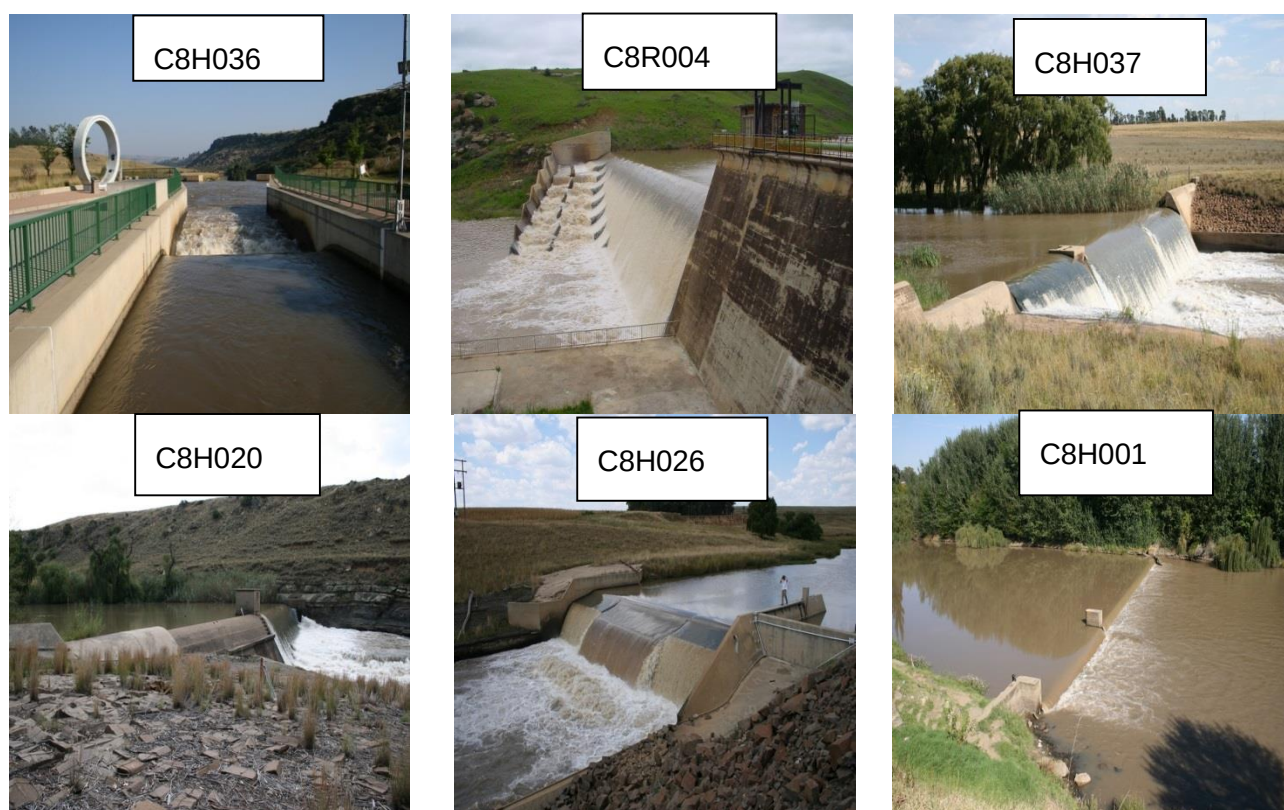


Figure 5: Flow Monitoring Stations Used

Table 2: Average Monthly Flows (Mm³/month) 1999-2009

Station Name	ID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Tunnel Outlet	C8H036	50	47	48	51	42	51	50	66	70	73	71	62
Sol Plaatje	C8R004	57	53	56	59	51	57	55	72	74	77	74	64
Loch Athlone	C8R005	1.6	1.3	1.6	1.8	2.2	1.3	0.9	0.8	0.6	0.5	0.5	0.6
Reward	C8H037	60	56	64	65	57	65	56	73	76	79	77	69
Roodekraal	C8H020	60	57	66	74	65	64	56	74	73	75	73	66
Frederiksdal	C8H026	60	59	71	79	69	69	57	75	72	75	73	66
Wilge, Frankfort	C8H001	75	91	117	148	156	151	81	94	77	74	71	69

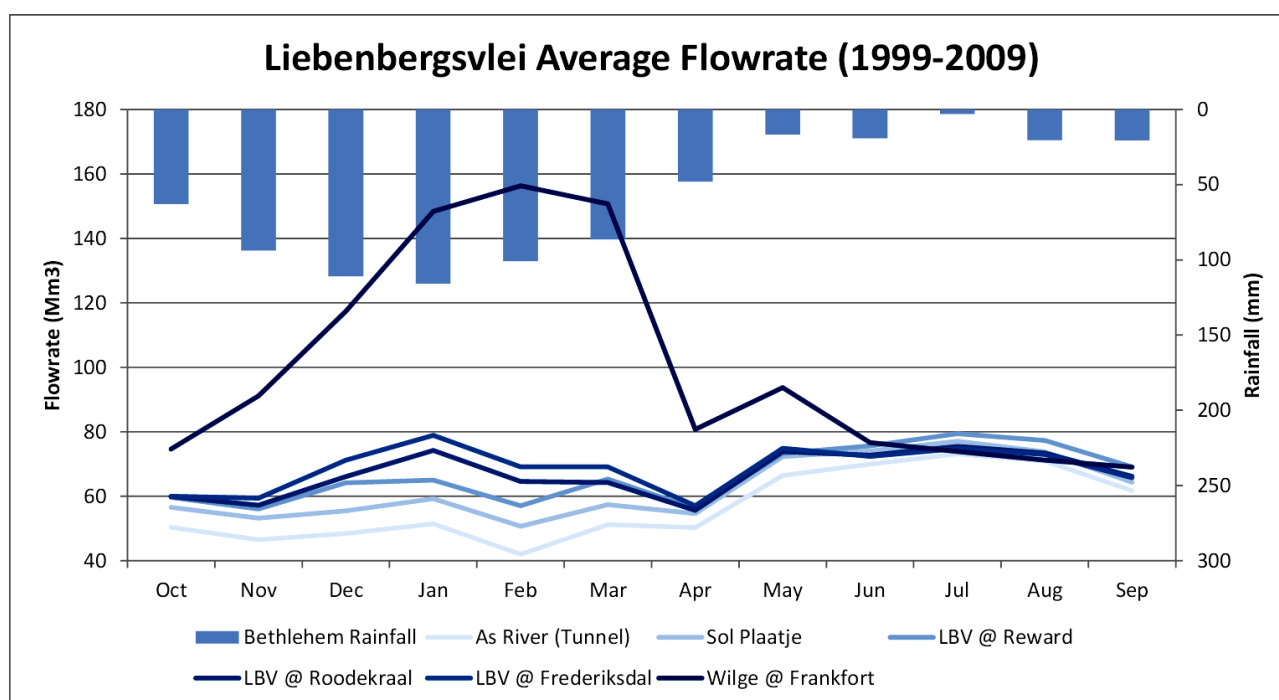


Figure 6: Liebenbergsvlei Average Monthly Flow Rates (1999-2009)

The annual stream flow volumes over this period were also analysed and are presented in Table 3. These results indicate that on average 143 Mm³ of water is added to the system between the Tunnel discharge (683 Mm³) and Frederiksdal, with a further 378Mm³ added between Frederiksdal and Frankfort, primarily via the Wilge River. This addition along the Liebenbergsvlei varies between 4Mm³ (2002) and 440Mm³ (1999) per annum during the analysed period.

Table 3: Annual Stream Flow Statistics (Mm³) 1999-2000

Station Name	ID	5 th Percentile		Average		95 th Percentile	
		Mm ³ /yr	l/s	Mm ³ /yr	l/s	Mm ³ /yr	l/s
Tunnel Outlet	C8H036	538	17	683	22	803	25
Sol Plaatje	C8R004	624	20	749	24	887	28
Loch Athlone	C8R005	0	-	13	0	33	1
Reward	C8H037	626	20	798	25	933	30
Roodekraal	C8H020	606	19	804	25	970	31
Frederiksdal	C8H026	636	20	826	26	995	32
Wilge, Frankfort	C8H001	725	23	1204	38	2008	64

3.2.2 Natural Runoff

Natural monthly runoff data was sourced from the WR2012 datasets for all the quaternary catchments within the study area. The monthly averages over the October 1999 to September 2009 period are provided in Table 4. A number of very wet October's and January's significantly influence the total average annual runoff volume, which is estimated at 191Mm³. This is in line with the average annual volume contribution measured along the river as noted in Table 3 above (143Mm³). The discrepancy is partly due to the location of the final monitoring station (upstream of catchment C83J and half of C83H) but potentially also due to irrigation and other abstractions along the river reach.

Table 4: Average Monthly Natural Runoff from Quaternary Catchments (1999-2009)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
C83A	4.2	2.0	1.5	6.8	5.4	3.7	1.6	0.9	0.8	0.6	0.6	0.5	29
C83B	2.2	0.8	1.0	3.3	1.9	1.2	0.5	0.2	0.2	0.2	0.2	0.1	12
C83C	7.2	2.8	3.2	10.7	6.2	4.0	1.5	0.7	0.7	0.6	0.6	0.5	39
C83D	0.5	0.6	0.6	0.7	1.0	1.0	0.9	0.7	0.6	0.5	0.5	0.4	8
C83E	3.4	1.3	1.5	4.8	2.8	1.7	0.7	0.3	0.3	0.3	0.3	0.2	18
C83F	6.3	2.4	2.7	8.2	4.6	2.8	1.2	0.7	0.6	0.6	0.5	0.5	31
C83G	6.6	0.0	0.0	18.3	1.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	27
C83H	3.2	0.0	0.0	10.9	0.6	0.0	3.6	0.0	0.0	0.0	0.0	0.0	18
C83J	1.3	0.5	0.1	4.0	1.5	0.2	1.3	0.4	0.1	0.0	0.0	0.0	10
Total	34.9	10.5	10.5	67.8	25.3	15.4	11.2	4.0	3.3	2.9	2.7	2.3	191

3.2.3 Water Abstractions/Return Flows

Abstraction and return flow data was sourced from the WR2012 Land/Water Use information dataset for the catchment. Two abstractions (non-irrigation) are registered; the supply requirements for Bethlehem and the Reitz are indicated in Table 5 below. A single return flow from the Bethlehem sewage treatment plant is also indicated at an average annual flow rate of approximately 150l/s or 12.3Ml/d, 60% of the abstraction. The net non-irrigation related abstraction from the river over this reach is estimated at 4.15Mm³ per annum.

Table 5: Registered Abstraction & Return Flows (WR2012)

Catchment	Annual Abstraction (Mm ³)	Annual Return (Mm ³)	Comment	Upstream of
C83A	7.69		Bethlehem Town Supply 2009	Sol Plaatje Dam
C83C		4.50	Bethlehem Discharge 2009	Reward
C83G	0.96		Reitz Abstraction	Roodekraal

According to the WR2012 dataset the abstraction and return volumes do not vary significantly during the year as indicated in Table 6.

Table 6: Monthly Abstraction and Return Volumes (Mm³)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yr
Beth Abstraction	0.62	0.60	0.62	0.62	0.56	0.62	0.60	0.62	0.60	0.62	0.62	0.60	7.3
Beth Return	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	4.5
Reitz Abstract	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.96

A number of water abstractions for irrigation purposes within the catchment have been registered in the WARMS database (March 2013). The largest portion of the abstractions take place from the rivers/streams (88%) within the catchment as indicated in Table 7.

Table 7: Irrigated Areas per Quaternary (WARMS, 2013)

Catchment	Total Irrigated Area (km ²)	Split by Source (km ²)					
		Dam	Borehole	River/Stream	Lake	Wetland	Spring/Eye
C83A	19.1	0.84	0.02	18.2	0	0	0
C83B	0.8	0.7	0	0.11	0	0	0
C83C	19.7	1.95	0.26	16.6	0.3	0.55	0
C83D	0.6	0.24	0.05	0.3	0	0	0
C83E	17.9	0.58	0	17.0	0	0.26	0
C83F	15.3	4.3	0.02	11.0	0	0	0
C83G	23.4	3.25	0.01	20.2	0	0	0
C83H	20.8	0.35	0.31	19.9	0	0	0.21
C83J	5.0	0.3	0.5	4.2	0	0	0
Total	122.6	12.5	1.2	107.5	0.3	0.8	0.2
Percentage of Total		10%	1%	88%	0%	1%	0%

3.2.4 Analysis of Volumetric changes along the river reach

To improve the understanding of the catchment and identify if there are any irregularities as the water flows downstream (which may be caused by groundwater-surface water interaction), the dry winter months are analysed separately. This reduces the data noise generated by surface runoff between the monitoring locations. A graph showing the change in flow rate as one travels further downstream for each of the winter months, is provided in Figure 7.

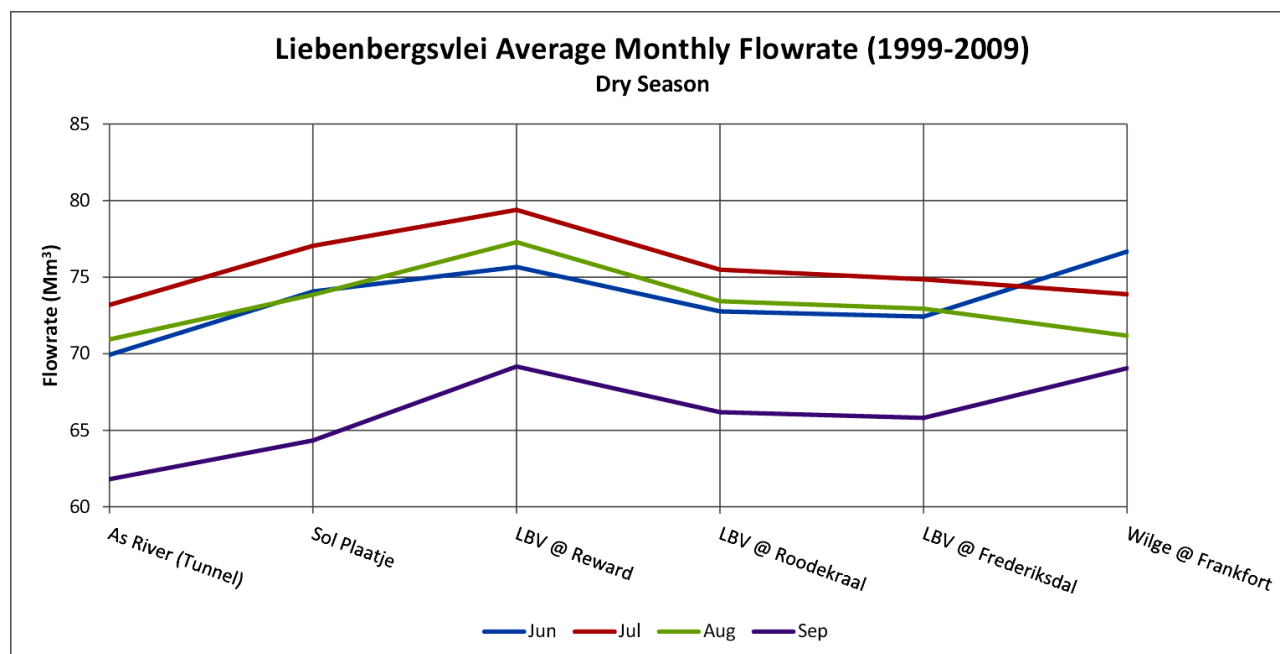


Figure 7: Liebenbergsvlei Average Monthly Flow Rates (1999-2009) – Dry Season

All four the driest months seem to follow the same pattern as one moves downstream - an initial increase from the tunnel outlet to Reward and thereafter a decrease in flow rate. A decrease over the entire river stretch would have been expected due to limited runoff and continued evaporation. On average this initial increase is around 6.4Mm^3 per month or $2.5\text{m}^3/\text{s}$, the driest month (September) shows an increase of 7.4Mm^3 or $2.8\text{m}^3/\text{s}$.

To rule out the possibility of the increase in observed flow being a result of runoff over this period, the quaternary runoff volumes were sourced from the WR2012 online dataset. These average runoff volumes were added systematically to the observed flow rates to estimate the expected flow rates at the next monitoring locations as shown in Figure 8. Even after taking the assumed runoff into account the estimated flow rates remain significantly higher than expected.

The average daily flow rates for all the September months within the period were analysed and are indicated in Figure 9 through Figure 12 for the three stations indicating the increased flow rates during September.

Variations in daily flow rates are expected when comparing the Tunnel outlet flow to the release from Sol Plaatje dam as the storage within the dam can impact the pattern. An example of this is seen during the September of 2000 where a significant peak is observed in the dam release flows even though no such peak was observed for the tunnel release. It is likely that additional water was released from dam storage during this time thus resulting in a dam level decrease.

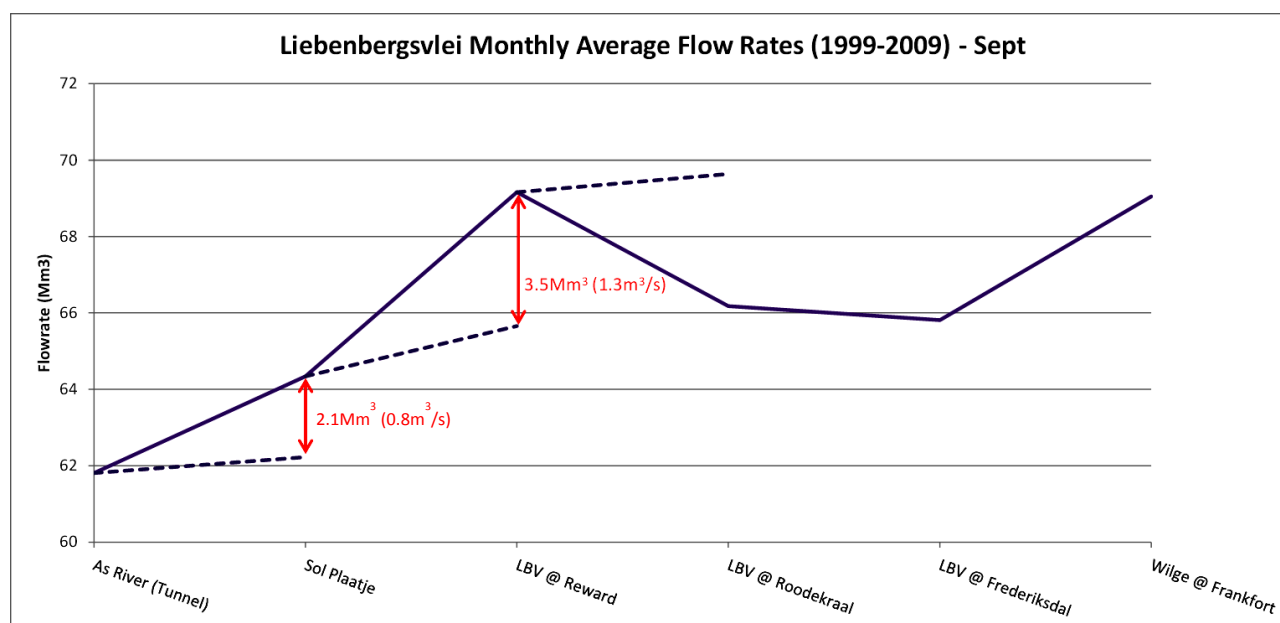


Figure 8: Liebenbergsvlei Average September Flow Rates (1999-2009) – Observed vs. WR2012 Estimates

The pattern seems to remain consistent during the period with the release from Sol Plaatje slightly higher than the discharge from the tunnel until September 2009. September 2009's flow rates indicate a different pattern with the Sol Plaatje flow rate consistently below the Tunnel outlet flow rate (Figure 10).

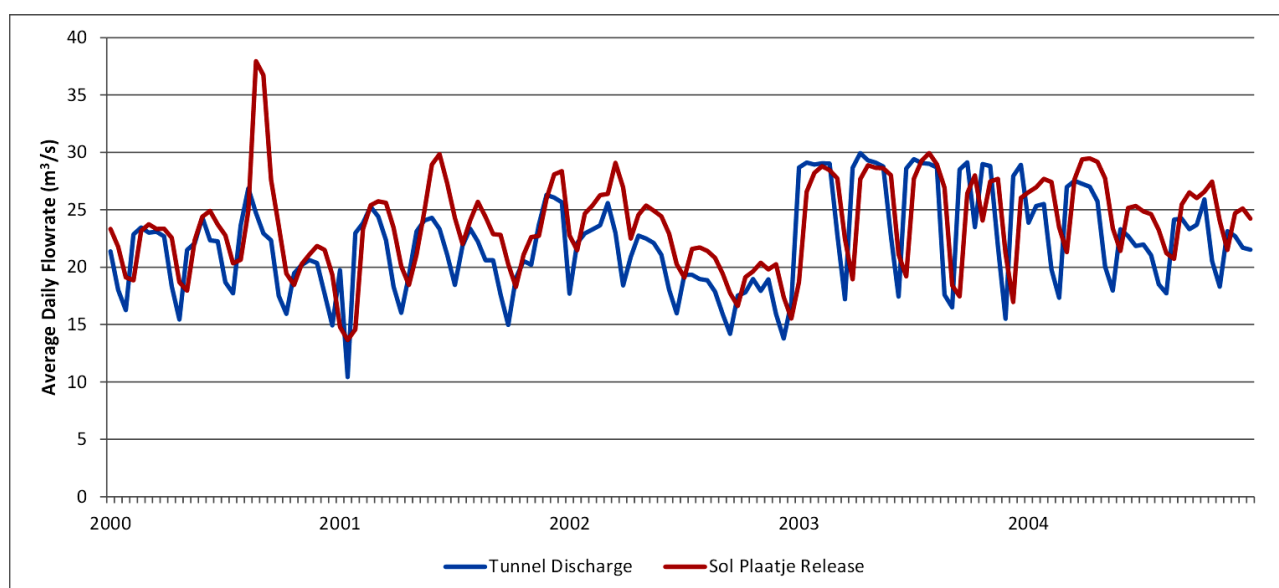


Figure 9: September Daily Average Flow Rates (Tunnel Outlet & Sol Plaatje Release) - 2000 to 2004

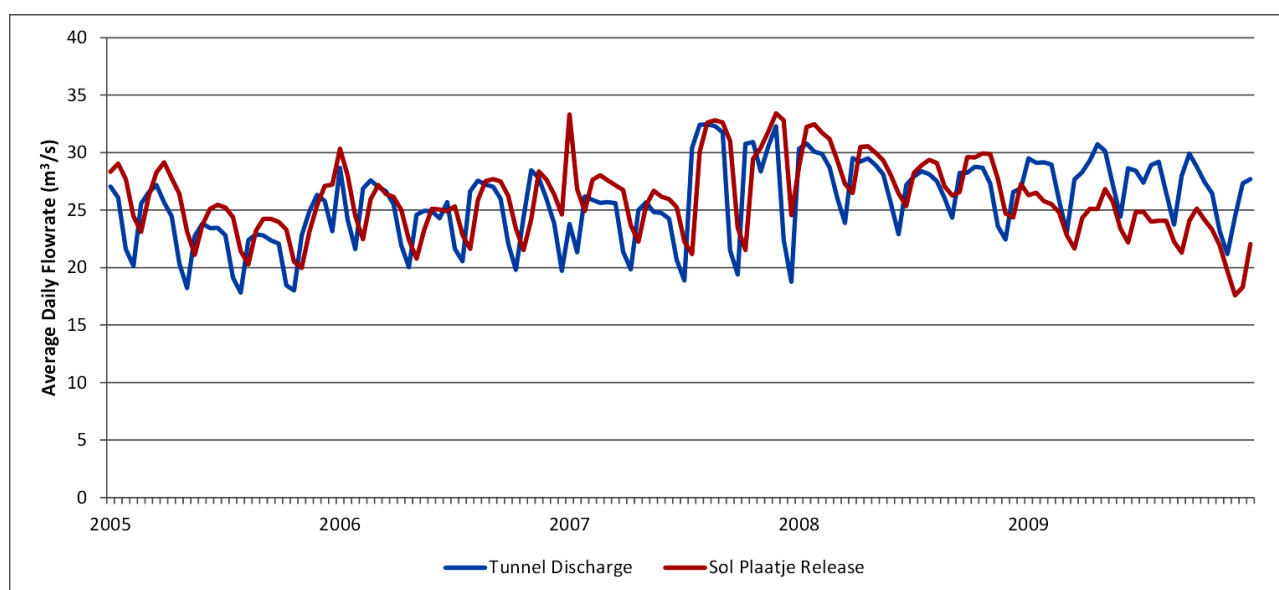


Figure 10: September Daily Average Flow Rates (Tunnel Outlet & Sol Plaatje Release) - 2005 to 2009

The Sol Plaatje daily flow rates are compared to the downstream Reward flow rates in Figure 11 and Figure 12.

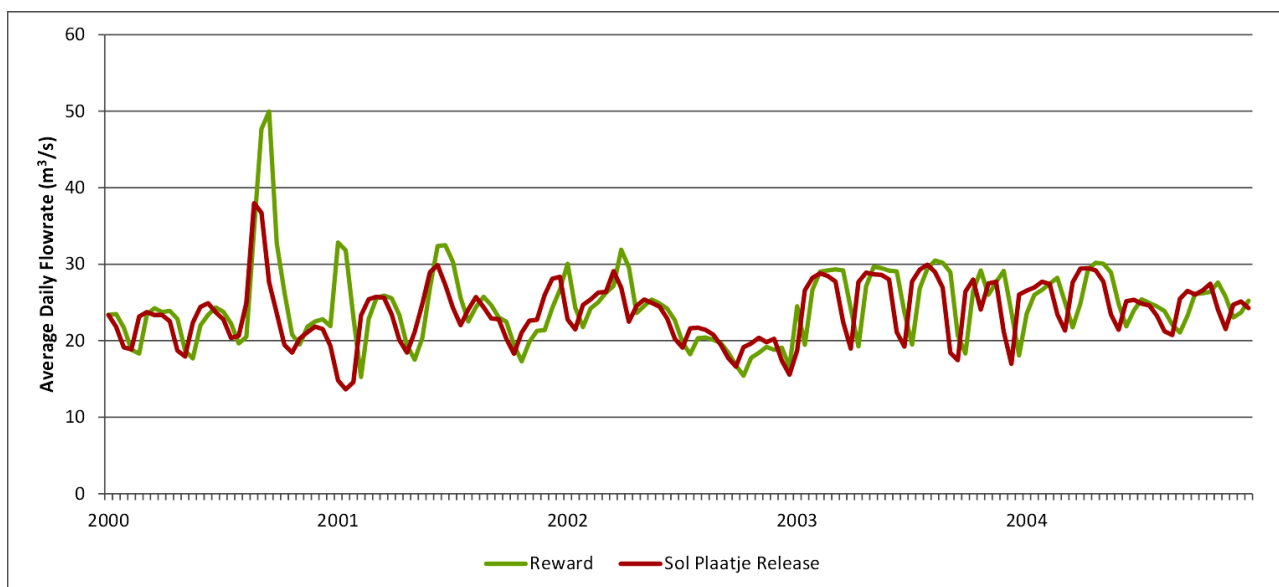


Figure 11: September Daily Average Flow Rates (Sol Plaatje Release & Reward) - 2000 to 2004

As with the comparison above the pattern seems to remain consistent for the first couple of years, from 2005 onwards there seems to be greater variance between the two monitoring stations. This could not be caused by storage changes along the river reach as no major dams are located between these two stations.

From September 2009 onwards the difference between the two stations' records seems to increase. It was noted in Section 3.1 that the rating curve was updated in November 2009 and all data subsequent to this date was discarded by DWS. It seems likely that the rating or calibration of the weir was already affected before November 2009.

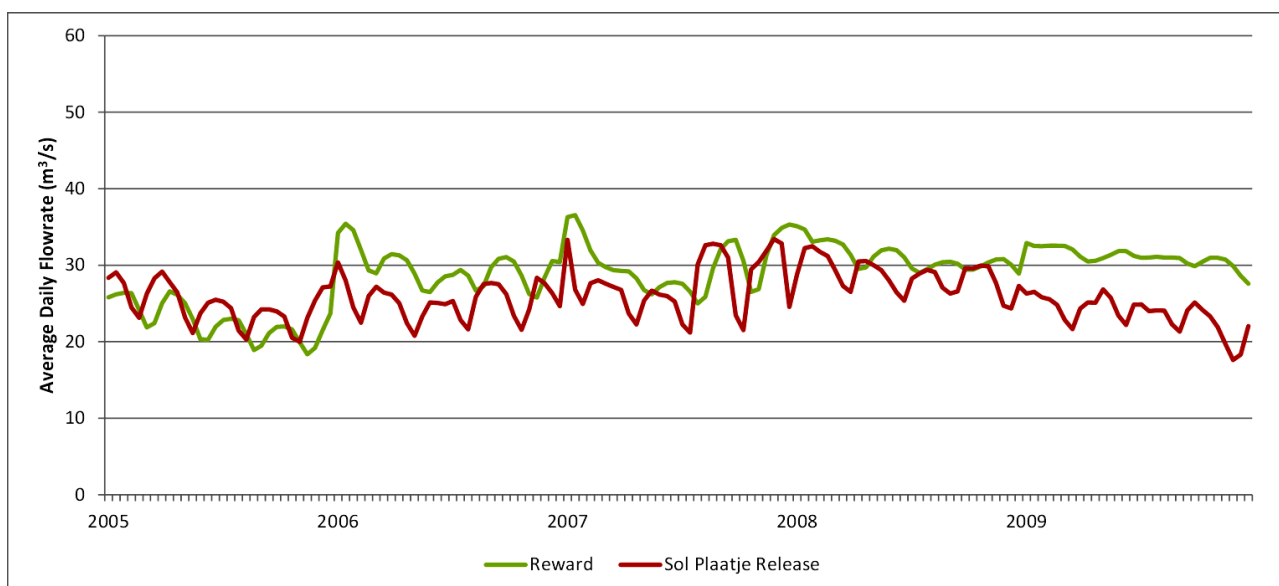


Figure 12: September Daily Average Flow Rates (Sol Plaatje Release & Reward) - 2005 to 2009

4. SURFACE WATER QUALITY

4.1 WATER QUALITY MONITORING STATIONS

A number of active and inactive water quality monitoring stations within the catchment were identified and the measured data sourced from the DWS Hydrology website (DWS, 2015). The metadata for these stations are provided in Table 8 below and the locations are indicated in Figure 13.

Table 8: Water Quality Monitoring Stations

Station ID	Name	Start Date	End Date	Comments
C8R004	Liebenbergsvlei @ Sol Plaatje Dam	Mar 1975	May 2015	
C8R005	Jordaan River @ Loch Athlone	Nov 1975	Jul 2015	
C8H007	Liebenbergsvlei @ Vogelfontein	Nov 1975	Mar 1978	1 Sample in Nov 1996
C8H037	Liebenbergsvlei @ Reward	May 2012	May 2015	
C8H004	Liebenbergsvlei @ De Molen	Nov 1975	Jul 2015	No samples in 1999, 2013
C8H020	Liebenbergsvlei @ Roodekraal	Jan 1978	Jul 2015	
C8H026	Liebenbergsvlei @ Frederiksdal	Mar 1985	Jul 2015	
C8H001	Wilge River @ Frankfort	Nov 1975	Jul 2015	2 Samples in 1971 & 1974

Discharge from the Katse Dam Tunnel started in January 1998. It was decided to analyse the data after this change thus the period analysed starts in October 1998 (beginning of the next hydrological year) and runs through to September 2014.

4.2 WATER QUALITY DATA ANALYSIS

Water quality monitoring data was sourced from the “Resource Quality Information Services water quality data exploration tool” using Google Earth for the stations listed above. A number of the available parameters were identified as potentially significant to the understanding of the groundwater-surface water interaction, these are:

- Dissolved Sulphate (SO₄);
- Dissolved Major Solids (DMS);
- Dissolved Chloride (Cl);
- Electrical Conductivity (EC);
- Dissolved Sodium (Na);
- Dissolved Silicon (Si); and
- Total Alkalinity as Calcium Carbonate (TALK).

The average measured concentrations for each of these parameters for each month over the period analysed (October 1998 to September 2014) are presented in Figure 14 through Figure 20 below. As a reference the concentrations observed at the Vaal Barrage over the same period are also indicated. Other than Silicon and Total Alkalinity, the concentrations observed in the Liebenbergsvlei are significantly lower.

Excluding the water in Loch Athlone the water quality along the river reach seems to be fairly consistent and minimal seasonal variability is observed. Loch Athlone seems to have elevated DMS, EC, Sodium and Total Alkalinity compared to the main stem of the river.

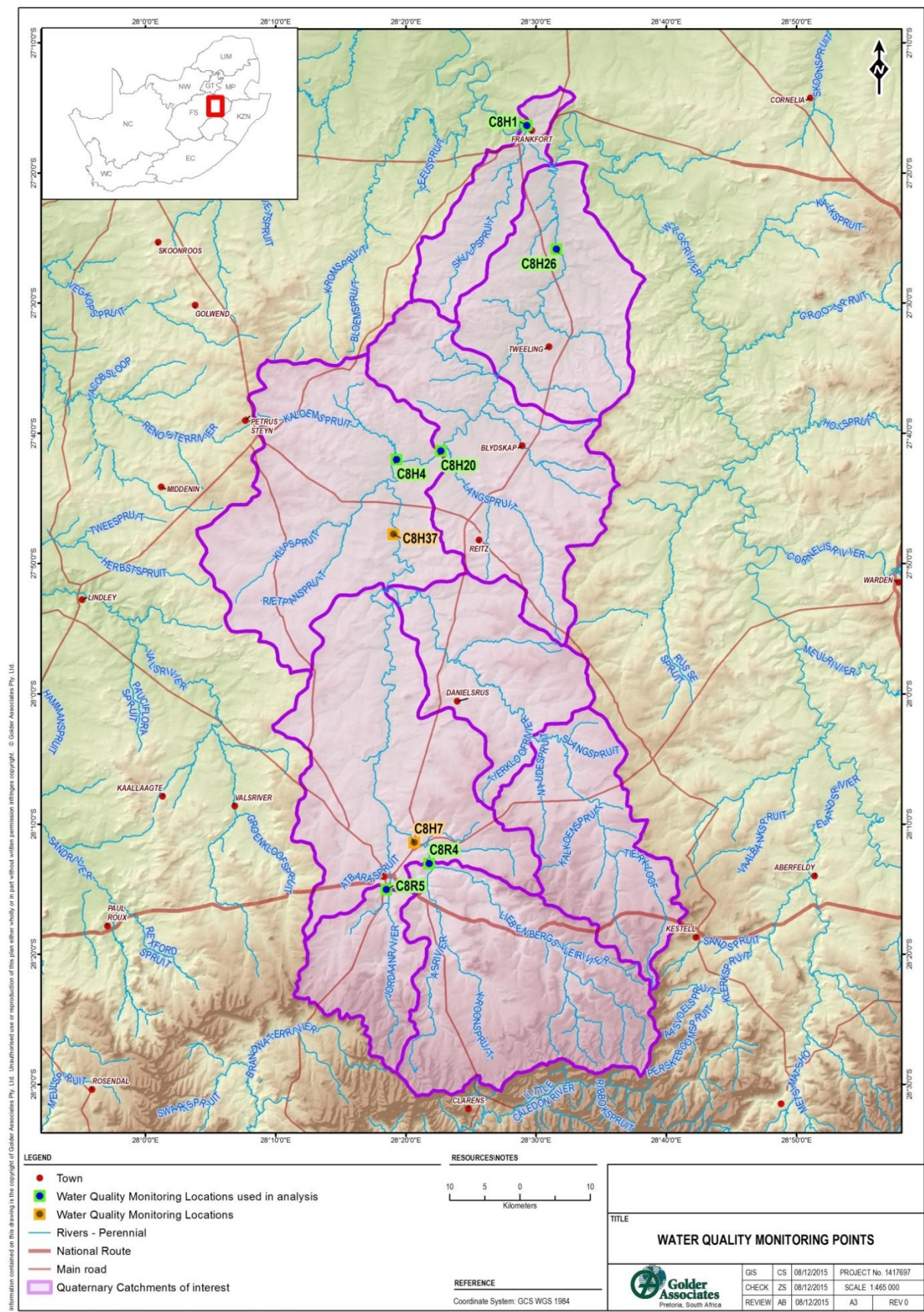


Figure 13: Water Quality Monitoring Locations

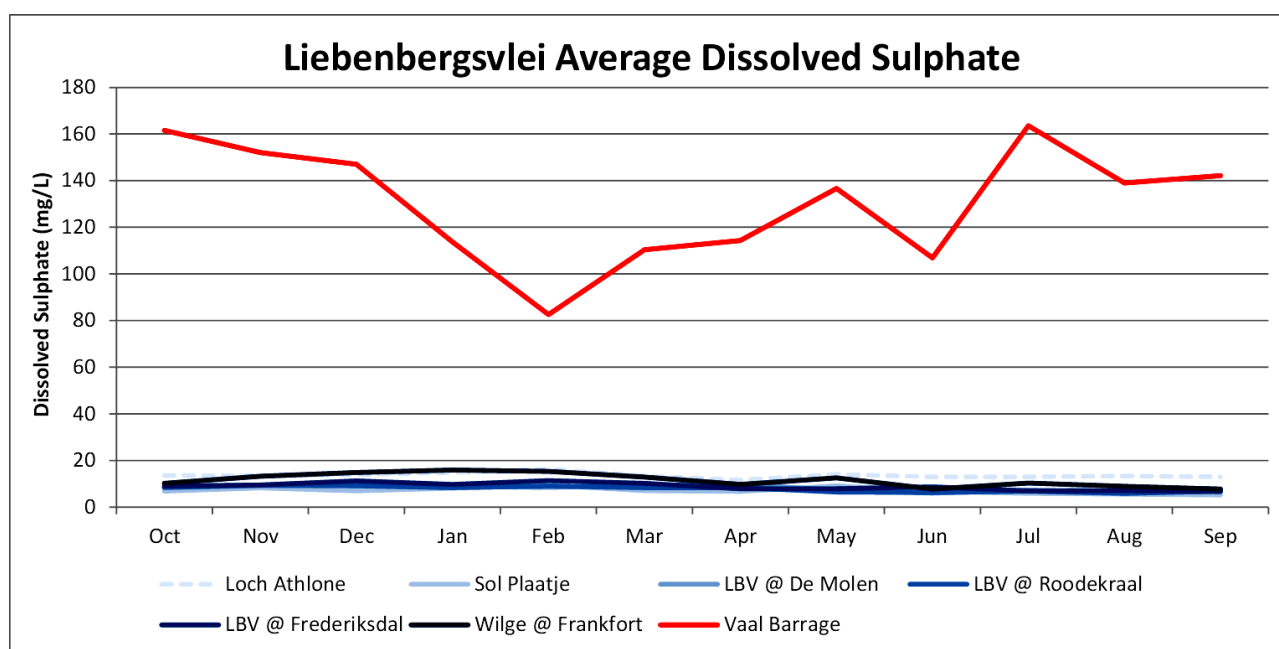


Figure 14: Dissolved Sulphate

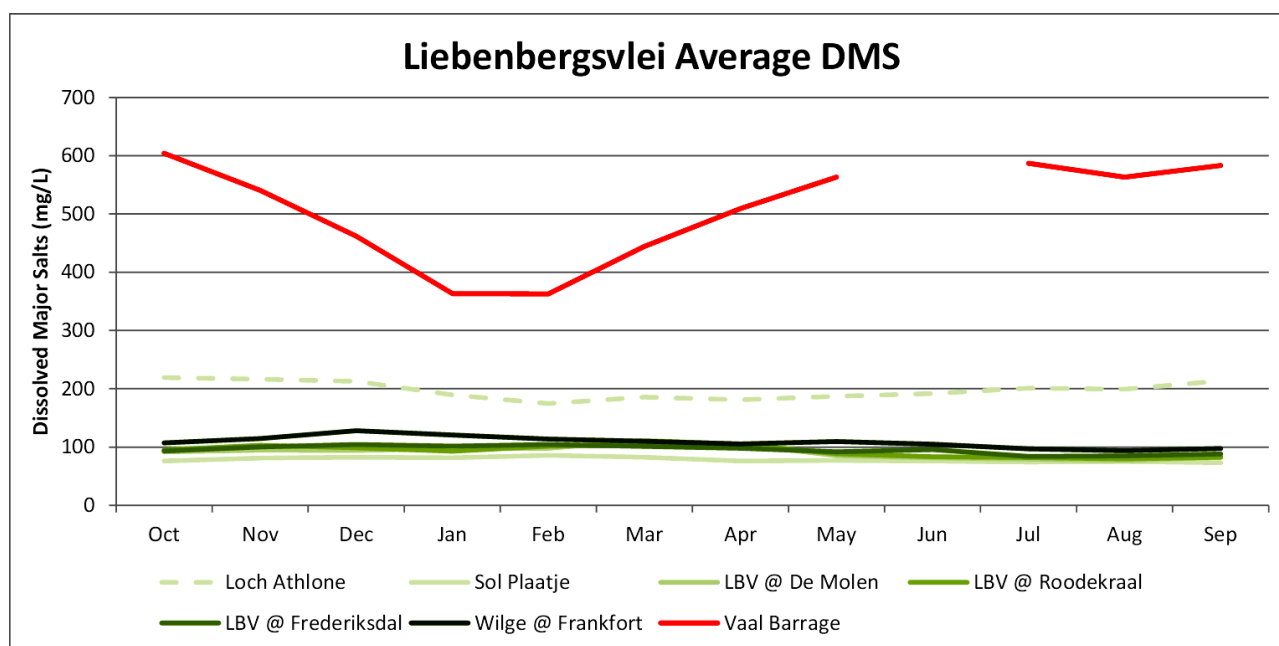


Figure 15: Dissolved Major Salts

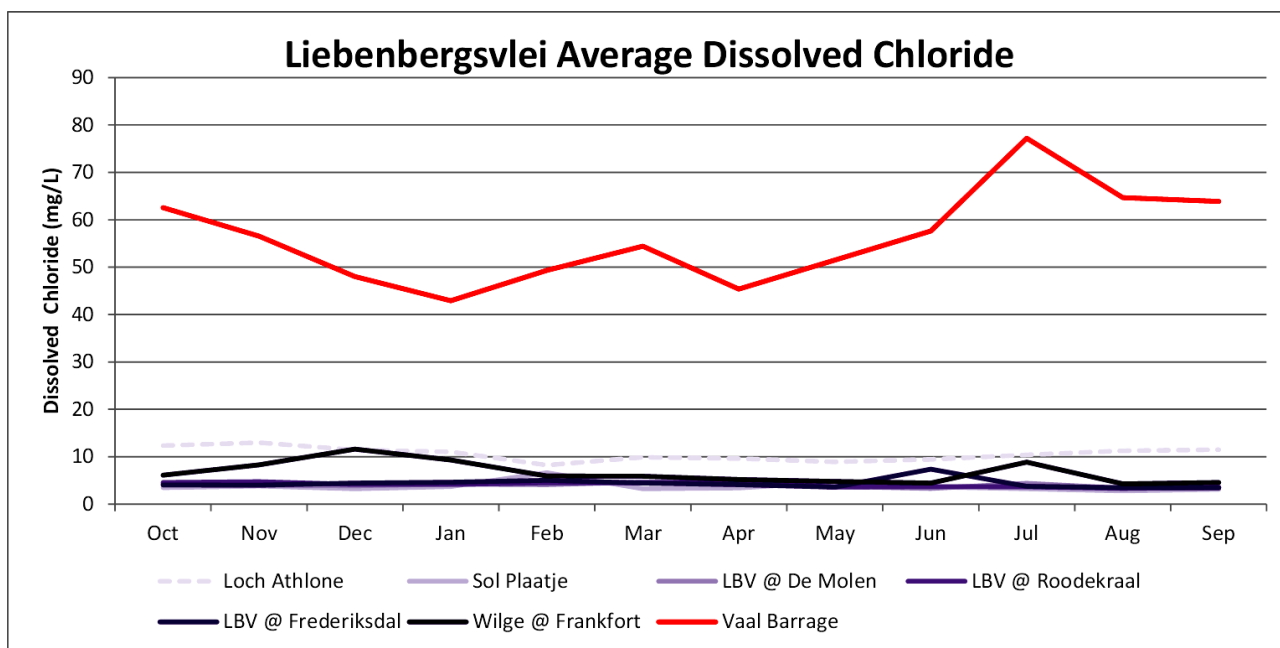


Figure 16: Dissolved Chloride

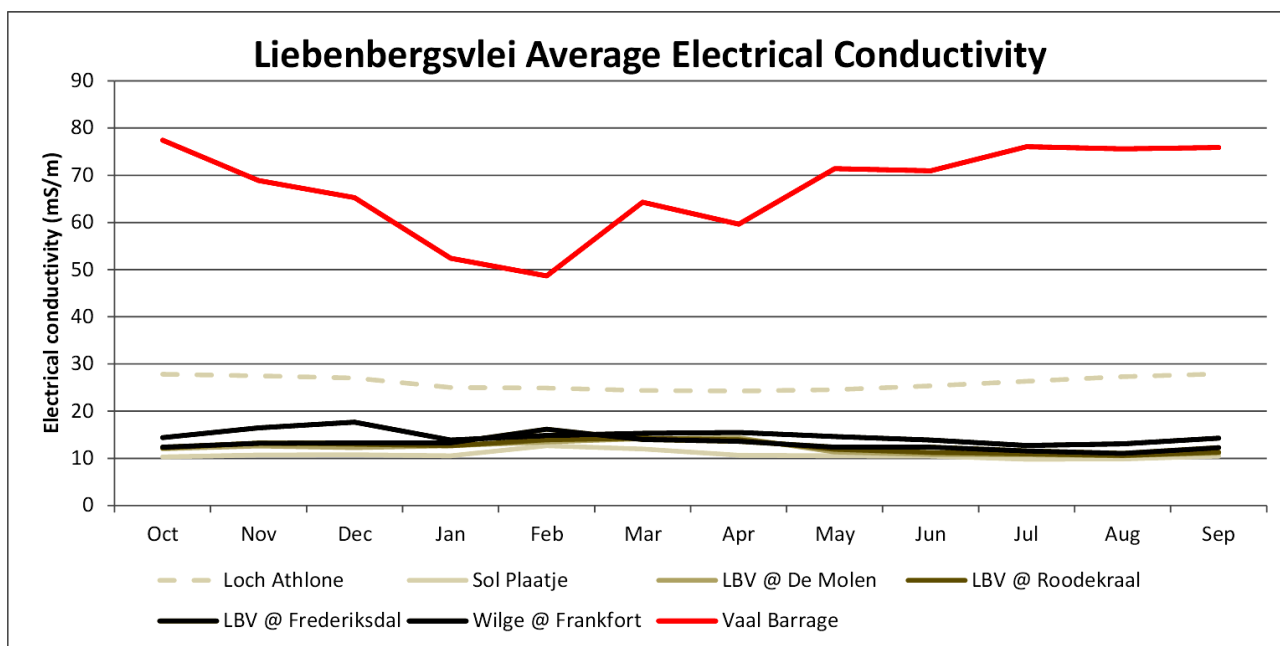


Figure 17: Electrical Conductivity

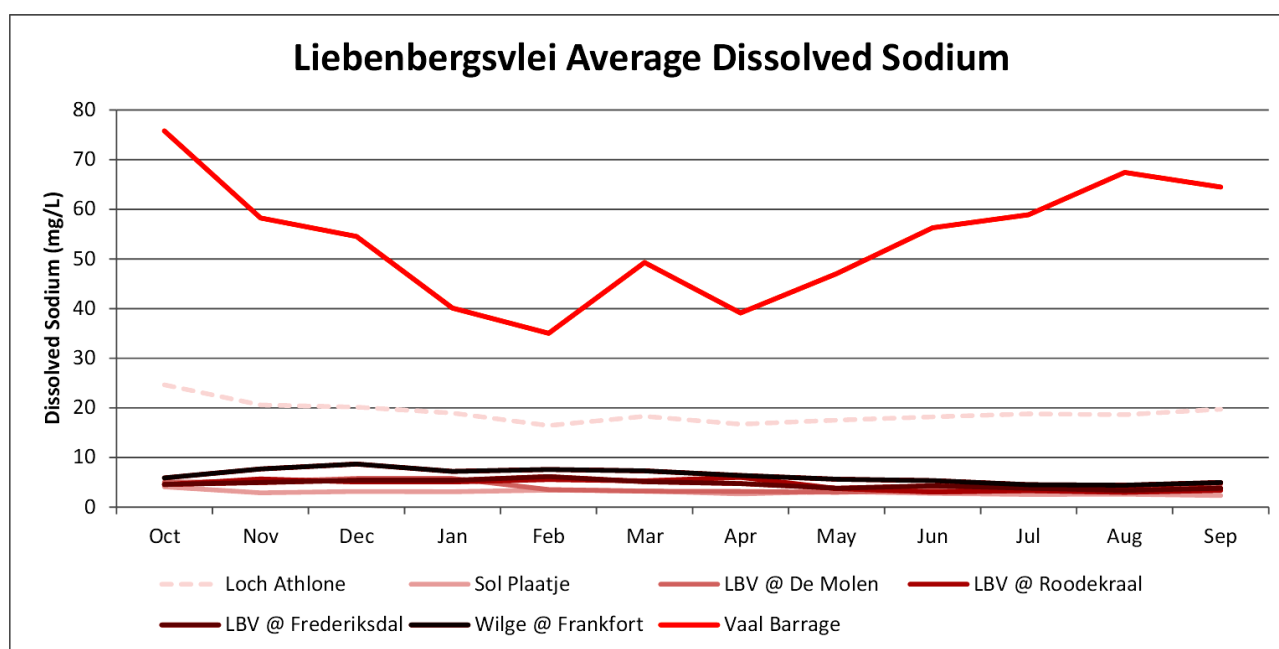


Figure 18: Dissolved Sodium

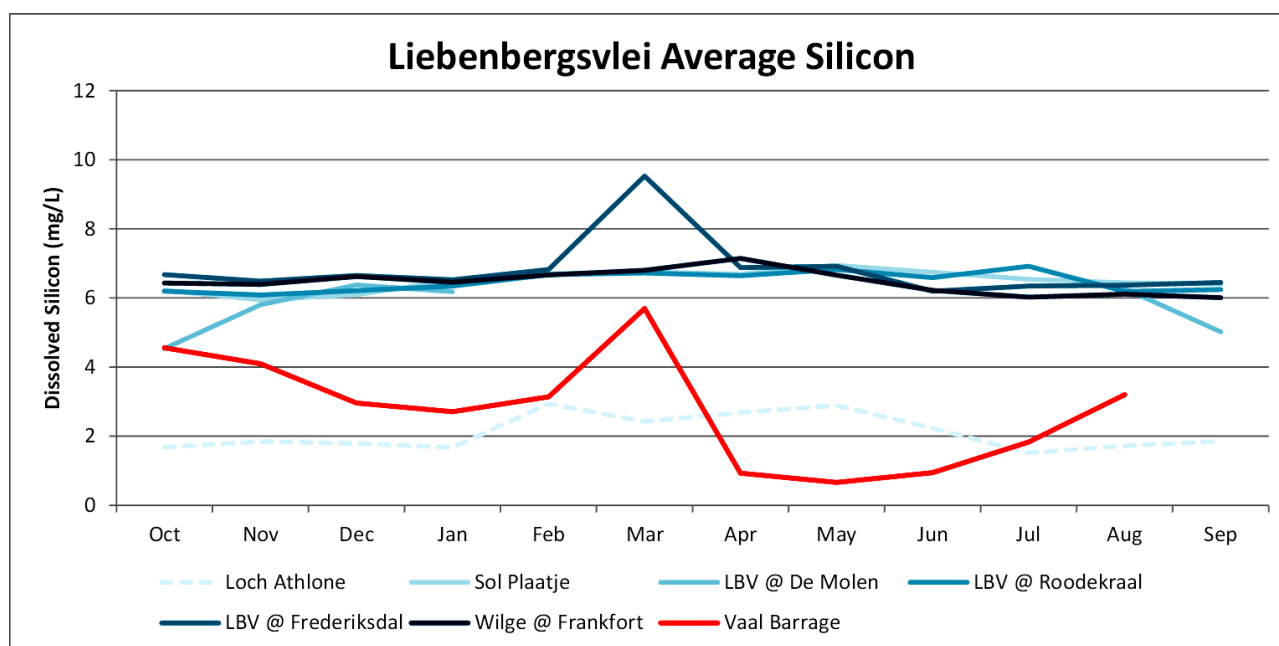


Figure 19: Dissolved Silicon (Limited Samples Analysed)

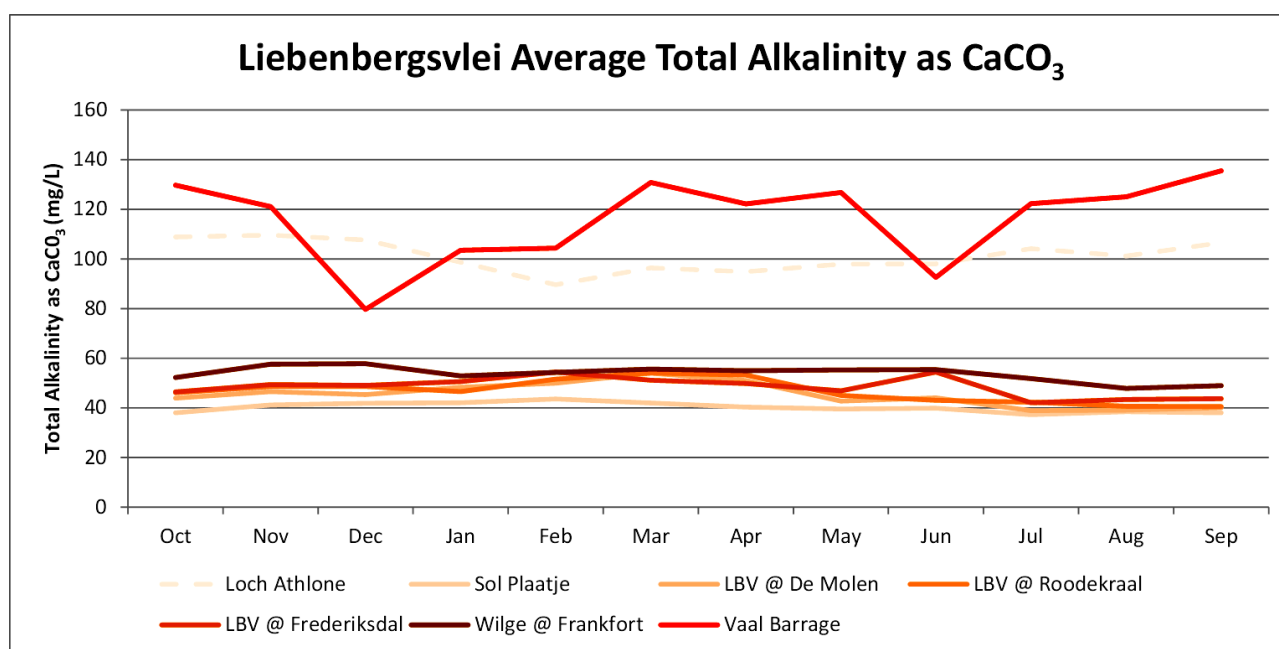


Figure 20: Total Alkalinity as CaCO₃

It is concluded that data from the following active flow monitoring stations located on the Liebenbergsvlei and the Wilge River will be used to calibrate the surface water model: C8R004, C8H037, C8H020, C8H026 and C8H001. Data over a 10-year period, October 1999 through September 2009, will be used for all the stations except C8R004. Station C8R004 (discharge from the Sol Plaatje Dam) seems to have been producing inaccurate data from approximately October 2008, thus data for the last year will also be excluded. The other inconsistencies observed in the flow data, for example the increase between the tunnel outlet and the station at Reward, will be studied further during the Q3 (Field Survey) Phase of the project, to attempt to determine the causes.

The water quality observed along the stretch of the river seems to be relatively stable and is indicative of the mostly un-impacted water being transferred from the Lesotho highlands via the tunnel. Any seasonal variation of the water quality is also deemed insignificant. The data does not suggest any noteworthy changes along the river reach and it is unlikely that it will contribute to the understanding of the surface and groundwater interactions.

For example, the contribution from the Jordaan River which drains the populated area of Bethlehem is a concern in terms of poor water quality impacts and releases. However, the current impact on the main stem water quality is probably significantly diluted below the confluence with the Liebenbergsvlei River.

5. GROUNDWATER CHARACTERISTICS

The groundwater characteristics of the study area are illustrated in Figure 21 and showing the predominant lithology of the rock formations, and the Aquifer Type/Borehole Yield Class (viz. median yield in l/s which excludes so-called “dry boreholes”).

The geology of the study area is listed in Table 9 and is explained as follows:

All the rock formation in the study area belongs to the Karoo Supergroup, Beaufort, Ecca and Drakensberg Groups with late Jurassic Karoo Dolerite intrusions in the form of sub-vertical dykes and flat-lying sills.

The sedimentary package consists mainly of different sequences of mudrock and sandstone/arenite formations, depositional environments varied from (i) Lucastrine/deltaic (Normandien Formation, alternating, lenticular sandstone and mudrock) formations in the north, (ii) braided river system (north) to distal meandering river facies (Tarkastad subgroup, sandstone and mudrock in the south), (iii) a combination of sedimentation in a braided river plain with a few coal seams accumulated in a alluvial-plain-swamp environment (Molteno Formation, medium to coarse sandstone and mudrock), (iv) a typical “red” bed fluvial deposition facies (Elliot Formation, mudrock and fine to medium sandstone, multi-layered 5-100m and 6-15m thick layers respectively), and (v) typical playa lakes and aeolian sand dune formation deposited in a drier climate (Clarens Formation, siltstone and fine grained sandstone, 100 to 300 m thick). The Karoo sediments are finally capped with the Drakensberg Group Basalts, only present in the C83B quaternary catchment in the extreme southern part of the study area.

The aquifer system over the study area is classified as “Intergranular and Fractured” aquifer type. Most of the Borehole Yields Classes falls in the “low” category, i.e. 0.1 to 0.5 l/s range in the northern quaternary catchments (C83C-I). The southern parts of quaternary catchments C83C and C83D have borehole yield classes of 0.5 to 2.0 l/s. Only a small area in the C83C Quaternary Catchment is classified as a “moderate” borehole yield class, i.e. 2.0 to 5.0 l/s (as illustrated in Figure 21).

The influence of dolerite dyke/sill contacts zones normally increases the borehole yields (i.e. specific targets for water supply production), however, it seems that the water bearing characteristics of the contact zones between the host rock formations and Karoo Dolerite intrusions have not been specifically studied in the upper Beaufort, Tarkastad and Stormberg Groups. The historic borehole information set (Appendix D) however indicates borehole blow test yields in the order of 5-10 l/s in boreholes where dolerite rock has been intercepted.

5.1 HYDROCENSUS SURVEY

In addition to sampling of surface water and groundwater in the surface water streams (viz. the 27 Bridges Monitoring Network), a groundwater hydrocensus has been conducted during November 2015 to augment the groundwater data component – this dataset is included as Appendix E. The focus of the hydrocensus survey was to augment the groundwater level dataset and hydrochemical signatures which was identified as an information gap during the Q1 (Inception) Phase.

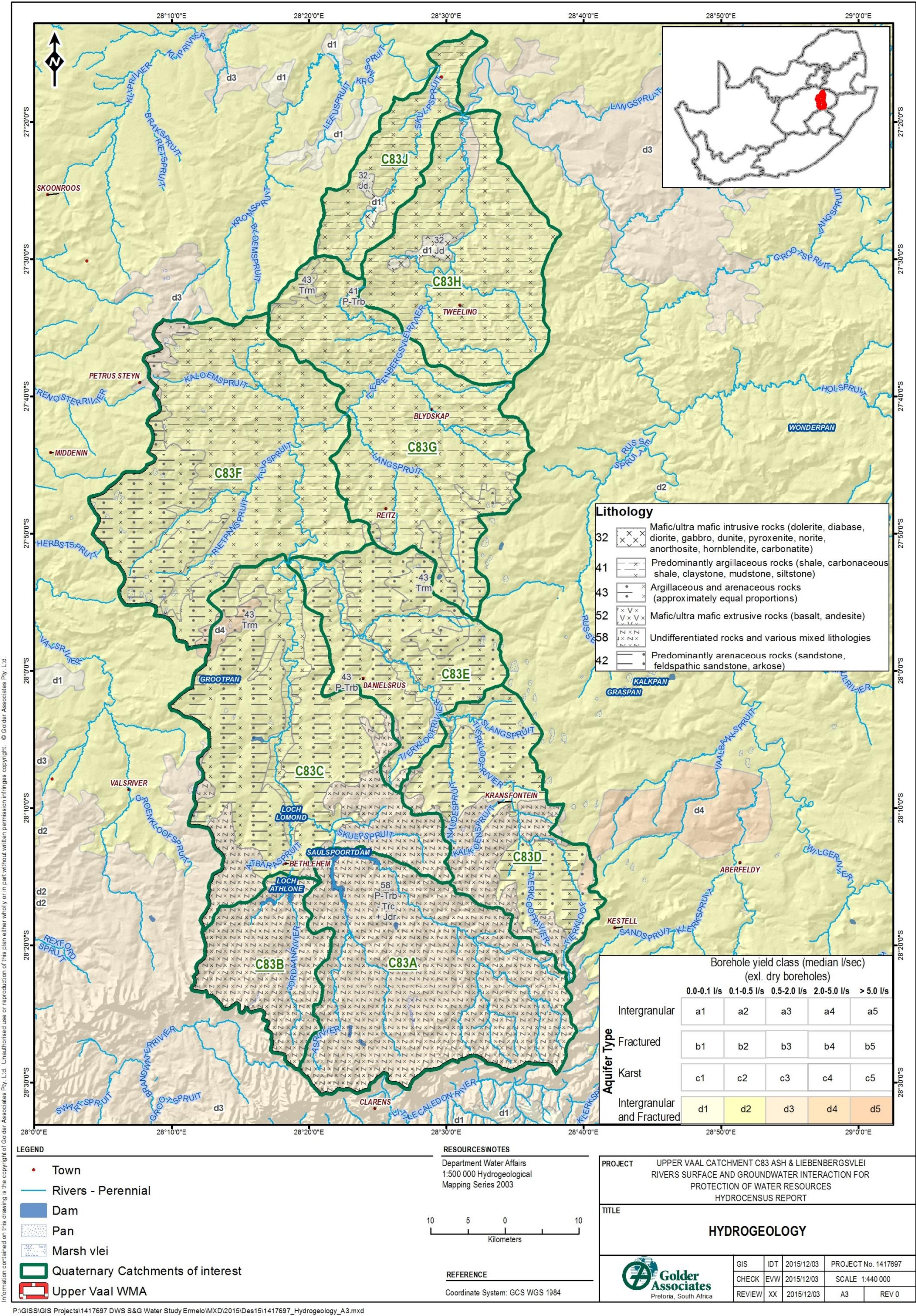


Figure 21: Study Area Hydrogeological Map

Table 9: Geological Formations and Hydrogeological Characteristics

Quaternary Catchment	Supergroup/Group/Subgroup/Formation1-Formation2.	Formation	Aquifer Type	Hydrogeological characteristics.
C83A and C83B	Karoo/Drakensberg/Clarens-Elliot-Molteno Formations/Tarkastad Sbgrp Intrusive rocks: Karoo Dolerite Dykes, major striking dykes: ~10-15 km's long.	Basaltic lava/ Sandstone, siltstone-; Mudstone, (sandstone)-; Sandstone, mudstone and shale/ Mudstone, arenite.	Intergranular and fractured.	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.5 to 2.0 l/s.
C83C	Karoo/Clarens-Elliot-Molteno Formations/Tarkastad Sbgrp Intrusive rocks: Karoo Dolerite Dykes, major striking dykes:<10 km long.	Sandstone, siltstone-; Mudstone, (sandstone)-; Sandstone, mudstone and shale/ Mudstone, arenite.	Intergranular and fractured.	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s (~75%); Borehole Yield Class: 0.5 to 2.0 l/s (<20%); Borehole Yield Class: 2.0 to 5.0 l/s (<5%).
C83D	Karoo/Molteno Formation/Tarkastad Sbgrp Intrusive rocks: Karoo Dolerite Dykes, minor dyke: <5 km long.	Sandstone, mudstone and shale/ Mudstone, arenite.	Intergranular and fractured.	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s (~80%); Borehole Yield Class: 0.5 to 2.0 l/s (~20%).
C83E	Karoo/Molteno Formation/Tarkastad Sbgrp Intrusive rocks: Karoo Dolerite Dykes, a few mapped minor dykes: <2.5 km long. Karoo Dolerite Sills become more prominent.	Sandstone, mudstone and shale/ Mudstone, arenite.	Intergranular and fractured.	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s.
C83F	Karoo/Tarkastad Sbgrp/Normandien Formation Intrusive rocks: Karoo Dolerite Dykes, a few mapped minor dykes: <2.5 km long. Karoo Dolerite Sills become more prominent.	Mudstone, arenite/ Mudstone and siltstone, shale, rhythmite and sandstone.	Intergranular and fractured.	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s.
C83G	Karoo/Molteno Formation/ Beaufort Spgrp/Tarkastad Sbgrp./Normandien Formation. Intrusive rocks: Large Karoo Dolerite Sills become more prominent (~20% of the area). Karoo Dolerite Dykes, a few mapped minor dykes: <2.5 km long.	Sandstone, mudstone and shale/ Mudstone, arenite/ Mudstone and siltstone, shale, rhythmite and sandstone.	Intergranular and fractured.	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s.

Quaternary Catchment	Supergroup/Group/Subgroup/Formation1-Formation2.	Formation	Aquifer Type	Hydrogeological characteristics.
C83H	Karoo/Beaufort/Adeliade & Escourt Spgrp/Normandien formation/Ecca/Volksrust Formation. Intrusive rocks: Regional Karoo Dolerite Sills become more prominent (~20% of the area). Karoo Dolerite Dykes, a few mapped minor dykes: <2.5 km long.	Mudstone and siltstone, shale, rhythmite and sandstone/; Mudrock.	Intergranular and fractured	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s (~97%); Borehole Yield Class: 0.5 to 2.0 l/s (~3%)
C83I	Karoo/Beaufort/Adeliade & Escourt Spgrp/Normandien formation/Ecca/Volksrust Formation. Intrusive rocks: Regional Karoo Dolerite Sills become more prominent (~20% of the area). Karoo Dolerite Dykes, a few mapped minor dykes: <2.5 km long.	Mudstone and siltstone, shale, rhythmite and sandstone/; Mudrock.	Intergranular and fractured	Gwater Quality: <70 mS/m; Borehole Yield Class: 0.1 to 0.5 l/s (~97%); Borehole Yield Class: 0.5 to 2.0 l/s (~3%).

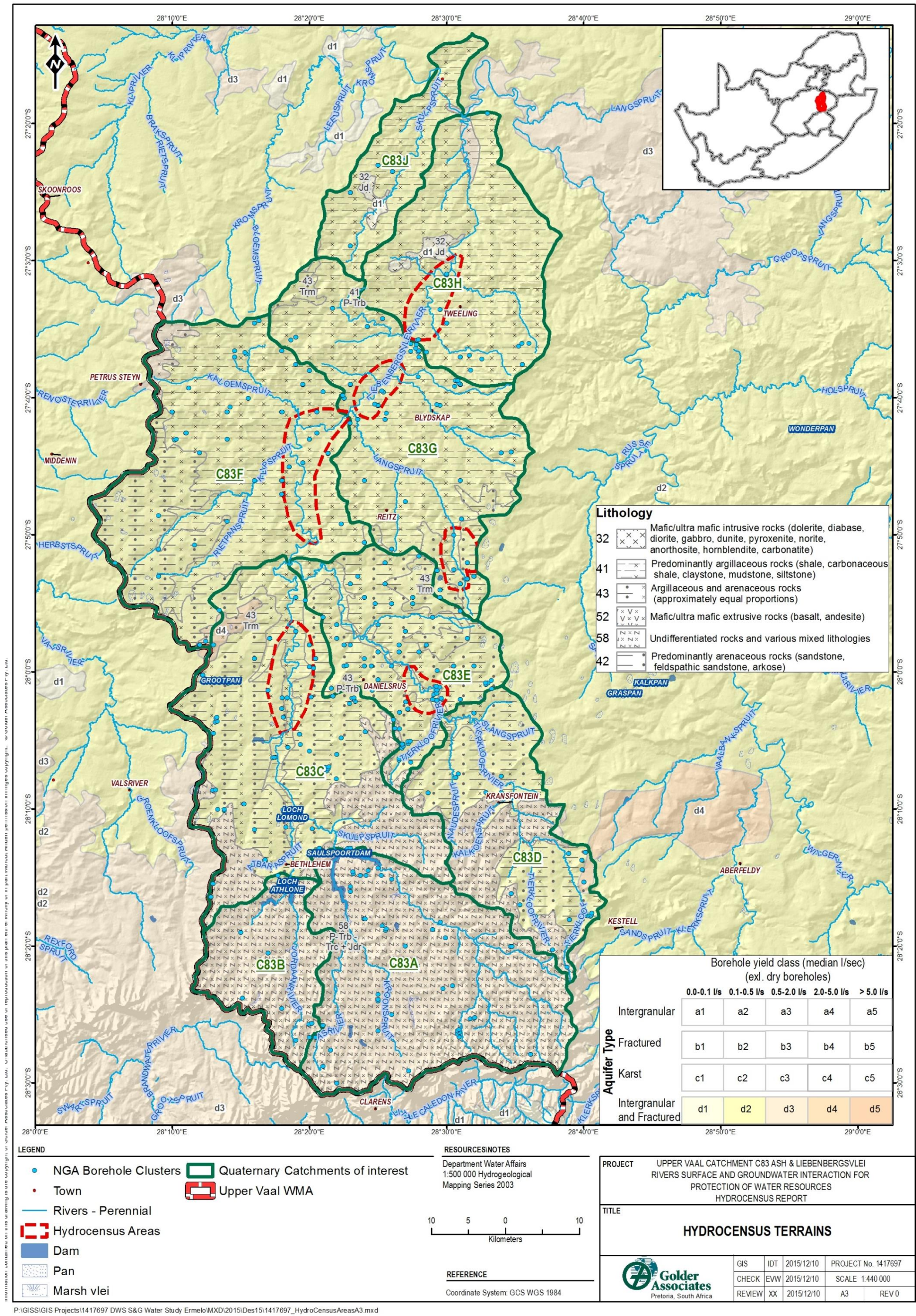
Water level depths in the areas where the November 2015 hydrocensus has been done, varies between 51.3 m (maximum depth, static water level) and 2.7 m (minimum depth, static water level) from 17 measurable boreholes with the median depth to water level at 10.5 mbgl. The historical water level depths (i.e. 1942 to 1999) indicates that the maximum (54 mbgl), minimum (1 mbgl) and median (10 mbgl) depths are rather similar to the 2015 hydrocensus dataset in the seven hydrocensus areas as indicated on Figure 22 The 1980-1990 dataset, however, indicate periods when water levels were in the order of 20 m lower than the long-term median water level depth; thus indicating that the aquifer water table depths in the study area can be significantly impacted by periods with low rainfall which could inverse groundwater – surface water interaction processes. The assessed section of the historical water level dataset is included in Appendix D4.

The groundwater hydrochemistry obtained during the November 2015 Hydrocensus Survey is listed in Table 10 and is compared with historical groundwater quality from the study area. This dataset has been generated from the following groundwater hydrochemistry datasets: Appendix F (November 2015 Hydrocensus water quality analyses) and Appendix G (historical water quality 1970 to 1997 and the 1996-2015 Time Series water quality dataset at ZQMBTM1).

Table 10: Hydrochemical characteristics of the local water resources in the study area (median values)

Element: Median Values.	Historical Dataset (1970 to 1997) n=15 sites: Gwater	Time Series Dataset ZQMBTM1 from 1996 to 2015 n=37 analyses at one site: Gwater.	LHTS Outfall August 2015 at Monitoring Site C83A-C n=1: Swater.	Nov'15 Hydro- census Dataset n=14 sites: Gwater.	Liebenbergsvlei River at Wilge River confluence August 2015 at Monitoring Site C83H-A n=1: Swater.
EC (mS/m)	43	60	9.2	54	10.6
TDS (mg/l)	Not available	470	48	278	53
Ca (mg/l)	24	52	9	45	10
Mg (mg/l)	4.5	27	2.9	18	3.2
K (mg/l)	1.8	0.8	0.4	1.5	0.6
Na (mg/l)	34	32	2	41	2.7
TAL _{CaCO3} (mg/l)	176	242	48	252	48
Cl (mg/l)	11	3.0	1.0	17	1.4
SO ₄ (mg/l)	11	35	4.06	19	4.39
NO ₃ (mg/l)	0.23	0.8	0.15	4.9	0.27
SiO ₂	18	14	8.4	24.8	8.4

The surface water quality for the LHTS water supply flowing through the Ash and Liebenbergsvlei Rivers drainage channels are included in Table 10 to provide a preliminary indication of the surface water and groundwater quality signatures collated during this project. The indication is that there exists a measurable difference between the LHTS water quality and the local groundwater quality that should be measurable as well if a significant amount of groundwater is contributing to the total main stem flow volume.



This long-term groundwater quality dataset show that the pre-1996, the 18 year time series analyses at ZQMBTM1 and the 2015 November Hydrocensus Survey water quality do not indicate any significant changes in the groundwater quality in the study area.

The time series data from ZQMBTM1 is illustrated in Figure 23 below, however a slight rising trend in the Ca/Mg-HCO₃ concentrations is observed.

The relationship between the surface water quality as collated from the 27-Bridges Monitoring Programme and the local groundwater resources in an area maximum 2000 m from the Liebenbergsvlei main stem, the Tierkloof River and the Langspruit is discussed below.

The water quality baseline assessment is used to characterise the ambient background water quality and signatures. Two surface water-sampling runs were conducted during July and August, and submitted to UIS Analytical Services and Jones Environmental Laboratories. Additionally, a groundwater hydrocensus was initiated by Golder between the 9th and 13th of November 2015 to assess local groundwater levels and water qualities. The hydrocensus focussed on borehole locations, status, depths, water levels depths, uses and owner's details. A total of 26 points of interest (boreholes and surface water points) were surveyed and 18 water samples, including three surface water samples, taken for analyses. . The water sampling points are indicated in Figure 24. The water samples were analysed for major and trace elements to provide an evaluation of the ambient water quality. Based on the results of the analyses, the following aspects are described:

- A description of the site-specific groundwater chemistry based on the major and trace element analyses; and
- The resulting parameters for the groundwater samples (hydrocensus) have been compared against the South African National Standards (SANS:241, 2011) drinking water quality limits, the South African Water Quality Guidelines by the Department of Water Affairs and Forestry (1996) for domestic use and the World Human Organisation (2011) water quality guidelines.

Guideline values have been determined for those chemical components that are considered to have significant potential to harm human health at concentrations above the specified limits.

5. THE 2015 WATER RESOURCES QUALITY CHARACTERISTICS

Two sample runs during the 13th and 28th of August 2015 were conducted at sixteen surface water points along the Liebenbergsvlei River and selected tributaries. A list of the water samples collected is given in Table 11 and the laboratory results provided in Appendix I1 and I2.

The surface water samples suggest generally a fresh, calcium-magnesium-bicarbonate (Ca-Mg-HCO₃) water facies as shown in the Piper plot (Figure 25). Such water type indicates a dominance of rainwater chemistry, with limited weathering reactions and CO₂ equilibrium with the atmosphere and soil vapour (elevated CO₂ due to decomposition of organic material) to form the dominant bicarbonate anion. In other words, the surface water chemistry is not significantly influenced by deeper groundwater contributions.

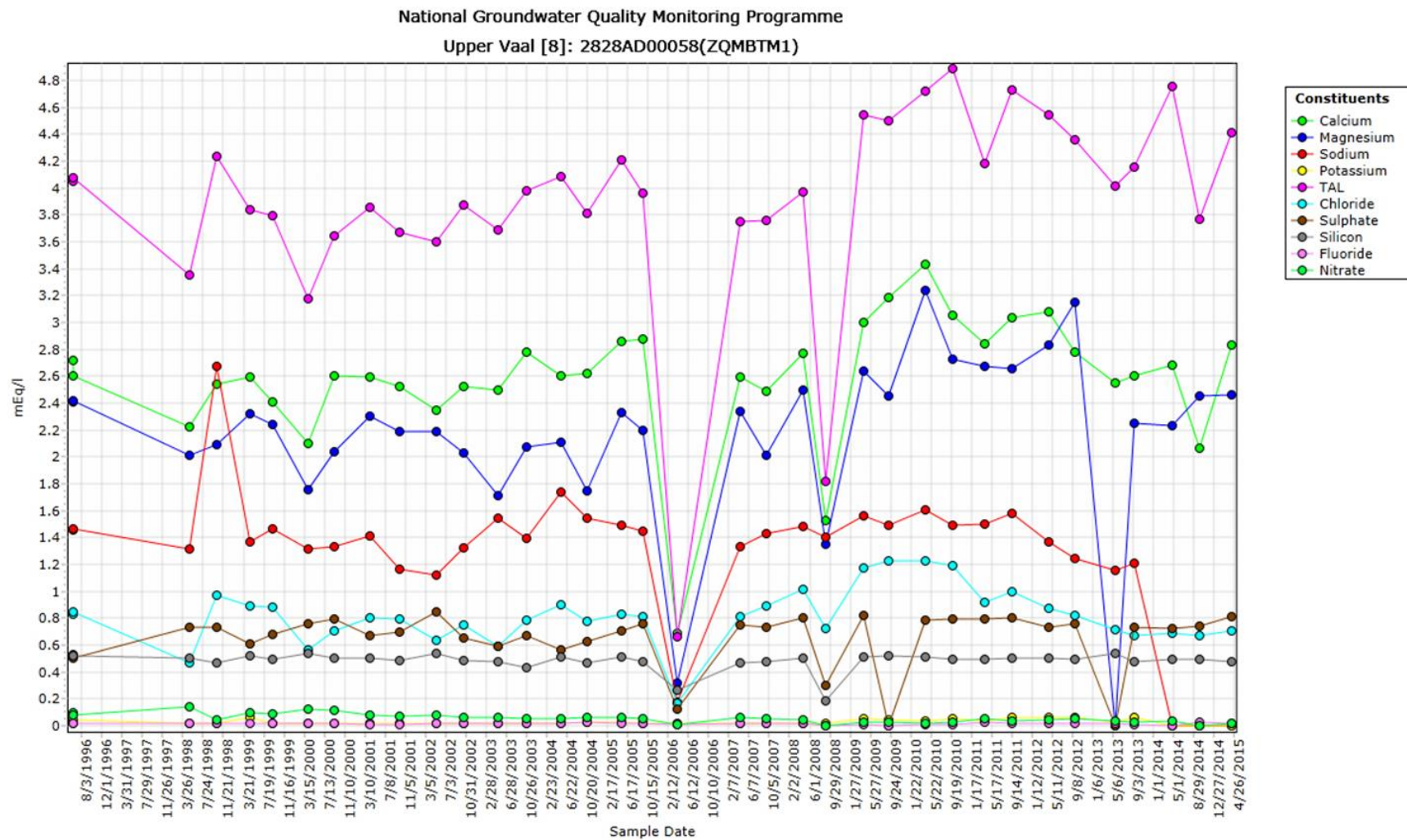


Figure 23: Long-term groundwater quality time series plot of Monitoring Site ZQMBTM1, in Bethlehem, QC C82C

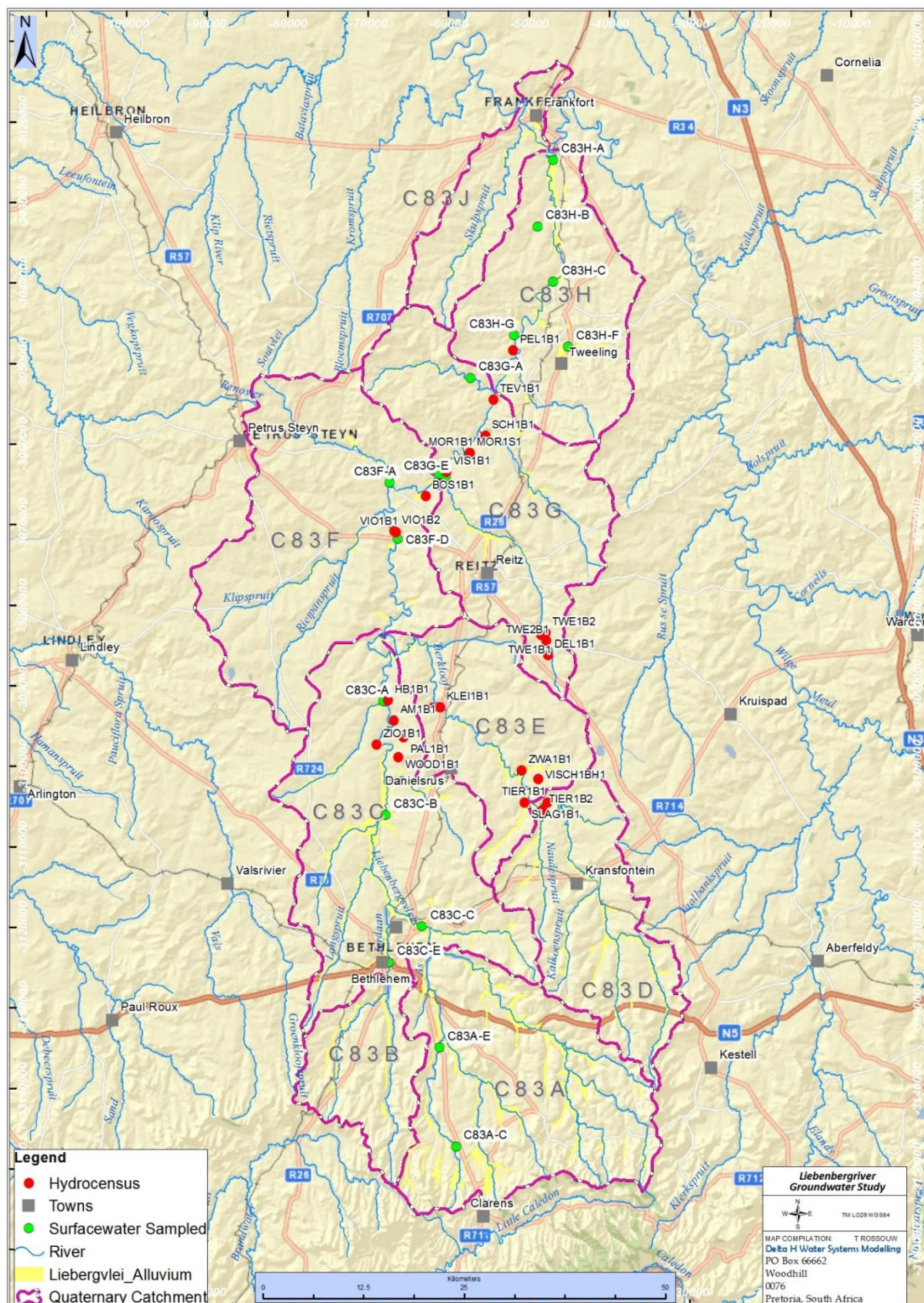


Figure 24: Location of the water sampling points (after Delta-H WSM, November 2015)

Table 11: Surface Water Sample Locations for chemical analysis

Sample Name	Latitude	Longitude
C83A-C	28.39723	-28.43947
C83A-E	28.37691	-28.32835
C83C-A	28.30835	-27.94016
C83C-B	28.31045	-28.06747
C83C-C	28.35564	-28.19263
C83C-E	28.31391	-28.23267
C83F-A	28.31759	-27.69529
C83F-D	28.32742	-27.75786
C83G-A	28.42043	-27.57822
C83G-D	28.38035	-27.68592
C83G-E	28.38872	-27.68904
C83H-A	28.52561	-27.33410
C83H-B	28.50579	-27.40892
C83H-F	28.54297	-27.54353
C83H-G	28.47561	-27.53064
C83H-C	28.52509	-27.47081

The water sample collected at C83F-D shows in comparison to the other samples a sodium-bicarbonate-chloride signature. Water sample C83F-D is located close to a number of irrigation point and return flows or other anthropogenic influences might explain the higher sodium and chloride concentrations.

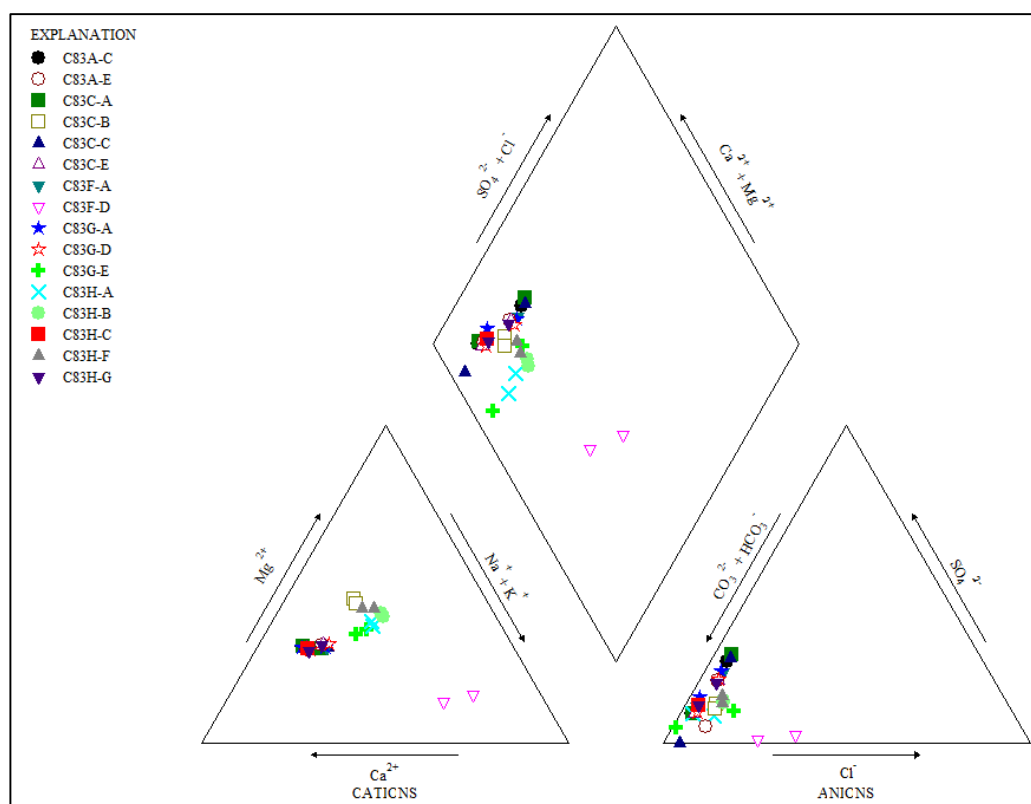


Figure 25: Piper diagram of surface water samples

Additionally to the surface water samples, 18 groundwater samples were collected during the groundwater hydrocensus survey. A summary of the boreholes identified during the hydrocensus is given in Table 12. A total of 17 groundwater level measurements were measured and range from 2.7 metres to ~51 metres below ground with an average water level of 10.5 metre below ground level (mbgl). Some of these water levels reflect pumping water levels. The full hydrocensus borehole list is included as Appendix F.

While generally higher mineralised than the surface water samples, most groundwater samples can still be described as a freshly recharged groundwater, which had limited time to equilibrate with the aquifer material along its flow path. The dominant calcium-magnesium-bicarbonate (Ca-Mg-HCO_3) water facies shown in the Piper plot (Figure 26) might be a result

- of the rainwater chemistry, limited weathering reactions and CO_2 equilibrium with the atmosphere and soil vapour for boreholes within the weathered aquifer further away from surface waters (mostly on slopes), or
- of hydraulic interaction with surface water for boreholes located in the alluvial aquifer next to the river (bank storage).

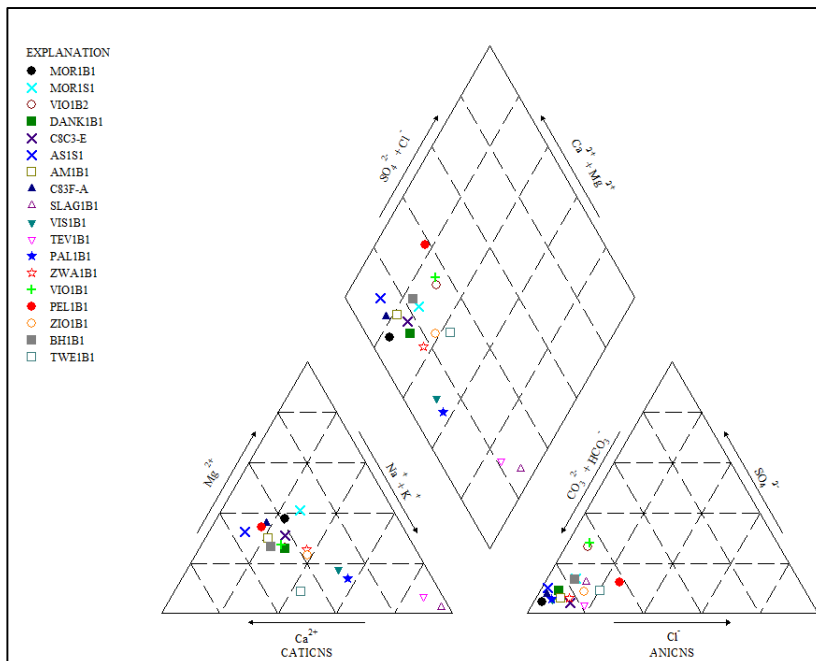


Figure 26: Piper diagram of groundwater samples

Groundwater samples SLAG1B1 and TEV1B1 show on the other hand a sodium-potassium cation dominance. Borehole SLAG1B1 is located on a dolerite dyke and the presence of secondary (weathered) minerals derived from the dolerite can explain the different cation signature. Water sample TEV1B1 was collected at a water storage tank, but there is no clear indication if the water is treated in the storage tank or if other anthropogenic influences could give rise to the different cations signature.

Table 12: Summary of borehole hydrocensus

Site ID	Lat	Long	Elevation (mamsl)	Distance from river/stream (m)	BH depth (m)	WL (m below measuring point)
HB1B1	-27.93897	28.31407	1609	320m from Liebenbergsvlei River		6.4
AM1B1	-27.9612	28.32131	1621	490m (870m downstream) from Liebenbergsvlei River	75.2	22.1
SLAG1B1	-28.05385	28.48597	1644	452m from Tierkloof River	12	7.4
TIER1B1	-28.05433	28.51466	1647	106m from Tierkloof River	±20	±7
TIER1B2	-28.06277	28.50837	1639	450m from the Tierkloof River	±20	±7
VISCH1BH1	-28.02801	28.50385	1663	1719m from the Tierkloof River		
TWE1B1	-27.86661	28.50789	1662	308m from the Langspruit to the east	24.4	
TWE2B1	-27.87272	28.51463	1667	132.46m from the Langspruit to the west	26.8	9.8
DEL1B1	-27.88895	28.51619	1676	483m from the Langspruit to the east	21.07	2.7
TWE1B2	-27.86353	28.51335	1676	297m from the Langspruit to the west		
DANK1B1	-27.69805	28.37822	1593	756m from the Liebenbergsvlei River to the west	29.8	20.1
VIS1B1	-27.68325	28.38975	1579	401m from Liebenbergsvlei River to the west	13.8	6.75
MOR1B1	-27.66231	28.41864	1560	726.39m from Liebenbergsvlei River and 30m from an unnamed stream	29.8	7.85
MOR1S1	-27.66219	28.41892	1557	Unnamed stream, 1435m from Liebenbergsvlei River		

Site ID	Lat	Long	Elevation (mamsl)	Distance from river/stream (m)	BH depth (m)	WL (m below measuring point)
SCH1B1	-27.64255	28.43848	1553	1.05km from Liebenbergsvlei River and 70m from a stream/river : "29649889"	27	
TEV1B1	-27.6024	28.4493	1544	90m from Liebenbergsvlei River	102	13.8
BOS1B1	-27.70982	28.36298	1569	588m from Liebenbergsvlei River to the north		
VIO1B1	-27.75028	28.32519	1571	13m from the Liebenbergsvlei River	16.7	10.5
VIO1B2	-27.74941	28.32362	1572	42m from the Liebenbergsvlei River	35.8	5.8
PEL1B1	-27.54732	28.47394	1556	285m from the Liebenbergsvlei River	19.8	11.8
KLEI1B1	-27.94681	28.37998	1608	402m from the Tierkloof River	11.7	6.5
KLEI1B2	-27.9472	28.37016	1638	604m from the Tierkloof River	61.1	51.3
WOOD1B1	-28.00244	28.32689	1652	1272m from the Liebenbergsvlei River	± 80	
PAL1B1	-27.9801	28.33343	1646	1700m from the Liebenbergsvlei River	39.2	15.1
ZIO1B1	-27.98859	28.29949	1624	334m from the Liebenbergsvlei River	43.3	21.85
ZWA1B1	-28.0182	28.48284	1630	19.48m from the Tierkloof River		18.28

The three surface water samples (represented by “X-symbols” in the piper diagram, MOR1S1, C8C3-E and AS1S1) retrieved during the hydrocensus show similar water chemistry signatures compared to the groundwater samples.

The groundwater samples were compared in I to the SANS 241, WHO and DWAF water quality standard guidelines and exceedances discussed below.

- Electrical conductivities for most of the samples (except samples AS1S1 and C83F-A) exceed the SANS 241 aesthetic (170mg/l) quality guideline limit.
- Nitrate concentrations for boreholes DANK1B1, VIO1B1, PEL1B1, ZIO1B1 and HB1B1 exceed the SANS 241 acute health (11mg/l) quality guideline limits. Borehole DANK1B1 and PEL1B1 are located near sheep enclosures, which might account for the elevated nitrate concentrations. Borehole sample VIO1B1 is used for rose gardening and the high nitrate concentration might be related to ill-practiced fertilizer use. There is no clear indication on the elevated nitrate concentrations for the samples collected at ZIO1B1 and HB1B1.
- Water sample TEV1B1 (not part of the hydrocensus) exceeds the chronic health limit for fluoride based on SANS 241 (1.5 mg/l), DWAF (1mg/l) and WHO (1.5mg/l) water quality guidelines.
- Iron concentrations for water samples C8C3-E and ZWA1B1 exceed the DWAF (0.1mg/l) domestic use water quality guidelines. Water sample ZWA1B1 was collected from a leaking pipe next to the borehole and rust can explain the elevated iron concentrations in the sample. Water sample C8C3-E is not described in the hydrocensus field notes.
- Manganese (Mn) concentrations in boreholes MOR1B1 and PAL1B1 exceed the DWAF (0.05mg/l) drinking water (0.05mg/l) quality guidelines.
- Water samples from boreholes AM1B1, TEV1B1 and PEL1B1 exceed lead concentration based on the SANS 241 chronic health (0.01mg/l) water quality guidelines. While boreholes TEV1B1 and PEL1B1 are located close to cattle or sheep farmsteads, no clear relation to the elevated lead concentration could be established.

5.1 WATER QUALITY TRENDS ALONG THE FLOW PATH

The electrical conductivity (mS/m) measurements from the surface water sample dataset were plotted from the upper to the lower river reaches of the main Liebenbergsvlei River to illustrate the change in conductivity along its flow path (Figure 27). The electrical conductivity increases slightly from 7.9 mS/m at the Ash River outlet (C83A-C) to 8.7 mS/m just above Frankfort (C83H-A).

Sample points at selected tributaries of the Liebenbergsvlei River show elevated conductivity values compared to the main river sample points (grey rows in Table 14), but fail to significantly increase the downstream electrical conductivity of the Liebenbergsvlei River due their negligible flow rates (and thereby mass fluxes) in comparison to the main stream.

Table 13: Water quality results for the hydrocensus samples showing major elements and element exceedance

Comments	Electrical Cond.	TDS	Turbidity NTU	Alkalinity as CaCO ₃	Chloride as Cl	Sulphate as SO ₄	Nitrate as N	Fluoride as F	Ca	Fe	K	Mg	Mn	Na	Pb
	mS/m	mg/L	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
WHO Standard for Drinking Water (2011)	N/A	N/A	N/A	N/A	N/A	N/A	11	1.5	N/A	N/A	N/A	N/A	N/A	N/A	0.01
DWAF (1996) Domestic	N/A	450	N/A	N/A	<100	<200	<6	<1	N/A	<0.1	N/A	N/A	<0.05	<100	<0.01
SANS 241 (2011) Operational	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SANS 241 (2011) Aesthetic	170	1200	5	N/A	300	250	N/A	N/A	N/A	0.3	N/A	N/A	0.1	200	N/A
SANS 241 (2011) Acute Health	N/A	N/A	N/A	N/A	N/A	500	11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SANS 241 (2011) Chronic Health	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.5	N/A	2	N/A	N/A	0.5	N/A	0.01
MOR1B1	558	248	11.2	338	6	13.15	<0.2	<0.0003	46.6	0.067	1.2	27.2	0.233	31.5	0.009
MOR1S1	589	307	5.9	300	19.3	36.06	3	<0.0003	43.5	<0.0002	3.1	33.7	-	40.3	-
VIO1B2	540	305	2.5	208	14	65.92	31.8	<0.0003	50.3	<0.0002	1.3	18	0.008	37.4	0.008
DANK1B1	396	179	25	211	8.9	17.72	8.2	<0.0003	37.9	<0.0002	2.7	13.2	0.008	27.5	0.006
C8C3-E	390	160	4.4	204	18.4	8	<0.2	<0.0003	35.2	0.119	2.9	15.7	-	24	-
AS1S1	90	15	2	50	0.6	4.54	0.7	<0.0003	9	<0.0002	0.5	3.2	-	2	-
AM1B1	464	230	0.8	244	14.2	13.66	9.8	<0.0003	48.4	<0.0002	0.9	18.1	<0.002	24.2	0.01

Comments	Electrical Cond.	TDS	Turbidity NTU	Alkalinity as CaCO ₃	Chloride as Cl	Sulphate as SO ₄	Nitrate as N	Fluoride as F	Ca	Fe	K	Mg	Mn	Na	Pb
	mS/m	mg/L	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
C83F-A	135	60	12.7	83	1.7	5.37	<0.2	<0.0003	13.3	0.027	1	6.3	-	5.5	-
SLAG1B1	604	277	1.4	323	25.2	29.32	<0.2	<0.0003	3.8	<0.0002	2.5	1.7	<0.002	140.6	0.008
VIS1B1	589	331	1	328	12.8	15.73	9.9	0.6	39.3	<0.0002	3.9	13.8	<0.002	74.4	0.006
TEV1B1	476	277	1	231	28.3	6.86	<0.2	3	6.9	<0.0002	0.4	4.3	0.025	103.6	0.014
PAL1B1	503	253	0.8	286	10.8	13.8	<0.2	0.6	32.5	0.032	2.2	9.4	0.003	72	0.007
ZWA1B1	537	278	1	284	22.7	16.34	<0.2	<0.0003	43.1	0.127	2.9	17.6	0.106	47.3	0.008
VIO1B1	529	308	0.8	196	13.1	66.91	35.8	<0.0003	49.7	<0.0002	1.1	18	0.012	34	0.007
PEL1B1	661	349	1.9	216	51.6	34.1	58.4	<0.0003	63.6	<0.0002	1.1	27.2	<0.002	25.5	0.013
ZIO1B1	717	379	33.6	318	37.3	28.4	45.6	<0.0003	59.9	<0.0002	12.3	22	0.006	62.3	0.007
HB1B1	549	302	0.6	260	19.5	35.46	11.6	<0.0003	57.5	<0.0002	1.7	18.8	<0.002	31.8	0.008
TWE1B1	428	215	1.6	191	32.6	18.69	<0.2	<0.0003	42.8	<0.0002	1.3	4.7	0.03	44.3	0.006

Table 14: Electrical conductivities of selected surface water monitoring points

Site #	S (Dec.Drg)	E (Dec.Drg)	EC @25C [mSm]	Comments
C83A-C	-28.43947	28.39723	7.48	LHTS Tunnel outfall
C83A-E	-28.32835	28.37691	7.6	
C83C-E	-28.23267	28.313913	49.2	Bethlehem
C83C-C	-28.19263	28.35564	7.85	
C83C-B	-28.06747	28.31045	8.1	
C83C-A	-27.94016	28.30835	8.14	
C83F-D	-27.75786	28.32742	8.46	
C83F-A	-27.69529	28.31759	35.2	Kalgemspruit
C83G-D	-27.68592	28.38035	8.18	
C83G-E	-27.68904	28.38872	87.3	Langspruit
C83G-A	-27.57822	28.42043	47.5	?
C83H-G	-27.53064	28.47561	8.76	
C83H-F	-27.54353	28.54297	57.5	?
C83H-B	-27.40892	28.50579	58.7	
C83H-A	-27.3341	28.52561	8.72	Upstream of the Liebenbergsvlei-Wilge Rivers confluence

A Whisker plot of minimum, maximum and median electrical conductivity values as observed over a 29 hour monitoring period at sample point C83C-A is overlain in Figure 27.

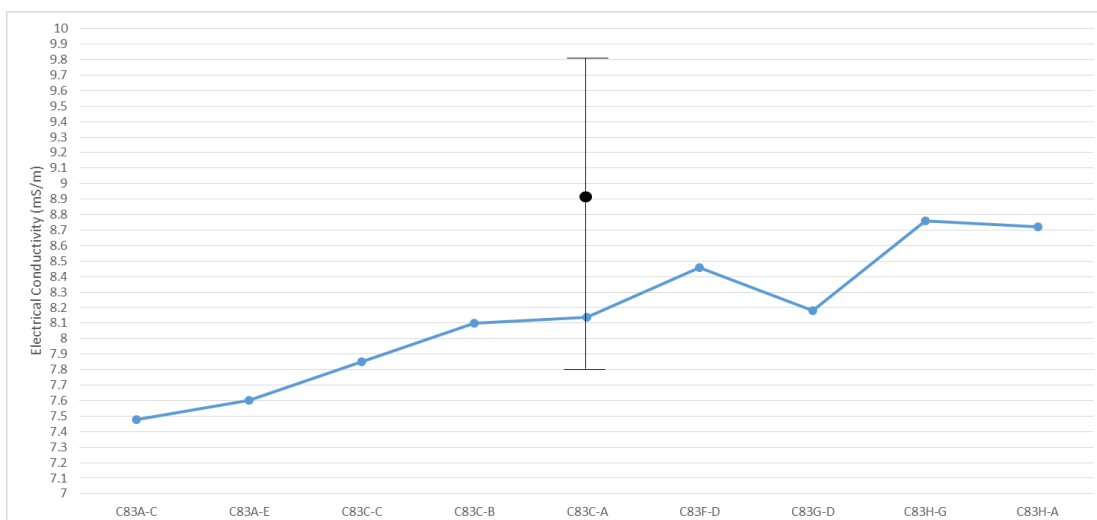


Figure 27: Electrical conductivity profile in the Liebenbergsvlei River and electrical conductivity monitoring at C83C-A

The daily variability of the electrical conductivity (EC), used as a proxy for the total mineralization (sic. ion activity) of the water, at a single monitoring point exceeds with a range of 2 mS/m the total variability of the EC along the river section under consideration (range of 1.28 mS/m).

Since the water samples of the Ash River and Liebenbergsvlei (Table 14) were taken at different times of the day, the observed slight increase in EC (from 7.48 to 8.76 mS/m) along the river section might therefore be a result of the daily variability in EC and not necessarily due to inflows from surface water tributaries or groundwater baseflow. The observed increases in EC along the flow section are therefore non-conclusive.

This is attributable to the substantial discharges of the Ash River and Liebenbergsvlei in comparison to potential contributions from the tributaries or groundwater baseflow. The dilution capacity of the river system masks simply any potential impact of limited mass fluxes from these.

5.2 PRELIMINARY WATER RESOURCES MONITORING RESULTS

At the onset of the study, an assessment of the operational water resources monitoring programmes and networks, were initiated. It became clear that no surface water flow/quality monitoring infrastructures have been installed on the major tributaries, such as the Langspruit and Tierkloof River that drains a large part of the study area from the eastern parts, i.e. quaternary catchments C83D, -E and -G.

There are seven (7) DWS gauging stations in the study area. Station C8H001 (Wilge River) at Frankfort represents flow from the Liebenbergsvlei and Wilge Rivers; thus a combination of flows from the LHTS and the Vaal-Tugela System. Two of the remaining six (6) stations, i.e. C8R004 and C8R005 are at the Loch Athlone and the Sol Plaatje Dams in the Jordaan and Liebenbergsvlei Rivers respectively – limited flow measurements are available at these C8R00X stations.

The detail of the positions and monitoring attributes of the DWS surface water monitoring programme/network in the study area is listed in Table 15.

Only five (5) flow-gauging stations are operational in the study area, including the Ash River LHTS tunnel outlet. Flow data from 1975 are available for gauging station C8H020 (Roodekraal in the Liebenbergsvlei River) and from C8H001 (Wilge River at Frankfort) since 1914.

Table 15: Detail of positions and monitoring attributes of the DWS Surface Water Monitoring Programme

Station No	Gauging In	Place Name	Latitude	Longitude	Sampling	Flow
			XX°XX'XX,X'	XX°XX'XX,X'	Frequency	Measurement
C8H001	Wilge River	Frankfort	27° 16' 19,0"	28° 29' 29,0"	Macro, Weekly	Yes
C8H020	Liebenbergsvlei River	Roodekraal	27° 41' 23,3"	28° 22' 30,8"	Macro, Ad Hoc	Yes
C8H026	Liebenbergsvlei River	Frederiksdal	27° 25' 51,6"	28° 31' 35,4"	Macro, Weekly	Yes
C8H036	As River (Tunnel Outlet From Katse)	Botterkloof	28° 26' 21,6"	28° 23' 50,4"	Macro, Ad Hoc	Yes
C8H037	Liebenbergsvlei River	Reward	27° 47' 45,5"	28° 19' 04,7"	Macro, Ad Hoc	Yes
C8R004	Liebenbergsvlei River	Saulspoort	28° 13' 01,9"	28° 21' 45,9"	Macro, Weekly	No
C8R005	Jordaan River	Wolhuterskop	28° 15' 00,3"	28° 18' 31,4"	Macro, Weekly	No

Surface water quality data for the gauging stations mentioned above is numerous and we're currently assessing the datasets for post-LHTS (1998) implementation as part of the surface water hydrocensus assessment.

In terms of groundwater, the only long-term time monitoring programme is that of DWS's National Groundwater Quality Monitoring Programme and a monitoring site close to Bethlehem, ZQMBTM1 are monitored biannually before and after the local wet season. This station is in operation for 21 years and the dataset is included in Appendix G, and schematically displayed in Figure 23 above.

During the initial information gap analysis, it was realised that a surface water quality monitoring network/programme that would cover a more detailed coverage of the surface water systems (main stem and tributaries) was required. The 27-Bridges Monitoring Network was therefore designed to monitor surface water parameters in the main stem and tributaries using the road bridges in the study area. This operation is regarded as a risk for the monitors and special health and safety provisions are required. Skills Transfer and Capacity Building exercises are linked to the LoP monitoring programme.

Monitoring runs were planned to include at least two sets of field parameter measurements and hydrochemical analyses for a "typical wet and dry cycle" of the hydrological year. The project started in July 2015 with a "dry cycle" monitoring run which was repeated six week later in August 2015 with the second "dry cycle".

The monitoring programme consists of the physical sampling of the surface water body at the monitoring sites and measurement of the physical water quality parameters (pH, electrical conductivity, oxidation-reduction potential, dissolved oxygen content and temperature). Flow indicator measurements were taken at each of the tributaries as an indicator of physical flows in the tributary. The field parameter measurements and water quality analyses of the July and August 2015 are included in Appendix H1 & H2 (covering the field parameters monitored for a typical "dry cycle" in July and August respectively) and Appendix I1 & I2 (covering the hydrochemical analyses for a selection of monitoring sites for the July and August 2015 "dry cycle").

The water quality results of the July and August monitoring runs indicated that the electrical conductivity values of the main stem and the tributaries are different with a factor of ~6-times. The results also indicated that the electrical conductivities changes along the main stem system are small (viz. ~1.5 mS/m), which are too small to indicate a considerable contribution of groundwater to the main stem at a particular moment, i.e. the two monitoring runs in July and August 2015.

In the light of these small electrical conductivity variances along the main stem of the Ask and Liebenbergsvlei River, a second water quality-monitoring programme was initiated covering a much shorter monitoring interval, i.e. a 24-hour or Diurnal Monitoring Programme. Monitoring Site C83C-A was selected and two monitoring runs were conducted in October and November 2015. The focus of this monitoring exercise was to measure the water quality on an hourly interval for a period of at least 24-hours. The following water quality parameters were logged:

- Electrical Conductivity (i.e. Specific conductance - 25°C);
- Temperature;
- Dissolved oxygen;
- Oxygen-Reduction Potential; and
- Total alkalinity (titrations done at the monitoring site on 3-hourly intervals).

The datasets for the October and November 2015 Diurnal water quality monitoring runs at Monitoring Site C83C-A are included in Appendix J (field observations on 13/14 October 2015), Appendix K (water quality multi parameter logging on 13/14 October 2015), Appendix L (alkalinity titrations on 13/14 October 2015), Appendix M (hydrochemical analyses of samples taken on the 13/14 October 2015,) and Appendix N (alkalinity and physical water quality analyses for samples taken on the 13/14 October 2015). The water quality data collated during the 2nd Diurnal monitoring run on Monitoring Site C83C-A on the 17/18 November are included in Appendix O (field observations on 17/18 November 2015), Appendix P (water quality analyses for samples taken on the 17/18 November 2015) and Appendix Q (alkalinity and physical water quality analyses for samples taken on the 17/18 November 2015).

The preliminary assessment of the Diurnal water quality analyses and field observation indicates that there is a diurnal water quality change which is probably related to day/night biological activities in the river water body, e.g. EC-values varied from a “high” value of 8.80 (11H00-17/11/2015) to a “low” value of 7.02 (03H00-18/11/2015). The daily EC-Values are illustrated in Figure 28 below. The daily EC-value variation between day-night is in the order of 2.2 mS/m which is very close to the tolerance of the conductivity meters generally used. This observation means that using the EC-values of the main stem water body to estimate where and at what volume groundwater is contributing to the total water balance in the study area, is difficult as the main stem is in a continuous flood condition with low-high flows between 17 and 34 m³/s.

The diurnal water quality variation was further investigated using other hydrochemical parameters such as the Total Alkalinity. This was achieved through physical TAL titrations at the C83C-A Monitoring Site during both diurnal monitoring runs. The TAL-values for the 13/14 October and 17/18 November diurnal monitoring runs are illustrated in Figure 29 and Figure 30.

The TAL-values of both diurnal monitoring periods indicates a daily fluctuation in the order of 50 to 65 mg/l TAL_{CaCO₃} which is probably related to cyclic day-night biological activity in the surface water bodies in the study area. The daily variations of this constituent will have to be further investigated during Q 3 (Field Survey) Phase.

Further investigations using the wider hydrochemical spectrum observed during the first and second 27-Bridges “dry cycle” monitoring runs and the data collated during the first and second Diurnal monitoring runs at Monitoring Site C83C-A will be addressed during the Q3 (Field Survey) Phase.

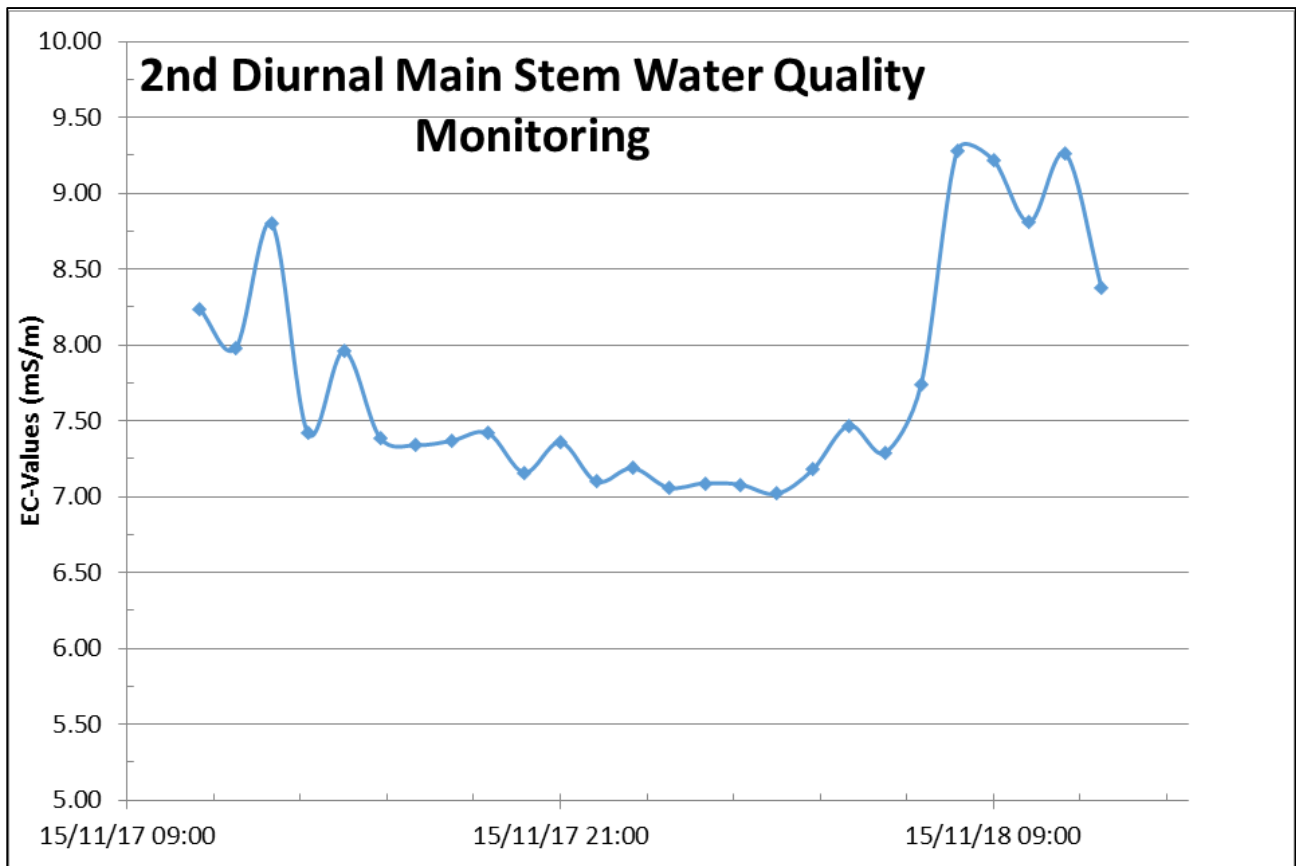


Figure 28 EC-Values during 2nd Diurnal monitoring run at Monitoring Site C83C-A on 17/18 November 2015

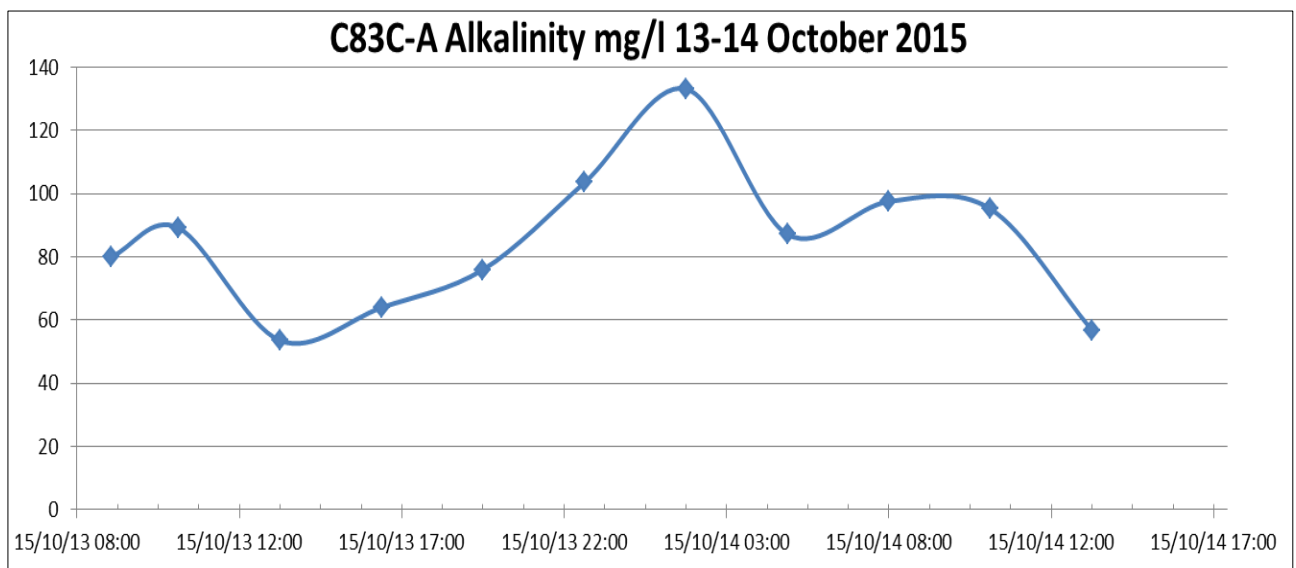


Figure 29 Total Alkalinity (TAL) titrations during 1st Diurnal monitoring run at Monitoring Site C83C-A

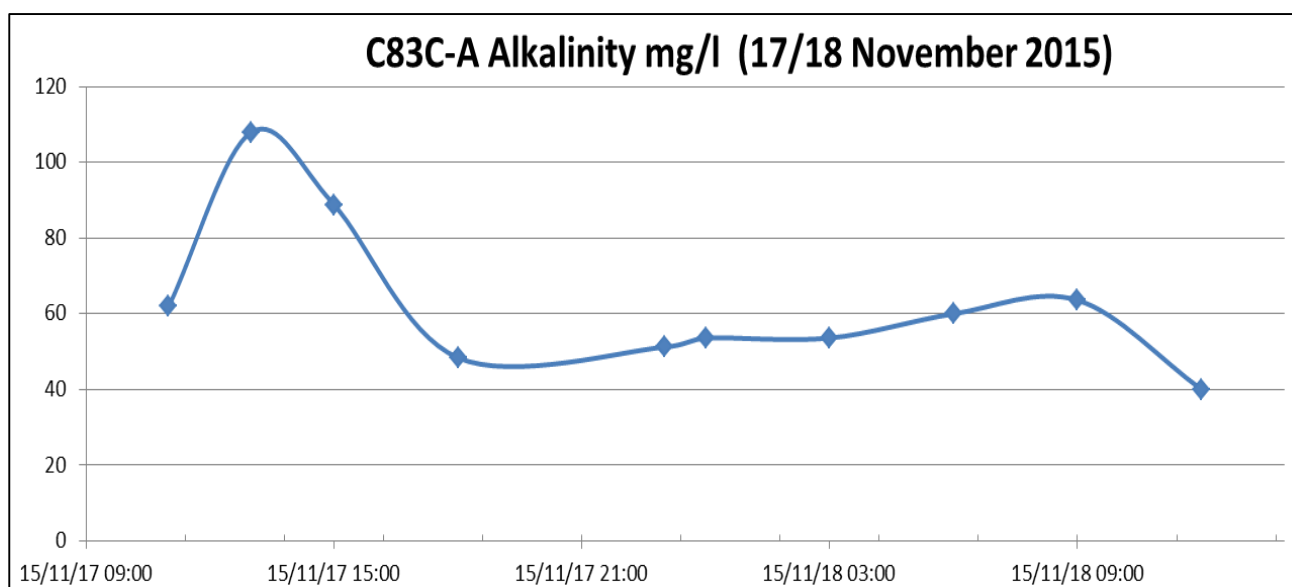


Figure 30 Total Alkalinity (TAL) titrations during 2nd Diurnal monitoring run at Monitor Site C83C-A

6. SURFACE WATER – GROUNDWATER MODELLING APPROACH

6.1 ANALYTICAL (MASS BALANCE) MODELLING PROGRESS

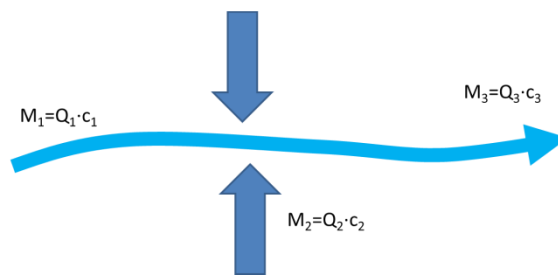
The analytical model is based on the salt load (mass balance) contribution between the LHTS Tunnel-outfall and the discharge mass balance and the confluence of the Liebenbergsvlei and Wilge Rivers at Frankfort.

The 27-Bridges Monitoring Programme indicates that the mass balance approach, based on the flow volume (Q in m^3/s) and the salt load concentrate (Total Dissolved Solids in mg/l , calculated from a numerical factor of 6.5) is not sensitive enough to evaluate the groundwater contribution to the main stem water supply.

The approach/theoretical background followed for this assessment is, however, discussed in detail below.

If it is assumed that an increase in mineralization (TDS) observed along a gaining river section is the sole result of diffuse groundwater leakage into the surface water body, the leakage rate of groundwater into can simply be estimated based on first principles (conservation of matter).

Neglecting evaporative concentration and rainfall, the mass flow rate M_3 (product of flow rate and concentration or mass of a solute which passes per unit time) at the downstream control point of a river section is the sum of the upstream mass flow rate M_1 and the mass flow rate M_2 due to leakage of groundwater into the river.



The leakage rate of groundwater into the river section can therefore be derived as follows:

$$M_3 = M_1 + M_2$$

$$Q_3 c_3 = Q_1 c_1 + Q_2 c_2$$

$$\text{Since } Q_3 = Q_1 + Q_2$$

$$(Q_1 + Q_2) c_3 = Q_1 c_1 + Q_2 c_2$$

$$Q_1 c_3 - Q_1 c_1 = Q_2 c_2 - Q_2 c_3$$

$$Q_1 (c_3 - c_1) = Q_2 (c_2 - c_3)$$

$$Q_2 = Q_1 \frac{(c_3 - c_1)}{(c_2 - c_3)}$$

Simply said, if the upstream mass flow rate M_1 (i.e. the discharge rate Q_1 and associated concentrations c_1) as well as the downstream concentration c_3 and the average concentration c_2 of a solute in groundwater are known, Q_2 can be determined.

While the mass balance is formulated above for a single solute of substance, it is in practice often applied using the electrical conductivity as a proxy for the total dissolved solute (TDS) content of a surface water body. This simplification is based on the assumption that the water type does not change significantly along the river section under consideration. In other words, the method assumes a uniform conversion factor between the electrical conductivity and TDS content, which is dependent on the ionic activity and thereby on the product of all ions and their activities in a solution.

If this assumption is not valid, the mass balance should be applied to the laboratory determined TDS values or individual solute concentrations only. This approach will be investigated during the Quarter 3 (Field Survey Reporting) Phase and will be based on the hydrochemical (laboratory) analyses collated during the Quarter 2 (Hydrocensus) Phase in greater detail.

Unfortunately at this stage, we should require a typical “wet cycle” water quality dataset to weigh if the groundwater contributions through the tributaries are not contributing a much higher influx into the main stem flow regime.

6.2 CONCEPTUAL MODEL OUTLINE

6.2.1 Regional Aquifer Systems

Three aquifer systems typically associated with the Karoo rocks, namely the upper weathered Karoo, the fractured Karoo and the fractured pre-Karoo aquifer. The pre-Karoo aquifer is not important in the context of the study and only the upper intergranular and fractured Karoo and fractured Karoo aquifers are discussed below.

6.2.2 Intergranular and Fractured Karoo Aquifer

Water levels are often shallow (few metres below ground level) and the water quality fresh due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments. The unconfined nature makes the aquifer also vulnerable to pollution. Localised perched aquifers may occur on clay layers or lenses and give rise to seeps and associated wetlands. Vertical infiltration of water in the weathered aquifer is typically limited by impermeable layers of sediments at the bottom of the weathered zone, with subsequent lateral water movement following topographical gradients. Groundwater often daylights at springs where the flow path is obstructed by dolerite dykes (contact spring) or paleo-topographic highs in the bedrock or where the surface topography cuts into the groundwater level at e.g. drainage lines (free draining springs).

6.2.3 Fractured Karoo Aquifer

The fractured Karoo aquifer consists of the various lithologies of siltstone, shale and sandstone. Groundwater flow is governed by secondary porosities like faults, fractures, joints, bedding planes or other geological contacts, while the rock matrix itself is considered impermeable. Geological structures are generally better developed in competent rocks like sandstone, which subsequently show better water yields than the less competent silt- or mudstones and shales. Not all secondary structures are water bearing due to e.g. compressional forces by the neo-tectonic stress field overburden closing the apertures. While fractured Karoo aquifers have typically a low hydraulic conductivity, they are highly heterogeneous with yields ranging from 0.1 to 2 L/sec. Higher yields are typically associated with higher hydraulic conductivities along dyke/sill contacts. The contact zones of dolerite dykes and sills with the host rock provide preferential flow paths, while the dolerite itself is rather impermeable or semi-permeable. This setting promotes groundwater flow along, but not across the dykes or sills. Depending on the residence time of the water in the aquifer, groundwater quality can be poor. The regional tectonic history, especially the intrusion of dolerite dykes and sill along with the geological formations control groundwater occurrence and aquifer productivity in the study area.

6.2.4 Aquifer Classification

Based on the aquifer classification map by Parsons and Conrad (1998), the aquifer system underlying the study area is regarded as being a “poor to minor aquifer”. The northern part of the study area, associated with the rocks of Normandien formation and intruded Karoo dolerites is regarded as a poor, while the central to southern part of the study area, less intruded with Karoo dolerites, is regarded as a minor aquifer system. A summary of the classification scheme is provided in Table 16. In this classification system, it is important to note that the concepts of Minor and Poor Aquifers are relative and that yield is not quantified.

Based on the 1:500 000 hydrogeological map sheets 2628 and 2828, the study area is located on a

poor to minor, intergranular & fractured and fractured aquifer system with potential groundwater yields up to 2 litres a second (i.e. a moderately yielding aquifer of acceptable quality water).

Table 16: Aquifer classification scheme (Parsons, 1995; Parsons and Conrad, 1998)

Sole source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources, should this aquifer be impacted upon or depleted.
Major aquifer region	High-yielding aquifer of acceptable quality water.
Minor aquifer region	Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor quality water.
Poor aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer that will never be utilised for water supply and that will not contaminate other aquifers.

The above-mentioned conceptualisation is based on the region context of the study area, however, when focussing down to the drainage valleys and the hydrogeological conditions in those channels, the conceptual model consists of a simple bedrock basement (Karoo Supergroup formations as described above (i.e. intergranular & fractured or fractured only).

A local conceptual model of a typical river channel section is schematically presented in Figure 31. The presentation shows a 100-200 m wide incised flood plain; filled with a soft, fine silty alluvial deposit (based on the NGA borehole descriptions and field observations by the study team on the 17th November 2015) and an incised river channel. The depth of these alluvial incisions varies and especially in the tributaries, the river channel incision cuts into the basement consisting of Karoo formations and in some cases Karoo Dolerite. According to the NGA Borehole Lithology dataset the median thickness of the alluvium-gravel combination in the study area is ~9 m, although thicknesses in excess of 15 m have been noted in the NGA dataset.

In Figure 31 a set of hypothetical boreholes are placed (i) Borehole C inside the alluvial flood plain with hypothetical water levels indicated at depths 1 and 2, (ii) Borehole B just outside the flood plain area with hypothetical water levels indicated as 1 and 2, and (iii) Borehole A situated in the background not further than 500 m from the flood plain area and drilled into a typical Karoo aquifer as indicated in Table 9 above. A simple application of this conceptual model for the surface water – groundwater interaction would be to observe the water levels indicated as ① and ② at the borehole positions A, B and C. In the case of boreholes A and B with water level elevations ①, the groundwater gradient is towards the river channel and depending on whether there is a hydraulic link between the aquifer systems (e.g. the underlying sandstone/arenite), the river will be a “gaining system”. In case of water levels ② in borehole A and B, the river will be a “losing system” and depending on whether a hydraulic link between the river channel and the local groundwater aquifer systems exists. The most appropriate assessment mechanism in these cases is to have a system of continuous water level logging at various distances from the main stem (i.e. with a waterlevel eLogger, operating on a 1-hour interval). Secondly, obtaining water samples from the boreholes and compare that with the river water hydrochemical signatures, will be a recommendation – this is in fact what was the main focus of the November 2015 Hydrocensus Survey on the project.

The hydraulic continuity in the flood plain region as indicated in Figure 31 is different from a river channel – local aquifer interaction as discussed above. The hydraulic connectivity between the basement of the channel (in this scenario, a weathered mudrock) and the flood plain deposits might

be rather complex interlayered lenses of clay, siltstone (low hydraulic permeabilities), or gravel lenses (with high hydraulic permeabilities). From observations done along the main stem and tributaries, it is expected that high, permeable gravel beds will not be present due to the “soft rock” nature of the Karoo mudrock/sandstone sediments in the study area.

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River Channel Conceptual Model

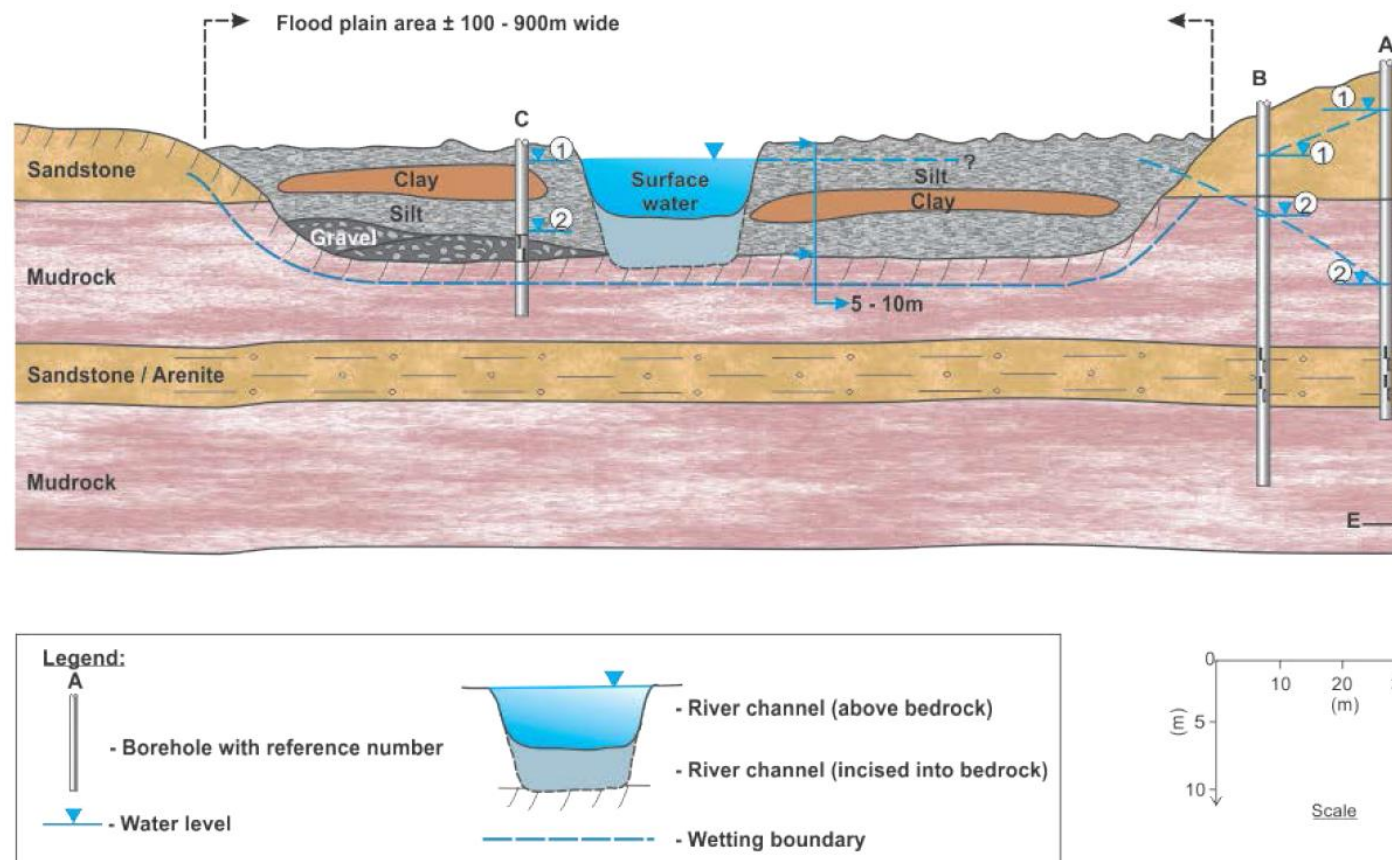


Figure 31 Local river channel conceptual model

However, in the case of borehole C, waterlevel ① or ② could indicate a hydraulically linked system (①), or hydraulically non-linked (②) and groundwater driven flood plain aquifer system. As with boreholes A and B cases, continuous eLogger logging of the water levels in the river channel (variations in flow) and boreholes technically intercepting the basement aquifers (weathered mudrock or sandstone arenite as indicated in Figure 31.

To conclude, the actual depth of the river channel is another important factor that needs to be considered in this surface water – groundwater evaluation on the scale of a river flood plain hydraulic perspective. This aspect will be addressed in the Quarter 3 (Field Survey) Phase during the numerical model scenario simulations.

The contribution of so-called “bank storage” is a hydraulic principle that needs to be included in this study. During the LHTS shut-offs, releases from the bank-storage in the flood plain aquifer system, over the length of the river, may contribute a significant volume of water in a river channel. One such “tunnel shut-off” was recorded in 2012 – assessment of these short-term observations will be included in the Quarter 3 (Field Survey) Phase.

The above-mentioned model was the focus of the November 2015 groundwater hydrocensus; thus the instruction was to locate a similar grouping of boreholes in and next to the main stem Liebenbergsvlei River flood plain based on the NGA borehole coverage as indicated in Figure 22 above. The reasoning for the borehole setup was to obtain groundwater levels as close as possible to the main stem river channel, with at least one borehole situated at the main stem boundary (i.e. borehole B’s position) and one in the flood plain area of the main stem, i.e. borehole C’s position.

Two cases were found comparable with the positions of boreholes B, several boreholes comparable to borehole A’s position, but unfortunately, none comparable to borehole C’s position could be located in the allocated hydrocensus survey slot.

Two Hydrocensus Boreholes VIO1B1 and VIO1B2 are situated 13 m (i.e. borehole position B) and 42 m (borehole position A) respectively from the Liebenbergsvlei River on the Farm Violet (No. 660); their water levels were 10.5 m and 5.8 m respectively during the November 2015 hydrocensus survey. The field conditions at the site fit therefore the borehole A-① and borehole B-② scenario. According to the conceptual model indicated in Figure 31, a gradient of ~6 m (corrected to piezometric levels, metre above mean sea level based on Google Earth elevations) occurs between the two boreholes directed towards the Liebenbergsvlei River – implying a gaining river system at this site.

Unfortunately, the hydrocensus survey located one set of boreholes fitting the local conceptual model. Secondly, accurate surveying of the Violet site is required to calculate to actual piezometric gradient value at this site.

6.3 NUMERICAL MODELLING OUTLINE

6.3.1 Computer Code

The software code chosen for the numerical finite-element modelling work was the 3D groundwater flow model SPRING, developed by the delta h Ingenieurgesellschaft mbH, Germany (König, 2011). The program, formerly known as SICK 100, was first published in 1970, and since then has undergone a number of revisions. The current saturated and unsaturated program module SPRING-SITRA is based on the well-known SUTRA model (Voss, 1984). SPRING is widely accepted by environmental scientists and associated professionals. SPRING uses the finite-element

approximation to solve the groundwater flow equation. This means that the model area or domain is represented by a number of nodes and elements. Hydraulic properties are assigned to these nodes and elements and an equation is developed for each node, based on the surrounding nodes. A series of iterations are then run to solve the resulting matrix problem utilising a pre-conditioning conjugate gradient (PCG) matrix solver for the current model. The model is said to have “converged” when errors reduce to within an acceptable range. SPRING is able to simulate steady and non-steady flow, in aquifers of irregular dimensions.

6.3.2 Governing Equations

SPRING solves the stationary flow equation independent of the density for variable saturated media as a function of the pressure according to:

$$-\nabla(K_{ij}\nabla h) = -\nabla\left(K_{perm}\frac{\rho g}{\mu}\nabla h\right) = q = -\nabla\left[\frac{K_{perm} \cdot k_{rel}}{\mu}(\rho g\nabla z + \nabla p)\right]$$

$$\nabla \quad \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$$

q Darcy flow

K_{ij} Hydraulic conductivity tensor

ρg Density · gravity

K_{perm} Permeability

μ Dynamic viscosity

k_{rel} Relative permeability

p Pressure

The relative hydraulic conductivity is hereby calculated as a function of water saturation, which in turn is a function of the saturation:

$$k_{rel}(S_r) = (S_e)^l \left[1 - \left(1 - (S_e)^{\frac{1}{m}} \right)^m \right]^2$$

$$S_e = \frac{S_r(p) - S_{res}}{S_s - S_{res}} = \left[1 + \left(\frac{p_c}{p_e} \right)^n \right]^{\frac{1-n}{n}}$$

$S_r(p)$ Relative saturation dependent on pressure

S_e Effective saturation

l Unknown parameter, determined by van Genuchten to 0.5

m equal to $1 - (1/n)$

n Pore size index

S_{res} Residual saturation

S_s Maximum saturation

p_c Capillary pressure

p_e Water entry pressure

Solving these equations for the relative saturation as a function of the capillary pressure $S_r(p_c)$ results in the capillary pressure- saturation function according to the Van Genuchten (1980) model as used in SPRING:

$$S_r(p_c) = S_{res} + (S_s - S_{res}) \cdot \left[1 + \left(\frac{p_c}{p_e} \right)^n \right]^{\frac{1-n}{n}}$$

The water entry pressure is a soil specific parameter and defined as the inverse of $a = 1/p_e$ in the saturation parameters.

The density independent, transient flow equation for variable saturated media as a function of the capillary pressure is given as follows:

$$\rho \left(S_r(p_c) S_{sp} + \theta \frac{\partial S_r(p_c)}{\partial p} \right) \frac{\partial p}{\partial t} + \theta S_r(p_c) \frac{\partial \rho}{\partial t} - \nabla \left[\rho \frac{K_{perm} k_{rel}}{\mu} (\nabla p + \rho g \nabla z) \right] = q$$

The specific pressure dependent storage coefficient S_{sp} is hereby given as

$$S_{sp} = \alpha(1 - \theta) + \beta\theta$$

- α Compressibility of porous media matrix
- β Compressibility of fluid (water)
- θ Aquifer porosity

The transport equation for a solute in variably saturated aquifers is given as follows:

$$\theta S_r(p_c) \frac{\partial c}{\partial t} + \theta S_r(p_c) v \nabla c - \nabla (\theta S_r(p_c) (D_m \bar{\mathbf{1}} + D_d) \nabla c) = qc^* + R_i$$

- qc^* Volumetric source/sink term with concentration c^*
- D_m Molecular diffusion
- $\bar{\mathbf{1}}$ Unit matrix
- D_d Hydrodynamic dispersion
- R_i Reactive transport processes (sorption, decay, etc.)

The software is therefore capable to derive quantitative results for groundwater flow and transport

problems in the saturated and unsaturated zones of an aquifer.

6.3.3 Equations describing Surface-Groundwater Interaction

Surface-groundwater interaction is in groundwater flow models commonly described with a third type or Cauchy boundary condition, whereby mathematically a relation between value of a function and its derivative (e.g. flow rate) is specified. In the case of surface-groundwater interaction, the value of the function represents the head whereas the derivative of the function represents the gradient, which in combination with Darcy's law gives a flow rate. The specific flux q (per unit area) is then directly proportional to the head gradient between a surface water course and groundwater.

$$q = -k\Delta h = \alpha(h_{WCL} - h_{GWL})$$

Depending on the prevailing gradient, a river might receive (gaining stream or effluent groundwater conditions) or lose (losing stream or influent groundwater conditions) water from the aquifer (Figure 32). While perennial streams are primarily effluent, ephemeral streams are primarily influent. Several other cases might be differentiated, like a disconnected or perched losing river (groundwater head falls below the base of the river) or a flow-through river which is simultaneously gaining and losing water due to different head gradients on either bank.

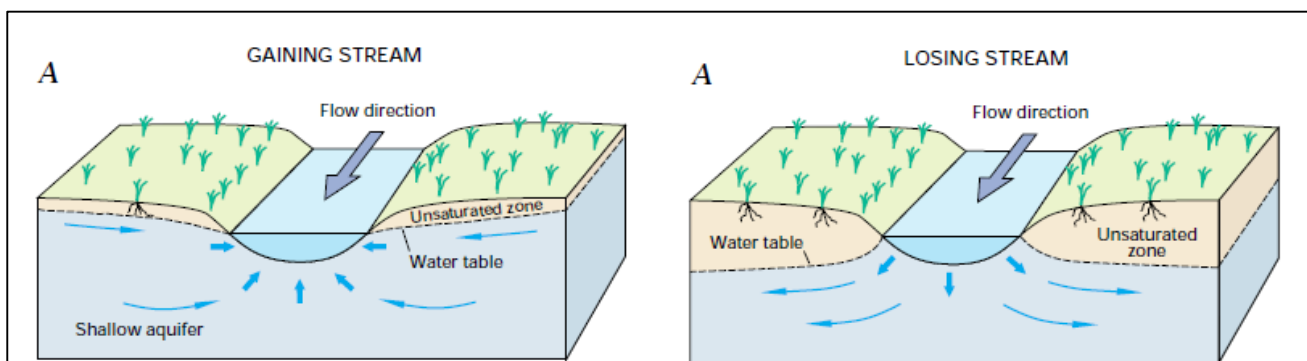


Figure 32 Conceptualisation of surface-groundwater interactions (Winter et al. 1998)

The rate at which a river gains or loses water is determined by the presence and conductivity of streambed sediments or colmation layers. The vertical streambed leakage coefficient α [1/s] is hereby defined as the ratio of the hydraulic conductivity of streambed sediments k_f divided by its thickness d , and usually differs for effluent and influent conditions:

$$\alpha = \frac{k_f}{d}$$

In other words, the direction of the flow and the flow rate between a surface water body and the aquifer is determined by the mostly linear relation between the watercourse level h_{WCL} in the surface water and the groundwater level h_{GWL} , and the corresponding function called the leakage function (Figure 33).

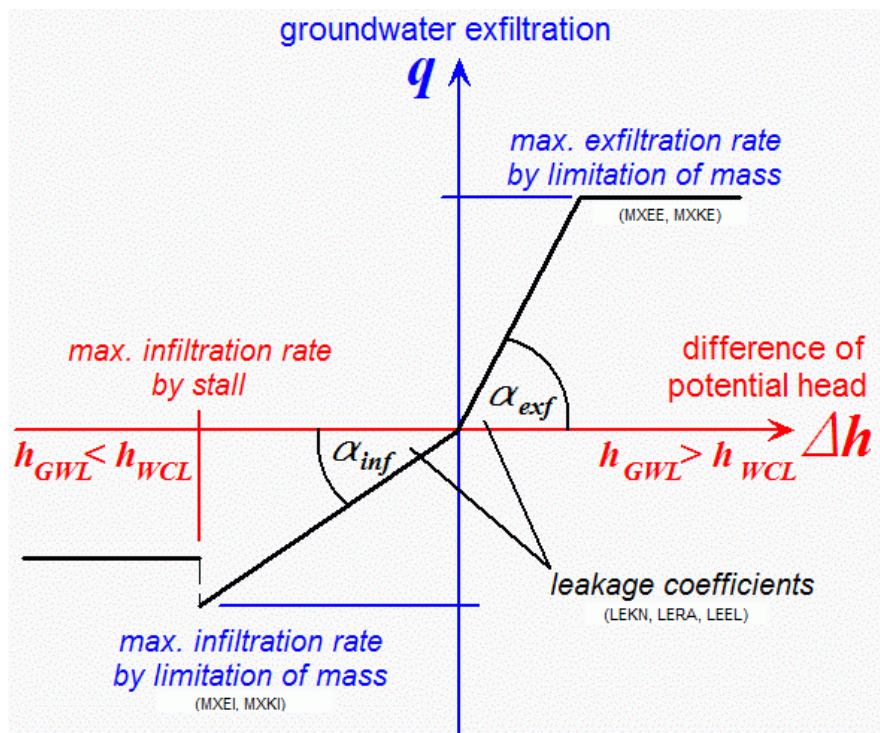


Figure 33 Schematic representation of the leakage function (König 2011)

Once the groundwater levels fall below the stream bottom and the stream becomes disconnected or perched, the river losses reach a maximum rate, which will not be exceeded regardless of further increases of the head difference. Bouwer and Maddock (1997) estimated that the losses from a losing river (influent conditions) reach already a maximum when the depth to the groundwater-table is greater than twice the river width. For certain situations, limiting the exfiltration rate might also be required.

While the chosen software code allows generally defining different leakage rates and limits for influent and effluent conditions, lack of data, especially for larger scale models, often precludes such detailed differentiation of the leakage function.

6.3.4 Model Domain

The Upper Vaal groundwater model domain covers a surface area of around 4831 km² and entails eight quaternary catchments (Figure 34), namely C83A, C83B, C83C, C83D, C83E, C83F, C83G, and C83H. A brief hydrological overview of the quaternary catchment based on the surface-groundwater assessment part of the GRAII project by the Department of Water Affairs and Sanitation is given in Table 17.

The model boundaries follow generally the quaternary surface water catchment boundaries along topographical highs, which are considered to represent also groundwater divides or natural flow boundaries based on the observed correlation between water table and surface elevation (Figure 35).

Table 17: Hydrological overview of the quaternary catchment (data source: GRA II by DWAF, 2005)

Quat	Area	MAP	Baseflow after			Recharge	Baseflow	Aquifer Recharge	GW Baseflow	Interflow	GW outflow
			Schultz	Pittman	Hughes						
	km ²	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a
C83A	746	691	4.89	10.9	17.45	18.33	16.94	11.08	9.44	7.50	0.10
C83B	251	667	4.56	9.2	14.83	15.94	14.53	11.08	9.05	5.47	0.29
C83C	828	662	4.20	9	13.23	14.28	12.91	10.70	8.65	4.25	0.09
C83D	465	649	4.22	8.1	13.14	14.22	12.83	10.75	8.68	4.15	0.16
C83E	426	653	4.08	8.5	12.42	13.57	12.24	10.64	8.46	3.77	0.17
C83F	875	636	2.58	8.6	12.27	13.42	10.67	8.85	6.53	4.12	0.08
C83G	695	646	2.71	9.1	13.42	14.46	11.60	8.96	6.75	4.83	0.11
C83H	547	646	2.69	8.9	13.37	14.04	11.47	8.74	6.41	4.93	0.13

The finite-element model was set-up as a three-dimensional groundwater flow model. In view of the capabilities of the used software to simulate outcropping layers, the layers were arranged to represent the conceptual model, i.e. the weathered, alluvial and fractured aquifers. The layer used to represent the alluvial sediments is therefore only present along the main surface water courses and not present throughout the model domain.

The model domain was spatially discretized into 123 006 nodes on four node layers, which make up three element layers with 153 832 elements (triangles and quadrangles) each. The horizontal element size (side length) varies from a minimum of 15 m along certain river sections to a maximum of 300 meters (Figure 34) further away from areas of expected steep groundwater gradients. The spatially variable discretization of the finite-element model domain allows to accurately incorporating the surface water features in the regional Upper Vaal groundwater flow model.

6.3.5 Groundwater Elevations and Flow Directions

One hundred seven (107) water levels were collated from boreholes over the study area, which includes monitoring data from the 2015 hydrocensus by the project team as well as data from the National Groundwater Archive (NGA). Water levels range from 1 mbgl to 55 mbgl, with an average of only 16.2 mbgl, suggesting that most of the boreholes measure the upper weathered aquifer. A plot of the groundwater table against surface elevation data for all boreholes (Figure 35) shows a correlation of 98% (Pearson product moment correlation coefficient $R^2 = 0.98$), indicating that the shallow regional water levels mimic surface topography within the study area and groundwater flows from higher lying ground towards lower lying ground and potentially into drainage systems (natural streams).

The observed correlation is used to improve the interpolation of initial water levels for the numerical model in data scarce environments by applying co-kriging based on known topography (Bayesian interpolation). A groundwater piezometric map was interpolated from the collated measured shallow water levels using Bayesian interpolation, based on the established correlation between surface topography and groundwater levels. The Bayesian interpolation method uses correlated data to improve the spatial interpolation of the unknown variable, in this case the groundwater level. As a Universal Kriging algorithm, it relies on a mathematical description of the change (or variance) of a variable with distance, i.e. to what extent neighboring observations are spatially correlated. Such correlation is expressed in a semi-variogram, as depicted in the empirical semi-variogram for the Upper Vaal study area below (Figure 36) with the fitted Bayesian model used for the interpolation. The semi-variogram model is then used in combination with the knowledge of the surface elevation and its correlation to the groundwater elevation as a qualified guess to improve the spatial interpolation of water levels.

The interpolated (unconfined) groundwater piezometric map using Bayesian interpolation (with the model parameters given above) is shown in Figure 37 and was subsequently used as initial heads for the model calibration. It must be noted that initial heads only accelerate the mathematical convergence of a steady-state model, but do not change the outcome of the model i.e. the calculated steady-state heads.

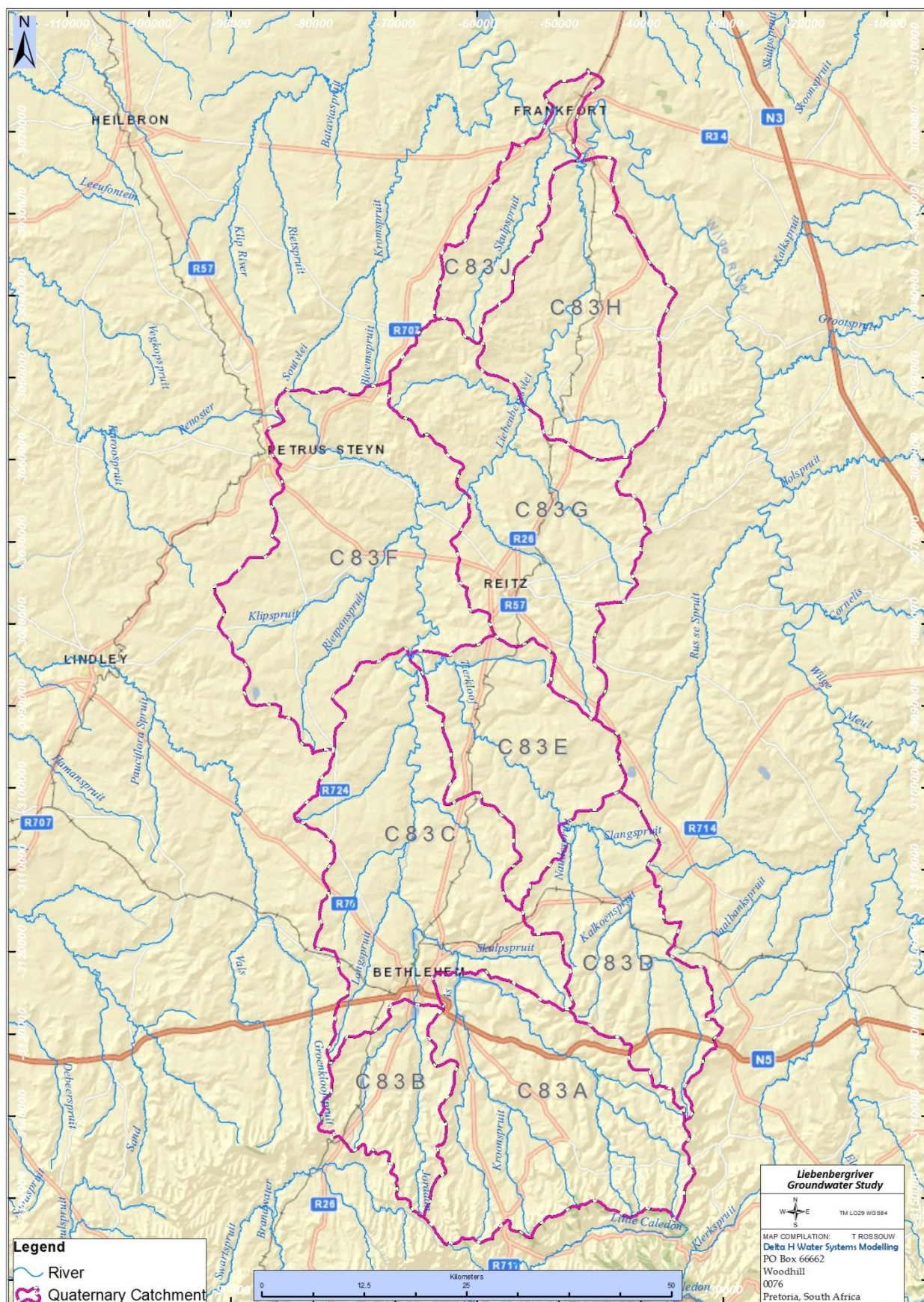


Figure 34: Upper Vaal groundwater model domain (after Delta-H WSM, November 2015).

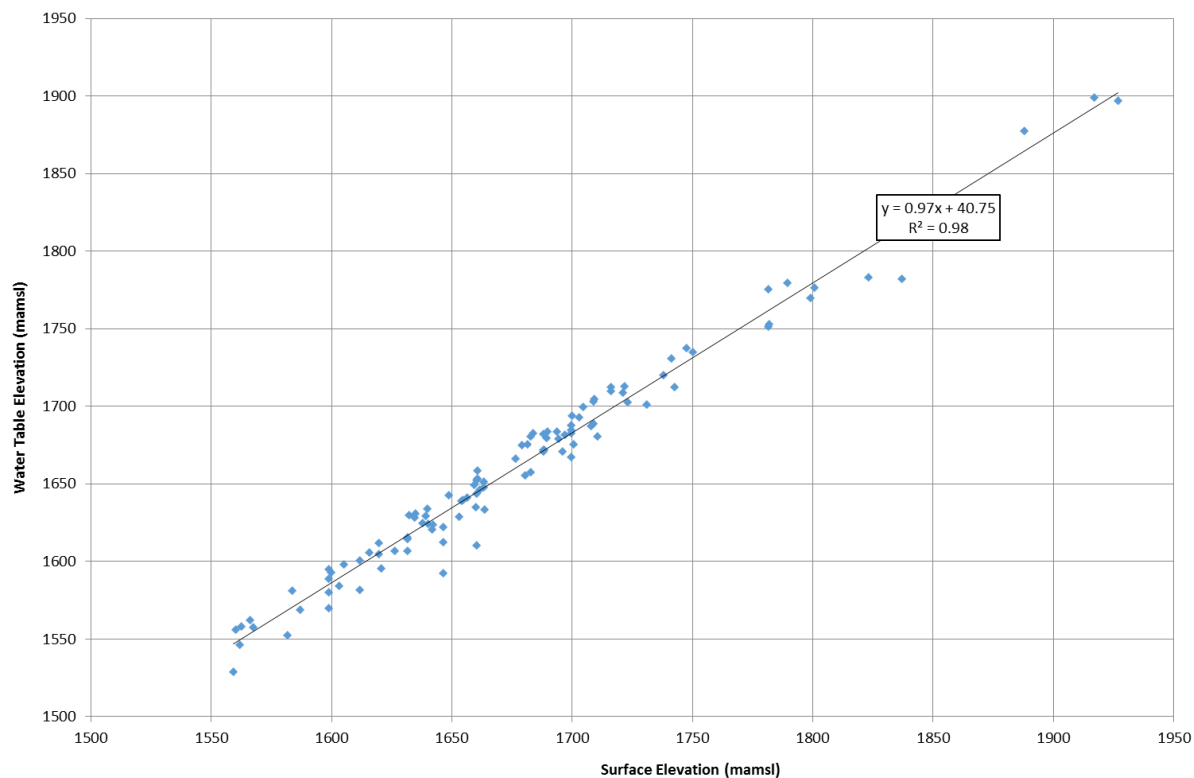


Figure 35: Correlation between surface topography and groundwater elevation in the Upper Vaal study area

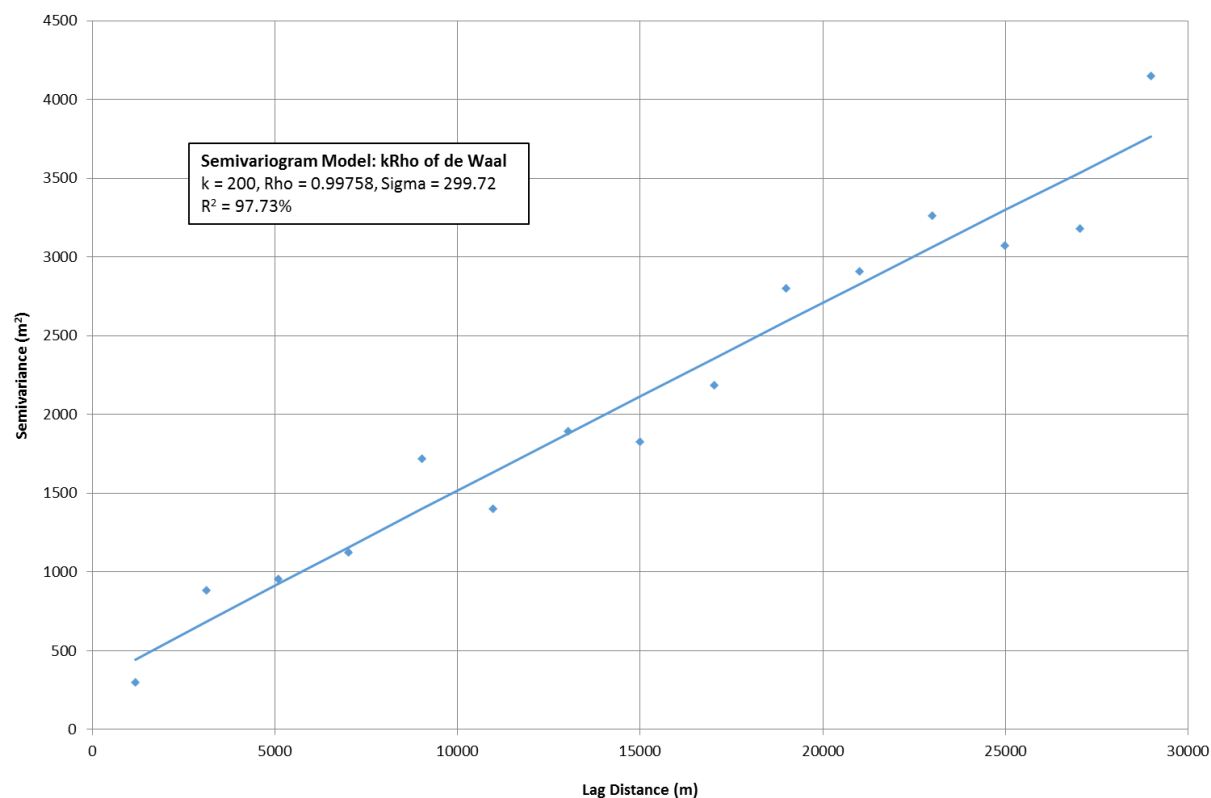


Figure 36: Empirical semi-variogram and fitted Bayesian model for the Upper Vaal study area

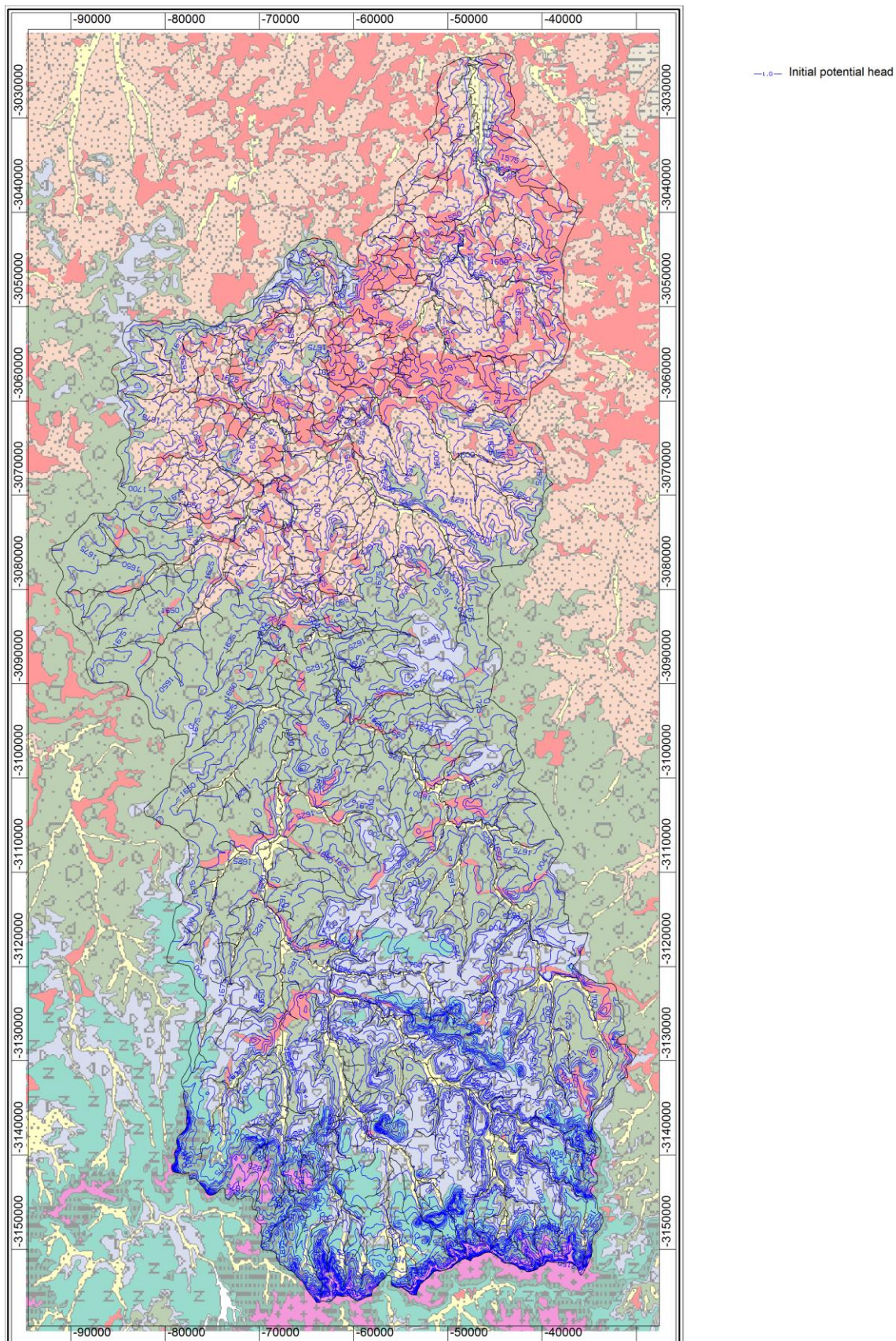


Figure 37: Initial water levels for the Upper Vaal study area (after Delt-H WSM, November 2015)

6.3.6 Sources and Sinks

6.3.6.1 Groundwater Recharge

The groundwater recharge rates, as estimated by the hydrological working group of the GRAII project by the Department of Water Affairs and Sanitation (Table 17, column “Recharge”) were assigned to the top layer of the different quaternary catchments of the model domain. The rates were considered fixed for the calibration of the model.

6.3.6.2 Groundwater Abstractions

Groundwater abstractions of 30 boreholes as registered in the WARMS database (Table 18) were assigned in the model setup. In the absence of verified abstraction rates, it was assumed that the registered use represents actual use.

Table 18: Registered groundwater abstractions (source: WARMS database)

Register_No	X-Coord	Y-Coord	WU_Sector	Type	Date	Volume (m³/a)
10002597	-50949.8	-3146206	Agriculture: Watering Livestock	Borehole	2002-04-01	4000
10002837	-69408.8	-3112531	Agriculture: Irrigation	Borehole	2002-04-01	18616
10003836	-62827.5	-3126589	Agriculture: Irrigation	Borehole	2002-04-01	5604
10004764	-68690.9	-3113973	Agriculture: Watering Livestock	Borehole	2002-04-01	2900
10004906	-62197.7	-3129175	Agriculture: Irrigation	Borehole	1980-01-01	5750
10004960	-69405.6	-3112537	Agriculture: Irrigation	Borehole	2002-04-01	46973
10005353	-56539.2	-3027264	Agriculture: Irrigation	Borehole	2002-04-01	200500
10005399	-50047	-3050805	Industry (Urban)	Borehole	2009-04-01	1095
10006352	-43662.4	-3054297	Agriculture: Irrigation	Borehole	2002-04-01	121500
10010891	-41218.7	-3046901	Agriculture: Irrigation	Spring/Eye	2002-04-01	213487.6
10015388	-47754.2	-3059852	Agriculture: Irrigation	Borehole	2002-04-01	6100
10015798	-46847.1	-3046152	Industry (Non-Urban)	Borehole	2002-04-01	12775
20001908	-62368	-3096547	Industry (Non-Urban)	Borehole	2010-01-01	1825
20003087	-72062.9	-3051784	Agriculture: Irrigation	Borehole	2002-04-01	12200
20003915	-50538.3	-3114960	Agriculture: Irrigation	Borehole	2002-04-01	13950
20013478	-48239	-3014572	Industry (Non-Urban)	Borehole	2002-04-01	1825
20016144	-76981.7	-3119103	Agriculture: Irrigation	Borehole	2008-10-01	12253
20020790	-68764.4	-3127876	Industry (Non-Urban)	Borehole	2002-04-01	1825
20021245	-64964.6	-3117492	Industry (Non-Urban)	Borehole	2002-04-01	5810
20030093	-82795.7	-3063950	Industry (Urban)	Borehole	1969-01-01	21900
20037899	-34231.9	-3145256	Industry (Urban)	Borehole	2007-07-01	5760
20038807	-60497.8	-3129996	Industry (Non-Urban)	Borehole	2002-04-01	277
20039129	-50802.5	-3047228	Industry (Urban)	Borehole	2002-04-01	263
20042268	-60295.2	-3059329	Industry (Urban)	Borehole	2006-01-01	1153
20042366	-63044.1	-3146164	Industry (Non-Urban)	Borehole	2007-03-01	335
20042918	-39127.9	-3037492	Industry (Urban)	Borehole	2011-06-01	21600
20043025	-50610.4	-3077943	Industry (Non-Urban)	Borehole	2012-11-01	10950
20044159	-39836	-3042006	Industry (Urban)	Borehole	2012-03-01	3600
20044239	-47838	-3050444	Industry (Non-Urban)	Borehole	2012-03-01	3600
20044809	-57325.6	-3078761	Industry (Non-Urban)	Borehole	2012-11-01	2250

6.3.7 Surface waters

Water leaves the model domain via numerous perennial and non-perennial rivers. A river or 3rd type (Cauchy) boundary condition was assigned to the streams and river courses within the model domain whereby the leakage of groundwater into the river (or vice versa) depends on the prevailing gradient.

Based on estimated baseflow rates for the catchments of interest Table 17, the streams/ rivers were generally classified as potentially gaining streams/ rivers with limited leakage of surface water into the aquifer respectively the model domain allowed along the perennial river stems. With the chosen approach no water losses occur from the non-perennial rivers into the model domain, but groundwater on either side of the river/ drainage might discharge into it as a function of the calculated gradients. In the absence of site specific data, leakage of groundwater into the rivers/ streams was initially assumed to be not constricted by semi-pervious layers in the river bed and a leakage coefficient equivalent to the aquifer permeability assigned to the river. The final leakage coefficients for the main river systems were then calibrated based on estimated baseflow values (see Table 17).

A uniform incision of 4 meters below the surrounding topography was assumed for the hydraulic active river bed for all rivers in the model domain.

6.3.8 Regional Groundwater Flow

While the shallow groundwater levels follow generally surface topography (Figure 35) and shallow groundwater and surface water catchments therefore likely to correspond, the same is not proven and likely to be true for the deeper fractured groundwater flow system. This is attributable to the heterogeneity of the fractured aquifers as well as the depth of such flow systems, where recharge and discharge areas can be substantial distance apart based on the geological, structural and topographic setting.

Especially deeper regional groundwater outflows from the model domain are important for the overall water balance of the model, as they allow water to leave the model domain without discharging into surface water courses, i.e. If no deeper groundwater outflows are assumed, the assigned groundwater abstractions and the river boundaries represent the only sinks available for water recharged over the model domain. So any recharged water not abstracted from boreholes would then have to report to surface water courses to comply with the water balance and artificially inflate the groundwater contribution to baseflow in the quaternary catchments.

Unfortunately, the absence of deep monitoring boreholes (beyond 60 meters below ground level) in the study area precludes the understanding or quantification of deeper groundwater flow systems.

6.3.9 Boundary Conditions

An overview of the physical features and assigned boundary conditions used in the Upper Vaal groundwater flow model is given in Table 19.

Table 19: Boundary conditions assigned in the Upper Vaal Groundwater Model

Boundary	Element layer	Natural feature	Assigned boundary condition
Top	I	Land surface	Rainfall recharge, see Table 17
Top	I	Surface water courses	River lines
E, S, W	I – III	Quaternary catchment boundary, topographic high	No-flow
N	II – III	Deeper groundwater flow	Specified head
Internal	I-II	Groundwater abstractions	Abstraction rates, see Table 18

6.3.10 Selection of Calibration Targets

6.3.10.1 Steady-state calibration targets

The average groundwater levels (in meters above mean sea level) measured in 107 boreholes within the model domain were used as targets for the steady-state calibration. It is obvious that the water levels, measured several years to decades (water levels measured between 1980 and today were considered) apart and potentially only as a once off in a single season are far from ideal for calibration purposes. The water levels were nevertheless utilised to increase the number of calibration targets (sic. monitoring points) and to ensure a regional spread of calibration targets, instead of only using the most recent water level measurements along the Liebenbergsvlei. However, more emphasis was placed on fitting the water levels measured during the 2015 hydrocensus by the project team.

To avoid errors associated with different elevation measurements or estimates in the data set, the water levels as measured in meters below ground level were converted into meters above mean sea level based on the digital elevation model used in the groundwater model for the purpose of calibration.

Secondary calibration targets were provided the estimated groundwater baseflow values per quaternary catchment as provided in Table 17. The leakage rates of the main river systems per quaternary catchment were for this purpose manually altered until a reasonable agreement of the baseflow values was achieved. Since the groundwater baseflow values provided in Table 17 are also outcomes of mathematical models with significant variability amongst the applied models, no further effort was placed on an exact match thereof.

The calibration was done by manually altering assigned hydraulic conductivity values until a best fit between observed and simulated water levels was achieved. As modelled groundwater levels are directly related to the assigned recharge rates and strata hydraulic conductivities, the estimated recharge rates were fixed during calibration to arrive at a potentially unique solution of the model. Similarly, to avoid the introduction of another set of unknown calibration parameter, vertical hydraulic conductivities were fixed at 5% of the horizontal conductivities.

6.3.11 Initial Conditions

The initial conditions specified in the steady state flow model were as follows:

- Starting heads for the aquifers were interpolated from measured shallow water levels using Gaussian interpolation and used as initial heads for the steady-state simulations (Figure 37)

- Horizontal hydraulic conductivities of 1E-06 m/s for the weathered and 1E-07 m/s for the fractured aquifer
- Vertical hydraulic conductivities were set at 10% of the horizontal conductivities
- Porosity values do not influence the outcome of the steady-state flow model, but only the transient model results. The effective porosity values were specified as 12% for the weathered and alluvial aquifer and 5% for the fractured aquifer.

6.3.12 Numerical Parameters

SPRING uses an efficient preconditioned conjugate gradient (PCG) solver for the iterative solution of the flow and transport equation. The closure criterion for the solver, i.e. the convergence limit of the iteration process was set at a residual below 1e-06. The Picard iteration, used for the iterative computation of the relative permeability for each element as a function of the relative saturation respectively capillary pressure, used a damping factor of 0.3 and was limited to 7 iterations. The relative difference between the two computed potential heads or capillary pressures after 8 iterations was generally below an acceptable 0.1 m.

6.3.13 Model Calibration

The 107 measured groundwater levels were assumed to be representative of the more recent, average aquifer conditions and used as the primary calibration targets. The baseflow estimates in Table 17 were used as broad secondary calibration targets to enable the calibration of leakage coefficients and the derivation of reasonable baseflow values.

The original model was run with the initial conditions and the hydraulic conductivities and leakage coefficients of the river courses adjusted using sensible boundaries until a best fit between measured and computed values was achieved. The hydraulic conductivity values vary according to the underlying geology and within different aquifers, and the leakage coefficients according to the order of the river stretch.

6.4 WATER RESOURCE PROTECTION APPROACH

The water resource protection approach will be addressed once the numerical flow model is calibrated, it will be utilised to delineate groundwater protection zones along the Liebenbergsvlei Rivers and its major tributaries. The hydraulic protection zones will be identified to investigate measures to prevent a reversal or unacceptable reduction of prevailing groundwater gradients towards gaining river stretches, i.e. the prevention of excessive interception of baseflow towards surface waters or induced leakage from surface waters by heavy groundwater abstractions near the main stem channel. The numerical model will treat these areas as essential minimum catchment areas required to (i) sustain baseflow support (product of recharge rate and catchment area for specific main stem channel stretches) or (ii) specify minimum groundwater elevations in the proposed protection zone, or (iii) specify maximum allowed water table drawdown in the proposed protection zones. The minimum catchment areas of gaining river stretches will be delineated using the calibrated groundwater model.

In addition, water quality protection zones will be based on the classical borehole protection zone concept (e.g. 50 day travel time). The SPRING numerical application allows for the calculation of contaminant transport with an inverted flow field for the accurate determination of minimum catchment areas. The applied methodology calculates the probability of a water particle arriving in a drainage channel stretch under consideration of advective and dispersive-/diffusive-processes, while conventional methods of velocity tracing reflect only advective processes and reflect therefore not all heterogeneities. This approach will be important for the main tributaries, especially cases such as the Langspruit where the surface water quality is impacted by land use activities above the confluence with the main stem channel, i.e. the Liebenbergsvlei River.

If requested by the client, other considerations for the delineation of protection zones will be accommodated during the scenario simulations in Quarter 3 (Field Survey) Phase.

7. SKILLS TRANSFER AND CAPACITY BUILDING (ST&CB) ACTIVITIES

This is a summary of Task No. 6 for the period of Quarter 1 and Quarter 2.

A group of 15 DWS officials were nominated during the first six-months of the study to participate in the ST&CB process. The names and disciplines required are listed in Table 20 below. Three groups were formed representing three of the quaternary catchments for each group.

Table 20: List of DWS Officials participating in the capacity building programme WP 10941 (GAA 1417697) Project

Surnames	Initials	Directorate – Focus of ST&CB activities
National Office.		
Netshitanini	E	Hydrological Services – Hydrocensus and modelling.
Gonah	T	DWS – /Hydrocensus, modelling and water quality assessments.
Maluleke	H	D: Reserve Determination – Hydrocensus and modelling.
Pule	MC	Hydrological Services – Hydrocensus, modelling and water quality assessments.
Mazibuko	M	D: Reserve Determination – Hydrocensus and modelling.
Ndimma	M	D: Reserve Determination – Hydrocensus and modelling.
Nzama	S	D: Reserve Determination – Hydrocensus, modelling and water quality assessments.
Chokoe	C	Integrated System– Hydrocensus, modelling and data base operations.
Khoza	P	D: Reserve Determination – Hydrocensus and modelling.
Morekgure	K	D: Surface and Groundwater Information – Hydrocensus and modelling.
Netshiendeulu	N	D: Reserve Determination – Hydrocensus and modelling.
Boniwe	N	D: Reserve Determination – Surface water – groundwater interaction.
Gauteng Regional Office		
Mmako	L	D: Planning and Information – Water Resources Information and field work (monitoring/hydrocensus).
Mazula-Mkabile	O	D: Planning and Information – Water Resources Information and field work (monitoring/hydrocensus).

The emphasis of the ST&CB programme is focussing on actual involvement with the field work component, i.e. participating in monitoring activities and hydrocensus procedures. Secondly, a fast amount of un-edited hydrological data is available and special procedures are required to verify and make these datasets useful for certain applications. At least three field work sessions and two desktop/in-house sessions were completed since July 2015. The field work sessions were conducted in the study area during the “dry cycle” period and hopefully, a “wet cycle” will be available for monitoring soon. Availability of hydrological datasets are problematic and a session was presented where the procedures to find, download and assessing (statistically) was demonstrated.

The group were amended by staff from the Gauteng Regional Office after the 1st Project Management Meeting on the 6th of August 2015.

Since the onset of the surface water – groundwater interaction study, there were six ST&CB Sessions including field activities and in-house data processing. They were:

- 17/18/19 August: Group 1 attended 27-Bridges Hydrological Monitoring Run No. 2);
- 18 September 2015: Golder's Offices at Hatfield – Introduction to the hydrological datasets and ways to refine datasets for specific applications;
- 13/14 October: 1st Diurnal Monitoring Run at Monitoring Site C83C-A: explain instruments for physical water quality measurements and demonstrate on site alkalinity titrations to DWS ST&CB Group 2;
- 17 November: 2nd Diurnal Swater monitoring survey on 27 Bridges Monitoring Network for whole DWS ST&CB Group. Explain instruments for physical water quality measurements and demonstrate on site alkalinity titrations;
- 18 November: Demonstrate and explain groundwater hydrocensus activities on site; and
- 23/24 November: ST&CB Session focussing on the Swater Component (incl. Flood Line Assessments), Dataset verification using mainly Excel's Statistical capabilities and introduction to Conceptual and Numerical Modelling Procedures.

The attendance lists of the in-house ST&CB Session are included as Appendix R (18 September 2015 Session) and Appendix S (23/24 November 2015).

8. SUMMARY ON PROGRESS FOR TASKS 5 AND 7

8.1 TASK 5 – COMMUNICATION AND LIAISON

Process progresses as planned as per Inception Report (Quarter 1 Reporting for July to September 2015).

A Stakeholder Information and Project Steering Committee meeting was held on the 19th of November 2015 on Daniëlsrus. The list of participants is included as Appendix T. Issues raised during the meeting highlighted the water quality importance of the Liebenbergsvlei main stem system, and the allocations for irrigation water. The latter concern is not part of the focus of this study, however, it is believed to be a general concern of the land owners in the area and has therefore been noted in the meeting's minutes. The minutes will be distributed once the sections of the surface, groundwater and numerical modelling have been finally edited.

The following individuals were nominated to become part of the Project Steering Committee:

- Mr. Reveck Hariram (Randwater);
- Dr. Chris Moseki (DWS);
- Dr. W Roets (DWS);
- Dr. M Gomo (Univ. for the Free State); and
- Mr Jack Armour (Agri Free State – Project Management Committee need to obtain letter from Agri Free State that Mr Armour may represent them).

In addition, three of the local landowners, each from the southern, central and northern parts of the study area, will be included to represents the local input into the study (and for the ease of moving over private land during monitoring and related field operations.

They will be:

- Dirk Viljoen (Clarens) – area above Sol Plaatje Dam (former Saulspoort);
- Callie Venter (Danielsrus) – Sol Plaatje Dam to Reitz;
- Ben Duminy – Reitz to Tweeling; and
- (To be confirmed) – Tweeling to Frankfort.

The Technical Task Team (Golder Associates and Delta-H Water Systems Modelling) would like to include Prof. Masihlelo (AFASA) in the PSC group. He was initially invited but could not make it to the 19th November 2015 meeting.

The 2nd Project Management Meeting for Quarter 2 (Hydrocensus) Phase were held on the 2nd of December 2015 at DWS Offices. A draft agenda has been submitted on the 4th of December 2015.

During this meeting it was recommended that due to the need of key scientists on the project, the following individuals will become part of the project's Technical Task Team:

- Dr. Matthys Dippenaar (Univ. Pretoria);
- Dr. Chris Moseki (DWS);
- Dr W Roets (DWS); and
- Dr Harold van Niekerk (DWS, Roodeplaat).

8.2 TASK 7 – STUDY MANAGEMENT AND CLOSE OUR REPORTING

Activities are ongoing as per Inception Report (Quarter 1 Reporting for July to September 2015). Unfortunately due to staff resignations at Golder, there have been a few changes in the Team Members list. Details of the group are listed in Table 21 below.

Table 21: Team members involved in study

Name	Study role	Company	Hourly rate (R/h)
Trevor Coleman	Study Director, Technical Advisor Water Resources	Golder	1450
Lee Ann Boyd	Study Manager	Golder	1100
Collen Monokofala	Hydrogeological Assessment and Stakeholder/PSC support.	Golder	900

Name	Study role	Company	Hourly rate (R/h)
Priya Moodley	Study Co-ordinator, Surface water quality and IWRM	Golder	900
Eddie van Wyk	Groundwater Resources – Advisor/Assessments (Mentor) and ST-CB Sessions. Hydrogeological assessments and	Golder	1200
Frans Wiegman	Hydrogeological and hydrological review, Geological assessments based on regional geophysical data and advise to numerical modelling team (Delta-H).	Golder	1200
Amelia Basson (replaces Mr. Oliver Malate who has resigned)	Surface water assessments and ST&CB Sessions.	Golder	600
Keretia Lupankwa	Water quality assessments and capacity building drive.	Golder	750
Tracy Skinner	GIS applications.	Golder	450
James Lerwele	Field operations and monitoring.	Golder	330
Kai Witthüser	Analytical/Conceptual/Numerical Modelling development.	Delta-H WSM.	830
Martin Holland	Numerical Modelling: Verification and scenario modelling.	Delta-H WSM.	830

9. STUDY COSTS

A summary of the project expenditure is listed below in Table 22 per quarterly deliverables. The financial expenditure is on track as planned; however, actual activities are ~two weeks ahead of the planned schedule.

The costs for water quality laboratory services are included under Q2 expenditure as per Invoice No. 2 (R 71 003.02, excl. VAT)

Table 22: Summary of Q1 and Q2 Expenses.

Project Item	Phase	Expenditure	Account Status	Remaining
Original allocation				R1 633 764-00
Quarter 1 (July-September 2015)	Inception Phase	R267 007-02	Paid (Thanks!)	R1 366 756-98
Quarter 2 (October to December 2015)	Hydrocensus Phase	R643 472-81	Invoice to be submitted: 4 th January 2016	R733 559-00
Budget remaining			–	R732 435.84

The following conclusions have relevance to the Quarter 2 (Hydrocensus) Phase of the study:

10. CONCLUSIONS

- Historical hydrological datasets are available, however, they required significant assessment to isolate specific components required, e.g. time series related data;
- The datasets cover a wide time period (1914 to 2015) and requires capturing of time and site specific datasets;
- Discharge from the Sol Plaatje Dam (Saulspoort Dam)) seems to have been producing inaccurate data from approximately October 2008, thus data for the last year should be excluded.
- No surface water flow or water quality from the tributary drainages is monitored. A special monitor network had to be designed and implemented at the start-up to at least observe the water quality in these systems which is believed to be driven by local groundwater base flows, viz. the 27 Bridges Monitoring Network were designed/implemented;
- The surface water monitor dataset collated from two monitoring runs on the 27 Bridges Monitoring indicated fresh mountain water all along the Ash and Liebenbergsvlei Rivers (electrical conductivity, EC, values <10 mS/m);
- The current surface water quality assessment indicate that the water quality data from the DWS gauging stations suggest minimal changes along the main stem reach as well as insignificant seasonal changes, this data is not sensitive enough to be used to aid in the understanding of the system from a mass balance perspective.
- The EC value differences between the LHTS Tunnel Outfall (Start Point) and upstream of the Wilge River confluence (End Point at Monitoring Site C83CA) is small (<2.5 mS/m) and falls within the diurnal water quality variation/limits of measurement tolerance of water quality equipment, i.e. 1.0 mS/m;
- The surface water quality (EC values) of the tributaries is in the range of 45 to 55 mS/m, except the Langspruit which has an EC value of 90 mS/m;
- Water quality deterioration has been noted in the Langspruit which drains the eastern part of the C83G quaternary catchment – elevated levels of dissolved Phosphorus, Iron and Aluminium are reported in the analytical results;
- No “modern” groundwater levels and quality data were available and a special hydrocensus were conducted on 7 selected sites – 5 on the Ash and Liebenbergsvlei Rivers and on the Tierkloof River and Langspruit (the two main eastern tributaries);
- Application of a simple analytical model to calculate the contributions of other than the Ash and Liebenbergsvlei River channel, based on the EC-values is not sensitive enough to conclusively indicate a permanent, significant (or measurable) groundwater contribution to the main stem, however, this could change during the annual “wet cycles”; and
- The numerical model has been developed and calibrated against water levels and base flow estimates and estimated recharge rates.

11. RECOMMENDATIONS

The following recommendations are proposed:

- At least one “wet cycle” coverage of the 27-Bridges Monitoring Network is required to assess the flow volume contribution and water quality characteristics of the tributaries;
- The YSI electrical conductivity measurements in the Hydras III database at the Free State Regional Office in Bloemfontein should be obtained. This dataset shows the surface water quality changes during long-term flows;
- All field water quality measurements should be conducted using at least three different water quality instruments during the field surveys;
- Surface water component: Data from the following active flow monitoring stations located on the Liebenbergsvlei and the Wilge River should be used to calibrate the surface water model: C8R004, C8H037, C8H020, C8H026 and C8H001;
- Data collated over a 10-year period, i.e. October 1999 through September 2009, should be used for all the stations except Gauging Station C8R004 (Sol Plaatje Dam);
- The other inconsistencies observed in the flow data, for example the increase between the LHTS Tunnel outlet and the DWs gauging station at Reward, will be studied further during the modelling phase of the project, to attempt to determine the causes;
- Groundwater level measurements in a specific group of boreholes close to the main stem and major tributaries should be measured at specific intervals over the remaining period of the study, or if possible eLoggers should be installed (could these be supplied by the DWS’s Directorate of Surface and Groundwater Information?);
- Scientists nominated for attending the Technical Task Team meeting in February 2016 should discuss the monitoring and numerical modelling results and give guidance to the project in the case of a No-Wet-Cycle-Event and
- As soon as a good “wet Cycle” has developed, at least one 27_Bridges Monitoring run must be conducted.

12. SUMMARY

The work described in this Q2 Hydrocensus Report covers the hydrocensus phase of Project WP10941. Collation and evaluation of the historical datasets were the main objective of this phase, however, activities were initiated to solve the data gaps identified during the inception phase of the project. Activities during this phase focussed on the surface water monitoring of the main stem and the tributaries, observing the diurnal surface water quality in the main stem, and obtaining “modern” groundwater levels and water quality to augment the groundwater component of the study. Where possible, the skills transfer and capacity building component of the project were kept in line with the fieldwork and processing of the various hydrological datasets.

Two specific aspects that are addressed in more detail in this report, are the surface water quality status/variations and flow regimes, and secondly the development of the groundwater flow model, based on the conceptual understanding of the hydrogeological characteristics of the study area. This model has been updated with the November 2015 groundwater hydrocensus data.

The design/implementation of the 27 Bridges Monitoring Network during the Q1 (Inception) Phase has provided a sound set of the main stem and contributory water quality data which highlighted to significant mountain water quality input into the Upper Vaal Catchment. The dataset indicated

that the analytical modelling approach which is based on the mass balance principle for the main stem drainage is not sensitive enough to indicate a minimum groundwater contribution to the main stem.

Although the 27-Bridges Monitoring Network indicates there is an almost ten-fold ratio difference between the main stem water quality and the base flows in the main tributaries. The latter is obviously driven by local groundwater as noted of the July 2015 baseflow water quality and the local groundwater quality observed during the November 2015 hydrocensus. A much larger groundwater contribution to the surface water is therefore required before an analytical model approach could provide measurable results. During the “dry cycle” monitoring period between July and August 2015, this case scenario could not be observed, nor quantified.

Monitoring of at least one “Wet Cycle” in the main stem and tributaries are therefore required and will hopefully materialised during the peak summer wet season (January-April 2016).

In terms of the water quality vulnerability on the main stem system, the long-term water quality contributions from the tributaries are a concern and protection protocols should be considered for potential anthropogenic impacts that may poses a threat to the main stem quality. Developments along the tributaries are taking place, e.g. irrigation and water treatment works. Water quality management protocols are probably not in place to control/manage return flows and/or discharges into the tributaries.

Understanding and development the conceptual model supported the development/calibration of the numerical model of the study area. Having the surface water flow calibration (using the Hec-Ras modelling application), surface water – groundwater interaction scenario modelling will commence including on actual land use activities along the main stem system including the base flow contributions from the tributaries.

Quarter 3 of the Upper Vaal Catchment surface water and groundwater interaction study will focus primarily on the interpretation/combination of short-term (2015) and medium-term (1998-2009) surface and groundwater datasets and depending of the “wet cycle” rainfall input, monitoring of the base flow conditions in the main tributaries. The numerical model will be used for the identification and verification of water resources protection zoning along the main stem applying a series of scenario modelling.

13. REFERENCES USED IN THIS HYDROCENSUS REPORT

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APPENDIX A

Surface Water - Monthly Daily Flows

APPENDIX A: RAW DATASETS

Monthly Flow Monitoring

Table A1: Monthly Flow Volumes (Data Source: DWS Hydrology Website)

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8R005 Loch Athlone	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
Oct-99	5.4	7.3	0.0	8.1	7.4	8.4	10.4
Nov-99	36.8	41.4	0.0	33.7	32.7	33.3	34.9
Dec-99	37.2	45.7	0.3	69.7	83.9	91.0	172.0
Jan-00	38.0	59.1	8.1	79.4	135.0	129.0	459.0
Feb-00	36.3	62.2	11.5	73.2	149.0	138.0	481.0
Mar-00	40.7	57.1	4.7	81.3	86.9	108.0	355.0
Apr-00	45.4	56.8	3.3	69.9	75.4	83.2	179.0
May-00	55.3	68.6	4.1	87.6	112.0	122.0	299.0
Jun-00	60.4	67.2	2.1	69.3	69.5	66.6	113.0
Jul-00	64.0	69.1	1.6	70.2	69.6	66.1	100.0
Aug-00	61.5	65.7	1.3	64.3	62.3	62.7	78.9
Sep-00	53.6	59.4	0.8	63.6	66.5	67.9	91.1
Oct-00	44.4	53.9	2.5	57.6	55.6	58.7	109.0
Nov-00	25.4	36.4	1.6	35.3	32.9	35.0	115.0
Dec-00	38.6	48.5	1.2	49.3	34.1	57.6	237.0
Jan-01	41.2	45.7	0.3	40.6	30.3	39.7	59.7
Feb-01	39.5	40.7	1.2	41.2	41.8	44.5	69.7
Mar-01	40.6	46.1	1.5	46.9	49.6	54.2	92.0
Apr-01	3.8	2.2	1.4	1.8	5.0	6.7	33.0
May-01	56.6	59.5	1.2	55.5	58.8	59.9	68.6
Jun-01	60.0	64.6	0.8	61.1	60.8	61.0	60.8
Jul-01	68.7	72.3	0.9	71.1	69.4	70.1	70.8
Aug-01	67.1	65.3	0.7	68.5	66.7	66.3	71.5
Sep-01	55.3	59.7	2.7	62.5	62.9	65.7	106.0
Oct-01	49.7	69.8	4.8	71.9	93.7	89.7	166.0
Nov-01	51.7	71.9	5.0	88.0	112.0	127.0	290.0
Dec-01	46.2	66.4	6.8	81.2	95.2	106.0	174.0
Jan-02	45.0	59.9	2.8	70.1	95.0	104.0	178.0
Feb-02	41.0	47.0	2.8	55.2	59.7	65.7	119.0
Mar-02	43.9	50.2	1.1	54.7	55.6	58.8	92.3
Apr-02	51.1	54.3	0.6	49.6	49.2	50.2	52.3
May-02	54.4	59.0	0.1	57.7	55.7	57.4	56.8
Jun-02	56.3	61.1	0.8	62.0	60.2	62.2	67.7
Jul-02	58.9	63.3	0.6	61.6	59.1	60.7	60.9
Aug-02	58.7	65.8	0.9	64.5	63.3	65.9	74.2
Sep-02	50.3	56.9	1.7	57.4	57.6	60.5	78.9
Oct-02	47.8	51.1	0.5	47.2	46.3	46.5	45.9
Nov-02	48.7	51.5	0.1	48.1	48.4	47.2	44.5
Dec-02	53.4	56.8	0.0	56.5	55.7	59.4	92.5

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8R005 Loch Athlone	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
Jan-03	51.4	52.3	0.0	49.3	46.8	46.8	69.6
Feb-03	0.1	3.5	0.0	8.6	8.5	10.9	47.2
Mar-03	49.1	43.5	0.0	41.6	39.4	39.1	52.6
Apr-03	50.0	51.6	0.0	51.1	50.3	53.0	53.8
May-03	72.3	77.5	0.0	72.6	71.7	72.8	67.6
Jun-03	70.9	74.5	0.0	72.3	70.8	73.9	66.8
Jul-03	76.7	76.5	0.0	77.0	74.8	76.2	70.6
Aug-03	73.1	72.7	0.0	76.1	74.0	74.4	69.1
Sep-03	67.6	65.5	0.0	67.7	65.2	64.7	60.1
Oct-03	54.8	54.6	0.0	57.6	53.8	53.6	49.0
Nov-03	44.6	44.8	0.0	48.7	45.0	45.6	47.8
Dec-03	42.5	42.3	0.0	44.4	40.2	40.4	39.7
Jan-04	48.7	51.0	0.0	52.7	48.5	48.1	50.4
Feb-04	40.7	44.6	0.0	47.8	44.5	44.3	65.0
Mar-04	44.7	48.6	0.0	53.0	51.6	52.6	98.2
Apr-04	46.8	50.3	0.0	50.7	48.9	46.5	56.9
May-04	58.5	62.3	0.0	62.3	59.5	57.1	54.9
Jun-04	69.8	73.6	0.0	72.8	70.6	66.7	64.1
Jul-04	73.5	78.5	0.0	78.5	77.6	73.4	69.4
Aug-04	66.3	72.2	0.0	73.0	72.1	68.1	62.0
Sep-04	58.8	65.5	0.0	65.8	63.9	59.7	55.0
Oct-04	50.9	58.4	0.0	58.3	55.5	52.6	49.5
Nov-04	48.2	52.8	0.0	51.1	48.4	45.7	43.8
Dec-04	48.6	57.9	0.0	58.7	56.7	54.3	75.5
Jan-05	55.1	72.0	0.0	81.6	103.0	104.0	171.0
Feb-05	51.0	60.5	0.0	69.3	71.8	81.0	109.0
Mar-05	55.9	64.8	0.5	64.3	61.3	63.1	144.0
Apr-05	60.5	70.6	1.6	69.8	69.9	74.7	105.0
May-05	71.3	80.8	1.0	75.8	72.7	74.0	77.9
Jun-05	74.8	80.2	0.3	77.7	75.9	75.8	89.3
Jul-05	71.0	78.6	0.1	75.1	74.2	74.2	71.6
Aug-05	71.6	77.3	0.0	72.0	72.5	72.0	70.1
Sep-05	59.4	64.2	0.0	58.6	59.6	58.3	54.9
Oct-05	64.7	69.1		63.7	65.4	64.0	67.4
Nov-05	57.9	61.4	0.0	56.4	59.8	59.7	82.9
Dec-05	55.8	58.6	0.1	53.0	57.0	56.5	59.5
Jan-06	74.0	86.5	0.2	84.0	93.7	109.0	210.0
Feb-06	49.3	74.5	2.7	72.6	79.1	85.0	282.0
Mar-06	58.2	70.6	2.3	86.5	87.6	93.0	328.0
Apr-06	57.6	62.9	1.1	67.2	65.2	66.3	122.0
May-06	74.0	79.5	1.0	84.2	77.8	79.2	95.9
Jun-06	74.8	81.1	0.7	85.1	76.0	76.6	82.3
Jul-06	74.3	80.4	0.5	87.6	77.1	78.3	79.3

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8R005 Loch Athlone	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
Aug-06	76.2	77.8	1.2	89.6	79.3	80.6	84.2
Sep-06	64.2	65.5	0.7	76.9	67.6	67.8	68.5
Oct-06	59.1	60.3	0.2	68.6	61.9	61.5	62.7
Nov-06	56.0	67.1	2.7	74.9	70.6	70.7	78.3
Dec-06	53.8	61.3	2.5	64.6	62.2	61.8	72.0
Jan-07	54.4	58.1	1.6	65.6	58.9	60.5	64.8
Feb-07	50.2	52.3	0.4	54.5	50.1	49.9	55.1
Mar-07	56.4	58.7	0.0	61.5	56.3	55.4	50.2
Apr-07	59.4	61.9	0.0	64.1	59.4	58.3	54.4
May-07	73.5	78.8	0.0	81.0	72.8	70.6	64.9
Jun-07	77.9	86.5	0.0	89.5	79.7	78.3	70.9
Jul-07	81.0	89.7	0.0	95.6	83.4	82.3	74.4
Aug-07	81.9	90.4	0.0	94.2	83.0	82.1	74.7
Sep-07	66.8	71.5	0.0	78.0	69.7	68.8	62.6
Oct-07	74.2	87.7	6.1	102.0	106.0	110.0	144.0
Nov-07	59.9	71.1	3.7	81.0	85.8	89.5	130.0
Dec-07	57.7	69.3	5.1	99.6	121.0	127.0	183.0
Jan-08	60.9	65.2	5.4	67.7	75.4	75.3	99.0
Feb-08	57.7	63.3	1.7	59.3	62.3	63.3	94.7
Mar-08	64.1	73.1	1.0	68.0	71.8	78.6	101.0
Apr-08	67.0	76.8	0.3	65.9	68.8	68.5	75.9
May-08	74.6	85.6	0.0	75.9	78.6	79.0	75.9
Jun-08	76.3	74.8	0.5	79.9	80.5	81.9	77.7
Jul-08	80.7	82.9	0.1	84.1	83.2	83.7	58.9
Aug-08	75.9	78.7	0.0	82.0	78.8	78.8	48.6
Sep-08	71.2	74.1	0.0	80.6	74.6	75.1	50.0
Oct-08	53.0	53.8	0.0	61.5	54.0	54.9	43.0
Nov-08	36.0	33.7	0.0	43.2	36.9	40.6	44.5
Dec-08	50.8	48.5	0.0	65.3	55.4	58.0	68.5
Jan-09	46.0	43.2	0.0	59.2	55.5	72.9	122.0
Feb-09	54.9	58.7	1.5	89.3	79.4	109.0	240.0
Mar-09	59.0	61.7	1.7	95.8	82.5	88.9	194.0
Apr-09	61.2	58.8	0.3	71.9	64.3	63.7	75.6
May-09	73.7	71.9	0.1	80.7	79.2	77.3	75.9
Jun-09	78.1	77.0	0.7	86.9	83.6	81.3	74.1
Jul-09	83.0	79.2	1.0	93.1	86.5	83.5	82.9
Aug-09	77.1	72.6	0.8	88.7	82.3	78.6	78.5
Sep-09	70.9	61.1	0.1	80.5	74.2	69.6	63.4

Daily Flow Monitoring

Table A2: September Average Daily Flow Rates (m³/s)

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
01-Sep-99	20.7	22.3	20.4	19.1	16.4	16.1
02-Sep-99	20.9	22.1	21.2	20.6	19.4	18.4
03-Sep-99	20.7	22.5	20.9	20.5	20.1	19.4
04-Sep-99	17.0	21.2	21.1	20.8	20.0	19.3
05-Sep-99	15.4	18.6	20.2	20.7	20.2	19.4
06-Sep-99	18.4	18.1	17.2	18.0	19.3	19.1
07-Sep-99	18.7	20.1	16.1	15.6	16.7	16.8
08-Sep-99	18.1	20.3	18.3	16.8	15.5	15.2
09-Sep-99	23.3	20.1	18.4	17.7	17.0	16.4
10-Sep-99	28.7	27.0	18.2	17.6	17.5	17.0
11-Sep-99	21.4	28.7	23.2	20.5	17.5	16.7
12-Sep-99	14.8	21.9	26.7	26.5	22.3	20.4
13-Sep-99	29.0	21.4	20.9	22.9	25.2	24.0
14-Sep-99	28.5	30.0	18.2	16.9	19.9	20.1
15-Sep-99	28.8	30.8	26.8	24.5	18.3	17.0
16-Sep-99	28.8	31.1	28.2	27.4	26.0	23.4
17-Sep-99	28.8	31.1	28.6	28.0	27.2	25.1
18-Sep-99	21.7	30.0	28.4	28.1	27.5	25.6
19-Sep-99	14.6	21.8	27.9	28.1	27.6	25.8
20-Sep-99	28.2	21.1	20.9	23.1	26.3	25.5
21-Sep-99	28.7	30.3	17.6	16.3	19.2	20.4
22-Sep-99	28.9	30.3	26.6	24.2	18.4	16.7
23-Sep-99	26.4	30.3	28.2	27.7	26.1	23.3
24-Sep-99	28.9	29.5	28.5	28.3	27.8	26.2
25-Sep-99	21.7	30.1	27.3	27.3	27.8	26.2
26-Sep-99	13.4	21.8	27.8	28.0	26.8	25.0
27-Sep-99	28.4	19.6	20.7	23.1	26.5	25.3
28-Sep-99	25.2	28.0	16.3	15.8	19.1	20.0
29-Sep-99	25.6	26.9	25.0	M	17.1	15.5
30-Sep-99	28.4	28.9	24.8	24.3	24.2	22.0
01-Sep-00	21.4	23.3	23.4	22.2	22.1	25.8
02-Sep-00	18.0	21.8	23.5	22.6	22.9	26.4
03-Sep-00	16.2	19.1	21.7	21.8	22.7	26.8
04-Sep-00	22.8	18.8	18.8	18.9	20.3	25.1
05-Sep-00	23.5	23.2	18.3	16.9	17.8	22.1
06-Sep-00	23.0	23.7	23.4	20.8	19.0	21.2
07-Sep-00	23.1	23.3	24.3	23.1	23.1	25.4
08-Sep-00	22.7	23.3	23.7	22.7	23.4	26.3
09-Sep-00	18.3	22.5	23.9	22.6	23.2	26.0
10-Sep-00	15.4	18.7	22.8	22.4	23.2	26.1

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
11-Sep-00	21.5	17.9	18.7	19.3	21.4	25.4
12-Sep-00	22.1	22.3	17.7	16.2	17.4	21.5
13-Sep-00	24.3	24.4	22.0	19.7	18.3	20.2
14-Sep-00	22.3	24.9	23.4	21.8	21.9	23.9
15-Sep-00	22.3	23.7	24.3	23.0	23.3	25.4
16-Sep-00	18.7	22.8	23.8	22.6	23.8	26.4
17-Sep-00	17.7	20.3	22.3	21.9	22.8	26.2
18-Sep-00	23.6	20.6	19.6	19.4	20.8	25.2
19-Sep-00	26.8	24.9	20.5	18.7	18.7	22.7
20-Sep-00	24.7	38.0	34.5	75.5	54.0	39.2
21-Sep-00	22.9	36.7	47.7	54.8	67.1	78.2
22-Sep-00	22.3	27.6	50.0	55.8	57.3	71.7
23-Sep-00	17.5	23.6	32.7	35.9	43.8	82.9
24-Sep-00	15.9	19.4	26.3	28.1	30.6	64.7
25-Sep-00	19.5	18.4	20.8	21.8	24.4	56.7
26-Sep-00	20.2	20.3	19.5	18.6	19.8	46.6
27-Sep-00	20.6	21.1	21.8	19.9	19.4	39.9
28-Sep-00	20.4	21.8	22.5	20.7	20.9	38.0
29-Sep-00	17.6	21.5	22.8	20.9	21.2	35.4
30-Sep-00	14.9	19.3	21.9	20.4	21.0	32.9
01-Sep-01	19.7	14.8	32.8	30.4	28.5	29.8
02-Sep-01	10.4	13.6	31.8	32.2	33.2	33.9
03-Sep-01	23.0	14.6	23.1	25.4	29.1	31.0
04-Sep-01	23.8	23.3	15.3	15.6	19.9	26.1
05-Sep-01	25.3	25.4	22.8	20.1	16.4	21.0
06-Sep-01	24.4	25.7	25.5	24.1	23.2	24.6
07-Sep-01	22.4	25.6	25.9	25.1	25.0	26.2
08-Sep-01	18.3	23.4	25.5	24.9	24.8	26.4
09-Sep-01	16.0	20.1	23.3	23.8	24.5	25.9
10-Sep-01	19.3	18.4	19.4	19.7	21.4	24.1
11-Sep-01	23.1	21.1	17.5	17.0	18.0	20.5
12-Sep-01	24.0	24.8	20.3	19.0	17.8	19.0
13-Sep-01	24.3	28.9	26.9	31.3	35.0	28.4
14-Sep-01	23.3	29.8	32.4	37.6	49.9	81.6
15-Sep-01	21.1	27.3	32.5	33.4	38.2	81.5
16-Sep-01	18.4	24.3	30.3	31.6	34.2	73.0
17-Sep-01	21.9	22.0	25.6	27.0	29.5	61.0
18-Sep-01	23.3	24.1	22.5	23.0	24.8	52.7
19-Sep-01	22.2	25.7	24.4	23.6	23.1	52.7
20-Sep-01	20.6	24.4	25.7	25.2	24.9	63.3
21-Sep-01	20.6	22.9	24.6	25.1	25.7	65.0
22-Sep-01	17.6	22.8	23.0	23.8	24.5	62.0
23-Sep-01	15.0	20.3	22.5	23.2	23.7	58.1

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
24-Sep-01	19.1	18.3	19.5	20.5	22.2	50.6
25-Sep-01	20.5	21.1	17.3	17.5	18.9	41.2
26-Sep-01	20.2	22.6	19.8	18.7	17.8	33.2
27-Sep-01	23.7	22.7	21.3	20.3	19.9	30.5
28-Sep-01	26.3	26.0	21.4	20.6	20.7	29.9
29-Sep-01	26.1	28.1	24.3	22.5	21.3	29.1
30-Sep-01	25.6	28.3	26.7	25.7	24.7	29.7
01-Sep-02	17.7	22.8	30.1	31.1	34.7	50.2
02-Sep-02	22.1	21.5	24.3	25.8	30.3	45.0
03-Sep-02	22.9	24.7	21.8	21.8	24.5	38.7
04-Sep-02	23.3	25.4	24.2	23.5	23.4	31.8
05-Sep-02	23.6	26.3	25.0	24.8	25.7	32.0
06-Sep-02	25.6	26.4	26.2	25.9	26.4	31.5
07-Sep-02	23.0	29.1	27.1	29.8	30.6	35.0
08-Sep-02	18.4	26.9	31.9	31.3	32.9	43.2
09-Sep-02	20.9	22.5	29.6	31.1	34.7	47.6
10-Sep-02	22.7	24.5	23.6	24.9	29.3	48.9
11-Sep-02	22.5	25.4	24.5	23.8	24.3	40.8
12-Sep-02	22.1	24.9	25.4	25.4	25.8	39.2
13-Sep-02	21.1	24.4	24.9	25.1	26.2	38.1
14-Sep-02	18.0	22.9	24.2	24.3	25.4	35.5
15-Sep-02	16.0	20.3	22.7	23.2	24.5	32.0
16-Sep-02	19.3	19.1	19.8	20.3	22.5	29.3
17-Sep-02	19.3	21.6	18.2	18.0	19.5	26.0
18-Sep-02	19.0	21.7	20.3	19.6	19.0	23.5
19-Sep-02	18.9	21.4	20.4	20.2	20.7	24.2
20-Sep-02	17.9	20.8	20.1	19.7	20.5	23.8
21-Sep-02	15.9	19.4	19.7	19.4	20.0	23.0
22-Sep-02	14.2	17.7	18.4	18.6	19.2	22.3
23-Sep-02	17.5	16.6	16.8	16.8	17.9	20.8
24-Sep-02	17.8	19.1	15.4	15.0	16.1	18.7
25-Sep-02	19.0	19.6	17.8	16.6	15.3	16.9
26-Sep-02	17.9	20.4	18.4	18.0	17.5	18.1
27-Sep-02	18.9	19.8	19.2	18.7	18.2	19.0
28-Sep-02	15.9	20.2	18.8	18.5	18.5	19.4
29-Sep-02	13.8	17.4	19.1	18.9	18.3	19.2
30-Sep-02	16.9	15.5	16.6	16.9	18.1	19.1
01-Sep-03	28.7	18.7	24.5	25.6	27.3	27.1
02-Sep-03	29.1	26.6	19.4	19.0	21.3	22.6
03-Sep-03	28.9	28.2	26.7	24.1	20.0	18.1
04-Sep-03	29.1	28.8	29.0	28.1	26.3	23.0
05-Sep-03	29.0	28.5	29.2	28.4	27.7	25.4
06-Sep-03	22.8	27.7	29.3	28.4	27.8	25.8

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
07-Sep-03	17.2	22.5	29.2	28.5	28.2	26.0
08-Sep-03	28.7	18.9	24.2	25.1	27.2	25.7
09-Sep-03	29.9	27.7	19.3	18.7	21.1	21.6
10-Sep-03	29.3	28.9	27.1	24.2	20.3	17.5
11-Sep-03	29.1	28.7	29.7	28.5	26.6	22.8
12-Sep-03	28.8	28.6	29.5	28.6	27.7	25.5
13-Sep-03	22.7	28.0	29.2	28.3	27.6	25.7
14-Sep-03	17.4	21.1	29.0	28.3	27.5	25.7
15-Sep-03	28.6	19.2	23.7	25.1	27.0	25.7
16-Sep-03	29.4	27.7	19.5	18.6	20.6	21.6
17-Sep-03	29.1	29.3	26.8	24.3	20.3	17.5
18-Sep-03	29.0	29.9	29.4	28.5	26.9	22.9
19-Sep-03	28.7	29.0	30.5	29.2	28.5	26.0
20-Sep-03	17.6	26.9	30.2	28.9	28.7	26.5
21-Sep-03	16.5	18.4	29.0	28.0	28.0	26.2
22-Sep-03	28.5	17.5	20.7	21.3	25.0	24.6
23-Sep-03	29.1	26.4	18.3	16.8	18.1	18.4
24-Sep-03	23.5	28.0	26.5	23.4	19.3	16.3
25-Sep-03	29.0	24.1	29.2	27.5	26.1	22.0
26-Sep-03	28.8	27.5	26.0	25.3	26.6	24.5
27-Sep-03	21.8	27.7	27.6	25.6	23.9	22.5
28-Sep-03	15.5	21.2	29.1	27.7	26.8	23.6
29-Sep-03	27.9	17.0	23.7	24.1	26.3	24.8
30-Sep-03	28.9	26.0	18.1	17.1	20.0	20.5
01-Sep-04	23.9	26.5	23.5	23.7	20.4	18.3
02-Sep-04	25.3	27.0	26.0	26.0	23.9	21.0
03-Sep-04	25.5	27.7	26.6	26.1	24.5	22.4
04-Sep-04	19.8	27.4	27.4	27.0	24.8	22.6
05-Sep-04	17.3	23.4	28.2	27.8	25.9	23.4
06-Sep-04	27.0	21.3	25.0	23.8	24.4	23.4
07-Sep-04	27.5	27.6	21.7	20.1	20.1	20.0
08-Sep-04	27.3	29.4	24.8	25.2	20.4	17.9
09-Sep-04	27.0	29.5	29.3	29.5	26.7	22.8
10-Sep-04	25.7	29.2	30.2	29.7	27.8	25.2
11-Sep-04	20.0	27.7	30.0	29.4	27.7	25.3
12-Sep-04	17.9	23.4	28.9	28.4	27.0	25.0
13-Sep-04	23.3	21.4	24.8	23.9	24.6	23.7
14-Sep-04	22.7	25.2	21.9	20.2	20.2	20.0
15-Sep-04	21.8	25.3	23.9	23.3	20.1	17.9
16-Sep-04	22.0	24.8	25.4	24.6	23.0	20.6
17-Sep-04	21.0	24.6	24.9	23.9	22.7	21.1
18-Sep-04	18.5	23.2	24.5	23.6	22.0	20.6
19-Sep-04	17.7	21.2	23.9	23.0	22.0	20.5

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
20-Sep-04	24.1	20.7	22.1	20.5	20.3	19.7
21-Sep-04	24.2	25.5	21.1	19.3	18.6	17.7
22-Sep-04	23.3	26.5	23.3	23.3	19.7	17.2
23-Sep-04	23.7	26.0	26.1	25.9	23.6	20.7
24-Sep-04	25.9	26.6	26.2	26.1	23.9	22.3
25-Sep-04	20.5	27.5	26.4	25.5	23.4	21.6
26-Sep-04	18.3	24.0	27.6	27.1	24.9	22.6
27-Sep-04	23.1	21.5	25.7	24.3	24.4	23.0
28-Sep-04	22.7	24.7	23.0	20.9	21.0	20.5
29-Sep-04	21.7	25.1	23.7	23.0	20.1	18.5
30-Sep-04	21.5	24.2	25.2	24.6	22.8	20.6
01-Sep-05	27.1	28.3	25.8	26.7	25.4	23.6
02-Sep-05	26.1	29.0	26.2	26.6	26.3	24.9
03-Sep-05	21.6	27.7	26.4	26.8	25.9	24.5
04-Sep-05	20.1	24.5	26.4	26.6	26.4	25.0
05-Sep-05	25.6	23.1	24.2	23.9	24.8	24.4
06-Sep-05	26.6	26.2	21.9	21.4	21.9	21.7
07-Sep-05	27.2	28.3	22.4	23.1	21.5	20.0
08-Sep-05	25.7	29.2	25.0	26.2	24.7	22.4
09-Sep-05	24.4	27.8	26.6	27.6	26.4	24.4
10-Sep-05	20.3	26.4	26.1	26.4	26.7	25.1
11-Sep-05	18.2	23.1	25.0	25.2	25.1	23.8
12-Sep-05	22.8	21.1	22.9	22.8	23.6	22.9
13-Sep-05	23.8	23.7	20.3	19.8	20.6	20.4
14-Sep-05	23.4	25.1	20.3	21.0	19.6	18.3
15-Sep-05	23.4	25.5	21.9	22.8	21.9	20.0
16-Sep-05	22.8	25.2	22.8	23.4	22.8	21.2
17-Sep-05	19.1	24.4	23.0	23.3	22.9	21.5
18-Sep-05	17.8	21.4	22.8	23.0	22.7	21.3
19-Sep-05	22.4	20.3	21.0	21.1	21.8	20.8
20-Sep-05	22.9	23.2	18.9	18.7	19.2	18.7
21-Sep-05	22.8	24.2	19.5	20.0	18.4	17.2
22-Sep-05	22.4	24.2	21.1	21.7	20.6	18.6
23-Sep-05	22.1	24.0	21.9	22.4	21.6	19.8
24-Sep-05	18.5	23.3	22.0	22.2	21.9	20.5
25-Sep-05	18.0	20.5	21.6	21.6	21.3	20.2
26-Sep-05	22.8	20.0	19.9	19.8	20.1	19.4
27-Sep-05	24.9	23.1	18.3	18.4	18.4	17.9
28-Sep-05	26.3	25.4	19.2	20.1	18.1	16.7
29-Sep-05	25.8	27.1	21.5	22.8	21.1	18.6
30-Sep-05	23.2	27.2	23.7	24.6	23.1	20.8
01-Sep-06	28.7	30.3	34.2	30.8	30.5	32.5
02-Sep-06	24.2	28.0	35.4	31.4	31.9	33.3

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
03-Sep-06	21.6	24.5	34.6	30.2	31.2	33.1
04-Sep-06	26.9	22.5	32.0	27.1	28.5	31.1
05-Sep-06	27.6	26.0	29.3	24.4	25.3	27.6
06-Sep-06	27.0	27.2	28.9	25.4	24.4	25.4
07-Sep-06	26.6	26.4	30.9	27.8	27.3	26.4
08-Sep-06	25.5	26.1	31.4	27.8	28.0	27.8
09-Sep-06	21.9	25.0	31.3	27.5	27.6	27.8
10-Sep-06	20.0	22.4	30.6	26.8	27.1	27.4
11-Sep-06	24.6	20.8	28.9	24.7	25.7	26.3
12-Sep-06	24.9	23.3	26.7	22.0	23.0	24.0
13-Sep-06	24.9	25.1	26.5	23.1	22.2	22.1
14-Sep-06	24.3	25.0	27.7	24.9	24.5	22.9
15-Sep-06	25.7	24.9	28.5	25.3	25.2	23.8
16-Sep-06	21.6	25.3	28.7	25.2	25.2	24.0
17-Sep-06	20.6	22.8	29.4	26.2	25.9	24.5
18-Sep-06	26.6	21.6	28.6	24.7	25.9	25.8
19-Sep-06	27.6	25.9	26.7	22.4	23.4	23.8
20-Sep-06	27.2	27.5	27.2	24.5	23.1	22.3
21-Sep-06	27.0	27.7	29.7	27.5	26.7	24.8
22-Sep-06	26.0	27.5	30.8	27.7	27.8	27.7
23-Sep-06	22.1	26.2	31.1	27.5	27.6	28.8
24-Sep-06	19.8	23.4	30.5	26.8	27.0	28.8
25-Sep-06	24.4	21.5	28.6	24.5	25.4	27.3
26-Sep-06	28.5	24.2	26.2	21.7	22.7	24.8
27-Sep-06	27.8	28.4	25.8	22.8	21.7	22.3
28-Sep-06	26.0	27.6	28.4	26.6	25.1	23.3
29-Sep-06	23.8	26.3	30.5	28.2	28.0	26.1
30-Sep-06	19.7	24.6	30.4	26.9	27.2	26.5
01-Sep-07	23.8	33.3	36.3	32.7	32.7	29.7
02-Sep-07	21.3	26.8	36.5	32.7	33.1	30.0
03-Sep-07	26.2	24.9	34.5	27.6	30.2	28.9
04-Sep-07	25.9	27.6	31.9	23.4	24.2	23.7
05-Sep-07	25.6	28.0	30.3	24.5	23.2	20.9
06-Sep-07	25.7	27.6	29.7	25.8	25.0	22.3
07-Sep-07	25.6	27.1	29.4	25.8	25.5	23.0
08-Sep-07	21.4	26.7	29.2	25.9	25.4	22.8
09-Sep-07	19.8	23.7	29.2	25.9	25.5	23.1
10-Sep-07	25.0	22.2	28.3	23.6	24.5	22.8
11-Sep-07	25.7	25.4	26.7	21.1	21.5	20.3
12-Sep-07	24.8	26.7	26.2	23.1	21.4	18.9
13-Sep-07	24.7	26.2	27.1	25.5	24.2	21.0
14-Sep-07	24.3	26.0	27.7	25.3	25.1	22.6
15-Sep-07	20.7	25.3	27.8	25.0	24.6	22.3

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
16-Sep-07	18.9	22.3	27.6	24.7	24.4	22.4
17-Sep-07	30.4	21.2	26.5	22.5	23.2	21.9
18-Sep-07	32.4	30.1	25.0	20.3	20.5	19.7
19-Sep-07	32.4	32.6	25.9	25.6	21.7	18.6
20-Sep-07	32.3	32.8	29.6	30.9	28.9	24.4
21-Sep-07	31.8	32.6	32.1	31.8	31.5	28.1
22-Sep-07	21.5	31.0	33.1	31.6	31.5	28.6
23-Sep-07	19.4	23.5	33.3	31.1	31.1	28.3
24-Sep-07	30.8	21.5	30.6	25.4	28.2	27.1
25-Sep-07	30.9	29.5	26.5	20.6	21.3	21.1
26-Sep-07	28.4	30.4	26.9	26.2	22.2	18.8
27-Sep-07	30.6	31.8	31.2	31.2	30.0	26.3
28-Sep-07	32.3	33.4	33.9	31.6	31.2	28.6
29-Sep-07	22.4	32.8	34.9	32.5	32.1	28.9
30-Sep-07	18.8	24.6	35.3	32.9	32.7	29.6
01-Sep-08	30.3	28.8	35.1	37.0	37.4	22.9
02-Sep-08	30.8	32.2	34.7	30.7	34.3	23.5
03-Sep-08	30.1	32.5	33.1	30.3	29.7	18.9
04-Sep-08	29.9	31.7	33.2	31.5	31.7	19.7
05-Sep-08	28.7	31.2	33.4	31.0	31.5	20.1
06-Sep-08	26.0	29.3	33.2	30.5	30.8	19.7
07-Sep-08	23.9	27.3	32.7	29.8	30.4	19.4
08-Sep-08	29.5	26.5	31.3	27.8	28.7	18.6
09-Sep-08	29.2	30.5	29.5	25.8	26.5	16.9
10-Sep-08	29.5	30.5	29.7	28.5	26.9	15.9
11-Sep-08	28.9	30.0	31.1	29.9	29.7	18.4
12-Sep-08	28.1	29.3	31.9	30.5	30.5	19.4
13-Sep-08	25.6	28.0	32.1	30.1	30.5	19.8
14-Sep-08	22.9	26.4	32.0	29.4	29.8	19.5
15-Sep-08	27.2	25.4	31.0	27.3	28.2	18.6
16-Sep-08	27.9	28.3	29.6	25.2	26.1	16.9
17-Sep-08	28.4	28.9	29.0	26.8	25.6	15.7
18-Sep-08	28.1	29.4	29.5	28.7	28.0	17.6
19-Sep-08	27.5	29.1	30.1	29.0	29.0	18.9
20-Sep-08	26.0	27.1	30.4	28.7	28.5	19.2
21-Sep-08	24.3	26.3	30.5	28.5	28.3	19.5
22-Sep-08	28.2	26.6	30.2	27.2	27.4	19.5
23-Sep-08	28.2	29.6	29.4	25.7	25.9	18.8
24-Sep-08	28.8	29.6	29.4	28.1	26.8	18.0
25-Sep-08	28.7	29.9	29.8	29.0	28.7	20.0
26-Sep-08	27.3	29.9	30.4	29.4	29.2	20.7
27-Sep-08	23.6	27.7	30.7	29.5	29.4	21.0
28-Sep-08	22.4	24.7	30.8	28.3	28.8	21.0

Date	C8H036 Tunnel Outlet	C8R004 Sol Plaatje Dam	C8H037 Reward	C8H020 Roodekraal	C8H026 Frederiksdal	C8H001 Wilge, Frankfort
29-Sep-08	26.6	24.4	30.0	25.6	26.9	21.3
30-Sep-08	26.9	27.3	28.9	23.9	24.4	19.2
01-Sep-09	29.5	26.3	32.9	27.7	26.7	25.7
02-Sep-09	29.1	26.5	32.5	29.9	27.1	24.6
03-Sep-09	29.1	25.8	32.5	30.4	28.5	26.1
04-Sep-09	29.0	25.5	32.5	30.7	28.9	26.3
05-Sep-09	25.8	24.8	32.5	30.3	28.8	26.3
06-Sep-09	23.1	22.8	32.5	30.2	28.4	26.2
07-Sep-09	27.7	21.6	32.0	27.9	27.2	25.7
08-Sep-09	28.3	24.3	31.1	25.5	24.8	23.7
09-Sep-09	29.3	25.1	30.5	27.2	24.4	22.3
10-Sep-09	30.7	25.1	30.6	29.4	26.9	23.4
11-Sep-09	30.1	26.8	30.9	30.5	28.5	25.5
12-Sep-09	27.2	25.7	31.4	31.4	28.9	26.0
13-Sep-09	24.4	23.4	31.8	31.5	30.0	26.8
14-Sep-09	28.6	22.2	31.8	29.1	28.4	26.8
15-Sep-09	28.4	24.8	31.2	26.6	25.6	24.4
16-Sep-09	27.4	24.9	31.0	28.7	25.6	22.9
17-Sep-09	28.9	24.0	31.0	29.8	27.6	24.4
18-Sep-09	29.2	24.1	31.1	29.8	28.3	25.1
19-Sep-09	26.4	24.1	31.0	29.1	27.2	24.7
20-Sep-09	23.7	22.3	31.0	30.0	27.8	24.5
21-Sep-09	28.0	21.3	30.9	28.4	27.4	24.9
22-Sep-09	29.9	24.1	30.2	25.8	24.9	23.2
23-Sep-09	28.8	25.1	29.9	27.9	24.8	21.8
24-Sep-09	27.4	24.2	30.4	30.4	27.6	23.7
25-Sep-09	26.5	23.3	30.9	30.2	28.7	25.4
26-Sep-09	23.2	21.9	31.0	28.8	27.3	25.4
27-Sep-09	21.2	19.7	30.7	27.7	26.2	24.3
28-Sep-09	24.4	17.6	29.9	25.3	24.5	23.2
29-Sep-09	27.3	18.3	28.6	23.7	22.4	21.0
30-Sep-09	27.7	22.0	27.6	24.3	22.1	19.8

APPENDIX B

Surface Water Quality – Hydrochemical variables analysed

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	ASAR-Diss-Water	null	54	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Al-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	B-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Ba-Diss-Water	mg/L	18	08/09/2010	06/06/2012
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	COD	mg/L	42	02/02/2010	03/09/2013
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	CORR-Diss-Water	null	73	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Ca-Diss-Water	mg/L	77	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Cd-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Cl-Diss-Water	mg/L	119	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Cr-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Cu-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	DMS-Tot-Water	mg/L	47	04/08/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	E.COLI-Susp-Water	cfu/100mL	41	02/02/2010	03/09/2013
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	EC-Phys-Water	mS/m	154	05/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	F-Diss-Water	mg/L	68	04/08/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	FC-Susp-Water	cfu/100mL	40	02/02/2010	03/09/2013
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Fe-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	HARD-Mg-Calc-Water	mg/L	78	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	HARD-Tot-Water	mg/L	76	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	K-Diss-Water	mg/L	62	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	LANGL-Index-Water	null	46	22/09/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Mg-Diss-Water	mg/L	78	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Mn-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Mo-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	NH3(25)-Union-Diss-W	mg/L	120	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	NH4-N-Diss-Water	mg/L	121	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	NO3+NO2-N-Diss-Wate	mg/L	120	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Na-Diss-Water	mg/L	61	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Ni-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	PO4-P-Diss-Water	mg/L	120	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Pb-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	RYZNAR-Index-Water	null	46	22/09/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	SAR-Diss-Water	null	59	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	SO4-Diss-Water	mg/L	79	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	SO4Ion/MajAnions-Wat	null	17	09/04/2014	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	SO4Ion/TotAnions-Wat	null	14	02/07/2014	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Si-Diss-Water	mg/L	79	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Sr-Diss-Water	mg/L	15	08/09/2010	06/06/2012
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	TAL-Diss-Water	mg/L	73	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	TURB-Phys-Water	NTU	53	07/07/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	V-Diss-Water	mg/L	41	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	Zn-Diss-Water	mg/L	42	08/09/2010	15/10/2014
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	pH-Diss-Water	pH units	120	20/01/2010	12/05/2015
90893	C8R004Q01 Saulspoort 945 - Saulspoort dam on Liebenbergsvleirivier: near dam wall	-28.2175	28.3635	Dam / Barrage	C83A	Yes	pHs-Calc-Water	null	47	04/08/2010	12/05/2015

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	ASAR-Diss-Water	null	30	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Al-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	As-Diss-Water	mg/L	1	06/06/2012	06/06/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	B-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Ba-Diss-Water	mg/L	8	07/09/2011	06/06/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	CORR-Diss-Water	null	38	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Ca-Diss-Water	mg/L	39	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Cd-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Cl-Diss-Water	mg/L	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Cr-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Cu-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	DMS-Tot-Water	mg/L	30	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	EC-Phys-Water	mS/m	40	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	F-Diss-Water	mg/L	39	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Fe-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	HARD-Mg-Calc-Water	mg/L	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	HARD-Tot-Water	mg/L	39	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	K-Diss-Water	mg/L	34	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	LANGL-Index-Water	null	30	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Mg-Diss-Water	mg/L	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Mn-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Mo-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	NH3(25)-Union-Diss-W	mg/L	39	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	NH4-N-Diss-Water	mg/L	40	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	NO3+NO2-N-Diss-Wate	mg/L	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Na-Diss-Water	mg/L	34	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Ni-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	PO4-P-Diss-Water	mg/L	40	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Pb-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	RYZNAR-Index-Water	null	30	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	SAR-Diss-Water	null	32	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	SO4-Diss-Water	mg/L	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	SO4Ion/MajAnions-Wat	null	7	16/04/2014	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	SO4Ion/TotAnions-Wat	null	5	02/09/2014	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Si-Diss-Water	mg/L	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Sr-Diss-Water	mg/L	6	07/09/2011	06/06/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	TAL-Diss-Water	mg/L	38	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	TURB-Phys-Water	NTU	25	30/06/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	V-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	Zn-Diss-Water	mg/L	9	07/09/2011	07/09/2012
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	pH-Diss-Water	pH units	41	23/03/2011	26/03/2015
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	-28.437778	28.398056	Tunnel	C83A	Yes	pHs-Calc-Water	null	30	23/03/2011	26/03/2015

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	ASAR-Diss-Water	null	78	13/01/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	COD	mg/L	42	02/02/2010	03/09/2013
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	CORR-Diss-Water	null	102	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	Ca-Diss-Water	mg/L	104	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	Cl-Diss-Water	mg/L	146	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	DMS-Tot-Water	mg/L	60	14/07/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	E.COLI-Susp-Water	cfu/100mL	42	02/02/2010	03/09/2013
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	EC-Phys-Water	mS/m	159	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	F-Diss-Water	mg/L	88	02/02/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	FC-Susp-Water	cfu/100mL	40	02/02/2010	03/09/2013
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	HARD-Mg-Calc-Water	mg/L	106	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	HARD-Tot-Water	mg/L	103	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	K-Diss-Water	mg/L	84	13/01/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	LANGL-Index-Water	null	50	14/07/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	Mg-Diss-Water	mg/L	106	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	NH3(25)-Union-Diss-W	mg/L	127	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	NH4-N-Diss-Water	mg/L	148	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	NO3+NO2-N-Diss-Wate	mg/L	148	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	Na-Diss-Water	mg/L	83	13/01/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	PO4-P-Diss-Water	mg/L	148	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	RYZNAR-Index-Water	null	50	14/07/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	SAR-Diss-Water	null	80	13/01/2010	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	SO4-Diss-Water	mg/L	107	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	SO4Ion/MajAnions-Wat	null	22	12/03/2014	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	SO4Ion/TotAnions-Wat	null	16	24/06/2014	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	Si-Diss-Water	mg/L	88	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	TAL-Diss-Water	mg/L	104	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	TURB-Phys-Water	NTU	14	08/03/2012	12/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	pH-Diss-Water	pH units	130	13/01/2010	13/05/2015
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	-28.2506	28.3084	Dam / Barrage	C83B	Yes	pHs-Calc-Water	null	60	14/07/2010	12/05/2015

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	ASAR-Diss-Water	null	8	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	CORR-Diss-Water	null	15	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	Ca-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	Cl-Diss-Water	mg/L	15	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	DMS-Tot-Water	mg/L	8	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	EC-Phys-Water	mS/m	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	F-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	HARD-Mg-Calc-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	HARD-Tot-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	K-Diss-Water	mg/L	9	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	LANGL-Index-Water	null	8	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	Mg-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	NH3(25)-Union-Diss-W	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	NH4-N-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	NO3+NO2-N-Diss-Wate	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	Na-Diss-Water	mg/L	8	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	PO4-P-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	RYZNAR-Index-Water	null	8	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	SAR-Diss-Water	null	8	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	SO4-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	SO4Ion/MajAnions-Wat	null	10	21/05/2014	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	SO4Ion/TotAnions-Wat	null	10	21/05/2014	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	Si-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	TAL-Diss-Water	mg/L	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	TURB-Phys-Water	NTU	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	pH-Diss-Water	pH units	16	09/05/2012	12/05/2015
86199	C8H037 REWARD 7 - @ weir on Liebenbergsvleirivier	-27.795833	28.3177778	Rivers	C83F	Yes	pHs-Calc-Water	null	8	09/05/2012	12/05/2015

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	ASAR-Diss-Water	null	88	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	CORR-Diss-Water	null	105	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	Ca-Diss-Water	mg/L	108	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	Cl-Diss-Water	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	DMS-Tot-Water	mg/L	72	09/06/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	EC-Phys-Water	mS/m	111	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	F-Diss-Water	mg/L	88	09/06/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	HARD-Mg-Calc-Water	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	HARD-Tot-Water	mg/L	108	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	K-Diss-Water	mg/L	92	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	LANGL-Index-Water	null	72	09/06/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	Mg-Diss-Water	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	NH3(25)-Union-Diss-W	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	NH4-N-Diss-Water	mg/L	111	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	NO3+NO2-N-Diss-Wate	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	Na-Diss-Water	mg/L	91	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	PO4-P-Diss-Water	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	RYZNAR-Index-Water	null	72	09/06/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	SAR-Diss-Water	null	91	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	SO4-Diss-Water	mg/L	109	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	SO4Ion/MajAnions-Wat	null	16	12/03/2014	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	SO4Ion/TotAnions-Wat	null	12	06/08/2014	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	Si-Diss-Water	mg/L	110	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	TAL-Diss-Water	mg/L	106	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	TURB-Phys-Water	NTU	80	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	pH-Diss-Water	pH units	112	06/01/2010	12/05/2015
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	-27.689167	28.378333	Rivers	C83F	Yes	pHs-Calc-Water	null	72	09/06/2010	12/05/2015

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	ASAR-Diss-Water	null	67	13/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Al-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	B-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Ba-Diss-Water	mg/L	5	07/07/2010	03/08/2011
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	CORR-Diss-Water	null	85	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Ca-Diss-Water	mg/L	89	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Cd-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Cl-Diss-Water	mg/L	89	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Cr-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Cu-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	DMS-Tot-Water	mg/L	49	23/06/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	EC-Phys-Water	mS/m	88	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	F-Diss-Water	mg/L	65	23/06/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Fe-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	HARD-Mg-Calc-Water	mg/L	89	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	HARD-Tot-Water	mg/L	89	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	K-Diss-Water	mg/L	71	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	KJEL N-Tot-Water	mg/L	68	20/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	LANGL-Index-Water	null	46	23/06/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Mg-Diss-Water	mg/L	89	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Mn-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Mo-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	N-Tot-Calc-Water	mg/L	67	20/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	NH3(25)-Union-Diss-W	mg/L	81	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	NH4-N-Diss-Water	mg/L	90	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	NO3+NO2-N-Diss-Wate	mg/L	78	20/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Na-Diss-Water	mg/L	70	13/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Ni-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	P-Tot-Water	mg/L	65	20/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	PO4-P-Diss-Water	mg/L	89	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Pb-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	RYZNAR-Index-Water	null	46	23/06/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	SAR-Diss-Water	null	69	13/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	SO4-Diss-Water	mg/L	88	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	SO4Ion/MajAnions-Wat	null	18	12/03/2014	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	SO4Ion/TotAnions-Wat	null	12	06/08/2014	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Si-Diss-Water	mg/L	82	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Sr-Diss-Water	mg/L	5	07/07/2010	03/08/2011
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	TAL-Diss-Water	mg/L	87	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	TN_TP-Calc-Water	null	17	13/02/2014	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	TURB-Phys-Water	NTU	64	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	V-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	Zn-Diss-Water	mg/L	26	07/07/2010	15/10/2014
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	pH-Diss-Water	pH units	83	06/01/2010	06/05/2015
90883	C8H026Q01 at Frederiksdal on Liebenbergsvlei River	-27.4275	28.525833	Rivers	C83H	Yes	pHs-Calc-Water	null	49	23/06/2010	06/05/2015

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Located Type	Drainage Region Name	Monitoring Active	Monitoring Variable	Measuring Unit	Number of Analyses	First Analyses	Last Analyses
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	ASAR-Diss-Water	null	87	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Al-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	B-Diss-Water	mg/L	37	03/08/2011	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Ba-Diss-Water	mg/L	10	03/08/2011	09/05/2012
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	COD	mg/L	42	12/01/2010	03/09/2013
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	CORR-Diss-Water	null	105	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Ca-Diss-Water	mg/L	109	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Cd-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Cl-Diss-Water	mg/L	152	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Cr-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Cu-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	DMS-Tot-Water	mg/L	64	23/06/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	E.COLI-Susp-Water	cfu/100mL	41	02/02/2010	03/09/2013
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	EC-Phys-Water	mS/m	151	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	F-Diss-Water	mg/L	83	23/06/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	FC-Susp-Water	cfu/100mL	41	02/02/2010	03/09/2013
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Fe-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	HARD-Mg-Calc-Water	mg/L	110	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	HARD-Tot-Water	mg/L	108	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	K-Diss-Water	mg/L	94	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	KJEL N-Tot-Water	mg/L	82	02/02/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	LANGL-Index-Water	null	54	27/07/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Mg-Diss-Water	mg/L	110	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Mn-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Mo-Diss-Water	mg/L	37	03/08/2011	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	N-Tot-Calc-Water	mg/L	82	02/02/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	NH3(25)-Union-Diss-W	mg/L	138	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	NH4-N-Diss-Water	mg/L	154	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	NO3+NO2-N-Diss-Wate	mg/L	154	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Na-Diss-Water	mg/L	91	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Ni-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	P-Tot-Water	mg/L	80	02/02/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	PO4-P-Diss-Water	mg/L	154	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Pb-Diss-Water	mg/L	38	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	RYZNAR-Index-Water	null	54	27/07/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	SAR-Diss-Water	null	89	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	SO4-Diss-Water	mg/L	112	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	SO4Ion/MajAnions-Wat	null	16	12/03/2014	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	SO4Ion/TotAnions-Wat	null	10	17/09/2014	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	SOLIDS-Susp-Water	mg/L	1	02/02/2010	02/02/2010
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Si-Diss-Water	mg/L	96	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Sr-Diss-Water	mg/L	8	03/08/2011	09/05/2012
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	TAL-Diss-Water	mg/L	107	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	TN_TP-Calc-Water	null	16	12/03/2014	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	TURB-Phys-Water	NTU	54	09/11/2010	04/06/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	V-Diss-Water	mg/L	37	03/08/2011	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	Zn-Diss-Water	mg/L	39	09/11/2010	15/10/2014
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	pH-Diss-Water	pH units	140	06/01/2010	14/05/2015
90859	C8H001Q01 WILGE RIVER AT FRANKFORT	-27.273889	28.49	Rivers	C83J	Yes	pHs-Calc-Water	null	64	23/06/2010	14/05/2015

APPENDIX C

Long Term Surface Water Statistics

Monitoring Point ID	Monitoring Point Name	Located on Type	Latitude	Longitude	Drainage Region Name	Monitoring Variable	N	Min	Max	5% P	10% P	25% P	50% P	75% P	90% P	95% P	L 95%	U 95%	Mean	GeoMean	StdDev	% VarCoef
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	pH-Diss-Water(pH units)	16	5.013	8.103	6.68	7.378	7.606	7.855	7.908	8.023	8.052	7.254	7.968	7.611	7.57	0.728	9.565
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	NO3+NO2-N-Diss-Water(mg/L)	16	0.025	0.69	0.044	0.05	0.05	0.143	0.211	0.254	0.371	0.093	0.247	0.17	0.122	0.158	92.941
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	NH4-N-Diss-Water(mg/L)	16	0.025	0.05	0.025	0.025	0.025	0.05	0.05	0.05	0.05	0.035	0.047	0.041	0.039	0.013	31.707
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	TAL-Diss-Water(mg/L)	16	29.585	51.215	32.067	33.57	36.885	39.784	41.922	45.725	48.503	36.964	42.286	39.625	39.277	5.43	13.703
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	Na-Diss-Water(mg/L)	8	1.5	6.612	1.5	1.5	1.875	2	4.709	5.451	6.031	1.792	4.506	3.149	2.688	1.958	62.178
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	Si-Diss-Water(mg/L)	16	1.717	6.53	3.641	4.36	4.58	4.887	5.292	5.644	5.926	4.338	5.32	4.829	4.683	1.003	20.77
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	PO4-P-Diss-Water(mg/L)	16	0.005	0.044	0.005	0.005	0.005	0.01	0.01	0.025	0.04	0.006	0.018	0.012	0.01	0.012	100
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	SO4-Diss-Water(mg/L)	16	3.646	6.732	3.741	3.9	4.152	4.58	5.458	5.794	6.068	4.362	5.206	4.784	4.716	0.861	17.997
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	SAR-Diss-Water(null)	8	0.105	0.452	0.105	0.106	0.133	0.145	0.339	0.387	0.419	0.129	0.317	0.223	0.191	0.136	60.987
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	TURB-Phys-Water(NTU)	16	0.5	36.4	0.5	0.5	3.405	7.35	11.625	17	24.55	4.632	13.6	9.116	5.093	9.152	100.395
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	RYZNAR-Index-Water(null)	8	9.602	10.502	9.62	9.638	9.71	9.832	10.008	10.275	10.388	9.7	10.12	9.91	9.906	0.303	3.058
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	pHs-Calc-Water(null)	8	8.75	8.895	8.755	8.76	8.771	8.794	8.853	8.877	8.886	8.774	8.848	8.811	8.811	0.053	0.602
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	NH3(25)-Union-Diss-W(mg/L)	16	0	0.004	0	0	0.001	0.002	0.002	0.003	0.003	0.002	0.002	0.002	-8888	0.001	50
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	SO4Ion/MajAnions-Wat(null)	10	0.08	0.118	0.085	0.09	0.1	0.107	0.11	0.114	0.116	0.097	0.111	0.104	0.103	0.011	10.577
86199	C8H037 REWARD 7 - @ Weir on Liebenbergsvleirivier	Rivers	-27.795833	28.3177778	C83F	SO4Ion/TotAnions-Wat(null)	10	0.079	0.117	0.084	0.089	0.097	0.104	0.108	0.111	0.114	0.094	0.108	0.101	0.101	0.011	10.891
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	pH-Diss-Water(pH units)	2	7.4	7.6	7.41	7.42	7.45	7.5	7.55	7.58	7.59	7.305	7.695	7.5	7.499	0.141	1.88
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	NO3+NO2-N-Diss-Water(mg/L)	5	0.05	0.4	0.08	0.11	0.2	0.3	0.3	0.36	0.38	0.134	0.366	0.25	0.205	0.132	52.8
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	NH4-N-Diss-Water(mg/L)	2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	PO4-P-Diss-Water(mg/L)	5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	TURB-Phys-Water(NTU)	1	41	41	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	41	-9999	-9999	-9999
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Ni-Diss-Water(mg/L)	1	0.005	0.005	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.005	-9999	-9999	-9999
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Zn-Diss-Water(mg/L)	1	0.01	0.01	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.01	-9999	-9999	-9999
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Pb-Diss-Water(mg/L)	1	0.01	0.01	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.01	-9999	-9999	-9999
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	NH3(25)-Union-Diss-W(mg/L)	1	0.001	0.001	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.001	-9999	-9999	-9999
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	pH-Diss-Water(pH units)	138	6.6	8.8	7.085	7.3	7.524	7.847	8.002	8.097	8.173	7.692	7.812	7.752	7.744	0.359	4.631
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	NO3+NO2-N-Diss-Water(mg/L)	149	0.025	1.2	0.025	0.025	0.116	0.224	0.3	0.49	0.681	0.218	0.282	0.25	0.173	0.2	80
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	NH4-N-Diss-Water(mg/L)	152	0.02	35.1	0.02	0.025	0.025	0.025	0.05	0.3	0.545	-0.115	0.791	0.338	0.049	2.85	843.195
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	TAL-Diss-Water(mg/L)	107	30.502	114.893	37.769	41.733	43.993	51.639	60.965	73.864	80.389	51.774	57.124	54.449	52.876	14.117	25.927
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Na-Diss-Water(mg/L)	91	1	16.091	2	2.018	3.824	5.472	8.101	9.928	11.69	5.363	6.655	6.009	5.156	3.144	52.322
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Si-Diss-Water(mg/L)	96	2.279	8.59	4.404	4.552	5.389	5.889	6.477	7.522	7.872	5.758	6.21	5.984	5.869	1.132	18.917
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	P-Tot-Water(mg/L)	80	0.006	0.878	0.019	0.022	0.042	0.062	0.14	0.201	0.335	0.083	0.147	0.115	0.072	0.146	126.957
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	PO4-P-Diss-Water(mg/L)	149	0.005	5.7	0.005	0.005	0.005	0.021	0.05	0.05	0.2	0.013	0.207	0.11	0.02	0.601	546.364
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	SO4-Diss-Water(mg/L)	112	3.022	30	4.249	4.615	5.398	6.88	10.242	13.056	14.521	7.408	8.846	8.127	7.425	3.884	47.791
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	SAR-Diss-Water(null)	89	0.055	0.779	0.137	0.143	0.232	0.347	0.482	0.587	0.679	0.329	0.399	0.364	0.322	0.167	45.879
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	TURB-Phys-Water(NTU)	53	0.5	223	2.38	3.676	4.8	11.9	25.4	62.6	107.62	15.419	37.899	26.659	12.621	41.751	156.611
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	SOLIDS-Susp-Water(mg/L)	1	182	182	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	182	-9999	-9999	-9999
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	V-Diss-Water(mg/L)	37	0.001	0.011	0.002	0.002	0.002	0.005	0.005	0.005	0.006	0.003	0.005	0.004	0.003	0.002	50
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Ni-Diss-Water(mg/L)	37	0.001	0.004	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	50
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Zn-Diss-Water(mg/L)	38	0.001	0.161	0.002	0.002	0.002	0.003	0.005	0.016	0.028	0.002	0.02	0.011	0.004	0.028	254.545
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Sr-Diss-Water(mg/L)	8	0.001	0.109	0.001	0.001	0.001	0.027	0.052	0.072	0.09	0.008	0.06	0.034	0.011	0.037	108.824
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	Pb-Diss-Water(mg/L)	37	0.002	0.013	0.002	0.002	0.004	0.004	0.004	0.004	0.007	0.003	0.005	0.004	0.004	0.002	50
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	RYZNAR-Index-Water(null)	54	8.141	10.551	8.674	8.825	9.182	9.395	9.617	9.891	10.134	9.271	9.507	9.389	9.378	0.443	4.718
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	pHs-Calc-Water(null)	64	8.085	8.96	8.275	8.391	8.562	8.678	8.754	8.789	8.873	8.597	8.685	8.641	8.64	0.178	2.06
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	NH3(25)-Union-Diss-W(mg/L)	137	0	0.841	0	0	0.001	0.002	0.003	0.007	0.013	-0.002	0.022	0.01	-8888	0.072	720
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	N-Tot-Calc-Water(mg/L)	82	0.405	10.393	0.459	0.607	0.735	0.953	1.457	2.095	2.245	1.021	1.643	1.332	1.071	1.436	107.808
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	TN_TP-Calc-Water(null)	16	1.132	61.607	1.252	3.445	9.593	12.941	18.527	34.423	48.232	9.425	24.711	17.068	11.323	15.598	91.387
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	SO4Ion/MajAnions-Wat(null)	16	0.06	0.163	0.077	0.086	0.1	0.112	0.132	0.148	0.153	0.101	0.127	0.114	0.111	0.027	23.684
90859	C8H001Q01 Wilge River at Frankfort	Rivers	-27.273889	28.49	C83J	SO4Ion/TotAnions-Wat(null)	10	0.058	0.155	0.074	0.09	0.101	0.111	0.124	0.144	0.15	0.095	0.129	0.112	0.109	0.027	24.107
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	Rivers	-27.689167	28.378333	C83F	pH-Diss-Water(pH units)	112	6.873	11.76	7.421	7.482	7.668	7.852	7.993	8.078	8.124	7.766	7.93	7.848	7.837	0.441	5.619
90877	C8H020Q01 Libenbergsvlei River at Roodekraal	Rivers	-27.689167	28.378333	C83F	NO3+NO2-N-Diss-Water(mg/L)	110	0.025	1.742	0.025	0.025	0.071	0.175	0.23	0.314							

Monitoring Point ID	Monitoring Point Name	Located on Type	Latitude	Longitude	Drainage Region Name	Monitoring Variable	N	Min	Max	5% P	10% P	25% P	50% P	75% P	90% P	95% P	L 95%	U 95%	Mean	GeoMean	StdDev	% VarCoef
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	pH-Diss-Water(pH units)	83	6.846	8.527	7.249	7.416	7.66	7.833	7.994	8.059	8.099	7.733	7.849	7.791	7.786	0.271	3.478
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	NO3+NO2-N-Diss-Water(mg/L	78	0.005	0.626	0.005	0.005	0.025	0.136	0.214	0.266	0.302	0.12	0.172	0.146	0.084	0.117	80.137
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	NH4-N-Diss-Water(mg/L)	90	0.025	0.813	0.025	0.025	0.025	0.025	0.05	0.05	0.055	0.024	0.058	0.041	0.032	0.084	204.878
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	TAL-Diss-Water(mg/L)	87	28.38	153.576	34.208	35.185	39.443	43.491	47.898	57.661	71.081	43.238	50.402	46.82	45.003	17.044	36.403
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	Na-Diss-Water(mg/L)	70	0.221	11.3	0.963	1.5	2	3.62	5.005	7.437	8.76	3.383	4.517	3.95	3.212	2.42	61.266
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	Si-Diss-Water(mg/L)	82	0.5	8.957	4.619	4.743	5.221	5.994	6.357	7	7.691	5.66	6.14	5.9	5.723	1.109	18.797
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	P-Tot-Water(mg/L)	65	0.013	0.378	0.02	0.024	0.032	0.053	0.096	0.145	0.217	0.058	0.092	0.075	0.055	0.07	93.333
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	PO4-P-Diss-Water(mg/L)	89	0.005	0.783	0.005	0.005	0.005	0.01	0.029	0.053	0.076	0.012	0.046	0.029	0.013	0.084	289.655
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	SO4-Diss-Water(mg/L)	88	1.372	20.078	3.035	3.507	4.116	4.67	6.769	8.319	10.914	5.008	6.134	5.571	5.063	2.695	48.376
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	SAR-Diss-Water(null)	69	0.017	0.743	0.068	0.111	0.137	0.268	0.34	0.452	0.5	0.225	0.295	0.26	0.217	0.147	56.538
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	TURB-Phys-Water(NTU)	64	1.01	124	1.758	2.722	6.158	9.805	21.25	54.54	79.4	13.515	26.055	19.785	11.044	25.591	129.345
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	V-Diss-Water(mg/L)	26	0.002	0.009	0.002	0.002	0.005	0.005	0.005	0.006	0.007	0.004	0.006	0.005	0.004	0.002	40
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	Ni-Diss-Water(mg/L)	26	0.001	0.006	0.001	0.002	0.002	0.002	0.002	0.006	0.006	0.002	0.004	0.003	0.002	0.002	66.667
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	Zn-Diss-Water(mg/L)	26	0.001	0.074	0.002	0.002	0.003	0.003	0.006	0.025	0.047	0.003	0.017	0.01	0.005	0.017	170
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	Sr-Diss-Water(mg/L)	5	0.008	0.196	0.013	0.019	0.035	0.044	0.138	0.173	0.184	0.015	0.153	0.084	0.051	0.079	94.048
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	Pb-Diss-Water(mg/L)	26	0.002	0.013	0.003	0.004	0.004	0.004	0.004	0.009	0.013	0.004	0.006	0.005	0.004	0.003	60
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	RYZNAR-Index-Water(null)	46	8.914	10.717	9.123	9.241	9.492	9.664	9.799	10.04	10.306	9.566	9.764	9.665	9.659	0.343	3.549
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	pHs-Calc-Water(null)	49	8.479	8.918	8.582	8.604	8.676	8.771	8.8	8.848	8.859	8.715	8.769	8.742	8.742	0.097	1.11
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	NH3(25)-Union-Diss-W(mg/L)	81	0	0.008	0	0	0.001	0.001	0.002	0.003	0.004	0.002	0.002	0.002	-8888	0.002	100
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	N-Tot-Calc-Water(mg/L)	67	0.269	9.266	0.354	0.427	0.603	0.746	1.075	1.326	1.507	0.721	1.367	1.044	0.807	1.35	129.31
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	TN_TP-Calc-Water(null)	17	6.017	30.125	6.295	6.927	8.103	10.729	12.393	21.568	24.15	9.276	15.464	12.37	11.145	6.508	52.611
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	SO4Ion/MajAnions-Wat(null)	18	0.032	0.15	0.034	0.07	0.094	0.104	0.112	0.132	0.137	0.087	0.113	0.1	0.094	0.029	29
90883	C8H026Q01 at Frederiksdal on Libenbergsvlei River	Rivers	-27.4275	28.525833	C83H	SO4Ion/TotAnions-Wat(null)	12	0.03	0.128	0.032	0.039	0.086	0.101	0.105	0.123	0.126	0.074	0.11	0.092	0.084	0.031	33.696
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	pH-Diss-Water(pH units)	41	7.363	8.262	7.443	7.526	7.638	7.801	7.99	8.066	8.12	7.738	7.876	7.807	7.804	0.225	2.882
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	NO3+NO2-N-Diss-Water(mg/L	41	0.025	0.355	0.025	0.025	0.068	0.23	0.3	0.323	0.334	0.163	0.235	0.199	0.14	0.116	58.291
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	NH4-N-Diss-Water(mg/L)	40	0.025	0.383	0.025	0.025	0.025	0.025	0.05	0.086	0.101	0.03	0.068	0.049	0.037	0.06	122.449
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	TAL-Diss-Water(mg/L)	38	22.995	75.499	29.443	30.347	33.487	36.396	40.699	42.108	50.422	34.959	40.333	37.646	36.902	8.452	22.451
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	Na-Diss-Water(mg/L)	34	0.794	6.01	1.381	1.5	1.5	2	2	4.407	4.7	1.948	2.79	2.369	2.126	1.251	52.807
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	Si-Diss-Water(mg/L)	41	3.455	7.542	4.582	4.856	5.199	5.986	6.399	6.656	6.802	5.527	6.065	5.796	5.723	0.88	15.183
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	PO4-P-Diss-Water(mg/L)	40	0.005	0.037	0.005	0.005	0.005	0.005	0.01	0.011	0.013	0.006	0.01	0.008	0.006	0.006	75
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	SO4-Diss-Water(mg/L)	41	1.5	18.709	1.5	3.17	3.717	4.083	4.669	6.115	9.149	3.768	5.666	4.717	4.138	3.099	65.699
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	SAR-Diss-Water(null)	32	0.06	0.372	0.092	0.102	0.112	0.144	0.151	0.332	0.349	0.136	0.196	0.166	0.15	0.087	52.41
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	TURB-Phys-Water(NTU)	25	0.5	1.72	0.5	0.5	0.5	0.5	0.5	0.5	1.276	0.468	0.708	0.588	0.548	0.305	51.871
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	V-Diss-Water(mg/L)	9	0.001	0.004	0.001	0.002	0.002	0.002	0.003	0.004	0.004	0.001	0.003	0.002	0.002	0.001	50
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	Ni-Diss-Water(mg/L)	9	0.001	0.005	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.001	0.003	0.002	0.002	0.001	50
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	Zn-Diss-Water(mg/L)	9	0.002	0.107	0.002	0.002	0.006	0.008	0.011	0.045	0.076	-0.002	0.042	0.02	0.009	0.034	170
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	Sr-Diss-Water(mg/L)	6	0.016	0.041	0.016	0.017	0.017	0.024	0.031	0.036	0.039	0.017	0.033	0.025	0.024	0.01	40
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	Pb-Diss-Water(mg/L)	9	0.002	0.01	0.002	0.002	0.002	0.004	0.004	0.008	0.009	0.002	0.006	0.004	0.004	0.003	75
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	RYZNAR-Index-Water(null)	30	9.408	10.6	9.502	9.591	9.714	9.941	10.093	10.346	10.434	9.835	10.047	9.941	9.937	0.295	2.968
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	pHs-Calc-Water(null)	30	8.65	9.032	8.692	8.738	8.823	8.859	8.929	8.979	8.986	8.823	8.891	8.857	8.857	0.094	1.061
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	NH3(25)-Union-Diss-W(mg/L)	39	0	0.01	0	0.001	0.001	0.001	0.002	0.003	0.005	0.001	0.003	0.002	-8888	0.002	100
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	SO4Ion/MajAnions-Wat(null)	7	0.06	0.121	0.068	0.076	0.088	0.097	0.11	0.116	0.119	0.081	0.111	0.096	0.094	0.02	20.833
90887	C8H036Q01 as river tunnel outlet from Katse at Botterkloof/	Tunnel	-28.437778	28.398056	C83A	SO4Ion/TotAnions-Wat(null)	5	0.083	0.108	0.084	0.084	0.086	0.096	0.103	0.106	0.107	0.085	0.105	0.095	0.095	0.011	11.579
90893	C8R004Q01 Saulspoort 945 - Saulspoort Dam on Libenbergsveirivier: near dam wall	Dam / Barrage	-28.2175	28.3635	C83A	pH-Diss-Water(pH units)	1	7.6	7.6	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	7.6	-9999	-9999	-9999
90893	C8R004Q01 Saulspoort 945 - Saulspoort Dam on Libenbergsveirivier: near dam wall	Dam / Barrage	-28.2175	28.3635	C83A	NO3+NO2-N-Diss-Water(mg/L	4	0.3	0.4	0.3	0.3	0.3	0.35	0.4	0.4	0.4	0.293	0.407	0.35	0.346	0.058	16.571
90893	C8R004Q01 Saulspoort 945 - Saulspoort Dam on Libenbergsveirivier: near dam wall	Dam / Barrage	-28.2175	28.3635	C83A	NH4-N-Diss-Water(mg/L)	5	0.05	0.6	0.05	0.05	0.05	0.05	0.4	0.52	0.56	0.006	0.454	0.23	0.125	0.256	111.304
90893	C8R004Q01 Saulspoort 945 - Saulspoort Dam on Libenbergsveirivier: near dam wall	Dam / Barrage	-28.2175	28.3635	C83A	PO4-P-Diss-Water(mg/L)	5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
90893	C8R004Q01 Saulspoort 945 - Saulspoort Dam on Libenbergsveirivier: near dam wall	Dam / Barrage	-28.2175	28.3635	C83A	NH3(25)-Union-Diss-W(mg/L)	2	0	0.001	0	0	0	0.001	0.001	0.001	0.001	0	0.002	0.001	-8888	0.001	100
9																						

Monitoring Point ID	Monitoring Point Name	Located on Type	Latitude	Longitude	Drainage Region Name	Monitoring Variable	N	Min	Max	5% P	10% P	25% P	50% P	75% P	90% P	95% P	L 95%	U 95%	Mean	GeoMean	StdDev	% VarCoef
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	pH-Diss-Water(pH units)	1	8	8	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	8	-9999	-9999	-9999
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	NO3+NO2-N-Diss-Water(mg/L)	4	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	NH4-N-Diss-Water(mg/L)	1	0.9	0.9	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.9	-9999	-9999	-9999
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	PO4-P-Diss-Water(mg/L)	1	0.05	0.05	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.05	-9999	-9999	-9999
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	NH3(25)-Union-Diss-W(mg/L)	1	0.052	0.052	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	0.052	-9999	-9999	-9999
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	pH-Diss-Water(pH units)	129	6.4	10.1	7.35	7.53	7.802	8.194	8.398	8.8	8.953	8.049	8.233	8.141	8.124	0.531	6.523
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	NO3+NO2-N-Diss-Water(mg/L)	144	0.005	3.181	0.005	0.025	0.025	0.05	0.05	0.102	0.3	0.052	0.182	0.117	0.043	0.4	341.88
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	NH4-N-Diss-Water(mg/L)	147	0.025	17.8	0.025	0.025	0.025	0.05	0.054	0.3	0.4	0.016	0.522	0.269	0.055	1.564	581.413
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	TAL-Diss-Water(mg/L)	104	42.5	140.135	64.398	70.238	87.398	103.077	113.754	126.924	132.021	96.389	104.507	100.45	97.921	21.12	21.026
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	Na-Diss-Water(mg/L)	83	5.25	26.307	10.02	10.601	11.824	17.519	21.533	24.506	25.39	16.015	18.431	17.223	16.228	5.614	32.596
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	Si-Diss-Water(mg/L)	88	0.245	8.052	0.437	0.5	0.5	1.031	4.394	5.448	5.94	1.768	2.668	2.218	1.342	2.152	97.024
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	PO4-P-Diss-Water(mg/L)	147	0.005	16	0.005	0.005	0.006	0.015	0.05	0.051	0.2	-0.044	0.388	0.172	0.019	1.336	776.744
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	SO4-Diss-Water(mg/L)	107	0.6	29.342	3	3.519	5.513	7.806	10.851	18.576	20.013	8.086	10.21	9.148	7.573	5.605	61.27
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	SAR-Diss-Water(null)	80	0.371	1.288	0.53	0.568	0.657	0.871	1.091	1.149	1.183	0.817	0.921	0.869	0.835	0.238	27.388
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	TURB-Phys-Water(NTU)	14	0.5	13.2	0.5	0.5	1.273	2.93	4.558	7.598	10.074	1.88	5.612	3.746	2.376	3.563	95.115
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	RYZNAR-Index-Water(null)	50	7.068	9.682	7.396	7.548	7.923	8.197	8.513	9.121	9.544	8.107	8.439	8.273	8.252	0.599	7.24
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	pHs-Calc-Water(null)	60	7.927	8.766	7.981	8.021	8.101	8.182	8.246	8.429	8.58	8.159	8.249	8.204	8.202	0.179	2.182
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	NH3(25)-Union-Diss-W(mg/L)	126	0	5.581	0.001	0.001	0.001	0.003	0.008	0.034	0.08	-0.018	0.214	0.098	-8888	0.663	676.531
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	SO4Ion/MajAnions-Wat(null)	22	0.005	0.208	0.019	0.032	0.063	0.111	0.139	0.16	0.194	0.083	0.129	0.106	0.083	0.055	51.887
90894	C8R005Q01 Bethlehem - Loch Athlone Dam on Jordaanrivier: near dam wall	Dam / Barrage	-28.2506	28.3084	C83B	SO4Ion/TotAnions-Wat(null)	16	0.005	0.138	0.015	0.025	0.043	0.103	0.12	0.132	0.137	0.063	0.107	0.085	0.065	0.045	52.941

APPENDIX D

National Groundwater Archive Data Set

- D1: Basic Information (boreholes)
- D2: Lithology (borehole)
- D3: Discharges (boreholes)
- D4: Water levels (boreholes)

GeositeInfo_Identifier	GeositeInfo_Geosite Type	GeositeInfo_Latitude	GeositeInfo_Longitude	GeositeInfo_Elevation	GeositeInfo_ElevationMethod	GeositeInfo_ElevationGPS Accuracy	GeositeInfo_Farm	GeositeInfo_Farm Number	GeositeInfo_QuaternaryDrainageRegion	GeositeInfo_ObservedActualWaterUses	GeositeInfo_WaterUserAssociation	GeositeInfo_Geomorphology	GeositeInfo_LandCover	GeositeInfo_TasteOfWater	GeositeInfo_DWAFGeositePurpose
2828AD00061	Borehole	-28.25682	28.30273	1660	Arcview	100	BETHLEHEM PTN. WOLHUTERSKOP	0	C83B						
2828AB00177	Borehole	-28.16766	28.30079	1640	Arcview		BETHLEHEM	0	C83C						Observation
2828AB00177	Borehole	-28.16766	28.30079	1640	Arcview		BETHLEHEM	0	C83C						Observation
2828AB00176	Borehole	-28.16766	28.30078	1640	Arcview		BETHLEHEM	0	C83C						Observation
028444T	Borehole	-27.7095	28.18302	1660	Arcview	100	BETHEL	7	C83F						
2728CA00219	Borehole	-27.70949	28.18302	1660	Arcview	100	BETHEL	7	C83F						
28451	Borehole	-27.70948	28.18302	1660	Arcview	100	BETHEL	7	C83F						
028444F	Borehole	-27.70942	28.18302	1660	Arcview	100	BETHEL	7	C83F						
028444D	Borehole	-27.70941	28.18302	1660	Arcview	100	BETHEL	7	C83F						
28444	Borehole	-27.70939	28.18302	1660	Arcview	100	BETHEL	7	C83F						
028444A	Borehole	-27.70938	28.18303	1660	Arcview	100	BETHEL	7	C83F						
028450A	Borehole	-27.70938	28.18311	1660	Arcview	100	BETHEL	7	C83F						
028451A	Borehole	-27.70938	28.18312	1660	Arcview	100	BETHEL	7	C83F						
2728CA00220	Borehole	-27.70938	28.18313	1660	Arcview	100	BETHEL	7	C83F						
2728CD00179	Borehole	-27.96716	28.38302	1620	Arcview	100	DRIEHOEK	14	C83E						
2728DC00138	Borehole	-27.76717	28.51636	1660	Arcview	100	ONVERWAG	18	C83G						
2728DC00137	Borehole	-27.76716	28.51636	1660	Arcview	100	ONVERWAG	18	C83G						
2728DC00139	Borehole	-27.76716	28.51637	1660	Arcview	100	ONVERWAG	18	C83G						
2828BC00030	Borehole	-28.29693	28.67147	1760	Arcview	100	LISMORE	27	C83D						
2828BC00062	Borehole	-28.26985	28.57837	1820	Arcview	100	CONTEST	29	C83D						
2828BC00060	Borehole	-28.26984	28.57837	1820	Arcview	100	CONTEST	29	C83D						
2828BC00059	Borehole	-28.26983	28.57837	1820	Arcview	100	CONTEST	29	C83D						
2828BC00061	Borehole	-28.26983	28.57838	1820	Arcview	100	CONTEST	29	C83D						
2828BC00063	Borehole	-28.26983	28.57839	1820	Arcview	100	CONTEST	29	C83D						
2828BC00031	Borehole	-28.29723	28.67457	1780	Arcview	100	LISMORE	37	C83D						
2828BC00029	Borehole	-28.29653	28.66837	1760	Arcview	100	LISMORE	37	C83D						
2828BC00032	Borehole	-28.29593	28.67587	1780	Arcview	100	LISMORE	37	C83D						
2828BC00028	Borehole	-28.29363	28.67607	1760	Arcview	100	LISMORE	37	C83D						
2828BC00027	Borehole	-28.29353	28.66907	1760	Arcview	100	LISMORE	37	C83D						
2828BC00046	Borehole	-28.44413	28.51517	1900	Arcview	100	BRAMLEYSHOEK	52	C83A	Stock Watering					
2828BC00044	Borehole	-28.44073	28.51287	1840	Arcview	100	BRAMLEYSHOEK	52	C83A	Stock Watering				Fresh	
2828BC00045	Borehole	-28.43843	28.51547	1820	Arcview	100	BRAMLEYSHOEK	52	C83A	Stock Watering					
2828BC00042	Borehole	-28.43683	28.51287	1820	Arcview	100	BRAMLEYSHOEK	52	C83A						
2828BC00043	Borehole	-28.43493	28.51477	1820	Arcview	100	BRAMLEYSHOEK	52	C83A						
2828BC00026	Borehole	-28.29343	28.66657	1740	Arcview	100	LISMORE	59	C83D	Stock Watering				Fresh	
2828AB00086	Borehole	-28.21461	28.34493	1690	ated 1:50 000	10	VOGELFONTEIN	69	C83C						
2828AB00084	Borehole	-28.2146	28.34493	1690	ated 1:50 000	10	VOGELFONTEIN	69	C83C						
2828AB00083	Borehole	-28.21459	28.34493	1690	ated 1:50 000	10	VOGELFONTEIN	69	C83C						
2828AB00085	Borehole	-28.21459	28.34494	1690	ated 1:50 000	10	VOGELFONTEIN	69	C83C						
2828AD00003	Borehole	-28.44453	28.333	1810	ated 1:50 000	10	KEEROM	76	C83B						
2828AD00031	Borehole	-28.43666	28.41634	1780	ated 1:50 000	10	NODE	77	C83A						
2828AD00030	Borehole	-28.43663	28.41634	1780	ated 1:50 000	10	NODE	77	C83A						
2728DA00029	Borehole	-27.60049	28.59969	1660	Arcview	100	SANDSPRUIT ONDERV VAN EENSGEVOND	79	C83H						
2828BC00050	Borehole	-28.29733	28.60807	1740	Arcview	100	GEMSBOKFONTEIN	80	C83D						

GeositeInfo_Identifier	GeositeInfo_GeositeType	GeositeInfo_Latitude	GeositeInfo_Longitude	Lithology_DescriptorName	Lithology_EventDate	Lithology_DepthTop	Lithology_DepthBottom		Lithology_LithologyName	Lithology_PrimaryColour	Lithology_ColourQualifier	Lithology_SecondaryColour	Lithology_CompositionQualifier	Lithology_FabricQualifier	Lithology_FabricAttribute	Lithology_MaterialType	Lithology_FormationType	Lithology_ParticleShape	Lithology_Sorting	Lithology_WeatheringDegree	Lithology_FracturingDegree
2728AD00005	Borehole	-27.38382	28.41636		24/01/1963	0	15.24	15.24	Dolerite							Consolidated	Igneous				
2728AD00005	Borehole	-27.38382	28.41636		24/01/1963	15.24	21.94	6.7	Dolerite							Consolidated	Igneous				Moderately
2728AD00005	Borehole	-27.38382	28.41636		24/01/1963	21.94	22.25	0.31	Dolerite							Consolidated	Igneous				
2728AD00006	Borehole	-27.38383	28.41636		14/01/1963	0	21.64	21.64	Dolerite							Consolidated	Igneous				
2728AD00006	Borehole	-27.38383	28.41636		14/01/1963	21.64	22.55	0.91	Slate	Grey						Consolidated	Metamorphic				
2728AD00006	Borehole	-27.38383	28.41636		14/01/1963	22.55	27.43	4.88	Slate	Black						Consolidated	Metamorphic				
2728AD00006	Borehole	-27.38383	28.41636		14/01/1963	27.43	28.65	1.22	Dolerite							Consolidated	Igneous				
2728AD00006	Borehole	-27.38383	28.41636		14/01/1963	28.65	39.62	10.97	Dolerite							Consolidated	Igneous				Moderately
2728AD00008	Borehole	-27.41716	28.38302		29/10/1962	0	3.65	3.65	Boulders							Unconsolidated	Sedimentary				
2728AD00008	Borehole	-27.41716	28.38302		29/10/1962	3.65	45.72	42.07	Dolerite							Consolidated	Igneous				
2728AD00009	Borehole	-27.41717	28.38302		05/11/1962	0	2.13	2.13	Boulders							Unconsolidated	Sedimentary				
2728AD00009	Borehole	-27.41717	28.38302		05/11/1962	2.13	7.31	5.18	Dolerite							Consolidated	Igneous				
2728AD00010	Borehole	-27.41716	28.38303		29/10/1962	0	3.65	3.65	Boulders							Unconsolidated	Sedimentary				
2728AD00010	Borehole	-27.41716	28.38303		29/10/1962	3.65	45.72	42.07	Dolerite							Consolidated	Igneous				
2728AD00011	Borehole	-27.41718	28.38302		28/09/1962	0	3.04	3.04	Sandstone							Unconsolidated	Sedimentary				
2728AD00011	Borehole	-27.41718	28.38302		28/09/1962	3.04	8.53	5.49	Dolomite							Consolidated	Sedimentary				Moderately
2728AD00011	Borehole	-27.41718	28.38302		28/09/1962	8.53	12.19	3.66	Dolomite							Consolidated	Sedimentary				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	0	3.04	3.04	Sandstone							Unconsolidated	Sedimentary				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	3.04	5.79	2.75	Dolerite							Consolidated	Igneous				Moderately
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	5.79	42.67	36.88	Dolerite							Consolidated	Igneous				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	42.67	78.94	36.27	Sandstone							Unconsolidated	Sedimentary				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	78.94	89.91	10.97	Dolerite							Consolidated	Igneous				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	89.91	95.4	5.49	Dolerite							Consolidated	Igneous				Moderately
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	95.4	105.46	10.06	Sandstone							Unconsolidated	Sedimentary				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	105.46	115.21	9.75	Shale	Black						Consolidated	Sedimentary				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	115.21	117.04	1.83	Sandstone							Unconsolidated	Sedimentary				
2728AD00012	Borehole	-27.41716	28.38304		12/09/1962	117.04	118.87	1.83	Dolerite							Consolidated	Igneous				
2728AD00013	Borehole	-27.41719	28.38302		21/07/1962	0	6.09	6.09	Dolerite							Consolidated	Igneous				Moderately
2728AD00013	Borehole	-27.41719	28.38302		21/07/1962	6.09	10.05	3.96	Dolerite							Consolidated	Igneous				
2728AD00013	Borehole	-27.41719	28.38302		21/07/1962	10.05	21.33	11.28	Dolerite							Consolidated	Igneous				
2728AD00014	Borehole	-27.41716	28.38305		11/07/1962	0	1.82	1.82	SOIL							Unconsolidated					
2728AD00014	Borehole	-27.41716	28.38305		11/07/1962	1.82	6.09	4.27	Sandstone							Unconsolidated	Sedimentary				
2728AD00014	Borehole	-27.41716	28.38305		11/07/1962	6.09	11.88	5.79	Dolerite							Consolidated	Igneous				Moderately
2728AD00014	Borehole	-27.41716	28.38305		11/07/1962	11.88	60.96	49.08	Dolerite							Consolidated	Igneous				
2728AD00020	Borehole	-27.48187	28.38302		15/04/1994	0	12	12	SOIL							Unconsolidated					
2728AD00020	Borehole	-27.48187	28.38302		15/04/1994	12	60	48	Shale							Consolidated	Sedimentary				
2728AD00021	Borehole	-27.48188	28.38303		14/04/1994	0	12	12	SOIL							Unconsolidated					
2728AD00021	Borehole	-27.48188	28.38303		14/04/1994	12	36	24	Shale					Broken		Consolidated	Sedimentary				
2728AD00021	Borehole	-27.48188	28.38303		14/04/1994	36	66	30	Sandstone					Broken		Unconsolidated	Sedimentary				
2728AD00022	Borehole	-27.3916	28.43386		09/06/1997	0	1	1	SOIL							Unconsolidated					
2728AD00022	Borehole	-27.3916	28.43386		09/06/1997	1	5	4	Dolerite							Consolidated	Igneous			Highly	
2728AD00022	Borehole	-27.3916	28.43386		09/06/1997	5	180	175	Dolerite							Consolidated	Igneous				

GeositeInfo_Identifier	GeositeInfo_GeositeType	GeositeInfo_Latitude	GeositeInfo_Longitude	Lithology_DescriptorName	Lithology_EventDate	Lithology_DepthToTop	Lithology_DepthToBottom		Lithology_LithologyName	Lithology_PrimaryColour	Lithology_ColorQualifier	Lithology_SecondaryColour	Lithology_CompositionQualifier	Lithology_FabricQualifier	Lithology_FabricAttribute	Lithology_MaterialType	Lithology_FormationType	Lithology_ParticleShape	Lithology_Sorting	Lithology_WeatheringDegree	Lithology_FracturingDegree
2728AD00023	Borehole	-27.39161	28.43387		12/06/1997	0	1	1	SOIL							Unconsolidated					
2728AD00023	Borehole	-27.39161	28.43387		12/06/1997	1	4	3	Dolerite							Consolidated	Igneous			Highly	
2728AD00023	Borehole	-27.39161	28.43387		12/06/1997	4	126	122	Dolerite							Consolidated	Igneous				
2728BA00006	Borehole	-27.68382	28.23302					0													
2728BC00015	Borehole	-27.32049	28.54969		26/04/1994	0	6	6	SOIL							Unconsolidated					
2728BC00015	Borehole	-27.32049	28.54969		26/04/1994	6	24	18	Shale							Consolidated	Sedimentary				
2728BC00015	Borehole	-27.32049	28.54969		26/04/1994	24	36	12	Dolerite							Consolidated	Igneous				
2728BC00015	Borehole	-27.32049	28.54969		26/04/1994	36	60	24	Sandstone							Unconsolidated	Sedimentary				
2728CA00004	Borehole	-27.68383	28.23302		03/10/1983	0	5	5	Clay							Unconsolidated	Sedimentary				
2728CA00004	Borehole	-27.68383	28.23302		03/10/1983	5	15	10	Sandstone							Unconsolidated	Sedimentary				
2728CA00004	Borehole	-27.68383	28.23302		03/10/1983	15	36	21	Dolerite							Consolidated	Igneous				
2728CA00004	Borehole	-27.68383	28.23302		03/10/1983	36	55	19	Dolerite	Blue						Consolidated	Igneous				
2728CA00004	Borehole	-27.68383	28.23302		03/10/1983	55	60	5	Clay	Brown						Unconsolidated	Sedimentary				
2728CA00005	Borehole	-27.68382	28.23303		04/10/1983	0	6	6	Clay							Unconsolidated	Sedimentary				
2728CA00005	Borehole	-27.68382	28.23303		04/10/1983	6	12	6	Sandstone							Unconsolidated	Sedimentary				
2728CA00005	Borehole	-27.68382	28.23303		04/10/1983	12	20	8	Dolerite							Consolidated	Igneous				
2728CA00005	Borehole	-27.68382	28.23303		04/10/1983	20	40	20	Dolerite	Blue						Consolidated	Igneous				
2728CA00005	Borehole	-27.68382	28.23303		04/10/1983	40	42	2	Clay	Brown						Unconsolidated	Sedimentary				
2728CA00006	Borehole	-27.68384	28.23302		05/10/1983	0	9	9	Clay							Unconsolidated	Sedimentary				
2728CA00006	Borehole	-27.68384	28.23302		05/10/1983	9	12	3	Dolerite							Consolidated	Igneous				
2728CA00006	Borehole	-27.68384	28.23302		05/10/1983	12	36	24	Sandstone							Unconsolidated	Sedimentary				
2728CA00006	Borehole	-27.68384	28.23302		05/10/1983	36	48	12	Dolerite	Blue						Consolidated	Igneous				
2728CA00007	Borehole	-27.68382	28.23304		11/10/1983	0	10	10	Clay							Unconsolidated	Sedimentary				
2728CA00007	Borehole	-27.68382	28.23304		11/10/1983	10	36	26	Dolerite							Consolidated	Igneous				
2728CA00007	Borehole	-27.68382	28.23304		11/10/1983	36	40	4	Sandstone							Unconsolidated	Sedimentary				
2728CA00007	Borehole	-27.68382	28.23304		11/10/1983	40	42	2	Clay	Brown						Unconsolidated	Sedimentary				
2728CA00008	Borehole	-27.60938	28.24191		23/11/1983	0	24	24	Sandstone							Unconsolidated	Sedimentary				
2728CA00008	Borehole	-27.60938	28.24191		23/11/1983	24	42	18	Dolerite							Consolidated	Igneous				
2728CA00008	Borehole	-27.60938	28.24191		23/11/1983	42	86	44	Shale	Blue						Consolidated	Sedimentary				
2728CA00009	Borehole	-27.60938	28.24192		22/11/1983	0	12	12	Sandstone							Unconsolidated	Sedimentary				
2728CA00009	Borehole	-27.60938	28.24192		22/11/1983	12	36	24	Dolerite							Consolidated	Igneous				
2728CA00009	Borehole	-27.60938	28.24192		22/11/1983	36	60	24	Dolerite	Blue						Consolidated	Igneous				
2728CA00010	Borehole	-27.61716	28.24191		23/11/1983	0	6	6	Sandstone							Unconsolidated	Sedimentary				
2728CA00010	Borehole	-27.61716	28.24191		23/11/1983	6	50	44	Dolerite							Consolidated	Igneous				
2728CA00010	Borehole	-27.61716	28.24191		23/11/1983	50	70	20	Dolerite	Blue						Consolidated	Igneous				
2728CA00011	Borehole	-27.61716	28.24192		24/11/1983	0	6	6	Gravel							Unconsolidated	Sedimentary				
2728CA00011	Borehole	-27.61716	28.24192		24/11/1983	6	32	26	Dolerite							Consolidated	Igneous				
2728CA00011	Borehole	-27.61716	28.24192		24/11/1983	32	42	10	Dolerite	Blue						Consolidated	Igneous				
2728CA00012	Borehole	-27.73382	28.19969		09/02/1984	0	1	1	Gravel							Unconsolidated	Sedimentary				
2728CA00012	Borehole	-27.73382	28.19969		09/02/1984	1	12	11	Sandstone							Unconsolidated	Sedimentary				
2728CA00012	Borehole	-27.73382	28.19969		09/02/1984	12	48	36	Dolerite	Blue						Consolidated	Igneous				
2728CA00013	Borehole	-27.73383	28.19969		09/02/1984	0	1	1	SOIL							Unconsolidated					
2728CA00013	Borehole	-27.73383	28.19969		09/02/1984	1	20	19	Gravel							Unconsolidated	Sedimentary				
2728CA00013	Borehole	-27.73383	28.19969		09/02/1984	20	24	4	Dolerite	Blue						Consolidated	Igneous				

GeositeInfo_Identifier	GeositeInfo_GeositeType	GeositeInfo_Latitude	GeositeInfo_Longitude	Lithology_DescriptorName	Lithology_EventDate	Lithology_DepthToTop	Lithology_DepthToBottom		Lithology_LithologyName	Lithology_PrimaryColour	Lithology_ColourQualifier	Lithology_SecondaryColour	Lithology_CompositionQualifier	Lithology_FabricQualifier	Lithology_FabricAttribute	Lithology_MaterialType	Lithology_FormationType	Lithology_ParticleShape	Lithology_Sorting	Lithology_WeatheringDegree	Lithology_FracturingDegree
2728CA00014	Borehole	-27.71716	28.23302		21/08/1942	0	8.53	8.53	Dolerite							Consolidated	Igneous				
2728CA00014	Borehole	-27.71716	28.23302		21/08/1942	8.53	40.84	32.31	Shale							Consolidated	Sedimentary				
2728CA00014	Borehole	-27.71716	28.23302		21/08/1942	40.84	44.2	3.36	Dolerite							Consolidated	Igneous				
2728CA00015	Borehole	-27.71717	28.23302		10/09/1942	0	7.31	7.31	Clay							Unconsolidated	Sedimentary				
2728CA00015	Borehole	-27.71717	28.23302		10/09/1942	7.31	42.67	35.36	Shale							Consolidated	Sedimentary				
2728CA00015	Borehole	-27.71717	28.23302		10/09/1942	42.67	43.58	0.91	Dolerite							Consolidated	Igneous				
2728CA00016	Borehole	-27.71716	28.23303		31/08/1942	0	40.23	40.23	Shale							Consolidated	Sedimentary				
2728CA00016	Borehole	-27.71716	28.23303		31/08/1942	40.23	41.14	0.91	Dolerite							Consolidated	Igneous				
2728CA00025	Borehole	-27.65492	28.18634		04/07/1984	0	2	2	SOIL							Unconsolidated					
2728CA00025	Borehole	-27.65492	28.18634		04/07/1984	2	17	15	Shale	Yellow						Consolidated	Sedimentary				
2728CA00025	Borehole	-27.65492	28.18634		04/07/1984	17	52	35	Shale	Blue						Consolidated	Sedimentary				
2728CA00025	Borehole	-27.65492	28.18634		04/07/1984	52	68	16	Shale	Black						Consolidated	Sedimentary				
2728CA00027	Borehole	-27.6549	28.18632		02/07/1984	0	2	2	SOIL							Unconsolidated					
2728CA00027	Borehole	-27.6549	28.18632		02/07/1984	2	17	15	Shale	Yellow						Consolidated	Sedimentary				
2728CA00027	Borehole	-27.6549	28.18632		02/07/1984	17	45	28	Shale	Blue						Consolidated	Sedimentary				
2728CA00027	Borehole	-27.6549	28.18632		02/07/1984	45	68	23	Shale	Black						Consolidated	Sedimentary				
2728CA00028	Borehole	-27.65491	28.18633		03/07/1984	0	3	3	SOIL							Unconsolidated					
2728CA00028	Borehole	-27.65491	28.18633		03/07/1984	3	22	19	Shale	Yellow						Consolidated	Sedimentary				
2728CA00028	Borehole	-27.65491	28.18633		03/07/1984	22	40	18	Shale	Blue						Consolidated	Sedimentary				
2728CA00028	Borehole	-27.65491	28.18633		03/07/1984	40	68	28	Shale	Black						Consolidated	Sedimentary				
2728CA00030	Borehole	-27.65493	28.18635		30/06/1984	0	2	2	SOIL							Unconsolidated					
2728CA00030	Borehole	-27.65493	28.18635		30/06/1984	2	16	14	Shale	Yellow						Consolidated	Sedimentary				
2728CA00030	Borehole	-27.65493	28.18635		30/06/1984	16	51	35	Shale	Blue						Consolidated	Sedimentary				
2728CA00030	Borehole	-27.65493	28.18635		30/06/1984	51	68	17	Shale	Black						Consolidated	Sedimentary				

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 Audited_&_reduced_water_wbw_2015713_135639_DataExport_1	2015/09/02 10:33	Microsoft Excel W...	44 KB
 Basic_wbw_2015713_134822_DataExport_1	2015/12/10 14:02	Microsoft Excel W...	443 KB
 Casing_wbw_2015713_141740_DataExport_1	2015/09/02 10:48	Microsoft Excel W...	87 KB
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GeositeInfo_Identifier	GeositeInfo_GeositeType	GeositeInfo_Latitude	GeositeInfo_Longitude	WaterLevel_ReferencePoint	WaterLevel_ReferenceHeight	WaterLevel_MeasuringMethod	WaterLevel_WaterLevelStatus	WaterLevel_DrawdownPeriod	WaterLevel_RecoveryPeriod	WaterLevel_PiezometerNumber	WaterLevel_MeasurementDateAndTime	WaterLevel_WaterLevel		Difference from Median Level	
2728CB00108	Borehole	-27.7344	28.35581				Static Water Level				20/01/1942 08:00	21.03		-11.28	
2728CB00107	Borehole	-27.73447	28.35581				Static Water Level				08/02/1942 08:00	15.24		-5.49	
2728CB00059	Borehole	-27.68382	28.34191				Static Water Level				15/05/1942 08:00	24.38		-14.63	
2728CB00061	Borehole	-27.68382	28.34192				Static Water Level				03/06/1942 08:00	12.19		-2.44	
2728CB00062	Borehole	-27.69271	28.42525				Static Water Level				24/06/1944 08:00	9.75		0	
2728CB00063	Borehole	-27.69271	28.42526				Static Water Level				30/06/1944 08:00	6.1		3.65	
2728CB00121	Borehole	-27.68551	28.42665				Static Water Level				07/07/1944 08:00	8.53		1.22	
2728CB00065	Borehole	-27.69271	28.42527				Static Water Level				12/07/1944 08:00	9.14		0.61	
2728CB00066	Borehole	-27.69271	28.42528				Static Water Level				17/07/1944 08:00	9.14		0.61	
2728CB00069	Borehole	-27.69271	28.39192				Static Water Level				16/08/1944 08:00	5.18		4.57	
2728CB00113	Borehole	-27.59634	28.31053				Static Water Level				13/02/1945 08:00	2.74		7.01	
2728CB00110	Borehole	-27.558	28.36108				Static Water Level				01/05/1945 08:00	3.96		5.79	
2728CB00109	Borehole	-27.55799	28.36103				Static Water Level				09/05/1945 08:00	0.91		8.84	
2728CD00042	Borehole	-27.99826	28.4883				Static Water Level				05/09/1957 08:00	6.1		3.65	
2728CD00269	Borehole	-27.99243	28.3783				Static Water Level				21/12/1957 08:00	2.44		7.31	
2828BC00087	Borehole	-28.35931	28.64605				Static Water Level				18/04/1958 08:00	6.1		3.65	
2828BC00088	Borehole	-28.35932	28.64605			Dip Meter	Static Water Level				24/04/1958 12:00	6.1		3.65	
2728CB00117	Borehole	-27.57968	28.40331				Static Water Level				19/05/1960 08:00	2.44		7.31	
2728CB00118	Borehole	-27.57968	28.40332				Static Water Level				24/05/1960 08:00	12.19		-2.44	
2728CB00119	Borehole	-27.57969	28.40332				Static Water Level				30/05/1960 08:00	7.62		2.13	
2728DC00152	Borehole	-27.81382	28.51803				Static Water Level				04/07/1961 08:00	21.33		-11.58	
2728DC00151	Borehole	-27.81383	28.51803				Static Water Level				11/07/1961 08:00	9.14		0.61	
2728DC00150	Borehole	-27.81383	28.51804				Static Water Level				12/07/1961 08:00	9.75		0	
2728DC00149	Borehole	-27.81384	28.51804				Static Water Level				26/07/1961 08:00	15.24		-5.49	
17304	Borehole	-27.86799	28.09719				Static Water Level				24/12/1963 08:00	3.66		6.09	
2828AD00014	Borehole	-28.30043	28.39969			Dip Meter	Static Water Level				28/01/1966 12:00	3.65		6.1	
2728CD00233	Borehole	-27.87689	28.4883				Static Water Level				24/04/1976 08:00	8		1.75	
2728CD00268	Borehole	-27.87688	28.4883				Static Water Level				11/05/1976 08:00	8		1.75	
2728DC00019	Borehole	-27.99274	28.50858				Static Water Level				09/07/1981 08:00	25		-15.25	
2728CD00217	Borehole	-27.96717	28.33302				Static Water Level				31/07/1981 08:00	21		-11.25	
2728CD00216	Borehole	-27.96716	28.33303				Static Water Level				06/08/1981 08:00	18		-8.25	
2728CD00270	Borehole	-27.91299	28.32823				Static Water Level				06/01/1982 08:00	25		-15.25	
2828AD00062	Borehole	-28.42793	28.36856				Static Water Level				07/05/1983 08:00	10		-0.25	
2728CB00122	Borehole	-27.57273	28.27164				Static Water Level				30/05/1983 08:00	6		3.75	
2728CB00123	Borehole	-27.57272	28.27164				Static Water Level				03/06/1983 08:00	4		5.75	
2828AB00182	Borehole	-28.02211	28.48856				Static Water Level				04/06/1983 08:00	16		-6.25	
2828AB00189	Borehole	-28.03654	28.48911				Static Water Level				08/06/1983 08:00	6		3.75	
2828AB00187	Borehole	-28.03459	28.488				Static Water Level				08/06/1983 08:00	16		-6.25	
2828AB00188	Borehole	-28.02212	28.48857				Static Water Level				08/06/1983 08:00	17		-7.25	
2828AB00190	Borehole	-28.02599	28.488				Static Water Level				09/06/1983 08:00	4		5.75	
2828AA00083	Borehole	-28.14368	28.21905			Dip Meter	Static Water Level				12/10/1983 12:00	6.1		3.65	
2828BA00154	Borehole	-28.01571	28.54772				Static Water Level				18/10/1983 08:00	25		-15.25	
2828AB00147	Borehole	-28.24765	28.4205				Static Water Level				20/12/1983 08:00	15		-5.25	
2728DA00044	Borehole	-27.64576	28.51025				Static Water Level				04/01/1984 08:00	24		-14.25	
2728CB00125	Borehole	-27.61021	28.45636				Static Water Level				05/04/1984 08:00	29		-19.25	
2728CB00128	Borehole	-27.60105	28.45636				Static Water Level				06/04/1984 08:00	10		-0.25	
2728CB00129	Borehole	-27.61105	28.47525				Static Water Level				09/04/1984 08:00	19		-9.25	
2728CB00124	Borehole	-27.59576	28.4658				Static Water Level				11/04/1984 08:00	4		5.75	
2728CB00134	Borehole	-27.67466	28.48802				Static Water Level				04/05/1984 08:00	7		2.75	
2728DA00030	Borehole	-27.65049	28.51638				Static Water Level				13/02/1986 08:00	34		-24.25	
2728DA00031	Borehole	-27.65051	28.51636				Static Water Level				20/02/1986 08:00	54		-44.25	
2728CD00197	Borehole	-27.76716	28.29971				Static Water Level				09/05/1986 08:00	11		-1.25	
2728CD00195	Borehole	-27.76716	28.2997				Static Water Level				15/05/1986 08:00	30		-20.25	
2728CA00226	Borehole	-27.71716	28.17108				Static Water Level				28/01/1994 08:00	2		7.75	
2728CA00230	Borehole	-27.71802	28.16914				Static Water Level				02/02/1994 08:00	1		8.75	
2828AA00140	Borehole	-28.1671	28.22134				Static Water Level				21/03/1994 08:00	4		5.75	
2728AD00020	Borehole	-27.48187	28.38302				Static Water Level				15/04/1994 08:00	2.2		7.55	
2728CB00144	Borehole	-27.65966	28.42302				Static Water Level				22/04/1994 08:00	4		5.75	
2728CB00137	Borehole	-27.65827	28.42107				Static Water Level				22/04/1994 08:00	4		5.75	
2728BC00015	Borehole	-27.32049	28.54969				Static Water Level				26/04/1994 08:00	15.75		-6	
2828BA00158	Borehole	-28.14655	28.56605				Static Water Level				17/06/1994 08:00	20		-10.25	
2728CB00141	Borehole	-27.5705	28.42192				Static Water Level				07/07/1994 08:00	2.25		7.5	
2828AD00058	Borehole	-28.25682	28.30273				Static Water Level				13/06/1996 08:00	10.22		-0.47	
2828AD00058	Borehole	-28.25682	28.30273				Static Water Level				13/06/1996 09:00	10.05		-0.3	
2828BC00096	Borehole	-28.33432	28.57911				Static Water Level				07/03/1997 08:00	24		-14.25	
2828AD00066	Borehole	-28.30876	28.42134				Static Water Level				22/03/1997 08:00	30		-20.25	
2828AD00064	Borehole	-28.42765	28.33606				Static Water Level				25/03/1997 08:00	30		-20.25	
2728AD00023	Borehole	-27.39161	28.43387				Static Water Level				12/06/1997 08:00	30		-20.25	
2828AD00069	Borehole	-28.31237	28.42634				Static Water Level				04/11/1999 08:00	9		0.75	
													Max	Min	Median
2728CD00194	Borehole	-27.79271	28.4497								03/08/1912 08:00	30.48	54	0.91	9.75
2828AB00046	Borehole	-28.2369	28.32224								29/08/1916 08:00	7.62			
2828AD00006	Borehole	-28.39704	28.25189								08/04/1922 08:00	8.53			
2828AD00005	Borehole	-28.39703	28.25189								25/04/1922 08:00	8.53			
2828AD00021	Borehole	-28.34214	28.283								21/06/1922 08:00	12.19			
2728CD00128	Borehole	-27.96716	28.44191								09/12/1928 08:00	12.19			
2828AB00098	Borehole	-28.19071	28.33652								25/05/1934 08:00	33.53			
2828AB00097	Borehole	-28.19072	28.3365								20/07/1934 08:00	41.76			

GeositeInfo_J dentifier	GeositeInfo_ GeositeType	GeositeInfo_L altitude	GeositeInfo_L ongitude	WaterLevel_R eferencePoint	WaterLevel_R eferenceHeig ht	WaterLevel_M easuringMeth od	WaterLevel_ WaterLevelSt atus	WaterLevel_D rawdownPeri od	WaterLevel_R ecoveryPerio d	WaterLevel_P iezometerNu mber	WaterLevel_M easurementD ateAndTime	WaterLevel_ WaterLevel		Difference from Median Level	
													Max	Min	Median
2828AB00003	Borehole	-28.10447	28.28821								01/01/1940 08:00	12			
2728CD00209	Borehole	-27.76716	28.39969								18/11/1941 08:00	9.14			
2728CD00211	Borehole	-27.76716	28.3997								25/11/1941 08:00	10.67			
2728CB00053	Borehole	-27.71716	28.33302								03/03/1942 08:00	6.1			
2728CB00054	Borehole	-27.71717	28.33302								10/03/1942 08:00	30.48			
2728CB00055	Borehole	-27.71716	28.33303								18/03/1942 08:00	24.38			
2728CB00003	Borehole	-27.70938	28.34191								25/03/1942 08:00	21.34			
2728CB00004	Borehole	-27.70938	28.34192								07/04/1942 08:00	15.24			
2728CB00006	Borehole	-27.70938	28.34193								30/04/1942 08:00	18.29			
2728CB00022	Borehole	-27.65938	28.34969								23/06/1942 08:00	3.05			
2728CB00044	Borehole	-27.68382	28.29969								30/06/1942 08:00	12.19			
2728CA00016	Borehole	-27.71716	28.23303								31/08/1942 08:00	27.43			
2728CA00015	Borehole	-27.71717	28.23302								10/09/1942 08:00	12.19			
2728CD00225	Borehole	-27.75049	28.30858								13/10/1942 08:00	21.34			
2728CD00227	Borehole	-27.7505	28.30858								03/11/1942 08:00	18.29			
2728CD00202	Borehole	-27.88382	28.39191								16/11/1942 08:00	21.34			
2728CD00069	Borehole	-27.97606	28.44191								06/01/1943 08:00	12.19			
2728DA00029	Borehole	-27.60049	28.59969								25/01/1943 08:00	22.86			
2728DC00140	Borehole	-27.95938	28.52525								09/03/1943 08:00	6.09			
2728DC00012	Borehole	-27.92605	28.51637								05/06/1943 08:00	9.14			
2728DC00011	Borehole	-27.92605	28.51636								14/06/1943 08:00	6.09			
2728CD00183	Borehole	-27.85938	28.46636								06/08/1943 08:00	18.28			
2728DC00133	Borehole	-27.99271	28.53303								18/11/1943 08:00	14.63			
2728DC00132	Borehole	-27.99271	28.53302								24/11/1943 08:00	15.24			
2728CD00238	Borehole	-27.99273	28.40858								01/02/1944 08:00	4.88			
2728CD00237	Borehole	-27.99271	28.4086								11/02/1944 08:00	0.61			
2728CD00236	Borehole	-27.99272	28.40858								29/02/1944 08:00	4.57			
2728CD00235	Borehole	-27.99271	28.40859								06/03/1944 08:00	27.43			
2728CD00234	Borehole	-27.99271	28.40858								16/03/1944 08:00	9.14			
2728CD00189	Borehole	-27.9094	28.39969								23/05/1944 08:00	12.8			
2728CD00190	Borehole	-27.90938	28.39972								29/05/1944 08:00	12.19			
2728CD00191	Borehole	-27.90941	28.39969								03/06/1944 08:00	6.71			
2728CD00192	Borehole	-27.90938	28.39973								10/06/1944 08:00	7.93			
2728CB00064	Borehole	-27.69272	28.42525								07/07/1944 08:00	8.53			
2728CB00098	Borehole	-27.61716	28.46636								07/09/1944 08:00	12.8			
2728CB00099	Borehole	-27.61717	28.46636								13/09/1944 08:00	15.85			
2728DC00014	Borehole	-27.99271	28.50858								28/09/1944 08:00	7.92			
2728DC00017	Borehole	-27.99273	28.50858								07/10/1944 08:00	10.97			
2728DC00018	Borehole	-27.99271	28.5086								12/10/1944 08:00	14.02			
2728DC00015	Borehole	-27.99272	28.50858								17/10/1944 08:00	8.53			
2728DC00016	Borehole	-27.99271	28.50859								23/10/1944 08:00	6.7			
2728CB00012	Borehole	-27.62605	28.31638								07/11/1944 08:00	7.01			
2728CB00013	Borehole	-27.59271	28.31636								12/01/1945 08:00	5.49			
2728CB00014	Borehole	-27.59271	28.31637								20/01/1945 08:00	4.88			
2728CB00015	Borehole	-27.59272	28.31636								25/01/1945 08:00	9.75			
2728CB00016	Borehole	-27.59271	28.31638								31/01/1945 08:00	9.14			
2728CB00017	Borehole	-27.59273	28.31636								07/02/1945 08:00	9.75			
2728CB00042	Borehole	-27.62605	28.31639								22/02/1945 08:00	12.8			
2728CB00043	Borehole	-27.62608	28.31636								28/02/1945 08:00	7.01			
2728CB00008	Borehole	-27.60939	28.29969								04/04/1945 08:00	7.62			
2728CB00007	Borehole	-27.60938	28.29969								13/04/1945 08:00	18.28			
2728CB00046	Borehole	-27.68382	28.2997								16/07/1945 08:00	9.14			
2728DA00017	Borehole	-27.62605	28.59191								09/08/1945 08:00	27.43			
2728DA00018	Borehole	-27.62605	28.59192								18/08/1945 08:00	18.29			
2728DA00020	Borehole	-27.62605	28.59193								12/09/1945 08:00	5.79			
2728CB00048	Borehole	-27.68382	28.29971								04/08/1946 08:00	12.19			
2828AB00152	Borehole	-28.23001	28.27941								22/08/1950 08:00	9.14			
2828AB00145	Borehole	-28.23464	28.31833								02/09/1950 08:00	9.14			
2828AB00154	Borehole	-28.23001	28.27942								08/09/1950 08:00	9.14			
2828AB00051	Borehole	-28.23001	28.27939								18/09/1950 08:00	4.57			
2828AB00156	Borehole	-28.23001	28.27943								14/09/1951 08:00	11.27			
2828AD00023	Borehole	-28.40963	28.29967								06/02/1955 08:00	12.19			
2728CB00074	Borehole	-27.67605	28.41637								12/07/1957 08:00	15.24			
2728CB00081	Borehole	-27.67609	28.41636								09/08/1957 08:00	0.3			
2728CB00082	Borehole	-27.67605	28.41641								12/08/1957 08:00	15.24			
2728CB00083	Borehole	-27.6761	28.41636								17/08/1957 08:00	3.05			
2728CD00137	Borehole	-27.99271	28.43302								29/08/1957 08:00	12.19			
2728CD00140	Borehole	-27.99271	28.43304								09/09/1957 08:00	1.83			
2828BA00059	Borehole	-28.24043	28.66457								10/09/1957 08:00	9.14			
2828BA00060	Borehole	-28.24043	28.66458								18/09/1957 08:00	6.1			
2828BA00061	Borehole	-28.24044	28.66457								09/10/1957 08:00	3.05			
2728CD00239	Borehole	-27.99271	28.37525								16/10/1957 08:00	4.57			
2828BA00133	Borehole	-28.21936	28.66855								22/10/1957 08:00	6.1			
2728CD00241	Borehole	-27.99272	28.37525								24/10/1957 08:00	3.05			
2828BA00132	Borehole	-28.21935	28.66854								26/10/1957 08:00	6.1			
2728CD00242	Borehole	-27.99271	28.37527								31/10/1957 08:00	6.1			
2828BA00131	Borehole	-28.21934	28.66858								04/11/1957 08:00	12.2			
2728CD00243	Borehole	-27.99273	28.37525								06/11/1957 08:00	9.14			
2828BA00130	Borehole	-28.21933	28.66856								08/11/1957 08:00	12.2			
2828BA00128	Borehole	-28.2194	28.66864								23/11/1957 08:00	3			
2728CD00244	Borehole	-27.99271	28.37528								29/11/1957 08:00	3.05			
2728CD00245	Borehole	-27.99274	28.37525								10/12/1957 08:00	9.14			
2728CD00246	Borehole	-27.99271	28.37529								12/12/1957 08:00	4.57			

GeositeInfo_J dentifier	GeositeInfo_ GeositeType	GeositeInfo_L altitude	GeositeInfo_L ongitude	WaterLevel_R eferencePoint	WaterLevel_R eferenceHeig ht	WaterLevel_M easuringMeth od	WaterLevel_ WaterLevelSt atus	WaterLevel_D rawdownPeri od	WaterLevel_R ecoveryPerio d	WaterLevel_P iezometerNu mber	WaterLevel_M easurementD ateAndTime	WaterLevel_ WaterLevel		Difference from Median Level	
2828AB00052	Borehole	-28.23001	28.27952								13/01/1958 08:00	3.05			
2728CD00118	Borehole	-27.95938	28.36639								16/01/1958 08:00	6.1			
2728CD00119	Borehole	-27.95942	28.36636								23/01/1958 08:00	24.38			
2728CD00117	Borehole	-27.95941	28.36636								28/01/1958 08:00	7.62			
2728CD00116	Borehole	-27.95938	28.36638								31/01/1958 08:00	7.62			
2728CD00112	Borehole	-27.95938	28.36636								15/02/1958 08:00	2.74			
2828AB00053	Borehole	-28.23002	28.27952								15/02/1958 08:00	6.09			
2728CD00110	Borehole	-27.96719	28.37525								26/02/1958 08:00	22.86			
2728CD00109	Borehole	-27.96716	28.37527								27/02/1958 08:00	6.1			
2728CD00105	Borehole	-27.96716	28.37525								12/03/1958 08:00	4.67			
2728CD00053	Borehole	-27.9941	28.33308								01/05/1958 08:00	12.19			
2728CD00054	Borehole	-27.99416	28.33302								04/05/1958 08:00	6.09			
2728CD00056	Borehole	-27.99417	28.33302								20/05/1958 08:00	9.14			
2828AB00034	Borehole	-28.02963	28.36188								05/07/1958 08:00	10.67			
2828AB00031	Borehole	-28.06857	28.43695								08/07/1958 08:00	6.1			
2828AB00033	Borehole	-28.02963	28.36187								04/08/1958 08:00	12.19			
2828AB00039	Borehole	-28.02975	28.36189								19/08/1958 08:00	4.57			
2828AB00041	Borehole	-28.03642	28.45011								03/09/1958 08:00	5.49			
2828AB00121	Borehole	-28.18049	28.32033								20/10/1958 08:00	4.57			
2728CD00073	Borehole	-27.97605	28.46637								05/11/1958 08:00	9.14			
2728CD00072	Borehole	-27.97605	28.46636								13/11/1958 08:00	5.49			
2728CD00082	Borehole	-27.97605	28.41636								22/11/1958 08:00	9.14			
2728CD00180	Borehole	-27.96717	28.44191								28/11/1958 08:00	5.48			
2728CD00080	Borehole	-27.94272	28.41636								02/01/1959 08:00	6.1			
2728CD00256	Borehole	-27.91716	28.43302								04/01/1959 08:00	6.1			
2728CD00079	Borehole	-27.94271	28.41637								08/01/1959 08:00	1.83			
2728CD00081	Borehole	-27.94271	28.41638								13/01/1959 08:00	2.44			
2728CD00165	Borehole	-27.95049	28.44969								19/01/1959 08:00	2.43			
2728CD00168	Borehole	-27.95049	28.44971								04/02/1959 08:00	5.48			
2828BA00127	Borehole	-28.21939	28.66863								11/06/1959 08:00	6.1			
2828BA00126	Borehole	-28.21938	28.66862								27/06/1959 08:00	4.27			
2728DC00076	Borehole	-27.88382	28.53306								24/07/1959 08:00	9.14			
2828BA00121	Borehole	-28.21933	28.66857								31/07/1959 08:00	12.2			
2728DC00075	Borehole	-27.88385	28.53302								01/08/1959 08:00	1.83			
2728DC00073	Borehole	-27.88384	28.53302								11/08/1959 08:00	9.14			
2728DC00072	Borehole	-27.88382	28.53304								14/08/1959 08:00	2.13			
2728DC00069	Borehole	-27.88382	28.53302								18/08/1959 08:00	7.62			
2728DC00071	Borehole	-27.88383	28.53302								21/08/1959 08:00	6.1			
2728DC00070	Borehole	-27.88382	28.53303								26/08/1959 08:00	2.13			
2728DC00094	Borehole	-27.88716	28.52525								01/09/1959 08:00	9.14			
2728DC00091	Borehole	-27.86717	28.52525								08/09/1959 08:00	12.19			
2728DC00093	Borehole	-27.86718	28.52525								16/09/1959 08:00	6.1			
2728DC00096	Borehole	-27.88717	28.52525								18/09/1959 08:00	7.62			
2728DC00089	Borehole	-27.86716	28.52525								23/09/1959 08:00	9.14			
2728DC00090	Borehole	-27.86716	28.52526								28/09/1959 08:00	15.24			
2728DC00092	Borehole	-27.86716	28.52527								02/10/1959 08:00	28.96			
2728DC00095	Borehole	-27.88716	28.52526								07/10/1959 08:00	7.62			
2728DC00083	Borehole	-27.87605	28.50858								13/10/1959 08:00	3.05			
2728CD00172	Borehole	-27.91716	28.45858								26/10/1959 08:00	7.62			
2728CD00129	Borehole	-27.90049	28.49191								28/10/1959 08:00	1.83			
2728CD00130	Borehole	-27.90049	28.49192								31/10/1959 08:00	0.61			
2728CD00077	Borehole	-27.93383	28.48302								17/11/1959 08:00	4.57			
2728CD00065	Borehole	-27.93382	28.48302								18/11/1959 08:00	6.1			
2728CD00177	Borehole	-27.91718	28.45858								02/12/1959 08:00	6.09			
2728CD00176	Borehole	-27.91716	28.4586								04/12/1959 08:00	4.57			
2728CD00174	Borehole	-27.91716	28.45857								11/12/1959 08:00	4.57			
2728CD00173	Borehole	-27.91716	28.45859								19/12/1959 08:00	4.57			
2828BC00026	Borehole	-28.29343	28.66657								22/12/1959 08:00	3.66			
2728CD00257	Borehole	-27.91716	28.41302								07/01/1960 08:00	1.83			
2728CD00258	Borehole	-27.91717	28.41302								12/01/1960 08:00	12.19			
2728CD00259	Borehole	-27.91716	28.41303								14/01/1960 08:00	9.14			
2728CD00261	Borehole	-27.91716	28.43303								18/01/1960 08:00	1.22			
2728CD00263	Borehole	-27.91716	28.43304								27/01/1960 08:00	15.24			
2728CD00260	Borehole	-27.91717	28.43302								03/02/1960 08:00	12.19			
2728CD00201	Borehole	-27.89271	28.42529								08/02/1960 08:00	6.1			
2728CD00200	Borehole	-27.89275	28.42525								11/02/1960 08:00	12.19			
2728CD00199	Borehole	-27.89271	28.42528								16/02/1960 08:00	12.19			
2728CD00141	Borehole	-27.89271	28.42525								23/02/1960 08:00	9.14			
2728CD00143	Borehole	-27.89271	28.42526								29/02/1960 08:00	4.57			
2728CD00145	Borehole	-27.89271	28.42527								07/03/1960 08:00	10.67			
2728CD00091	Borehole	-27.90938	28.45861								22/03/1960 08:00	7.62			
2728CD00087	Borehole	-27.90938	28.45859								01/04/1960 08:00	12.19			
2828BC00068	Borehole	-28.25583	28.66698								06/05/1960 08:00	5.18			
2828BC00067	Borehole	-28.25583	28.66697								24/05/1960 08:00	1.22			
2728CB00071	Borehole	-27.55938	28.49191								03/06/1960 08:00	6.1			
2728CB00072	Borehole	-27.55939	28.49191								09/06/1960 08:00	4.57			
2728CD00163	Borehole	-27.94271	28.36638								13/06/1960 08:00	9.14			
2728CD00164	Borehole	-27.94274	28.36636								15/06/1960 08:00	4.57			
2728CD00159	Borehole	-27.94271	28.36636								24/06/1960 08:00	12.19			
2728CD00160	Borehole	-27.94272	28.36636								28/06/1960 08:00	15.24			
2728CD00179	Borehole	-27.96716	28.38302								04/07/1960 08:00	4.57			
2728CD00232	Borehole	-27.99272	28.39969								04/08/1960 08:00	10.97			
2728CD00231	Borehole	-27.99271	28.3997								12/08/1960 08:00	10.67			
2728CD00230	Borehole	-27.99271	28.39969								20/08/1960 08:00	4.57			

GeositeInfo_ID dentifier	GeositeInfo_GeositeType	GeositeInfo_Latitude	GeositeInfo_Longitude	WaterLevel_ReferencePoint	WaterLevel_ReferenceHeight	WaterLevel_MeasuringMethod	WaterLevel_WaterLevelStatus	WaterLevel_DraindownPeriod	WaterLevel_RecoveryPeriod	WaterLevel_PiezometerNumber	WaterLevel_MeasurementDateAndTime	WaterLevel_WaterLevel		Difference from Median Level	
2728CD00248	Borehole	-27.99271	28.3753								02/09/1960 08:00	12.19			
2728CD00249	Borehole	-27.99276	28.37525								08/09/1960 08:00	5.49			
2728CD00250	Borehole	-27.99271	28.37531								13/09/1960 08:00	15.24			
2728CD00251	Borehole	-27.99277	28.37525								16/09/1960 08:00	4.57			
2728CD00253	Borehole	-27.99278	28.37525								23/09/1960 08:00	5.48			
2728CD00254	Borehole	-27.99271	28.37533								30/09/1960 08:00	9.14			
2728CD00223	Borehole	-27.9672	28.33302								11/10/1960 08:00	9.14			
2828BA00040	Borehole	-28.12717	28.56647								17/10/1960 08:00	6.09			
2728CD00219	Borehole	-27.96718	28.33302								09/11/1960 08:00	15.24			
2728CD00220	Borehole	-27.96716	28.33305								19/11/1960 08:00	18.29			
2728CD00218	Borehole	-27.96716	28.33304								28/11/1960 08:00	4.57			
2728CD00124	Borehole	-27.95051	28.31636								03/12/1960 08:00	2.44			
2728CD00121	Borehole	-27.95049	28.31637								15/12/1960 08:00	10.67			
2728CD00120	Borehole	-27.95049	28.31636								04/01/1961 08:00	8.23			
2728CD00204	Borehole	-27.84272	28.39969								12/01/1961 08:00	15.24			
2728CD00208	Borehole	-27.84274	28.39969								19/01/1961 08:00	6.1			
2728CD00207	Borehole	-27.84271	28.39971								27/01/1961 08:00	7.62			
2728CD00206	Borehole	-27.84273	28.39969								03/02/1961 08:00	0.91			
2828AB00024	Borehole	-28.04563	28.45259								04/02/1961 08:00	21.34			
2828AB00025	Borehole	-28.04563	28.4526								07/02/1961 08:00	6.1			
2828AB00026	Borehole	-28.04564	28.4526								09/02/1961 08:00	3.05			
2728CD00096	Borehole	-27.86716	28.42525								10/02/1961 08:00	18.29			
2728CD00100	Borehole	-27.86716	28.42527								14/02/1961 08:00	6.1			
2828AB00027	Borehole	-28.04563	28.45261								14/02/1961 08:00	15.24			
2828AB00130	Borehole	-28.04941	28.44246								18/02/1961 08:00	12.19			
2728CD00099	Borehole	-27.86718	28.42525								23/02/1961 08:00	6.1			
2828AB00131	Borehole	-28.04942	28.44245								23/02/1961 08:00	18.29			
2828AB00132	Borehole	-28.04941	28.44247								28/02/1961 08:00	21.34			
2828AB00133	Borehole	-28.06941	28.44245								06/03/1961 08:00	21.33			
2728CD00097	Borehole	-27.86717	28.42525								08/03/1961 08:00	6.1			
2728CB00085	Borehole	-27.67609	28.41637								14/03/1961 08:00	5.49			
2728CB00086	Borehole	-27.67608	28.41637								16/03/1961 08:00	21.34			
2728CD00101	Borehole	-27.86719	28.42525								20/03/1961 08:00	0.31			
2728CB00087	Borehole	-27.67605	28.41642								22/03/1961 08:00	7.62			
2728CD00098	Borehole	-27.86716	28.42526								25/03/1961 08:00	0.61			
2728CB00089	Borehole	-27.67605	28.41643								29/03/1961 08:00	10.67			
2728CB00090	Borehole	-27.67612	28.41636								03/04/1961 08:00	7.62			
2728CD00213	Borehole	-27.89272	28.38302								07/04/1961 08:00	4.57			
2728CB00091	Borehole	-27.67605	28.41644								11/04/1961 08:00	7.62			
2728CD00212	Borehole	-27.89271	28.38302								15/04/1961 08:00	9.14			
2728CB00093	Borehole	-27.67605	28.41645								24/04/1961 08:00	6.1			
2728CB00094	Borehole	-27.67611	28.41636								25/04/1961 08:00	6.1			
2728CB00095	Borehole	-27.67608	28.41638								02/05/1961 08:00	7.62			
2728CB00096	Borehole	-27.67611	28.41637								05/05/1961 08:00	6.1			
2728CB00097	Borehole	-27.67608	28.41639								09/05/1961 08:00	6.4			
2828AB00029	Borehole	-28.04563	28.45262								18/05/1961 08:00	6.1			
2828AB00030	Borehole	-28.04566	28.4526								24/05/1961 08:00	9.14			
2728DC00138	Borehole	-27.76717	28.51636								21/06/1961 08:00	22.86			
2728DC00137	Borehole	-27.76716	28.51636								27/06/1961 08:00	21.33			
2828AB00091	Borehole	-28.03853	28.38177								04/07/1961 08:00	9.14			
2828AB00092	Borehole	-28.03238	28.38505								13/07/1961 08:00	12.19			
2828AB00090	Borehole	-28.03296	28.38688								31/07/1961 08:00	4.57			
2728DA00039	Borehole	-27.57605	28.49969								31/07/1961 08:00	7.62			
2728CD00063	Borehole	-27.9839	28.34052								12/08/1961 08:00	12.19			
2728DA00013	Borehole	-27.51605	28.49969								15/08/1961 08:00	7.62			
2728CD00009	Borehole	-27.98382	28.34056								17/08/1961 08:00	4.57			
2728DA00014	Borehole	-27.51716	28.49969								21/08/1961 08:00	9.14			
2728CD00010	Borehole	-27.98387	28.34052								26/08/1961 08:00	6.1			
2728DA00015	Borehole	-27.51606	28.49969								29/08/1961 08:00	2.44			
2728CD00011	Borehole	-27.98382	28.34057								31/08/1961 08:00	7.62			
2728CD00012	Borehole	-27.98388	28.34052								06/09/1961 08:00	4.57			
2728CD00013	Borehole	-27.98382	28.34058								09/09/1961 08:00	6.1			
2728CD00014	Borehole	-27.98389	28.34052								25/09/1961 08:00	9.14			
2828AB00109	Borehole	-28.04563	28.45263								28/09/1961 08:00	12.2			
2728DA00016	Borehole	-27.51605	28.4997								02/10/1961 08:00	15.24			
2728CD00004	Borehole	-27.98384	28.34052								03/10/1961 08:00	6.1			
2728DC00102	Borehole	-27.83382	28.50858								11/10/1961 08:00	3.65			
2728CD00015	Borehole	-27.98382	28.34059								16/10/1961 08:00	6.1			
2728DC00001	Borehole	-27.89271	28.51636								16/10/1961 08:00	15.24			
2728DC00002	Borehole	-27.89272	28.51636								19/10/1961 08:00	12.19			
2728CD00037	Borehole	-27.98382	28.26637								27/10/1961 08:00	9.14			
2728CD00038	Borehole	-27.98383	28.26636								31/10/1961 08:00	9.14			
2728CD00039	Borehole	-27.98382	28.26638								04/11/1961 08:00	6.1			
2728CD00040	Borehole	-27.98384	28.26636								10/11/1961 08:00	7.62			
2728CD00021	Borehole	-27.95938	28.28471								30/11/1961 08:00	18.29			
2728CD00022	Borehole	-27.9594	28.28469								05/12/1961 08:00	18.29			
2728CD00023	Borehole	-27.95938	28.28472								12/12/1961 08:00	18.29			
2728CD00024	Borehole	-27.95941	28.28469								19/12/1961 08:00	15.24			
2728CD00029	Borehole	-27.95938	28.28475								17/01/1962 08:00	24.38			
2728DC00003	Borehole	-27.89271	28.51637								22/01/1962 08:00	4.57			
2728CD00028	Borehole	-27.95943	28.28469								24/01/1962 08:00	12.19			
2728CD00027	Borehole	-27.95938	28.28474								27/01/1962 08:00	12.19			
2728CD00026	Borehole	-27.95942	28.28469								31/01/1962 08:00	3.05			

GeositeInfo_J dentifier	GeositeInfo_ GeositeType	GeositeInfo_L altitude	GeositeInfo_L ongitude	WaterLevel_R eferencePoint	WaterLevel_R eferenceHeig ht	WaterLevel_M easuringMeth od	WaterLevel_ WaterLevelSt atus	WaterLevel_D rawdownPeri od	WaterLevel_R ecoveryPerio d	WaterLevel_P iezometerNu mber	WaterLevel_M easurementD ateAndTime	WaterLevel_ WaterLevel		Difference from Median Level	
2728DC000005	Borehole	-27.89271	28.51638								01/02/1962 08:00	12.19			
2728CD00214	Borehole	-27.89271	28.38303								22/02/1962 08:00	6.1			
2728CD00018	Borehole	-27.95938	28.28469								27/02/1962 08:00	12.19			
2728DA00036	Borehole	-27.73382	28.56637								14/03/1962 08:00	33.53			
2828AB00095	Borehole	-28.19071	28.3365								11/04/1962 08:00	21.34			
2728CD00146	Borehole	-27.85049	28.43302								25/04/1962 08:00	6.1			
2728CD00265	Borehole	-27.85054	28.43302								05/05/1962 08:00	4.57			
2828AB00100	Borehole	-28.19071	28.33653								07/05/1962 08:00	21.34			
2728CD00266	Borehole	-27.85049	28.43307								17/05/1962 08:00	6.14			
2828AD00001	Borehole	-28.31363	28.483								23/05/1962 08:00	12.19			
2828AD00002	Borehole	-28.31363	28.48301								06/06/1962 08:00	12.19			
2728CD00152	Borehole	-27.85049	28.43305								15/06/1962 08:00	4.57			
2728CD00153	Borehole	-27.85053	28.43302								20/06/1962 08:00	4.57			
2728CD00154	Borehole	-27.85049	28.43306								03/07/1962 08:00	8.84			
2728CB00025	Borehole	-27.60939	28.46636								25/07/1962 08:00	1.83			
2728CB00019	Borehole	-27.66716	28.25858								09/08/1962 08:00	4.27			
2728CB00020	Borehole	-27.66717	28.25858								08/09/1962 08:00	6.1			
2728CB00021	Borehole	-27.66716	28.25859								24/09/1962 08:00	7.62			
2728AD00011	Borehole	-27.41718	28.38302								28/09/1962 08:00	6.09			
2828CB00002	Borehole	-28.50044	28.36634								13/11/1962 08:00	16.76			
2728AD00006	Borehole	-27.38383	28.41636								14/01/1963 08:00	18.28			
2728AD00005	Borehole	-27.38382	28.41636								24/01/1963 08:00	9.75			
2728CC00049	Borehole	-27.84549	28.1933								19/02/1964 08:00	14.38			
20667	Borehole	-28.30043	28.39967								03/12/1965 08:00	3.35			
20676	Borehole	-28.30047	28.39967								14/12/1965 08:00	16.76			
2828AA00005	Borehole	-28.01423	28.23412								01/01/1966 08:00	18.29			
2828AD00016	Borehole	-28.30046	28.39967								28/01/1966 08:00	3.04			
2828AD00011	Borehole	-28.30044	28.39967								28/01/1966 08:00	4.27			
2828AD00013	Borehole	-28.30045	28.39967								28/01/1966 08:00	10.36			
2828AB00067	Borehole	-28.13016	28.36597								01/01/1967 08:00	19.81			
2828AB00068	Borehole	-28.11555	28.35671								01/01/1967 08:00	42.37			
2728CC00008	Borehole	-27.96719	28.19969								22/05/1967 08:00	12.8			
2828AB00017	Borehole	-28.0552	28.30134								07/10/1971 08:00	60			
2828AB00108	Borehole	-28.03155	28.30018								30/11/1971 08:00	50			
2828AB00018	Borehole	-28.05517	28.30137								18/04/1972 08:00	20			
2828AB00020	Borehole	-28.05517	28.30148								26/04/1972 08:00	15			
2828AB00014	Borehole	-28.05517	28.30135								29/05/1972 08:00	8.53			
2828BC00055	Borehole	-28.33793	28.62847								15/08/1972 08:00	20			
2728CD00032	Borehole	-27.81994	28.37164								20/09/1972 08:00	23.16			
2828BC00059	Borehole	-28.26983	28.57837								03/10/1972 08:00	20			
2828AB00001	Borehole	-28.10412	28.29183								01/01/1973 08:00	10.5			
2728CB00052	Borehole	-27.6505	28.38302								18/07/1973 08:00	9			
2728CB00056	Borehole	-27.66716	28.37525								13/08/1973 08:00	15			
2728CD00155	Borehole	-27.78382	28.29969								25/10/1973 08:00	19			
2728CB00037	Borehole	-27.6505	28.32525								07/10/1974 08:00	22			
2728CB00039	Borehole	-27.65051	28.32525								01/11/1974 08:00	15			
2828BA00039	Borehole	-28.07744	28.58837								01/01/1975 08:00	33.61			
2828BA00110	Borehole	-28.22913	28.66437								07/03/1975 08:00	21			
28444	Borehole	-27.70939	28.18302								11/03/1975 08:00	3.8			
028444A	Borehole	-27.70938	28.18303								14/03/1975 08:00	2.3			
028445A	Borehole	-27.68382	28.16636								19/03/1975 08:00	3.2			
028445B	Borehole	-27.68382	28.16637								21/03/1975 08:00	3.4			
028446A	Borehole	-27.68382	28.16638								26/03/1975 08:00	3.8			
028445D	Borehole	-27.68382	28.16639								01/04/1975 08:00	1.5			
028445E	Borehole	-27.68385	28.16636								01/04/1975 08:00	2.8			
028444D	Borehole	-27.70941	28.18302								04/04/1975 08:00	4.5			
028444F	Borehole	-27.70942	28.18302								14/04/1975 08:00	2			
028444L	Borehole	-27.68382	28.16641								23/04/1975 08:00	3			
2828BA00034	Borehole	-28.12843	28.51087								01/05/1975 08:00	21			
028450A	Borehole	-27.70938	28.18311								07/05/1975 08:00	0.5			
28451	Borehole	-27.70948	28.18302								14/05/1975 08:00	2.8			
028451A	Borehole	-27.70938	28.18312								15/05/1975 08:00	2.3			
2828BA00036	Borehole	-28.12844	28.51087								22/05/1975 08:00	9			
2728CA00220	Borehole	-27.70938	28.18313								28/05/1975 08:00	3.6			
028444T	Borehole	-27.7095	28.18302								29/05/1975 08:00	4.1			
2728CB00034	Borehole	-27.63382	28.33302								08/03/1976 08:00	0.1			
2728CB00035	Borehole	-27.63382	28.33303								17/03/1976 08:00	4			
2728CC00015	Borehole	-27.81716	28.23304								11/05/1976 08:00	8			
2728CD00125	Borehole	-27.76716	28.29969								26/05/1976 08:00	9			
2728CD00157	Borehole	-27.76716	28.26636								24/06/1976 08:00	3			
2728CD00126	Borehole	-27.76717	28.29969								15/09/1976 08:00	15			
2828AD00025	Borehole	-28.3171	28.24968								03/10/1980 08:00	7			
2828AB00114	Borehole	-28.03078	28.3351								27/01/1981 08:00	8			
2828AB00086	Borehole	-28.21461	28.34493								11/09/1981 08:00	20.5			
2728CD00181	Borehole	-27.90938	28.31636								06/01/1982 08:00	25			
2728CC00045	Borehole	-27.88384	28.14969								25/05/1982 08:00	2			
2828AB00117	Borehole	-28.11021	28.45613								18/10/1982 08:00	15			
2828AB00127	Borehole	-28.09302	28.44583								22/10/1982 08:00	25			
2828AD00026	Borehole	-28.43003	28.34967								07/05/1983 08:00	10			
2828AD00029	Borehole	-28.47993	28.34967								11/05/1983 08:00	10			
2828AD00004	Borehole	-28.38553	28.4955								25/05/1983 08:00	29			
2828BC00054	Borehole	-28.38171	28.50682								25/05/1983 08:00	29			

GeositeInfo_J dentifier	GeositeInfo_ GeositeType	GeositeInfo_L altitude	GeositeInfo_L ongitude	WaterLevel_R eferencePoint	WaterLevel_R eferenceHeig ht	WaterLevel_M easuringMeth od	WaterLevel_ WaterLevelSt atus	WaterLevel_D rawdownPeri od	WaterLevel_R ecoveryPerio d	WaterLevel_P iezometerNu mber	WaterLevel_M easurementD ateAndTime	WaterLevel_ WaterLevel		Difference from Median Level	
2728CB00001	Borehole	-27.57605	28.26636								30/05/1983 08:00	6			
2728CB00002	Borehole	-27.57605	28.26637								03/06/1983 08:00	4			
2828BA00007	Borehole	-28.03376	28.51635								04/06/1983 08:00	16			
2828BA00013	Borehole	-28.03376	28.51638								08/06/1983 08:00	6			
2828BA00012	Borehole	-28.03379	28.51634								08/06/1983 08:00	16			
2828BA00010	Borehole	-28.03378	28.51634								08/06/1983 08:00	17			
2828AB00161	Borehole	-28.03377	28.483								09/06/1983 08:00	6			
2828BA00017	Borehole	-28.12715	28.56647								18/06/1983 08:00	17			
2828BA00019	Borehole	-28.12716	28.56647								18/06/1983 08:00	32			
2828AD00039	Borehole	-28.46023	28.35857								28/06/1983 08:00	6			
2828AB00056	Borehole	-28.24169	28.40471								01/07/1983 08:00	9.7			
2828AB00062	Borehole	-28.24759	28.39516								15/08/1983 08:00	15			
2728CD00102	Borehole	-27.93382	28.34969								01/10/1983 08:00	7			
2728CA00004	Borehole	-27.68383	28.23302								03/10/1983 08:00	15			
2828BA00003	Borehole	-28.05043	28.53301								18/10/1983 08:00	25			
2728CC00001	Borehole	-27.96716	28.21636								08/11/1983 08:00	20			
2828AB00088	Borehole	-28.16092	28.25301								10/11/1983 08:00	50			
2728CA00011	Borehole	-27.61716	28.24192								24/11/1983 08:00	15			
2828BC00071	Borehole	-28.25585	28.66697								06/12/1983 08:00	15			
2828AD00007	Borehole	-28.2671	28.383								07/12/1983 08:00	6			
2828AB00059	Borehole	-28.24758	28.39515								19/12/1983 08:00	12			
2828AB00172	Borehole	-28.23848	28.41634								20/12/1983 08:00	15			
2728DA00007	Borehole	-27.65049	28.51636								04/01/1984 08:00	24			
2828AA00009	Borehole	-28.00409	28.20325								03/02/1984 08:00	10			
2828AB00028	Borehole	-28.04565	28.4526								03/02/1984 08:00	25			
2828AB00128	Borehole	-28.05845	28.43518								03/02/1984 08:00	30			
2828AB00129	Borehole	-28.04941	28.44245								04/02/1984 08:00	15			
2828AB00063	Borehole	-28.14717	28.47724								10/02/1984 08:00	10			
2728CB00026	Borehole	-27.60938	28.46638								05/04/1984 08:00	29			
2728CB00029	Borehole	-27.60941	28.46636								06/04/1984 08:00	10			
2728CB00030	Borehole	-27.60938	28.4664								09/04/1984 08:00	19			
2728CB00033	Borehole	-27.60943	28.46636								11/04/1984 08:00	4			
2728CB00040	Borehole	-27.67605	28.49191								04/05/1984 08:00	7			
2828AB00009	Borehole	-28.0872	28.45309								04/05/1984 08:00	30			
2828BC00050	Borehole	-28.29733	28.60807								22/05/1984 08:00	10			
2828AC00109	Borehole	-28.27363	28.21367								28/05/1984 08:00	12			
2728CD00060	Borehole	-27.98382	28.39969								14/06/1984 08:00	30			
2828AB00048	Borehole	-28.09193	28.30705								19/06/1984 08:00	15			
2828AB00119	Borehole	-28.09631	28.33312								22/06/1984 08:00	13			
2828AB00081	Borehole	-28.07592	28.32111								26/06/1984 08:00	10			
2828BC00044	Borehole	-28.44073	28.51287								04/07/1984 08:00	18			
2828BC00045	Borehole	-28.43843	28.51547								05/07/1984 08:00	40			
2828BC00046	Borehole	-28.44413	28.51517								09/07/1984 08:00	30			
2828AB00004	Borehole	-28.02008	28.35963								11/07/1984 08:00	6			
2828AB00007	Borehole	-28.02008	28.35989								12/07/1984 08:00	5			
2828BC00051	Borehole	-28.42183	28.52837								12/07/1984 08:00	55			
2728CD00002	Borehole	-27.98383	28.34052								02/08/1984 08:00	10			
2828AD00009	Borehole	-28.48513	28.45387								06/09/1984 08:00	18			
2828AA00072	Borehole	-28.05526	28.22068								26/09/1984 08:00	8			
2828AB00139	Borehole	-28.22886	28.27899								26/09/1984 08:00	9.5			
2828AB00047	Borehole	-28.22875	28.27912								01/10/1984 08:00	6			
2728CB00105	Borehole	-27.69745	28.38249								10/03/1987 08:00	18			
2828AD00054	Borehole	-28.33376	28.44967								17/05/1991 08:00	18			
2828AB00167	Borehole	-28.19209	28.26634								27/08/1991 08:00	15			
2828AB00140	Borehole	-28.23377	28.31634								07/02/1992 08:00	19.1			
2728DA00041	Borehole	-27.60049	28.59135								13/02/1992 08:00	16.5			
2728CC00058	Borehole	-27.81021	28.14969								10/03/1992 08:00	11.6			

APPENDIX E

Hydrocensus Field Dataset: Nov 2015

APPENDIX F

Hydrocensus Chemical Analysis (Nov 2015)

Jones Environmental Laboratory

Report:	Liquid	Sample ID	MOR1B1	MOR1S1	VIO1B2	DANK1B1	C8C3-E	AS1S1	AM1B1	C83F-A	SLAG1B1	VIS1B1	TEV1B1	PAL1B1	ZWA1B1	VIO1B1	PEL1B1	ZIO1B1	HB1B1	TWE1B1
JE Job No:	15/16704	Depth	7.83	0.0	5.8	20.1	0.0	0.0	22.1	0.0	10.0	6.75	13.8	15.1	18.28	10.5	11.8	21.85	12.0	21.5
Client:	Golder Associates Africa Ltd	Sample Type	Ground Water	Surface Water	Ground Water	Ground Water	Surface Water	Surface Water	Ground Water	Surface Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Client ref:	1417697	Sampled Date	10/11/2015 17:56	10/11/2015 18:11	19/11/2015 13:04	10/11/2015 14:03	14/11/2015 10:00	14/11/2015 09:00	18/11/2015 13:02	14/11/2015 14:11	09/11/2015 11:03	10/11/2015 15:00	11/11/2015 11:24	13/11/2015 09:52	13/11/2015 15:27	12/11/2015 09:07	12/11/2015 11:04	13/11/2015 11:06	09/11/2015 08:30	10/11/2015 09:28
Location:	Liebenberg Vlei	Sample Received Date	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015	23/11/2015
Contact	Eddie van Wyk	J E Sample No	1-2	3	4-5	6-7	8	9	10-11	12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	31-32
		Batch Number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Test	Method	Units	LOD																	
Dissolved Aluminium #	TM30/PM14	ug/l	<20	<20	-	<20	<20	-	-	<20	-	<20	<20	<20	<20	<20	<20	<20	<20	<20
Dissolved Antimony #	TM30/PM14	ug/l	<2	<2	-	<2	<2	-	-	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dissolved Arsenic #	TM30/PM14	ug/l	<2.5	<2.5	-	4.6	3.2	-	-	<2.5	-	8.8	<2.5	<2.5	<2.5	6.8	<2.5	2.8	3	<2.5
Dissolved Barium #	TM30/PM14	ug/l	<3	156	-	22	60	-	-	59	-	35	12	8	117	389	18	14	68	93
Dissolved Beryllium	TM30/PM14	ug/l	<0.5	<0.5	-	<0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved Bismuth	TM30/PM14	ug/l	<5	<5	-	<5	<5	-	-	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Boron	TM30/PM14	ug/l	<12	32	-	29	24	-	-	<12	-	74	119	630	92	58	41	<12	30	25
Dissolved Cadmium #	TM30/PM14	ug/l	<0.5	<0.5	-	<0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5
Dissolved Calcium #	TM30/PM14	mg/l	<0.2	46.6	43.5	50.3	37.9	35.2	9	48.4	13.3	3.8	39.3	6.9	32.5	43.1	49.7	63.6	59.9	57.5
Total Dissolved Chromium #	TM30/PM14	ug/l	<1.5	<1.5	-	<1.5	<1.5	-	-	<1.5	-	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Dissolved Cobalt #	TM30/PM14	ug/l	<2	<2	-	<2	<2	-	-	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dissolved Copper #	TM30/PM14	ug/l	<7	<7	-	<7	<7	-	-	<7	-	<7	35	<7	87	<7	<7	<7	<7	<7
Total Dissolved Iron #	TM30/PM14	ug/l	<20	67	<20	<20	<20	119	<20	<20	27	<20	<20	<20	32	127	<20	<20	<20	<20
Dissolved Lead #	TM30/PM14	ug/l	<5	9	-	8	6	-	-	10	-	8	6	14	7	8	7	13	7	8
Dissolved Lithium	TM30/PM14	ug/l	<5	15	-	27	19	-	-	14	-	32	55	37	71	29	31	17	37	27
Dissolved Magnesium #	TM30/PM14	mg/l	<0.1	27.2	33.7	18	13.2	15.7	3.2	18.1	6.3	1.7	13.8	4.3	9.4	17.6	18	27.2	22	18.8
Dissolved Manganese #	TM30/PM14	ug/l	<2	233	-	8	8	-	-	<2	-	<2	<2	25	3	106	12	<2	6	<2
Dissolved Mercury #	TM30/PM14	ug/l	<1	<1	-	<1	<1	-	-	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Molybdenum #	TM30/PM14	ug/l	<2	<2	-	3	<2	-	-	<2	-	<2	<2	<2	2	<2	3	<2	<2	11
Dissolved Nickel #	TM30/PM14	ug/l	<2	<2	-	3	<2	-	-	<2	-	<2	<2	<2	<2	<2	3	<2	<2	3
Dissolved Phosphorus #	TM30/PM14	ug/l	<5	6	-	14	21	-	-	9	-	8	<5	34	<5	11	<5	24	<5	<5
Dissolved Potassium #	TM30/PM14	mg/l	<0.1	1.2	3.1	1.3	2.7	2.9	0.5	0.9	1	2.5	3.9	0.4	2.2	2.9	1.1	1.1	12.3	1.7
Dissolved Selenium #	TM30/PM14	ug/l	<3	<3	-	<3	<3	-	-	<3	-	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dissolved Silver	TM30/PM14	ug/l	<5	<5	-	<5	<5	-	-	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Sodium #	TM30/PM14	mg/l	<0.1	31.5	40.3	37.4	27.5	24	2	24.2	5.5	140.6	74.4	103.6	72	47.3	34	25.5	62.3	31.8
Dissolved Strontium	TM30/PM14	ug/l	<5	522	-	718	443	-	-	309	-	66	497	112	785	949	692	304	516	669
Dissolved Tellurium	TM30/PM14	ug/l	<5	<5	-	<5	<5	-	-	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Thallium #	TM30/PM14	ug/l	<3	<3	-	<3	<3	-	-	<3	-	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dissolved Tin	TM30/PM14	ug/l	<5	<5	-	<5	<5	-	-	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Titanium	TM30/PM14	ug/l	<5	<5	-	<5	<5	-	-	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Vanadium #	TM30/PM14	ug/l	<1.5	<1.5	-	5.9	<1.5	-	-	4.4	-	<1.5	3	<1.5	<1.5	6.8	9.8	4.1	8.3	1.8
Dissolved Zinc #	TM30/PM14	ug/l	<3	272	-	20	466	-	-	23	-	8	88	6	54	30	42	16	57	71
Dissolved Zirconium	TM30/PM14	ug/l	<5	<5	-	<5	<5	-	-	<5	-	<5	7	<5	<5	6	<5	<5	<5	<5
Total Hardness Dissolved (as CaCO3)	TM30/PM14	mg/l	<1	231	250	201	150	154	36	197	60	17	156	35	121	182	200	273	242	223
Fluoride	TM27/PM0	mg/l	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.6	3	0.6	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Sulphate #	TM38/PM0	mg/l	<0.05	13.15	36.06	65.92	17.72	8	4.54	13.66	5.37	29.32	15.73	6.86	13.8	16.34	66.91	34.1	28.4	35.46
Chloride #	TM38/PM0	mg/l	<0.3	6	19.3	14	8.9	18.4	0.6	14.2	1.7	25.2	12.8	28.3	10.8	22.7	13.1	51.6	37.3	19.5
Nitrate as NO3 #	TM38/PM0	mg/l	<0.2	<0.2	3	31.8	8.2	<0.2	0.7	9.8	<0.2	<0.2	9.9	<0.2	<0.2	<0.2	35.8	58.4	45.6	11.6
Total Alkalinity as CaCO3 #	TM75/PM0	mg/l	<1	338	300	208	211	204	50	244	83	323	328	231	286	284	196	216	318	260
Bicarbonate Alkalinity as CaCO3	TM75/PM0	mg/l	<1	338	257	208	211	204	50	244	83	225	328	210	286	284	196	216	318	260
Electrical Conductivity @25C #	TM76/PM0	uS/cm	<2	558	589	540	396	390	90	464	135	604	589	476	503	537	529	661	717	549
Silica	TM52/PM0	mg/l	<0.01	31.1	38.5	26.2	25.2	19.1	14.4	35	13.1	21.4	23.7	38.6	21.5	23.9	23.3	39.4	24.3	28.5
Total Dissolved Solids #	TM20/PM0	mg/l	<10	248	307	305	179	160	15	230	60	277	331	277	253	278	308	349	379	302
Total Suspended Solids #	TM37/PM0	mg/l	<10	72	35	13	61	22	<10	18	45	13	<10	13	13	14	16	22	96	13
Turbidity	TM34/PM0	NTU	<0.1	11.2	5.9	2.5	25	4.4	2	0.8	12.7	1.4	1	1	0.8	1	0.8	1.9	33.6	0.6

APPENDIX G

ZQMBTM1: Long Term Hydrochemical Analysis

APPENDIX H

Field Parameters, 27–Bridges Surface Water Monitoring Network

- H1: Field Parameters – July 2015
- H2: Field Parameters – August 2015

Site ID	Coordinates		FIELD PARAMETERS										Comments
	S	E	556 MPS Probe							Hanna Probe			
			EC (mS/cm)	PH	TEMP	DO %	DO mg/l	ORP	Ph.mV	EC (mS/cm)	TDS ppt	TEMP	
C83A													
C83A-A	-28.3083	28.49871	0.493	5.7	8.02	70.3	8.38	134.1	65.5	0.41	0.21	9.2	
C83A-B	-28.4155	28.37503	0.120	5.89	12.33	78.4	8.32	40.4	53.6	0.05	0.02	12.9	
C83A-C	-28.4395	28.39723	0.100	5.95	11.48	104.6	11.28	120.8	50.9	0.06	0.03	11.8	
C83A-D	-28.4678	28.33808	0.324	5.83	8.02	90.3	10.67	60.2	56.2	0.28	0.14	10.4	
C83A-E	-28.3284	28.37691	0.080	5.72	12.32	82.2	8.51	78.2	63.5	0.05	0.02	13.4	
C83C													
C83C-A	-27.9402	28.30835	0.086	6.38	10.46	81	8.75	75.2	26	0.06	0.03	11.3	
C83C-B	-28.0675	28.31045	0.103	6.28	9.35	82.5	9.35	57.8	31.6	0.06	0.03	8.8	
C83C-C	-28.1926	28.35564	0.083	6.3	11.64	95.3	9.6	115.4	6.3	0.05	0.02	14.9	
C83C-D	-28.1986	28.36472	0.082	6.18	11.72	93.6	10	111.5	36.8	0.08	0.02	12.9	
C83C-E	-28.2327	28.31391	0.514	6.02	9.03	54.7	6.18	97.0	47.4	0.45	0.22	12.5	
C83F													
C83F-A	-27.6953	28.31759	0.391	6.24	9.36	91.5	10.25	93.0	33.6	0.33	0.16	12.5	
C83F-B	-27.7077	28.32316	0.091	6.46	11.84	94.1	10.07	47.6	22.1	0.06	0.03	13.6	
C83F-D	-27.7579	28.32742	0.090	6.2	11.46	80.7	8.7	110.1	36.2	0.05	0.03	13.4	
C83F-E	-27.865	28.30785	0.092	6.48	11.74	78.2	8.32	102.6	6.48	0.06	0.03	14.7	
C83F-F	-27.9431	28.3842	0.460	6.2	13.04	82.5	8.63	152.0	36.1	0.42	0.21	14.1	No Flow
C83G													
C83G-A	-27.5782	28.42043	0.477	6.21	3.97	67.3	8.87	116.7	34.4	0.42	0.21	3.8	
C83G-B	-27.6387	28.39516	0.477	6.16	4.18	71.2	9.21	97.4	37.1	0.43	0.21	3.7	No Flow
C83G-C	-27.6386	28.45213	0.569	5.72	6.06	91.2	10.72	154.0	61.8	0.5	0.26	7.4	
C83G-D	-27.6859	28.38035	0.084	6.3	7.93	82	9.65	66.8	30.2	0.05	0.02	6.8	
C83G-E	-27.689	28.38872	0.895	6.29	6.96	69.4	8.39	100.9	30.4	0.83	0.26	7.4	
C83G-F	-27.6862	28.49052	0.554	6.49	9.59	93.5	10.49	28.7	20.2	0.49	0.25	13.6	No Flow
C83H													
C83H-A	-27.3341	28.52561	0.089	6.65	11.4	97.3	10.5	75.0	11.4	0.06	0.03	12.3	
C83H-B	-27.4089	28.50579	0.593	6.53	8.55	91.9	10.95	43.8	18.3	0.53	0.26	10.9	
C83H-E	-27.5156	28.47522	0.583	5.79	9.92	80.2	8.94	55.6	59.1	0.53	0.27	10.3	No Flow
C83H-F	-27.5435	28.54297	0.564	6.49	10.77	96.5	10.51	38.5	21.2	0.51	0.26	12.4	
C83H-G	-27.5306	28.47561	0.085	5.81	10.27	83.8	9.27	82.3	5.8	0.06	0.03	13	
C83H-H	-27.6113	28.51603	0.670	5.64	8.34	88.5	10.33	61.7	66.7	0.6	0.3	8.9	No Flow

Site ID	Coordinates		Flow Measurements		
	S	E			
			Height (m)	Distance (m)	Time(min)
C83A-A	-28.308	28.499	2.8	30	0.28
C83A-E	-28.328	28.377	6	30	0.27
C83C-C	-28.193	28.356	6.5	30	0.46
C83C-D	-28.199	28.365	5	30	1.15
C83C-B	-28.067	28.310	4.3	30	0.16
C83F-E	-27.865	28.308	4	30	0.20
C83F-D	-27.758	28.327	10.5	30	0.26
C83F-B	-27.708	28.323	7.9	30	0.13
C83G-D	-27.686	28.380	13	30	0.12
C83H-G	-27.531	28.476	7.2	30	0.29

Site ID	Coordinates		FIELD PARAMETERS														Comments
	S	E	556 MPS Probe							AquaRead							
			EC (mS/cm)	PH	TEMP	DO %	DO mg/l	ORP	Ph.mV	EC (µs/cm)	Temp	PH	TDS (mg/l)	ORP (mV)	Tub (NTU)	SAL (ppt)	
C83A																	
C83A-A	-28.30832	28.49871															
C83A-B	-28.41548	28.37503	0.78	7.56	13.38	75.7	7.97	68.68	-39.6	74	13.5	6.59	50	46.1	32	46.1	
C83A-C	-28.43947	28.39723	0.145	7.45	13.55	91	8.31	99.4	-34.6	77	15	6.74	48	25.7	31.8	0.03	
C83A-D	-28.46778	28.33808															
C83A-E	-28.32835	28.37691	0.08	7.47	12.46	75.5	8.02	76.6	-34	73	13.5	6.57	47	59.6	37.3	0.03	
C83C																	
C83C-A	-27.94016	28.30835	0.082	7.54	13.15	80.39	8.39	80.7	-38	71	15.1	6.96	46	106.6	47.2	0.03	
C83C-B	-28.06747	28.31045	0.082	7.47	12.46	73.8	7.73	79.4	-34.8	69	14.3	6.87	44.6	108.9	44.6	0.03	
C83C-C	-28.19263	28.35564	0.085	7.54	12.85	77	8.09	73.6	-38.2	80	14.1	7.36	50	104.1	50	0.03	
C83C-D	-28.19864	28.36472	0.081	7.54	12.65	76.7	8.11	82.4	-38	67	14	7.12	44	98.5	39.8	0.03	
C83C-E	-28.23267	28.31391	0.558	7.75	10.6	35.3	3.99	47.7	-35.6	57.1	11.3	6.64	371	74.1	34.4	0.28	
C83F																	
C83F-A	-27.69529	28.31759	0.4	7.65	13.8	98.4	10.17	80.23	-44.6	420	15.9	7.48	273	118.5	32.2	0.2	
C83F-B	-27.7077	28.32316	0.082	7.56	13.63	84.1	8.66	102.6	-39.4	71	16.5	7.04	46	106.6	50.4	0.03	
C83F-D	-27.75786	28.32742	0.083	7.64	13.77	80.6	8.24	108.7	-43.8	70	17.3	7.34	45	109.8	47	0.03	
C83F-E	-27.86499	28.30785	0.084	7.69	13.28	80.8	8.4	112.3	-44.8	72	17	6.93	46	106.1	47	0.03	
C83F-F	-27.94311	28.3842															
C83G																	
C83G-A	-27.57822	28.42043	0.471	7.55	15.67	84	8.34	111.8	-39	490	16.8	7.65	318	121.7	26.8	0.24	
C83G-B	-27.63868	28.39516															
C83G-C	-27.63864	28.45213															
C83G-D	-27.68592	28.38035	0.082	7.54	12.81	76.7	8.08	52.5	-38.5	74	14.6	7.49	48	97.7	52.3	0.03	
C83G-E	-27.68904	28.38872	0.873	7.2	11.7	54.5	5.86	71.7	-41.4	905	14.7	7.56		98.8	60	0.45	
C83G-F	-27.68619	28.49052															
C83H																	
C83H-A	-27.3341	28.52561	0.087	7.58	15.86	75.4	7.44	115.8	-41.1	82	16.6	7.45	53	116.8	97	0.04	
C83H-B	-27.40892	28.50579	0.603	7.53	14.15	60.1	6.13	104.1	-37.9	630	14.7	7.42	410	128	30.9	0.31	
CH3H-C	-27.47072	28.5231	0.085	7.52	13.62	76.5	7.92	91.9	-37.6	87	13.9	7.09	56	116.4	51.6	0.04	Sampled
C83H-E	-27.5156	28.47522															
C83H-F	-27.54353	28.54297	0.608	7.49	11.2	77.2	8.37	100.7	-35.6	618	12.1	7.35	401	113.5	29.8	0.3	
C83H-G	-27.53064	28.47561	0.086	7.56	13.3	72.2	7.93	113.4	-39.4	83	14.5	7.56	52.3	104.8	52.3	0.04	
C83H-H	-27.61134	28.51603															

Site ID	Flow Measurements		
	Height (m)	Distance (m)	Time(min)
C83A-A	2.78	30	0.23
C83A-E	6.15	30	0.3014
C83C-C	6.77	30	0.2793
C83C-D	5	30	1.26
C83C-A	2.1	30	0.4671
C83C-B	4.5	30	0.271
C83F-E	4.4	30	0.244
C83F-D	11	30	0.2671
C83F-B	8.1	30	0.1633
C83G-D	13	30	13.23
C83H-G	7.2	30	0.298
C83H-C	13.02	30	0.4863

APPENDIX I

Laboratory Analysis: 27–Bridges Surface Water Monitoring Network

- I1: June 2015 UIS Laboratory
- I2: Aug 2015 Jones Env. Laboratory UK

June Laboratory Analyses

ID	SAMPLE #	Site #	S (Dec.Drg)	E (Dec.Drg)	Tot Cond @25C [mSm]	Total Cond [mS/m]	TC Temp. [Deg C]	TDS by EC*6.5 [mg/l]	TDS by EC*7 [mg/l]	TDS [mg/l]	TDS by Sum [mg/l]	TDS Factor	P Alk. [mg/l CaCO3]	M Alk. [mg/l CaCO3]	Ag [mg/l]	Al [mg/l]	As [mg/l]	B [mg/l]	Ba [mg/l]	Be [mg/l]	Bi [mg/l]	Ca [mg/l]	Cd [mg/l]	Co [mg/l]	Cr [mg/l]	Cu [mg/l]	Fe [mg/l]	K [mg/l]	Li [mg/l]	Mg [mg/l]	Mn [mg/l]	Mo [mg/l]	Na [mg/l]	Ni [mg/l]	P [mg/l]
438516	C83A-C	C83A-C	-28.43947	28.39723	7.48	7.48	21.7	48.6	52.4	32	50.1	6.7	<0.6	30.6	<0.05	0.61	<0.1	0.05	0.13	<0.05	<0.05	8.34	<0.05	<0.05	<0.05	<0.05	0.1	0.43	<0.05	2.99	<0.05	<0.05	3.17	<0.05	<0.05
438518	C83A-E	C83A-E	-28.32835	28.37691	7.6	7.6	21.5	49.4	53.2	<30	51.2	6.7	<0.6	30.3	<0.05	0.34	<0.1	0.06	0.12	<0.05	<0.05	8.76	<0.05	<0.05	<0.05	<0.05	0.07	0.41	<0.05	3.01	<0.05	<0.05	3.2	<0.05	<0.05
438519	C83C-A	C83C-A	-27.94016	28.30835	8.14	8.14	21.4	52.9	57	36	53.7	6.6	<0.6	32.9	<0.05	0.63	<0.1	0.05	0.13	<0.05	<0.05	8.75	<0.05	<0.05	<0.05	<0.05	0.16	0.53	<0.05	3.17	<0.05	<0.05	3.45	<0.05	<0.05
438520	C83C-B	C83C-B	-28.06747	28.31045	8.1	8.1	21.6	52.7	56.7	<30	52.8	6.5	<0.6	33	<0.05	0.36	<0.1	0.06	0.14	<0.05	<0.05	9.15	<0.05	<0.05	<0.05	<0.05	0.21	0.57	<0.05	3.27	<0.05	<0.05	3.6	<0.05	<0.05
438521	C83C-C	C83C-C	-28.19263	28.35564	7.85	7.85	21.8	51	55	<30	50.8	6.5	<0.6	32.1	<0.05	0.74	<0.1	0.05	0.14	<0.05	<0.05	8.89	<0.05	<0.05	<0.05	<0.05	0.19	0.56	<0.05	3.21	<0.05	<0.05	3.48	<0.05	<0.05
438523	C83C-E	C83C-E	-28.23267	28.313913	49.2	49.2	21.9	319	344	276	216	4.4	<0.6	186	<0.05	<0.05	<0.1	0.06	0.17	<0.05	<0.05	35.9	<0.05	<0.05	<0.05	<0.05	0.14	5.18	<0.05	20.8	<0.05	<0.05	27	<0.05	0.13
438524	C83F-A	C83F-A	-27.69529	28.31759	35.2	35.2	22	228	246	194	191	5.4	<0.6	157	<0.05	0.06	<0.1	0.06	0.19	<0.05	<0.05	25.1	<0.05	<0.05	<0.05	<0.05	<0.05	1.8	<0.05	16.8	<0.05	<0.05	21.6	<0.05	<0.05
438526	C83F-D	C83F-D	-27.75786	28.32742	8.46	8.46	22	55	59.2	58	51	6.0	<0.6	33.6	<0.05	0.49	<0.1	<0.05	0.12	<0.05	<0.05	8.92	<0.05	<0.05	<0.05	<0.05	0.28	0.6	<0.05	3.24	<0.05	<0.05	3.13	<0.05	<0.05
438529	C83G-A	C83G-A	-27.57822	28.42043	47.5	47.5	22	309	332	292	262	5.5	<0.6	214	<0.05	<0.05	<0.1	<0.05	0.14	<0.05	<0.05	35.5	<0.05	<0.05	<0.05	<0.05	<0.05	2.17	<0.05	27.2	<0.05	<0.05	20.1	<0.05	<0.05
438532	C83G-D	C83G-D	-27.68592	28.38035	8.18	8.18	22.1	53.2	57.3	30	51.6	6.3	<0.6	33.7	<0.05	0.56	<0.1	<0.05	0.12	<0.05	<0.05	8.98	<0.05	<0.05	<0.05	<0.05	0.31	0.58	<0.05	3.33	<0.05	<0.05	3.19	<0.05	<0.05
438533	C83G-E	C83G-E	-27.68904	28.38872	87.3	87.3	22.3	567	611	368	384	4.4	<0.6	234	<0.05	0.47	<0.1	0.07	0.12	<0.05	<0.05	20.8	<0.05	<0.05	<0.05	<0.05	0.45	18	<0.05	10.5	0.26	<0.05	75.4	<0.05	15.9
438535	C83H-A	C83H-A	-27.3341	28.52561	8.72	8.72	22.4	56.7	61	86	56.1	6.4	<0.6	36.2	<0.05	0.84	<0.1	0.05	0.17	<0.05	<0.05	9.19	<0.05	<0.05	<0.05	<0.05	0.51	0.81	<0.05	3.5	<0.05	<0.05	3.65	<0.05	<0.05
438536	C83H-B	C83H-B	-27.40892	28.50579	58.7	58.7	22.4	382	411	382	332	5.7	3.3	265	<0.05	<0.05	<0.1	<0.05	0.19	<0.05	<0.05	38.4	<0.05	<0.05	<0.05	<0.05	<0.05	2.1	<0.05	30.9	<0.05	<0.05	39.5	<0.05	<0.05
438538	C83H-F	C83H-F	-27.54353	28.54297	57.5	57.5	22.4	374	402	372	332	5.8	4.5	261	<0.05	<0.05	<0.1	<0.05	0.14	<0.05	<0.05	42.7	<0.05	<0.05	<0.05	<0.05	<0.05	1.76	<0.05	31.7	<0.05	<0.05	31.2	<0.05	<0.05
438539	C83H-G	C83H-G	-27.53064	28.47561	8.76	8.76	22.2	56.9	61.3	64	52.3	6.0	<0.6	35.1	<0.05	0.52	<0.1	<0.05	0.12	<0.05	<0.05	9.07	<0.05	<0.05	<0.05	<0.05	0.29	0.6	<0.05	3.29	<0.05	<0.05	3.19	<0.05	<0.05

ID	SAMPLE #	Site #	S (Dec.Drg)	E (Dec.Drg)	Tot Cond @25C [mSm]	Total Cond [mS/m]	TC Temp. [Deg C]	TDS by EC*6.5 [mg/l]	TDS by EC*7 [mg/l]	TDS [mg/l]	TDS by Sum [mg/l]	TDS Factor	P Alk. [mg/l CaCO3]	M Alk. [mg/l CaCO3]	Pb [mg/l]	S [mg/l]	Sb [mg/l]	Se [mg/l]	Si [mg/l]	Sn [mg/l]	Sr [mg/l]	Ti [mg/l]	Tl [mg/l]	V [mg/l]	Zn [mg/l]	F [mg/l]	Cl [mg/l]	NO2 [mg/l]	NO3 [mg/l]	NO3 as N [mg/l]	SO4 [mg/l]	Sum of Cat [me/l]	Sum of Ani [me/l]	Ion Balanc e [%]	SiO2 (Free) [%]	Total Al as Al [mg/l]
438516	C83A-C	C83A-C	-28.43947	28.39723	7.48	7.48	21.7	48.6	52.4	32	50.1	6.7	<0.6	30.6	<0.05	2.5	<0.1	<0.1	4.98	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.151	1.13	<0.2	1.39	0.31	9.17	0.89	1.12	-11.3	10.7	2.27
438518	C83A-E	C83A-E	-28.32835	28.37691	7.6	7.6	21.5	49.4	53.2	<30	51.2	6.7	<0.6	30.3	<0.05	2.71	<0.1	<0.1	4.75	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.139	1.18	<0.2	1.37	0.31	10.2	0.88	1.12	-11.7	10.2	2.65
438519	C83C-A	C83C-A	-27.94016	28.30835	8.14	8.14	21.4	52.9	57	36	53.7	6.6	<0.6	32.9	<0.05	2.57	<0.1	<0.1	4.93	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	1.45	<0.2	1.18	<0.3	10.4	0.94	1.18	-11.1	10.6	3.93
438520	C83C-B	C83C-B	-28.06747	28.31045	8.1	8.1	21.6	52.7	56.7	<30	52.8	6.5	<0.6	33	<0.05	2.69	<0.1	<0.1	5.32	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	1.4	<0.2	1.35	0.31	8.3	0.95	1.17	-10.1	11.4	3.73
438521	C83C-C	C83C-C	-28.19263	28.35564	7.85	7.85	21.8	51	55	<30	50.8	6.5	<0.6	32.1	<0.05	2.61	<0.1	<0.1	5.15	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	1.15	<0.2	1.08	<0.3	8	0.97	1.12	-7.07	11	3.12
438523	C83C-E	C83C-E	-28.23267	28.313913	49.2	49.2	21.9	319	344	276	216	4.4	<0.6	186	<0.05	11.4	<0.1	<0.1	5.66	<0.05	0.23	<0.05	<0.05	<0.05	<0.05	<0.1	1.17	<0.2	1.06	<0.3	7.91	4.83	3.71	13.1	12.1	2.16
438524	C83F-A	C83F-A	-27.69529	28.31759	35.2	35.2	22	228	246	194	191	5.4	<0.6	157	<0.05	4.79	<0.1	<0.1	6.66	<0.05	0.13	<0.05	<0.05	<0.05	<0.05	0.282	10.7	<0.2	<0.3	<0.3	13.3	3.64	3.69	-0.66	14.3	1.77
438526	C83F-D	C83F-D	-27.75786	28.32742	8.46	8.46	22	55	59.2	58	51	6.0	<0.6	33.6	<0.05	2.36	<0.1	<0.1	5.49	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	1.34	<0.2	1.03	<0.3	7.13	0.93	1.15	-10.5	11.8	3.96
438529	C83G-A	C83G-A	-27.57822	28.42043	47.5	47.5	22	309	332	292	262	5.5	<0.6	214	<0.05	8.85	<0.1	<0.1	7.97	<0.05	0.17	<0.05	<0.05	<0.05	<0.05	0.349	13.7	<0.2	<0.3	<0.3	26.4	4.96	5.09	-1.32	17.1	3.01
438532	C83G-D	C83G-D	-27.68592	28.38035	8.18	8.18	22.1	53.2	57.3	30	51.6	6.3	<0.6	33.7	<0.05	2.45	<0.1	<0.1	5.61	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	1.36	<0.2	1.13	<0.3	7.18	0.96	1.17	-9.96	12	5.25
438533	C83G-E	C83G-E	-27.68904	28.38872	87.3	87.3	22.3	567	611	368	384	4.4	<0.6	234	<0.05	3.67	<0.1	<0.1	9.1	<0.05	0.16	<0.05	<0.05	<0.05	0.05	0.241	78	<0.2	23.9	5.41	7.51	5.73	7.3	-12	19.5	2.41
438535	C83H-A	C83H-A	-27.3341	28.52561	8.72	8.72	22.4	56.7	61	86	56.1	6.4	<0.6	36.2	<0.05	2.59	<0.1	<0.1	6.33	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.127	1.53	<0.2	1.39	0.31	7.87	1.05	1.29	-10.4	13.6	64.6
438536	C83H-B	C83H-B	-27.40892	28.50579	58.7	58.7	22.4	382	411	382	332	5.7	3.3	265	<0.05	12.4	<0.1	<0.1	3.44	<0.05	0.3	<0.05	<0.05	<0.05	<0.05	0.615	20.2	<0.2	<0.3	<0.3	37.7	6.25	6.04	1.7	7.37	2.05
438538	C83H-F	C83H-F	-27.54353	28.54297	57.5	57.5	22.4	374	402	372	332	5.8	4.5	261	<0.05	13.2	<0.1	<0.1	8.85	<0.05	0.27	<0.05	<0.05	<0.05	<0.05	0.368	17.6	<0.2	<0.3	<0.3	40.8	6.16	6.36	-1.6	19	1.11
438539	C83H-G	C83H-G	-27.53064	28.47561	8.76	8.76	22.2	56.9	61.3	64	52.3	6.0	<0.6	35.1	<0.05	2.27	<0.1	<0.1	5.49	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	1.38	<0.2	1.19	<0.3	7.05	0.95	1.18	-10.8	11.8	1.55

J E Sample No.				26-28	1-3		4-6	7-9	10-12	13-16	17-19	20-22	23-25	29-31	32-34	35-37	38-40	41-43	44-46	47-49
Sample ID				C83A-C	C83H-A		C83H-F	C83H-C	C83C-E	C83C-A	C83A-E	C83C-C	C83F-D	C83G-E	C83G-D	C83F-A	C83G-A	C83C-B	C83H-G	C83H-B
Depth																				
COC No / misc																				
Containers				H HN P	H HN P		H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P
Sample Date				18/08/2015	20/08/2015		20/08/2015	20/08/2015	18/08/2015	18/08/2015	18/08/2015	18/08/2015	18/08/2015	19/08/2015	19/08/2015	19/08/2015	19/08/2015	18/08/2015	20/08/2015	20/08/2015
Sample Type				Ground Water	Ground Water		Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Batch Number	LOD/LOR	Units	Method No.	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
Date of Receipt				28/08/2015	28/08/2015		28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015	28/08/2015
Dissolved Calcium [#]	<0.2	mg/l	TM30/PM14	9	9.9		43.2	9.6	49.8	9.4	9.3	9.4	9.5	32.1	9.3	31.3	38.7	9.6	9.9	42.1
Dissolved Magnesium [#]	<0.1	mg/l	TM30/PM14	2.9	3.2		34.7	3.1	25.3	3	3	3	3	9.2	3	20	28.7	3.1	3.1	33.1
Dissolved Potassium [#]	<0.1	mg/l	TM30/PM14	0.4	0.6		1.8	0.5	3.6	0.4	0.4	0.4	0.5	19	0.5	2.1	2.6	0.5	0.5	2.2
Dissolved Sodium [#]	<0.1	mg/l	TM30/PM14	2	2.7		38.5	2.5	33	2.3	2.1	2.1	2.4	68.5	2.3	28.1	23.5	2.4	2.7	45.6
Total Alkalinity as CaCO3 [#]	<1	mg/l	TM75/PM0	48	48		282	49	246	48	47	49	221	332	49	47	234	53	49	287
Fluoride	<0.3	mg/l	TM27/PM0	<0.3	<0.3		<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.4	<0.3	<0.3	<0.3
Sulphate [#]	<0.05	mg/l	TM38/PM0	4.06	4.39		37.39	5.51	25.94	<0.05	4.1	6.86	10.89	3.91	4.25	4.12	25.35	5.79	5.62	38
Chloride [#]	<0.3	mg/l	TM38/PM0	1	1.4		20.4	1.3	27.5	1.3	1.1	1	13.9	67.6	1.3	1	15	1.3	1.3	22.2
Nitrate as NO3 [#]	<0.2	mg/l	TM38/PM0	0.7	1.2		<0.2	1.1	1.6	0.9	0.7	0.8	0.3	0.5	11	0.8	<0.2	1	1.2	<0.2
Silica	<0.01	mg/l	TM52/PM0	8.4	8.4		13.7	7.3	10.4	8.5	8.7	8.9	11.8	21.1	8.5	9.4	7.6	7.9	9	6.9
Bicarbonate Alkalinity as CaCO3	<1	mg/l	TM75/PM0	48	48		282	49	246	48	47	49	221	332	49	47	213	53	49	287
Total Hardness Dissolved (as CaCO3)	<1	mg/l	TM30/PM14	35	38		254	37	231	36	36	36	36	119	36	162	217	37	38	244
Electrical Conductivity @25C [#]	<2	uS/cm	TM76/PM0	92	106		621	99	557	101	176	95	455	884	99	98	482	94	91	617
Total Dissolved Solids [#]	<10	mg/l	TM20/PM0	48	53		323	52	288	49	39	34	236	353	58	51	238	76	36	327
Total Suspended Solids [#]	<10	mg/l	TM37/PM0	<10	22		12	12	22	14	<10	<10	15	41	24	23	15	13	13	11
Dissolved Aluminium [#]	<20	ug/l	TM30/PM14	<20	<20		<20	<20	<20	<20	<20	<20	<20	34	<20	<20	<20	<20	<20	<20
Dissolved Antimony [#]	<2	ug/l	TM30/PM14	<2	<2		<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dissolved Arsenic [#]	<2.5	ug/l	TM30/PM14	<2.5	<2.5		<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	3.1	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Dissolved Barium [#]	<3	ug/l	TM30/PM14	<3	15		48	13	75	10	5	8	10	68	10	47	63	11	13	113
Dissolved Beryllium	<0.5	ug/l	TM30/PM14	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved Bismuth	<5	ug/l	TM30/PM14	<5	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Boron	<12	ug/l	TM30/PM14	<12	<12		<12	<12	<12	<12	<12	<12	<12	21	<12	<12	<12	<12	<12	20
Dissolved Cadmium [#]	<0.5	ug/l	TM30/PM14	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Total Dissolved Chromium [#]	<1.5	ug/l	TM30/PM14	<1.5	<1.5		<1.5	<1.5	<1.5	<1.5	<1.5	2.7	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Dissolved Cobalt [#]	<2	ug/l	TM30/PM14	<2	<2		<2	<2	<2	<2	<2	<2	<2	3	<2	<2	<2	<2	<2	<2
Dissolved Copper [#]	<7	ug/l	TM30/PM14	<7	<7		<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	14	<7	<7	<7
Total Dissolved Iron [#]	<20	ug/l	TM30/PM14	<20	<20		46	<20	72	<20	<20	<20	<20	583	<20	<20	<20	<20	30	<20
Dissolved Lead [#]	<5	ug/l	TM30/PM14	<5	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Lithium	<5	ug/l	TM30/PM14	<5	<5		5	<5	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	11
Dissolved Manganese [#]	<2	ug/l	TM30/PM14	<2	4		24	<2	71	2	<2	<2	<2	1977	<2	3	16	<2	<2	<2
Dissolved Mercury [#]	<1	ug/l	TM30/PM14	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Molybdenum [#]	<2	ug/l	TM30/PM14	<2	<2		<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dissolved Nickel [#]	<2	ug/l	TM30/PM14	<2	<2		<2	<2	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2
Dissolved Phosphorus [#]	<5	ug/l	TM30/PM14	<5	17		14	19	69	12	<5	<5	11	15870 ^{AA}	20	<5	6	15	21	6
Dissolved Selenium [#]	<3	ug/l	TM30/PM14	<3	<3		<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dissolved Silver	<5	ug/l	TM30/PM14	<5	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Strontium	<5	ug/l	TM30/PM14	17	25		303	23	314	22	18	19	22	180	22	183	191	21	23	337
Dissolved Tellurium	<5	ug/l	TM30/PM14	5	<5		<5	<5	<5	8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Thallium [#]	<3	ug/l	TM30/PM14	<3	<3		<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dissolved Tin	<5	ug/l	TM30/PM14	<5	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Titanium	<5	ug/l	TM30/PM14	<5	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Vanadium [#]	<1.5	ug/l	TM30/PM14	2.4	3.3		5.7	2.6	2.6	2.4	2.8	2.4	2.5	5.1	3.2	4.1	5.8	2.2	2.6	3.1
Dissolved Zinc [#]	<3	ug/l	TM30/PM14	22	5		10	34	9	7	47	47	7	76	52	73	173	46	13	39
Dissolved Zirconium	<5	ug/l	TM30/PM14	<5	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity @25C [#]	<2	uS/cm	TM76/PM0	92	106		621	99	557	101	176	95	455	884	99	98	482	94	91	617

APPENDIX J

Diurnal 1 Field Measurements at Monitoring Site C83CA -13 & 14 Oct 2015

[illegible]

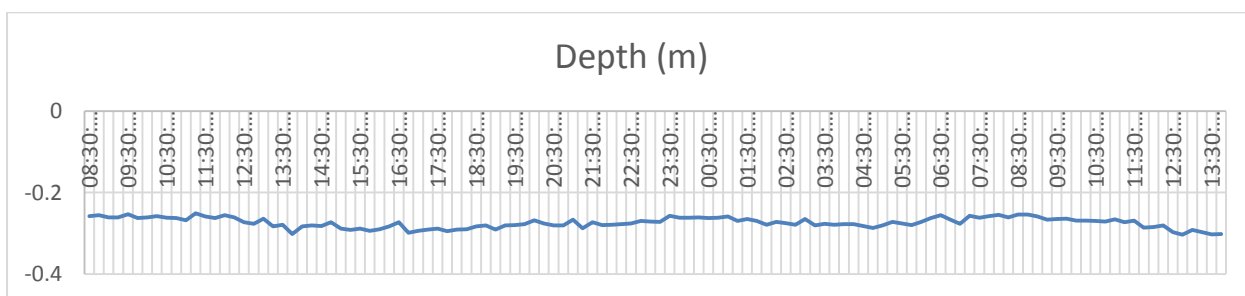
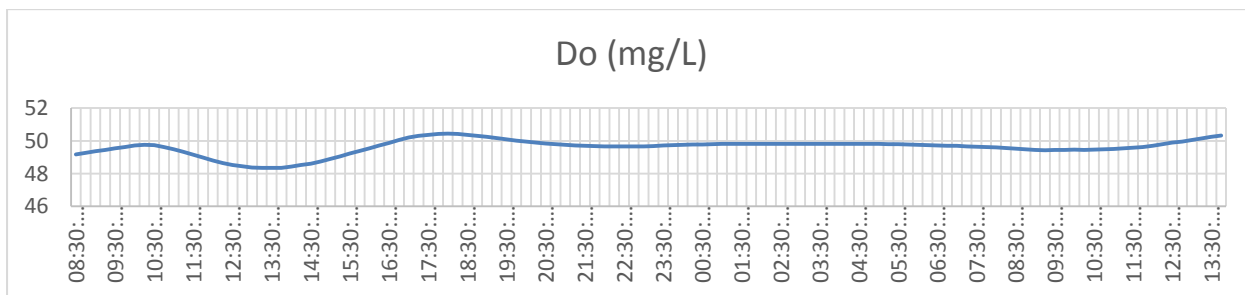
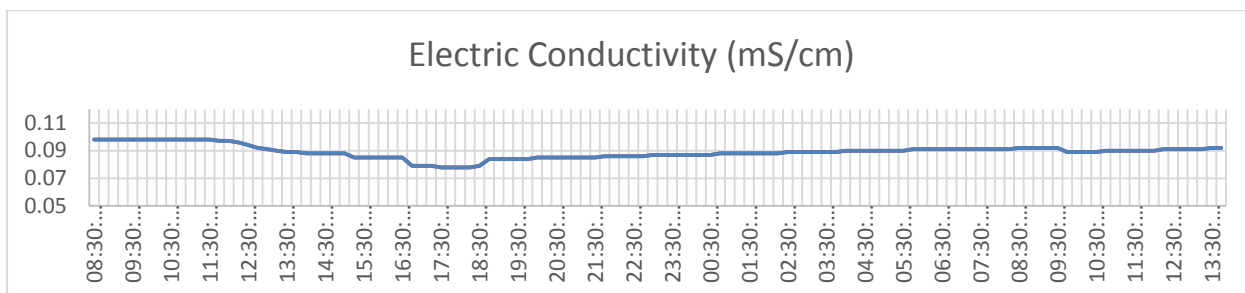
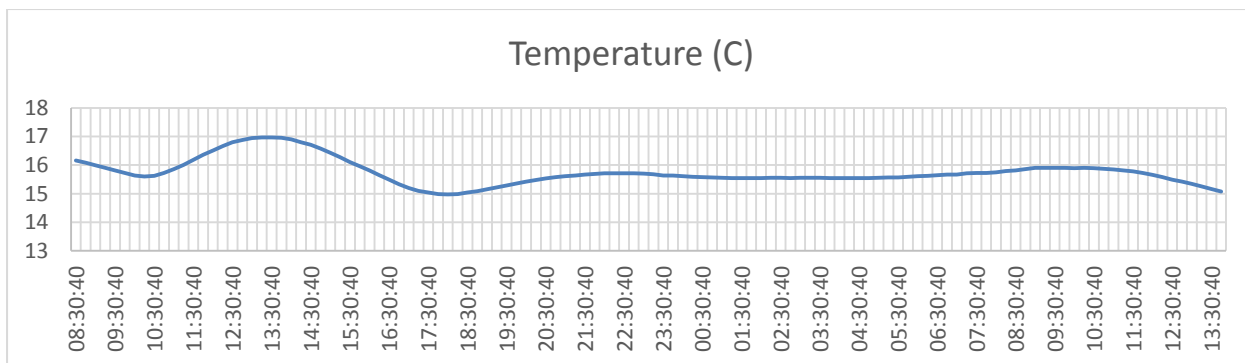
APPENDIX K

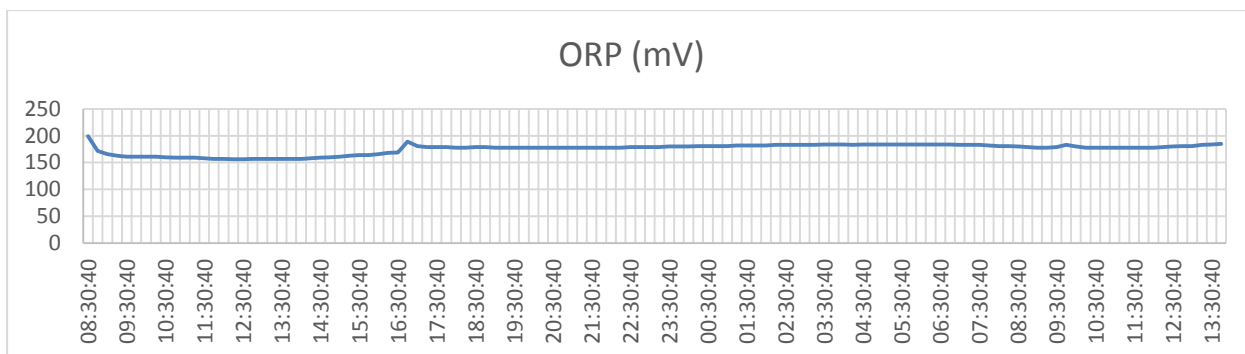
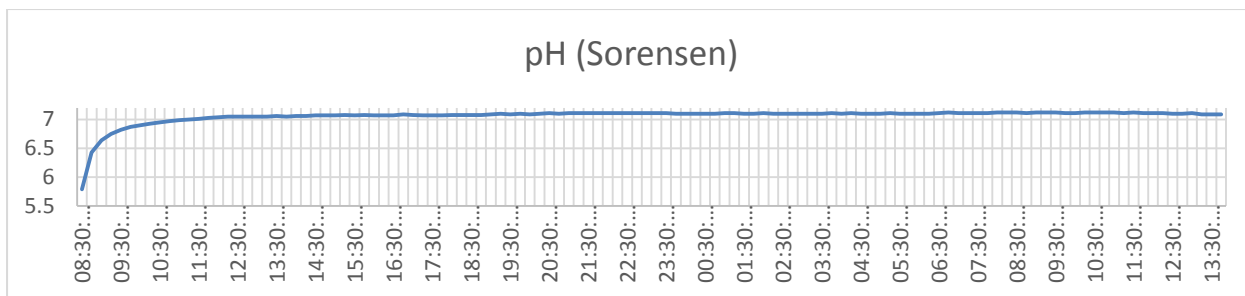
Diurnal 1 YSI Multi Probe Data set at
Monitoring Site C83CA -13 & 14 Oct 2015

Date	Time	Temp	SpCond	SpCond	DO Conc	Depth	pH	ORP
M/D/Y	hh:mm:ss	C	mS/cm	mS/m	mg/L	m		mV
10/13/15	08:30:40	16.16	0.098	9.8	49.18	-0.258	5.79	199
10/13/15	08:45:40	16.08	0.098	9.8	49.26	-0.256	6.43	172
10/13/15	09:00:40	15.99	0.098	9.8	49.36	-0.261	6.64	166
10/13/15	09:15:40	15.91	0.098	9.8	49.44	-0.261	6.75	163
10/13/15	09:30:40	15.81	0.098	9.8	49.54	-0.253	6.82	161
10/13/15	09:45:40	15.72	0.098	9.8	49.63	-0.263	6.87	161
10/13/15	10:00:40	15.64	0.098	9.8	49.72	-0.261	6.9	161
10/13/15	10:15:40	15.6	0.098	9.8	49.76	-0.258	6.93	161
10/13/15	10:30:40	15.62	0.098	9.8	49.74	-0.262	6.95	160
10/13/15	10:45:40	15.73	0.098	9.8	49.63	-0.263	6.97	159
10/13/15	11:00:40	15.86	0.098	9.8	49.49	-0.268	6.99	159
10/13/15	11:15:40	16.01	0.098	9.8	49.33	-0.251	7	159
10/13/15	11:30:40	16.19	0.098	9.8	49.15	-0.259	7.01	158
10/13/15	11:45:40	16.36	0.097	9.7	48.97	-0.263	7.03	157
10/13/15	12:00:40	16.51	0.097	9.7	48.81	-0.256	7.04	157
10/13/15	12:15:40	16.67	0.096	9.6	48.65	-0.261	7.05	156
10/13/15	12:30:40	16.8	0.094	9.4	48.52	-0.273	7.05	156
10/13/15	12:45:40	16.88	0.092	9.2	48.44	-0.277	7.05	157
10/13/15	13:00:40	16.95	0.091	9.1	48.37	-0.264	7.05	157
10/13/15	13:15:40	16.97	0.09	9	48.35	-0.283	7.05	157
10/13/15	13:30:40	16.97	0.089	8.9	48.35	-0.279	7.06	157
10/13/15	13:45:40	16.96	0.089	8.9	48.36	-0.302	7.05	157
10/13/15	14:00:40	16.9	0.088	8.8	48.42	-0.283	7.06	157
10/13/15	14:15:40	16.8	0.088	8.8	48.52	-0.281	7.06	158
10/13/15	14:30:40	16.71	0.088	8.8	48.61	-0.282	7.07	159
10/13/15	14:45:40	16.58	0.088	8.8	48.75	-0.273	7.07	160
10/13/15	15:00:40	16.43	0.088	8.8	48.89	-0.289	7.07	161
10/13/15	15:15:40	16.27	0.085	8.5	49.06	-0.292	7.08	163
10/13/15	15:30:40	16.11	0.085	8.5	49.23	-0.289	7.07	164
10/13/15	15:45:40	15.96	0.085	8.5	49.38	-0.294	7.08	164
10/13/15	16:00:40	15.81	0.085	8.5	49.54	-0.29	7.07	166
10/13/15	16:15:40	15.65	0.085	8.5	49.71	-0.283	7.07	168
10/13/15	16:30:40	15.49	0.085	8.5	49.88	-0.273	7.07	169
10/13/15	16:45:40	15.33	0.079	7.9	50.05	-0.299	7.09	189
10/13/15	17:00:40	15.2	0.079	7.9	50.2	-0.294	7.08	181
10/13/15	17:15:40	15.1	0.079	7.9	50.3	-0.291	7.07	179
10/13/15	17:30:40	15.04	0.078	7.8	50.37	-0.289	7.07	179
10/13/15	17:45:40	14.99	0.078	7.8	50.42	-0.295	7.07	179
10/13/15	18:00:40	14.97	0.078	7.8	50.44	-0.291	7.08	178
10/13/15	18:15:40	14.99	0.078	7.8	50.43	-0.29	7.08	178
10/13/15	18:30:40	15.04	0.079	7.9	50.37	-0.283	7.08	179
10/13/15	18:45:40	15.09	0.084	8.4	50.31	-0.281	7.08	179
10/13/15	19:00:40	15.15	0.084	8.4	50.25	-0.291	7.09	178
10/13/15	19:15:40	15.22	0.084	8.4	50.17	-0.281	7.1	178
10/13/15	19:30:40	15.29	0.084	8.4	50.09	-0.28	7.09	178
10/13/15	19:45:40	15.36	0.084	8.4	50.02	-0.278	7.1	178
10/13/15	20:00:40	15.42	0.085	8.5	49.95	-0.268	7.09	178
10/13/15	20:15:40	15.48	0.085	8.5	49.89	-0.276	7.1	178

10/13/15	20:30:40	15.53	0.085	8.5	49.84	-0.281	7.11	178
10/13/15	20:45:40	15.58	0.085	8.5	49.79	-0.281	7.1	178
10/13/15	21:00:40	15.61	0.085	8.5	49.76	-0.267	7.11	178
10/13/15	21:15:40	15.64	0.085	8.5	49.72	-0.288	7.11	178
10/13/15	21:30:40	15.67	0.085	8.5	49.69	-0.273	7.11	178
10/13/15	21:45:40	15.69	0.086	8.6	49.67	-0.28	7.11	178
10/13/15	22:00:40	15.71	0.086	8.6	49.65	-0.279	7.11	178
10/13/15	22:15:40	15.71	0.086	8.6	49.65	-0.278	7.11	178
10/13/15	22:30:40	15.71	0.086	8.6	49.65	-0.276	7.11	179
10/13/15	22:45:40	15.71	0.086	8.6	49.65	-0.27	7.11	179
10/13/15	23:00:40	15.7	0.087	8.7	49.66	-0.271	7.11	179
10/13/15	23:15:40	15.68	0.087	8.7	49.68	-0.272	7.11	179
10/13/15	23:30:40	15.64	0.087	8.7	49.72	-0.257	7.11	180
10/13/15	23:45:40	15.63	0.087	8.7	49.73	-0.262	7.1	180
10/14/15	00:00:40	15.61	0.087	8.7	49.75	-0.262	7.1	180
10/14/15	00:15:40	15.59	0.087	8.7	49.77	-0.261	7.1	181
10/14/15	00:30:40	15.58	0.087	8.7	49.78	-0.263	7.1	181
10/14/15	00:45:40	15.57	0.088	8.8	49.8	-0.262	7.1	181
10/14/15	01:00:40	15.56	0.088	8.8	49.81	-0.259	7.11	181
10/14/15	01:15:40	15.55	0.088	8.8	49.82	-0.27	7.11	182
10/14/15	01:30:40	15.55	0.088	8.8	49.82	-0.265	7.1	182
10/14/15	01:45:40	15.55	0.088	8.8	49.82	-0.27	7.1	182
10/14/15	02:00:40	15.55	0.088	8.8	49.82	-0.279	7.11	182
10/14/15	02:15:40	15.56	0.088	8.8	49.81	-0.272	7.1	183
10/14/15	02:30:40	15.56	0.089	8.9	49.81	-0.275	7.1	183
10/14/15	02:45:40	15.55	0.089	8.9	49.82	-0.279	7.1	183
10/14/15	03:00:40	15.56	0.089	8.9	49.81	-0.265	7.1	183
10/14/15	03:15:40	15.56	0.089	8.9	49.81	-0.281	7.1	183
10/14/15	03:30:40	15.56	0.089	8.9	49.81	-0.277	7.1	184
10/14/15	03:45:40	15.55	0.089	8.9	49.82	-0.279	7.11	184
10/14/15	04:00:40	15.55	0.09	9	49.82	-0.278	7.1	184
10/14/15	04:15:40	15.55	0.09	9	49.82	-0.278	7.11	183
10/14/15	04:30:40	15.55	0.09	9	49.82	-0.282	7.1	184
10/14/15	04:45:40	15.55	0.09	9	49.82	-0.287	7.1	184
10/14/15	05:00:40	15.56	0.09	9	49.81	-0.281	7.1	184
10/14/15	05:15:40	15.57	0.09	9	49.8	-0.272	7.11	184
10/14/15	05:30:40	15.57	0.09	9	49.8	-0.276	7.1	184
10/14/15	05:45:40	15.59	0.091	9.1	49.77	-0.28	7.1	184
10/14/15	06:00:40	15.61	0.091	9.1	49.75	-0.272	7.1	184
10/14/15	06:15:40	15.62	0.091	9.1	49.74	-0.263	7.1	184
10/14/15	06:30:40	15.65	0.091	9.1	49.71	-0.256	7.11	184
10/14/15	06:45:40	15.67	0.091	9.1	49.7	-0.267	7.12	184
10/14/15	07:00:40	15.67	0.091	9.1	49.69	-0.277	7.11	183
10/14/15	07:15:40	15.71	0.091	9.1	49.65	-0.257	7.11	183
10/14/15	07:30:40	15.72	0.091	9.1	49.64	-0.262	7.11	183
10/14/15	07:45:40	15.73	0.091	9.1	49.62	-0.258	7.11	182
10/14/15	08:00:40	15.75	0.091	9.1	49.6	-0.255	7.12	181
10/14/15	08:15:40	15.79	0.091	9.1	49.57	-0.261	7.12	181
10/14/15	08:30:40	15.82	0.092	9.2	49.53	-0.254	7.12	180
10/14/15	08:45:40	15.86	0.092	9.2	49.49	-0.254	7.11	179

10/14/15	09:00:40	15.9	0.092	9.2	49.45	-0.259	7.12	178
10/14/15	09:15:40	15.91	0.092	9.2	49.43	-0.267	7.12	178
10/14/15	09:30:40	15.9	0.092	9.2	49.45	-0.265	7.12	179
10/14/15	09:45:40	15.9	0.089	8.9	49.45	-0.264	7.11	183
10/14/15	10:00:40	15.89	0.089	8.9	49.46	-0.269	7.11	180
10/14/15	10:15:40	15.9	0.089	8.9	49.45	-0.269	7.12	178
10/14/15	10:30:40	15.89	0.089	8.9	49.46	-0.27	7.12	178
10/14/15	10:45:40	15.87	0.09	9	49.48	-0.271	7.12	178
10/14/15	11:00:40	15.85	0.09	9	49.51	-0.266	7.12	178
10/14/15	11:15:40	15.82	0.09	9	49.54	-0.273	7.11	178
10/14/15	11:30:40	15.78	0.09	9	49.58	-0.269	7.12	178
10/14/15	11:45:40	15.72	0.09	9	49.63	-0.286	7.11	178
10/14/15	12:00:40	15.66	0.09	9	49.7	-0.285	7.11	178
10/14/15	12:15:40	15.58	0.091	9.1	49.79	-0.281	7.11	179
10/14/15	12:30:40	15.49	0.091	9.1	49.89	-0.297	7.1	180
10/14/15	12:45:40	15.42	0.091	9.1	49.96	-0.304	7.1	181
10/14/15	13:00:40	15.34	0.091	9.1	50.05	-0.292	7.11	181
10/14/15	13:15:40	15.25	0.091	9.1	50.14	-0.297	7.09	183
10/14/15	13:30:40	15.16	0.092	9.2	50.24	-0.303	7.09	184
10/14/15	13:45:40	15.07	0.092	9.2	50.33	-0.302	7.09	185





APPENDIX L

Total Alkalinity Titrations at C83CA on 13 & 14 Oct 2015

	Time	PH Before	Total Digits	Digits Multiplier	Date-Time	mg/l as CaCO3	PH After
1	09H00	6.9	200	0.4	42290.375	80	4.1
2	11H00	6.5	223	0.4	42290.4583333333	89.2	4.2
3	14H00	6	134	0.4	42290.5833333333	53.6	4.4
4	17H00	6.4	160	0.4	42290.7083333333	64	4.4
5	20H00	6.8	190	0.4	42290.8333333333	76	4.1
6	23H00	6.7	259	0.4	42290.9583333333	103.6	4.3
7	02H00	6.6	333	0.4	42291.0833333333	133.2	4
8	05H00	6.5	218	0.4	42291.2083333333	87.2	4.2
9	08H00	6.5	244	0.4	42291.3333333333	97.6	4
10	11H00	6.3	238	0.4	42291.4583333333	95.2	3.9
11	14H00	6.1	142	0.4	42291.5833333333	56.8	4.8

APPENDIX M

Diurnal 1 Laboratory Analysis Monitoring
Site C83CA -13 & 14 Oct 2015, DWS
Roodeplaat Laboratory



water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

ENQ: Maggie Ndhlovu

TEL: (060) 521-7308

Reference 13/2/3

Test report No: 16/0115

Department of Water and Sanitation

Private Bag X313

Pretoria

0001

Attention: K. Morekgure

Analysis of nine water samples

Enclosed is Test Report No: 16/0115 with the results of 9 (nine) water samples received on 2015/11/20. This report includes the sodium and potassium results.

Scientific Manager: J. Lekekiso (Analytical Services)

Date: 2016/03/30



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Private Bag X313, PRETORIA, 0001 Tel: (012) 808 9500 Fax: (012) 808 0338
KwaMhlanga Road, Roodeplaat Dam
Testing Laboratory

Test Report No. 16/0115

Client Name: Kelebogile Morekgure
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No. of Samples: 9

Judy Reddy

Authorised Signatory: INORGANIC

Date of issue: 2016/03/30

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DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191205	Customer Sample Reference:	C83C-A1
Sample Date & Time:	2015/11/17 10:30AM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:20AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:40PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.8	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.1	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	9.0	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.180	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	1.8	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.218	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.8	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.017	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.5	20-Nov-2015
M5003.2	Temperature	°C		24.7	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	34.4	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191206	Customer Sample Reference:	C83C-A2
Sample Date & Time:	2015/11/17 01:00AM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:21AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:42PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.8	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.2	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	9.0	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.176	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	1.9	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.206	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.7	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.068	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.3	20-Nov-2015
M5003.2	Temperature	°C		24.6	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	33.9	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191207	Customer Sample Reference:	C83C-A3
Sample Date & Time:	2015/11/17 06:00PM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:24AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:43PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.8	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.1	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	9.0	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.176	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	2.0	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.220	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.8	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.042	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.2	20-Nov-2015
M5003.2	Temperature	°C		24.5	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	33.4	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191208	Customer Sample Reference:	C83C-A4
Sample Date & Time:	2015/11/17 09:00PM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:25AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:43PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.4	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.1	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	8.9	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.175	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	2.2	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.222	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.7	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.052	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.0	20-Nov-2015
M5003.2	Temperature	°C		24.5	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	35.6	20-Nov-2015



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Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191209	Customer Sample Reference:	C83C-A5
Sample Date & Time:	2015/11/18 12:00PM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:26AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:44PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	8.1	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.2	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	9.1	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.180	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	2.1	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.217	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.7	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.065	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.1	20-Nov-2015
M5003.2	Temperature	°C		24.5	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	35.6	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191210	Customer Sample Reference:	C83C-A6
Sample Date & Time:	2015/11/18 03:00PM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:27AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:45PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.8	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.3	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	9.2	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.168	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	2.1	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.226	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.7	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.026	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.2	20-Nov-2015
M5003.2	Temperature	°C		24.6	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	33.6	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191211	Customer Sample Reference:	C83C-A7
Sample Date & Time:	2015/11/18 06:00AM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:28AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:46PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.8	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.4	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	8.9	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.174	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	1.9	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.227	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.9	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	3.986	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.1	20-Nov-2015
M5003.2	Temperature	°C		24.6	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	32.3	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191212	Customer Sample Reference:	C83C-A8
Sample Date & Time:	2015/11/18 09:00AM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:29AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:46PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	8.4	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.3	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	9.3	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.203	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	2.0	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.229	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.7	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.062	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.0	20-Nov-2015
M5003.2	Temperature	°C		24.5	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	36.7	20-Nov-2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 16/0115

LIMS Sample ID:	191213	Customer Sample Reference:	C83C-A9
Sample Date & Time:	2015/11/18 12:00AM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:29AM	Sampling depth:	0.00 - 0.00
Date Finalised:	2016/03/30 02:47PM	Preservative:	Unpreserved

Method/SOP Number	Determinand	Units	Detection Limit	Result	Analysis Date
M5001.5	Ammonium as NH ₄	mg/L	<0.100	<0.100	20-Nov-2015
M5001.2	Calcium as Ca	mg/L	<2.5	7.7	20-Nov-2015
M5001.3	Chloride as Cl	mg/L	<1.0	1.2	20-Nov-2015
M5003.1	Conductivity	mS/m	<1.0	8.8	27-Nov-2015
M5004.1	Fluoride as F	mg/L	<0.050	0.221	20-Nov-2015
M5001.4	Magnesium as Mg	mg/L	<1.5	2.0	20-Nov-2015
M5001.6	Nitrate + Nitrite as N	mg/L	<0.100	0.214	20-Nov-2015
M5003.2	pH	pH units	<2.0	7.9	27-Nov-2015
M5001.7	Phosphate as P	mg/L	<0.020	<0.020	20-Nov-2015
M5008.2	Potassium as K	mg/L	<2.5	<2.5	30-Mar-2016
M5001.8	Silicon as Si	mg/L	<1.0	4.029	20-Nov-2015
M5008.1	Sodium as Na	mg/L	<5.0	<5.0	30-Mar-2016
M5001.9	Sulphate as SO ₄	mg/L	<3.0	4.0	20-Nov-2015
M5003.2	Temperature	°C		24.6	27-Nov-2015
M5001.1	Total Alkalinity as CaCO ₃	mg/L CaCO ₃	<10.0	35.4	20-Nov-2015

APPENDIX N

Diurnal 1 Laboratory Analysis, IGS
Laboratory 13 & 14 Oct 2015

Institute for Groundwater Studies

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Test Report

Case no: 2015-1109

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Determinand	Units	Sample name:										
		Lieben 1	Lieben 2	Lieben 3	Lieben 4	Lieben 5	Lieben 6	Lieben 7	Lieben 8	Lieben 9	Lieben 10	Lieben 11
		Lab number:										
		1109-1	1109-2	1109-3	1109-4	1109-5	1109-6	1109-7	1109-8	1109-9	1109-10	1109-11
		Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
Chemical determinands												
Electrical conductivity	mS/m	8.23	8.26	7.25	7.13	7.15	7.18	7.41	7.27	7.04	7.15	8.25
Calcium as Ca	mg/L	6.46			5.85				6.35			
Magnesium as Mg	mg/L	2.53			2.28				2.50			
Sodium as Na	mg/L	7.00			6.17				5.65			
Potassium as K	mg/L	1.63			2.45				1.32			
P-Alkalinity	mg/L	0	0	0	0	0	0	0	0	0	0	0
M-Alkalinity	mg/L	39.1	37.5	35.1	34.1	34.3	34.0	34.6	34.8	34.8	35	34.9
Chloride as Cl	mg/L	2.30	2.36	1.84	2.39	1.95	1.67	1.93	1.55	1.68	1.73	2.12
Bromide as Br	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Nitrate as N	mg/L	0.32	0.31	0.27	0.31	0.27	0.24	0.26	0.23	0.23	0.24	0.26
Sulphate as SO ₄	mg/L	4.96	4.82	4.60	4.73	4.75	4.50	4.69	4.50	4.52	4.60	4.63
Total Dissolved Solids	mg/L	93	88	71	78	91	90	69	71	69	69	72

Signature: _____

L Deyzel (Technical signatory / Technical manager)

END OF REPORT

APPENDIX O

Diurnal 2 Field Measurements at Monitoring Site C83CA -17 & 18 Nov 2015

Date	Time	Sample	Titration	EXTECH	YSI	EXTECH	ECTester11	YSI	EXTECH	ECTester11	EXTECH	YSI	YSI	Weather
				pH	ph	EC µS/cm	EC µS/cm	EC µS/cm	Temp °C	Temp °C	TDS mg/L	Orp	Do mg/L	
17/11/2015	11:00	No	No	8.01	7.67	82.4	90	110	19.9	20.2	68.9	61.2	5.44	Clear skies, slightly windy
17/11/2015	12:00	Yes	Yes	8.14	7.62	79.8	90	90	21.54	20.6	68.5	77.4	4.82	Clear skies, slightly windy
17/11/2015	13:00	No	No	8.05	7.75	88	90	85	24.1	23.8	59.5	72.3	5.91	Clear skies, slightly windy
17/11/2015	14:00	No	No	8.26	7.01	74.2	90	87	19.7	19.6	52.1	94.1	5.54	Clear skies, slightly windy
17/11/2015	15:00	Yes	Yes	8.25	7.66	79.6	90	85	18.37	19.7	55.1	93.6	5.31	Clear skies, slightly windy
17/11/2015	16:00	No	No	8.3	7.1	73.9	90	87	19.5	18.4	50.9	117.2	5.6	Clear skies, slightly windy
17/11/2015	17:00	No	No	8.29	7.66	73.4	90	85	19.4	18.6	50.1	82.6	4.9	Slightly overcast, windy
17/11/2015	18:00	Yes	Yes	8.18	7.69	73.7	90	83	19	18.3	51.4	100.2	5.26	Slightly overcast, windy
17/11/2015	19:00	No	No	8.24	7.17	74.2	90	85	18.9	18.5	53.2	111.3	5.97	Slightly overcast, windy
17/11/2015	20:00	No	No	8.3	7.59	71.6	90	85	18	17.4	50	111.7	5.3	Slightly overcast, windy
17/11/2015	21:00	Yes	Yes	8.1	7.75	73.6	80	83	17.9	17.1	51.3	111.3	5.2	Slightly overcast, windy
17/11/2015	22:00	No	No	8.3	7.78	71	80	84	17.4	17	49	119.2	5.83	Slightly overcast, windy
17/11/2015	23:00	No	No	8.22	7.81	71.9	80	84	16.5	16.6	50.2	105.9	5.4	Slightly overcast, windy
17/11/2015	24:00:00	Yes	Yes	8.24	7.86	70.6	80	84	16.3	16.1	49.2	101.8	5.63	Slightly overcast, windy
18/11/2015	01:00	No	No	8.31	7.25	70.9	80	82	15.7	15.7	48	130.3	5.7	Slightly overcast, windy
18/11/2015	02:00	No	No	7.97	7.64	70.8	80	84	15.3	15.2	49.5	107.8	5.52	Slightly overcast, windy
18/11/2015	03:00	Yes	Yes	8.17	7.83	70.2	80	83	14.6	14.8	47.8	104.2	5.67	Slightly overcast, windy
18/11/2015	04:00	No	No	8.29	6.82	71.8	80	82	14.3	14.7	49.3	156.3	5.44	Slightly overcast, windy
18/11/2015	05:00	No	No	8.27	7.21	74.7	80	84	14.7	15	52	120.8	5.75	Clear skies, slightly windy
18/11/2015	06:00	Yes	Yes	8.26	7.6	72.9	80	84	14.9	15.2	50.9	99.1	5.58	Clear skies, slightly windy
18/11/2015	07:00	No	No	8.23	6.63	77.4	80	83	15.4	16.1	53.8	154	5.5	Clear skies, slightly windy
18/11/2015	08:00	No	No	7.53	8.14	92.8	100	85	18.9	17.4	65.6	92.6	5.7	Clear skies, slightly windy
18/11/2015	09:00	Yes	Yes	7.39	7.56	92.2	100	85	18.9	18.1	64.1	88.1	5.42	Clear skies, slightly windy
18/11/2015	10:00	No	No	8	7.18	88.1	100	81	19.7	19.6	61.5	56	4.48	Clear skies, slightly windy
18/11/2015	11:00	No	No	7.9	7.52	92.6	100	88	21.9	21.4	65.1	46	5.19	Clear skies, slightly windy
18/11/2015	12:00	Yes	Yes	7.92	7.73	83.8	90	85	21.55	20.7	57.6	64.3	5.26	Clear skies, slightly windy

APPENDIX P

Diurnal 2 Water Quality Analyses by DWS
Laboratory Roodeplaat for Monitoring Site
C83CA -17 & 18 Nov 2015



water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

ENQ: Maggie Ndhlovu

TEL: (060) 521-7308

Reference 13/2/3

Test report No: 15/0369

Department of Water and Sanitation

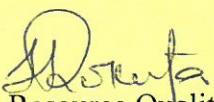
Pretoria

0001

Attention: K. Morekgure

Analysis of nine water samples

Enclosed is Test Report No: 15/0369 with the results of 9 (nine) water samples received on 20/11/2015.


Act. Director: Resource Quality Information Services

Date: 27/11/2015



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Private Bag X313, PRETORIA, 0001 Tel: (012) 808 9500 Fax: (012) 808 0338
KwaMhlanga Road, Roodeplaat Dam
Testing Laboratory

Test Report No. 15/0369

Client Name: Kelebogile Morekgure
Department Water & Sanitation
Client Address: Emanzini building, office 107
Private bag X313
PRETORIA
0001

Tel. No.: 0826004934 Fax No.:

No. of Samples: 9

Judy Reddy

Authorised Signatory: Inorganic

Date of issue: 2015/11/27

This report is a correct record of the measurements made at the time of analysis. Copyright of this report is owned by the issuing laboratory. This report may not be reproduced, except in full and with written permission from the Director of Resource Quality Information Services. This report relates only to the samples tested. Supporting data, such as printouts, chromatograms, etc. will be made available upon written request.



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191205 Customer Sample Reference: C83C-A1
Sample Date & Time: 2015/11/17 10:30AM Sample Type: Water
Sample Login Date: 2015/11/20 09:20AM Sampling depth:
Date Finalised: 2015/11/27 11:33AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5004.1	Fluoride as F	<0.050	0.180	mg/L
M5003.1	Conductivity	<1.0	9.0	mS/m
M5003.2	pH	<2.0	7.8	pH units
M5003.2	Temperature		24.7	°C
M5001.2	Calcium as Ca	<2.5	7.8	mg/L
M5001.3	Chloride as Cl	<1.0	1.1	mg/L
M5001.4	Magnesium as Mg	<1.5	1.8	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.218	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.017	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.5	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	34.4	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191206 Customer Sample Reference: C83C-A2
Sample Date & Time: 2015/11/17 01:00AM Sample Type: Water
Sample Login Date: 2015/11/20 09:21AM Sampling depth:
Date Finalised: 2015/11/27 11:34AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.176	mg/L
M5003.1	Conductivity	<1.0	9.0	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.7	pH units
M5003.2	Temperature		24.6	°C
M5001.2	Calcium as Ca	<2.5	7.8	mg/L
M5001.3	Chloride as Cl	<1.0	1.2	mg/L
M5001.4	Magnesium as Mg	<1.5	1.9	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.206	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.068	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.3	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	33.9	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191207 Customer Sample Reference: C83C-A3
Sample Date & Time: 2015/11/17 06:00PM Sample Type: Water
Sample Login Date: 2015/11/20 09:24AM Sampling depth:
Date Finalised: 2015/11/27 11:36AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.176	mg/L
M5003.1	Conductivity	<1.0	9.0	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.8	pH units
M5003.2	Temperature		24.5	°C
M5001.2	Calcium as Ca	<2.5	7.8	mg/L
M5001.3	Chloride as Cl	<1.0	1.1	mg/L
M5001.4	Magnesium as Mg	<1.5	2.0	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.220	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.042	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.2	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	33.4	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191208 Customer Sample Reference: C83C-A4
Sample Date & Time: 2015/11/17 09:00PM Sample Type: Water
Sample Login Date: 2015/11/20 09:25AM Sampling depth:
Date Finalised: 2015/11/27 11:36AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.175	mg/L
M5003.1	Conductivity	<1.0	8.9	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.7	pH units
M5003.2	Temperature		24.5	°C
M5001.2	Calcium as Ca	<2.5	7.4	mg/L
M5001.3	Chloride as Cl	<1.0	1.1	mg/L
M5001.4	Magnesium as Mg	<1.5	2.2	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.222	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.052	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.0	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	35.6	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID:	191209	Customer Sample Reference:	C83C-A5
Sample Date & Time:	2015/11/18 12:00PM	Sample Type:	Water
Sample Login Date:	2015/11/20 09:26AM	Sampling depth:	
Date Finalised:	2015/11/27 11:37AM	Preservative:	Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.180	mg/L
M5003.1	Conductivity	<1.0	9.1	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.7	pH units
M5003.2	Temperature		24.5	°C
M5001.2	Calcium as Ca	<2.5	8.1	mg/L
M5001.3	Chloride as Cl	<1.0	1.2	mg/L
M5001.4	Magnesium as Mg	<1.5	2.1	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.217	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.065	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.1	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	35.6	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191210 Customer Sample Reference: C83C-A6
Sample Date & Time: 2015/11/18 03:00PM Sample Type: Water
Sample Login Date: 2015/11/20 09:27AM Sampling depth:
Date Finalised: 2015/11/27 11:37AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.168	mg/L
M5003.1	Conductivity	<1.0	9.2	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.7	pH units
M5003.2	Temperature		24.6	°C
M5001.2	Calcium as Ca	<2.5	7.8	mg/L
M5001.3	Chloride as Cl	<1.0	1.3	mg/L
M5001.4	Magnesium as Mg	<1.5	2.1	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.226	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.026	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.2	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	33.6	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191211 Customer Sample Reference: C83C-A7
Sample Date & Time: 2015/11/18 06:00AM Sample Type: Water
Sample Login Date: 2015/11/20 09:28AM Sampling depth:
Date Finalised: 2015/11/27 11:37AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.174	mg/L
M5003.1	Conductivity	<1.0	8.9	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.9	pH units
M5003.2	Temperature		24.6	°C
M5001.2	Calcium as Ca	<2.5	7.8	mg/L
M5001.3	Chloride as Cl	<1.0	1.4	mg/L
M5001.4	Magnesium as Mg	<1.5	1.9	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.227	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	3.986	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.1	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	32.3	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

LIMS Sample ID: 191212 Customer Sample Reference: C83C-A8
Sample Date & Time: 2015/11/18 09:00AM Sample Type: Water
Sample Login Date: 2015/11/20 09:29AM Sampling depth:
Date Finalised: 2015/11/27 11:38AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.203	mg/L
M5003.1	Conductivity	<1.0	9.3	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.7	pH units
M5003.2	Temperature		24.5	°C
M5001.2	Calcium as Ca	<2.5	8.4	mg/L
M5001.3	Chloride as Cl	<1.0	1.3	mg/L
M5001.4	Magnesium as Mg	<1.5	2.0	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.229	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.062	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.0	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	36.7	mg/L CaCO ₃



DEPARTMENT: WATER & SANITATION RESOURCE QUALITY INFORMATION SERVICES

Inorganic Determinands

Test Report No. 15/0369

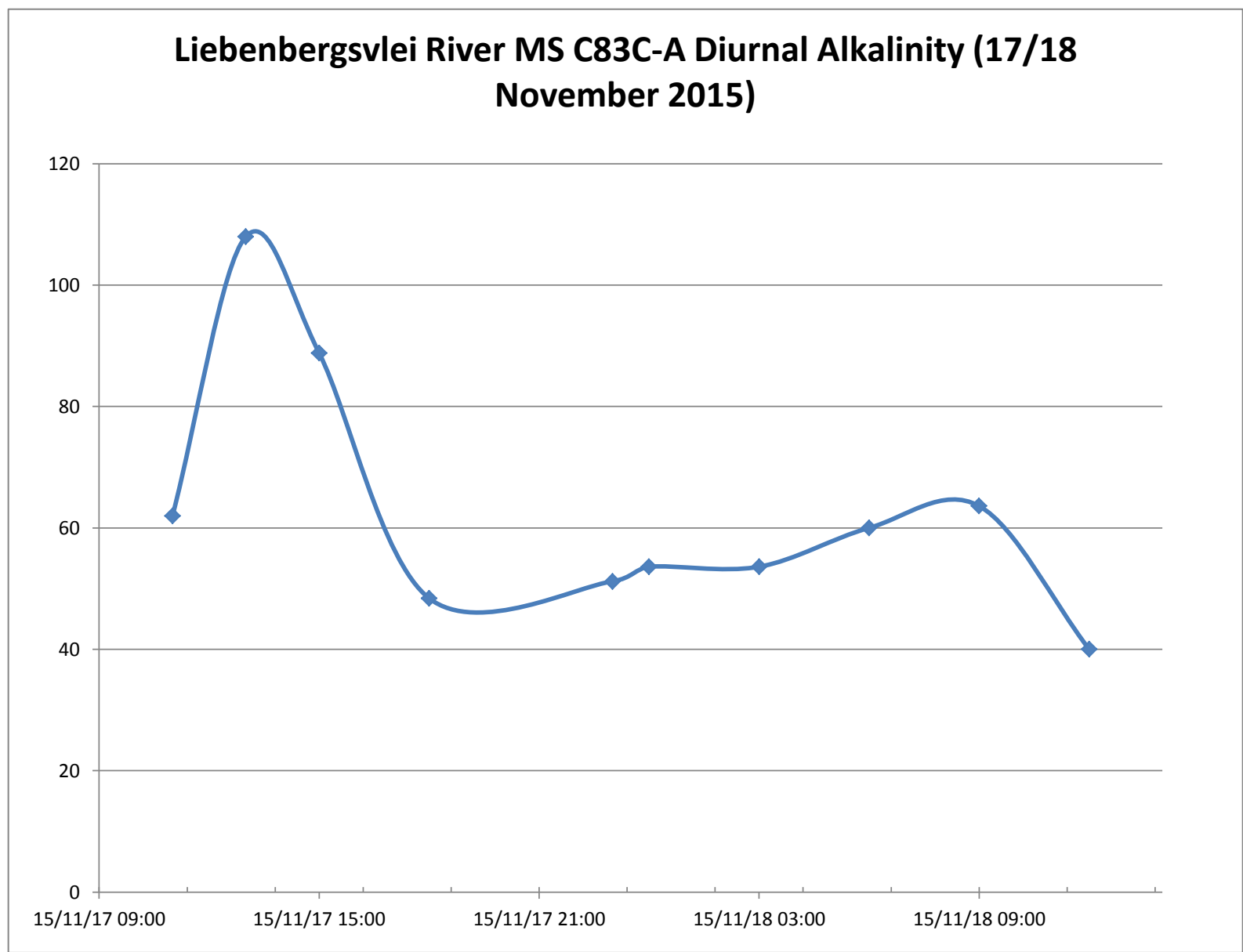
LIMS Sample ID: 191213 Customer Sample Reference: C83C-A9
Sample Date & Time: 2015/11/18 12:00AM Sample Type: Water
Sample Login Date: 2015/11/20 09:29AM Sampling depth:
Date Finalised: 2015/11/27 11:38AM Preservative: Unpreserved

Determinand Code	Determinand	Detection Limit	Result	Units
M5004.1	Fluoride as F	<0.050	0.221	mg/L
M5003.1	Conductivity	<1.0	8.8	mS/m
M5001.5	Ammonium as NH ₄	<0.100	<0.100	mg/L
M5003.2	pH	<2.0	7.9	pH units
M5003.2	Temperature		24.6	°C
M5001.2	Calcium as Ca	<2.5	7.7	mg/L
M5001.3	Chloride as Cl	<1.0	1.2	mg/L
M5001.4	Magnesium as Mg	<1.5	2.0	mg/L
M5001.6	Nitrate + Nitrite as N	<0.100	0.214	mg/L
M5001.7	Phosphate as P	<0.020	<0.020	mg/L
M5001.8	Silicon as Si	<1.0	4.029	mg/L
M5001.9	Sulphate as SO ₄	<3.0	4.0	mg/L
M5001.1	Total Alkalinity as CaCO ₃	<10.0	35.4	mg/L CaCO ₃

APPENDIX Q

Diurnal 2 Total Alkalinity Titrations at Monitoring Site C83CA -17 & 18 Nov 2015

Time	mg/l as CaCO3	PH Before	Total Digits	Digits Multiplier	PH After	Time taken
17/11/2015 11:00	62	7.67	155	0.4	4.49	
17/11/2015 13:00	108	7.75	270	0.4	3.37	
17/11/2015 15:00	88.8	7.66	222	0.4	3.77	
17/11/2015 18:00	48.4	7.69	121	0.4	4.33	
17/11/2015 23:00	51.2	7.75	128	0.4	4.29	
18/11/2015 00:00	53.6	7.86	134	0.4	5.23	
18/11/2015 03:00	53.6	7.83	134	0.4	4.46	
18/11/2015 06:00	60	7.6	150	0.4	3.95	
18/11/2015 09:00	63.6	7.56	159	0.4	3.95	
18/11/2015 12:00	40	7.73	100	0.4	4.64	



APPENDIX R

Attendance List – DWS Officials ST & CB Session on 18 September 2015

DWS-GOLDER – GW/SW interaction project (WP10941) capacity building. *Personal Detail.*

Group	Surnames	Name	Contact details	Capacity required
QUATERNARY CATCHMENTS: C83A, C83B & C83D.				
	Maluleke	Henry		Collection of field data Geohydrological survey (collecting of water samples etc) GW modeling
Group 1	Netshitanini	E ✓	Emanzini building Netshitanini@dwa.gov.za 012 336 7620	Collection of field data Geohydrological survey (collecting of water samples etc) GW modeling
	Gonah	T TICKATONGA	NDINAYE 5088 gonah.t@dwa.gov.za 012 336 7191	Collection of field data GW modeling Water Quality
	Pule	MC ✓	Emanzini 641 pule.m@dwa.gov.za 012 336 8110	Collection of field data GW modeling Water Quality
QUATERNARY CATCHMENTS: C83C, C83E & C83F				
	Maluleke	Henry		Collection of field data Geohydrological survey (collecting of water samples etc) GW modeling
Group 2	Mazibuko	M ✓	NDINAYE 5086 Mazibuko@dwa.gov.za 012 336 7312	Collection of field data Groundwater recharge
	Ndima	M ✓	NDINAYE BUILDINGS - 5075 ndima.m@dwa.gov.za 012 - 336 7957	Collection of field data Geohydrological survey (collecting of water samples etc)

Group 3	Nzama	S	NDINAYE: 5088 012 336 6501 Nzamas@dwg.gov.za QUATERNARY CATCHMENTS: C83G, C83H & C83J	Collection of field data GW modeling Water Quality
	Maluleke	Henry	NDINAYE BUDIN 5089 012 336 8309 malulekeh@dwg.gov.za	Collection of field data Geohydrological survey (collecting of water samples etc) GW modeling
Group 3	Chokoe	C Chwene	012 336 7865 023 320 4898 Chokoe@dwg.	Measuring interactions Modeling and information systems Understanding of groundwater recharge mechanisms
	Khoza	PHILANI	NDINAYE 5076 012-336-7866 khozap@dwg.gov.za	Collection of field data Geohydrological survey (collecting of water samples etc) GW modeling
	Morekgure	Kelebogile	012 336 8865 082 600 4934 morekgure@dwg.gov.za	Collection of field data Geohydrological survey (collecting of water samples etc) GW modeling

Ek

DWS-GOLDER - GW/SW interaction project (WP10941) capacity building.

Attendance List: 18 Sept 15

Group	Surnames	Name	Directorate	Signature
DWS PM	Maluleke	Henry	DWS RESERVE DETERMINATION	
Group 1			QUATERNARY CATCHMENTS: C83A, C83B & C83D.	
	Netshitanini	Elelwani	Hydrological Services	
	Gonah	T		
	Pule	MC Malefetsane Charles	Hydrological Services	
QUATERNARY CATCHMENTS: C83C, C83E & C83F				
Group 2	Mazibuko	M Molefi	RESERVE DETERMINATION: SURFACE WATER	
	Ndima	M MANELISI	RESERVE DETERMINATION GROUNDWATER	
	Nzama	S Stanley	RESERVE DETERMINATION GROUNDWATER	
	Netshindeulu	Ndivhuwo	RESERVE DETERMINATION	
QUATERNARY CATCHMENTS: C83G, C83H & C83J				

Group 3	Chokoe	CHOENE	Integrated systems	083 380 4898	
	Khoza	PHILANI	RESERVE DETERMINATION		
	Morekgure	Kelebogile	SURFACE & GROUNDWATER INFORMATION		
VISITORS/INVITED					
	Surname	Name	Dept./Direct/Division	Contact details	
	Netshindeulu	Ndivhuwo	Reserve Determination	012 336 8542	

EX

APPENDIX S

Attendance List – DWS Officials ST & CB Session on 23 & 24 November 2015

DWS-GOLDER – GW/SW interaction project (WP10941) capacity building.

3rd Skills Transfer and Capacity Building Session (Swater and Modelling).....23 November 2015.

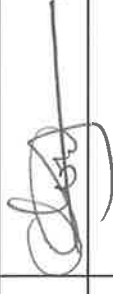
Group	Surnames	Name	Directorate	Signature
DWS PM	Maluleke	Henry	RD: RESEARCH & DEVELOPMENT	
Group 1	Netshitani	Elewani	QUATERNARY CATCHMENTS: C83A, C83B & C83D.	
	Gonah	Tichatonga	D:HS	
	Pule	Malefetsane Charles	RD:.....	
	Mako	LESIBA	D:HS	
			PLANNING & INFORMATION SYSTEMS REGION	
			QUATERNARY CATCHMENTS: C83C, C83E & C83F	
Group 2	Mazibuko	Molefi	RD-SW	
	Ndima	Manelisi	RD-GW	
	Nzama	Stanley	RD-GW	
	Netshiendeulu	Ndivhuwo	RD-GW	

QUATERNARY CATCHMENTS: C83G, C83H & C83J			
Group 3	Chokoe	Choene	:IS Information Programme
	Khoza	Philane	RD:
	Morekgure	Kelebogile	SW&GW Information
	Boniwe ~~Mazujia-Mkhabile~~	NOBUBELE Onodwa Dee	SW: RD. Planning & Information VISITORS/INVITED
	Surname	Name	Dept./Direct/Division
	Mazujia-Mkhabile	Onodwa Dee	DWS : Planning & Information
			0138256168
			Contact details

DWS-GOLDER – GW/SW Interaction Project (WP10941) Capacity Building.

3rd Skills Transfer and Capacity Building Session (Statistical Assessments and Numerical Modelling.....24 November 2015.

Group	Surnames	Name	Directorate	Signature
DWS PM	Maluleke	Henry	Reserve Determination	
QUATERNARY CATCHMENTS: C83A, C83B & C83D.				
Group 1	Netshitanini	Elewani	D:HS	
	Gonah	Tichatonga	RD	
	Pule	Malefetsane Charles	D:HS	
	Mmakoko	Lesiba	Gauteng Region: Planning and Information	
QUATERNARY CATCHMENTS: C83C, C83E & C83F				
Group 2	Mazibuko	Molefi	RD-SW	
	Ndima	Manelisi	RD-GW	
	Nzama	Stanley	RD-GW	
	Netshiendeulu	Ndivhuwo	RD-GW	

Group	Surnames	Name	Directorate	Signature
	Boniwe	Nobubele	Reserve Determination: Surface Water.	
QUATERNARY CATCHMENTS: C83G, C83H & C83J				
Group 3	Chokoe	Choene	Information Program	
	Khoza	Philane	RD:	
	Morekgure	Kelebogile	SW&GW Information	
	Mazula-Mkabile	Onodwa Dee	Gauteng Region: Planning and Information.	
VISITORS/INVITED				
	Surname	Name	Dept./Direct/Division	Contact details

APPENDIX T

Attendance List – Stakeholder Information and Project Steering Committee Meeting at Danielsrus on 19 November 2015

DWS Clarens / Frankfort: 19th November 2015 meeting

As on 18 November 2015

Attendees:

- Mr. Henry Maluleke (DWS)
- Mr. Sakhile Mndaweni (DWS)
- Dr. Martin Hollard (Delta-h)
- Mr. Jack Armour (Agri Free State) – he requested that he be nominated as representative to attend all future meetings
- Mr. Kobus Vermeulen (Agri Free State Clarens)
- Mr. Chris Helm (Agri Free State Danielsrus)
- Ms. Nancy Motebe (DWS)
- Ms. Joyce Machaba (DWS)
- Prof. Kai Witthuser (Delta-h)
- Mr. Reveck Haririm (Rand Water)
- Prof. Masihlelo (AFASA)
- Mr. Chris Viljoen (District Farmers Union)
- Mr. Hein Punt (Maluti Fruit)

Apologies:

- Mr. Zenzile Bayanda (DWS) - Moving to Cape Town and won't be able to take part in project
- Dr. Chirs Moseki (DWS)
- Dr. Wietsche Roets (DWS)
- Dr. Harold van Niekerk (DWS)
- Dr. M Gomo (UFS: Institute for Groundwater Studies)
- Dr. Matthys Dippenaar (UP)
- Mr. Kwazikwakhe Majola (DWS)

Registration sheets received up to date:

- Dr. Matthys Dippenaar (UP)
- Dr. Martin Hollard (Delta-h)
- Mr. Kobus Vermeulen (Agri Free State Clarens)
- Mr. Kwazikwakhe Majola (DWS)
- Mr. Sakhile Mndaweni (DWS)
- Mr. Hein Punt (Maluti Fruit)