APPENDIX E7 –COMMENTS FROM I&APS ON BASIC ASSESSMENT (BA) REPORT

APPENDIX E8 –COMMENTS FROM I&APS ON AMENDMENTS TO THE BA REPORT

APPENDIX E9 – COPY OF THE REGISTER OF I&APS

LEBONE ENGINEERING - KLIP MIDDLE SOWETO T -ENVIRONMENTAL STUDIES CITY PARKS AND ZOO

INTERESTED AND AFFCECTED PARTIES REGISTER FOR ENVIRONMENTAL STUDIES , AS PER THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT NO. 107 OF 1998)

Document Name: LSES-LRES-PI- IAPR

Date: 10 November 2015

Myezo Ref No:LSES,LRES2015/10IAP

First Name	Last Name	Company	Position	Tel	Fax	Mobile	E-mail	Address1	Address2	City	Code	EIA Process						
												Public Participation Process			Scoping consultation		EIA consultation	
												Type of notification and date	Comments received and date	Response and date	Type of notification and date	Comments received and date	Type of notification and date	Comments received and date
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APPENDIX F: WATER USE LICENSE(S) AUTHORISATION, SAHRA INFORMATION, SERVICE LETTERS FROM MUNICIPALITIES, WATER SUPPLY INFORMATION

APPENDIX G: SPECIALIST REPORTS

1. Hydrological Specialist studies - Appendix G.1
2. Geohydrology Assessment Report - Appendix G.2
3. Biodiversity Assessment Report - Appendix G.3
4. Wetland Assessment Report - Appendix G.4
5. Heritage Impact Assessment Report - Appendix G.5

APPENDIX G.1 HYDROLOGICAL SPECIALIST REPORT

LETSOLO WATER AND ENVIRONMENTAL SERVICES "Engineered Solutions for Environmental Quandary"	**Letsolo Water And Environmental Services cc** **P.O. Box 19016** **Pretoria West** **0117** **Reg: 2010/005979/23** **Tax ref Number: 9170/262/18/3** **Vat Number: 4380258477** Tel : (012) 373 4986 Cell : 082 821 6621 Fax : 0866 134 794 e-mail : ishmael@lwes.co.za Website : www.lwes.co.za

Lebone Engineering (Pty) Ltd

Block B, Lebone Engineering House

318 Rivonia Boulevard,

Rivonia,

2128

Attention: Kelvin Radebe

TITLE: DRAF REPORT – HYDROLOGICAL IMPACT ASSESSMENT: KLIP MIDDLE SOWETO AND KLIP UPPER RIETSPRUIT-ENVIRONMENTAL STUDIES CITY PARKS AND ZOO.

The above-mentioned project regarding the Hydrological Impact Assessment for the Riverine system located within the City of Johannesburg is herein referred to.

Please find the Hydrological Impact Assessment together with this letter.

Please do not hesitate to contact me should you have any queries.

Best regards,

Ishmael Phalane,

Candidate Engineering Technologist – Civil Engineering (ECSA: 201480763)

LETSOLO
WATER AND ENVIRONMENTAL SERVICES
"Engineered Solutions for Environmental Quandary"

LETSOLO WATER AND ENGINEERING SERVICES CC

KLIP MIDDLE SOWETO AND KLIP UPPER RIETSPRUIT

DRAFT REPORT FOR HYDROLOGICAL IMPACT ASSESSMENT

Reference: LWES 302

20 June 2016

Prepared By:	Prepared for:
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EXECTIVE SUMMARY

Letsolo Water and Environmental Services cc was appointed by Lebone Engineering Services (Pty) Ltd to conduct the Hydrological Impact Assessment Study for the Klip Middle Soweto Water Management Unit (WMU). The purpose of the study was to elaborate more on the hydrological impacts associated with the establishment of parks and rehabilitation of wetland systems. Klip Middle Soweto WMU is situated in Soweto under the City of Johannesburg (COJ) metropolitan municipality: Gauteng region.

The initial site visit was conducted on the 10th of February 2016, where all the specialists concerned met. The focus during this visit was on the Klip River Wetland system along the Lenasia and Soweto Area. The detailed site investigation was conducted on 19 April 2016 for an understanding of site conditions and collection of water samples in Klip Middle Soweto WMU as part of the study area.

Suitably scaled topographical maps were used to delineate the relevant catchments, which may be impacted on by the proposed activities. The following GIS information was used:

- 1:50 000 Topographical maps (2627bb, 2627bd, 2628aa & 2628ac), Raster as well as Vector;
- Site Layout Map (*.kmz); and
- Quaternary catchment boundaries.

<u>The extent of the study area</u>

The scope of the project covered under this report, focuses on one of the identified 18 WMUs, namely the Klip Middle Soweto WMU. Environmental studies on six other WMUs project are being conducted simultaneously with this project. The COJ previously conducted environmental studies on WMU's in order to identify environmentally impacted areas. This project on the WMU is now affording a continuous improvement opportunity to have a working programme of managing these sensitive environmental features.

The extent of the study area covered is within several townships of Soweto namely Orlando, Meadowlands, and Mofolo, and with major parks such as Orlando West, Dorothy Nyembe, and Thokoza Parks that are along the wetland river system.

<u>Potential Impact</u>

The Klip Middle Soweto WMU is within the urbanized area of Soweto that is affected by expansion of urban development's having some negative impacts on the riverine systems. Potential Impacts from Klip Middle Soweto wetland system along the Klipspruit and its tributaries are summarised as follows:

- Deterioration of water quality
- Change in flow regime
- Increase in Hydrological Yield
- Erosion/sediment transport

Sensitivities

The study area falls within WMA 08 – Upper Vaal. The Upper Vaal WMA lies predominantly in the eastern interior of the country, with the major rivers: Wilge, Liebenbergsvlei, and Vaal. This water management area is divided into three sub-areas: Downstream Vaal Dam, Upstream Vaal Dam and Wilge.

Northern part of the management area is influenced by extensive urbanisation and mining and industry activity. Because of these activities, the water resources in the area are highly developed and regulated (National Water Resource Strategy, 2004)

Climate over the Upper Vaal management area is fairly uniform, and the average rainfall varies between 600 mm and 800 mm per year (National Water Resource Strategy, 2004).

Legislative Requirements

For this Hydrological Assessment, the principal act of relevance is The National Water Act, 1998 (Act 36 of 1998) which provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis, upon which to develop tools and means to give effect to the protection of water resources.

The legal platform, on which the Hydrological Impact Assessment is based, is summarized briefly by the following main legislation and Guidelines (prescribed by the Department of Water and Sanitation, previously known as the Department of Water Affairs and Forestry):

The study was conducted in line with the requirements of the National Water Act, 1998 (Act 36 of 1998) as well as the Best Practice Guidelines for the Protection of Water Resources and "Regulations 704" as published in Government Gazette, Volume 408, No 20119 of June 1999 (Also known as General Notice 704, 04 June 1999).

In terms of the Section 40 of the National Water Act, 1998 (Act No 36 of 1998) [NWA], any person proposing water usage, as defined in Section 21 of the Act, must apply to the responsible authority for authorisation before such water use can commence. Attention is drawn to the following Sections of the NWA: Section 21 (c) & (i) - whereby 21(c) denotes diverting the flow of water and 21(i) denotes altering a water course. This is applicable to the rehabilitation of the wetland and river system at Klipspruit and its tributaries within the Klip Middle Soweto WMU.

Area of Influence

The site falls within the C22A Quaternary Catchments.

As it can be seen on Figure 3 (In the main report), Five (5) site specific catchments were delineated in order to provide site specific storm water management measures. The delineated catchment areas are summarised as follows:

- Effective Catchment - The Klip Middle River, which is a perennial stream flowing south westerly at the upper reaches and then changing flow direction to south of the Soweto township, is the most significant stream for the C22A Quaternary catchment area. Klip Middle River discharges into Klip Upper river which then flows in a south easterly direction. The Klip River is the main river draining the portion of Johannesburg south of the Witwatersrand, and its basin includes the Johannesburg CBD and Soweto. The mouth of the river is at Vereeniging where it empties into the Vaal River (Wikipedia, 2015).

- Catch 1- The stream 1 tributary of the Klip Middle River originates in Catchment 1 flowing from Florida park, traversing through Fleurhof dam to Orlando West and drains south easterly for approximately 10km before it discharges into the Klip Middle River.

- Catch 2- The stream 2 originates in catchment 2, flowing from Diepkloof to Orlando east and drains north westerly for approximately 5km before it discharges into the Klip middle river.

- Catch 3- The stream 3 tributary of the Klip Middle River originates in Catchment 3, flowing from Meadowlands West to Mofolo South, and drains south easterly for approximately 4km before it discharges into the Klip Middle River wetland system.

- Catch 4 A- The stream 4 tributary of the Klip Middle river originates in Catchment 4 and drains south easterly for approximately 2km before it discharges into the Klip Middle River wetland system.

- Catch 5- The stream 5 tributary of the Klip Middle river originates in Catchment 5, flowing from Meadowlands East to Orlando West. It drains south easterly for approximately 1km before it discharges into the Klip Middle River.

Methodology

A holistic approach is followed whereby the project area was analyzed and compared against greater Water Management Areas (WMAs) and Quaternary Catchment Areas delineated by the Department of Water and Sanitation. During the early stages of the project, Desktop Assessment was conducted. During this phase, existing hydrological information was reviewed and assessed for relevance to the study area. Detailed investigations commenced in after the appointment. A site visit was conducted in order to obtain an understanding of the hydrology in and around the site. Due to the nature of the water resources, flow was observed at most monitoring points during the assessment phase, hence water quality samples were taken.

Current water quality

Water quality samples collected were named alphabetically as follows:

- MP-A represents Monitoring Point A.

Looking at catchment 1 water quality monitoring conducted in upstream and downstream of Fleurhof dam along stream 1, reveals that the metals together with Total Dissolved Solids (TDS) are higher downstream than upstream except for Iron (Fe) and Aluminium (Al). Catchment 2 has a different water system. There's high concentration of metals, Electrical Conductivity (EC), TDS and Sulphates (SO_4) in this catchment following the concentrations in catchment 1, though both these catchment are on different water system.

Their similarities are that both Catchment 1 and 2 lie proximately within and to the south of the old mining slime dams. However a distinct difference with catchment 2 is that a unique blackish grey colour was observed during site visit leading to assumption that stream 2 is impacted by untreated final effluent from Waste Water Plants. This assumption was further confirmed by the analysis of Ammonia and Phosphate which showed relatively high concentrations in comparison with other monitoring points.

Quality of Catchment 3, 4 and 5 is of better quality compare to catchment 1 and 2 discussed above. Catchment 3 has two monitoring points; MPI has high concentration of Ammonia and its tributary to stream 3 downstream of MPJ. Dorothy Nyembe Park is located in Catchment 3. As observed on site, domestic waste is disposed within the water course at the park itself and there's a brick making facility close to the park. Thokoza Park is located within Catchment 4. When compared to Dorothy Nyembe Park, there is there's less waste disposal activities at this park. However, negative aesthetic water quality observations were made. The colour of the water sample collected was darker. According to SANS 241-1 2015 only Manganese (Mn), Fe and Ammonia (NH_4) are exceeding the standard limit while the other variables are within the limit in catchment 4. Generally, Catchment 5 concerned has the high iron concentration in relation to other catchments (except for MPA located in in catchment 1). However, other variables are of lower concentration when compared to other catchments. Orlando West Park falls within Catchment 5. Domestic waste is disposed off at some areas at Orlando West Park.

In conclusion, water quality from the Klipspruit and its tributaries is of poor quality on average and is not suitable for domestic use purposes. Indicator variables of pollutants from various sources where identified in the Laboratory analysis report. Activities which impacts negatively on surface water can be categorised as follows:

- Storm water from urban runoff,
- Sedimentation and siltation,
- Domestic waste disposal along river systems,

- Sewage and mining effluents.

Cummulative impacts of the above mentioned activities impacts negatively on the Klipspruit which discharges into the Klip River at the south, and eventually ends up in the Vaal River System. In support of this conclusion, according to Lotter (1992), pollution from gold mine slimes dams and tailing dumps has been an additional problem to the surface water quality within the Soweto and Johannesburg area. Again the article from Mail & Guardian by Kardas-Nelson (2010) revealed that Soweto area especially along the Klip River is largely polluted by sewage, garbage and mine waste. Mitigation measures need to be taken into account in order to reduce these above mentioned impacts.

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GLOSSARY OF TERMINOLOGY

Catchment – The area from which any rainfall will drain into the watercourse or watercourses or part of the water course, through surface flow to a common point or common points.

Environment – The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group; these circumstances include biophysical, social, economic, historical, cultural and political aspects. Environment means the surroundings within which humans exist and that are made up of-

(i) the land, water and atmosphere of the earth;

(ii) micro-organisms, plant and animal life;

(iii) any part or combination of (i) and (ii) and the interrelationships among and between them; and

(iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.

Hydrology. – The study of movement, distribution and quality of surface water and groundwater.

The Act – The National Water Act, (NWA) (Act 36 of 1998)

The Department – Means the Department of Water and Sanitation

Tributaries – A stream or river which flows directly into a larger river or stream.

Watercourse means -

(a) a river or spring;

(b) a natural channel in which water flows regularly or intermittently;

(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

Water quality – means the physical, chemical, toxicological, biological (including microbiological) and aesthetic properties of water that determine sustained (1) healthy functioning of aquatic ecosystems and (2) fitness for use (e.g. domestic, recreational, agricultural, and industrial). Water quality is therefore reflected in (a) concentrations or loads of substances (either dissolved or suspended) or micro-organisms, (b) physico-chemical attributes (e.g. temperature) and (c) certain biological responses to those concentrations, loads or physico-chemical attributes.

ABBREVIATIONS

BPG	: Best Practice Guideline
DWS	: Department of Water and Sanitation
m^3	: Cubic Meters
NWA	: National Water Act 1998 (Act 36 of 1998)
SWMP	Storm Water Management Plan
WMA	: Water Management Area

1. INTRODUCTION

Letsolo Water and Environmental Services cc (Hereafter referred to as Letsolo) was appointed was appointed by Lebone Engineering Services (pty) Ltd to conduct the Hydrological Impact Assessment Study for the Klip Middle Soweto Water Management Unit (WMU). The purpose of the study was to elaborate more on the hydrological impacts associated with the establishment of parks and rehabilitation of wetland systems. Klip Middle Soweto WMU is situated in Soweto under the City of Johannesburg (COJ) metropolitan municipality: Gauteng region..

The Hydrological Impact Assessment is required to predict and quantify the potential impacts on surface water resources as well as to recommend reasonable mitigation measures. This Assessment is fundamental to the discipline of environmental management and is a requirement of environmental impact assessments (EIA), water use license applications (WULA), Environmental Management Programmes (EMP), mine closure plans and other studies. In each instance there is a need to understand the future impact of a proposed / current activity and to then determine whether the management measures applied to that activity are appropriate or whether they should be modified.

The key areas of the study are simplified as follows:

- Hydrological Impacts Associated with the development of Parks;
- Hydrological Impact Associated with the rehabilitation of Wetlands.

The key areas indicated above, trigger water use activities. Non consumptive water uses are legislated through Section 21 (c) and (i) of the NWA. In order to reach a goal of maintaining and improving this unique wetland system, a holistic approach was applied. The wide range of nature types support different biological communities and different possibilities for utilization. At the same time the different nature types are interdependent and interaction between them is high. The study area was divided into smaller catchment areas according to the nature, type and characteristics of those areas.

1.1. Purpose of the study

The main purpose of the study is protecting and restoring the riverine systems. Because of the natural importance of the Klipspruit, a detailed Hydrological Impact Assessment Study was undertaken to conserve and restore its natural diversity and value, as well as to promote sustainable development of the local economy based on none-consumptive use of the natural resources.

The establishment of parks at location near the riverine systems may result in un-intended negative impacts like water quality deterioration.

The rehabilitation of impacted wetland systems may result in positive impacts. However, the construction phase of the rehabilitation process may result in un-intended negative impacts.

The purpose of this report is to highlight the status quo of the riverine systems in the Klip Middle Soweto Riverine Systems as well as to propose mitigation measures for the Development of Parks and the rehabilitation of the Wetland Systems.

1.2. Background information

As part of the City of Johannesburg's (CoJ's) commitment to achieving the environmental goals set out in the City's Growth and Development Strategy (GDS) and its support for the GDS goal for Management of Water Catchments and Sources, CoJ has embarked on a programme aimed at rehabilitation of the City's Water Management Units (WMU's).

The WMU play a vital role in the environment, as they provide habitat for various forms of fauna and flora which are part of the ecosystem of the wetlands in the riverine systems. The water management units provide open public spaces which are managed by the Johannesburg City Parks and Zoos (JCPZ) as public parks.

Johannesburg City Parks and Zoos (JCPZ is mandated by the City of Johannesburg (CoJ) to manage the parks and designated public open spaces. According to their website JCPZ currently maintains 22 278 hectares of open space and green areas made up of more than 2 343 parks.

1.3. Extent of the study area

The scope of the project covered under this report, will cover one of the identified 18 management units, namely the Klip Middle Soweto. Environmental studies on six other WMUs project are being conducted simultaneously with this project. The City had previously been conducting environmental studies on their WMU's on a need to know basis when the information was required and the rehabilitation interventions were also not forming part of a comprehensive programme. This project on the WMU is now affording a continuous improvement opportunity to have a working programme of managing these sensitive environmental features.

WMUs play a role in the management of storm water as they act as receiver of storm water diverted through the storm water drains from the city streets to the water units. The wetlands within the WMUs serve as a natural filtration system, thus preservation and sustainability is the key. This project is aimed at determining the actual impacts for which management measures will be developed in the Klip Upper and Klip Middle. However this report gives a full attention at the surface and water quality of the study area.

The Klip Middle Soweto WMU is within the urbanized area of Soweto that is affected by expansion of urban development's having some negative impacts on the riverine systems. These impacts, deterioration of rivers resulting from channelization and construction of the roads, bridges and culverts across rivers, place pressure on the rivers. As well with impacts from intense storm water runoff from urbanized catchments, and increased pollutant loads from illegal dumping within the wetland systems, add to deterioration of the rivers of wetlands system.

The extent of the study area covered is within several townships of Soweto, see site location map below, namely Orlando, Meadowlands, and Mofolo, and with major parks such as Orlando West, Dorothy Nyembe, and Thokoza Parks that are along the wetland river system.

1.4. Consultation with the Department of Water and Sanitation

The Department of Water and Sanitation was consulted on 08 April 2016 in order to present the scope of work and to seek clarity on aspects to be considered during the study. The key issues are summarised as follows;

- Water Use Activities can be classified as Consumptive water uses and Non-consumptive Water Uses.
- WR outlined the Water Use Licence Assessment (WULA)system they use in assessing the WULA application as follows:
- National Water Act (Act 36 of 1998) mainly S21 (c) and (i) look at the national water resource quality in terms of the factors influencing the impacts the wetlands are facing:
- Flow regime, water quality and morphology being the factors
- Habitat and biota being the impacts
- Some activities or project in respect of S21 (c) and (i) can be granted the General Authorisation (GA) in terms of revised GN1199
- The current GN1199 excludes activities within a 500m radius from the boundary of any wetland and these water uses currently would require a WULA.
- The recommended Risk Matrix for 2016 can be downloaded from the Department's website.

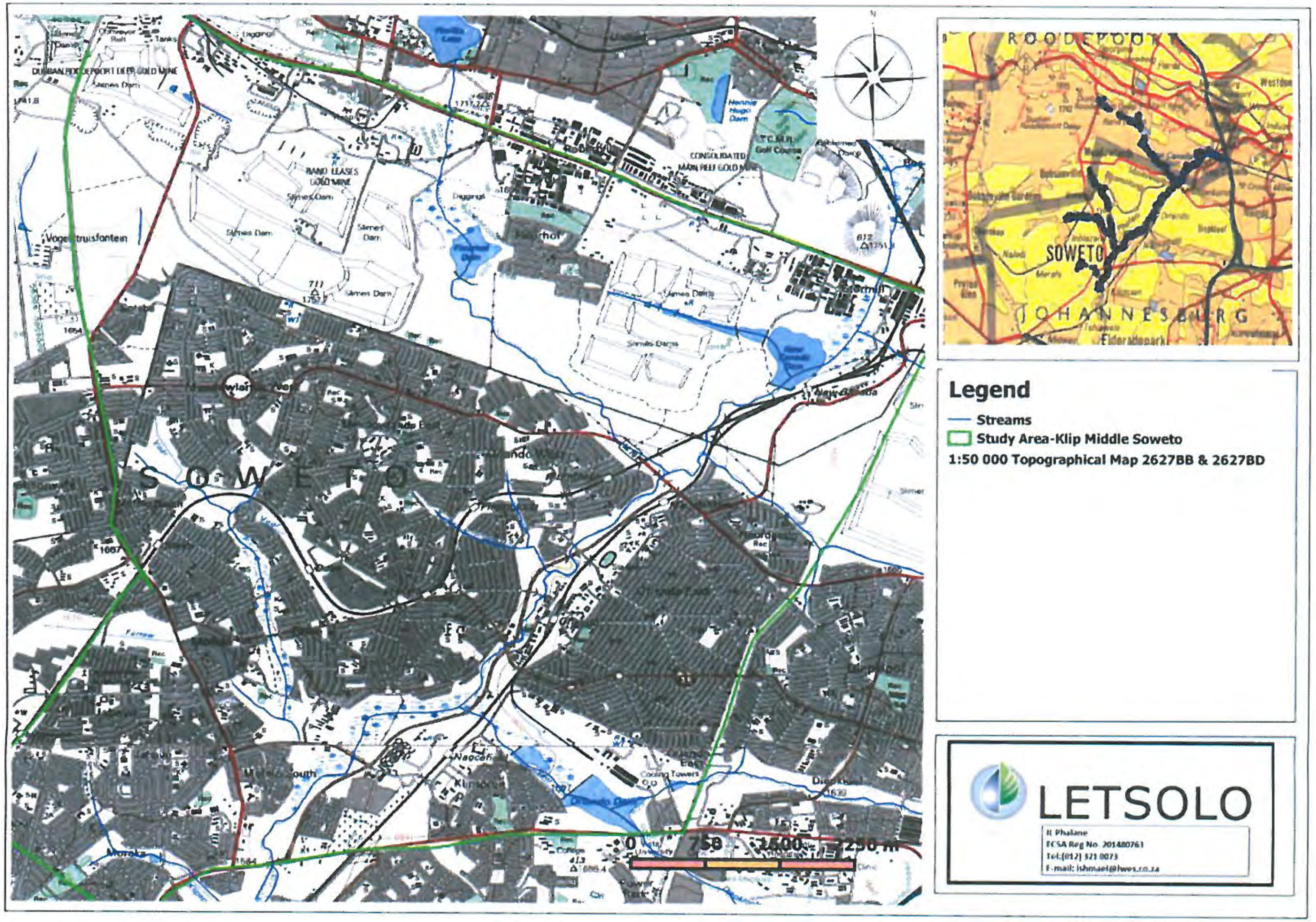


Figure 1-1: Site Location Map

1.5. Specialist Expertise

Mr Phalane has 12 years' experience in the field of Water and Environmental Engineering. Over the years Mr Phalane gained valuable experience in the implementation of the National Water Act, 1998 (Act 36 of 1998) and National Water Resource Strategy, the implementation of the General Authorizations as well as Water Use License Applications in terms of section 21 of the NWA, 1998.

(Please refer to Table 1-1 below for details regarding professional registration)

Table 1-1: Professional Registration

Class	Professional Society	Year of Registration
Member	Engineering Council of South Africa Civil Engineering Technologist (ECSA - registration no: 201480763)	2014
Member	Institute of Directors South Africa	2007
Member	Water Institute of South Africa	2005

1.6. Declaration of Independence:

I, Ishmael Phalane, act as the independent specialist will perform the work relating to the Hydrological Impact Assessment in an objective manner, even if this results in views and findings that are not favourable to the water user.

I declare that there are no circumstances that may compromise my objectivity in performing such work. I have expertise in conducting the Hydrological Impact Assessment specialist study. I confirm that I have knowledge of the relevant environmental Acts, Regulations and Guidelines that have relevance to the proposed activity and my field of expertise and will comply with the requirements therein.

I have no, and will not engage in, conflicting interests in the undertaking of the activity.

I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has, or may have, the potential of influencing any decision to be taken with respect to the application by the competent authority; and

the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

All particulars furnished by me in this report are true and correct. I realise that a false declaration is an offence in terms of regulation 48 of the National Environmental Management Act, 107 of 1998 (NEMA) and is punishable in terms of section 24F of the Act.

Signature of the environmental assessment practitioner:

Letsolo Water and Environmental Services cc

Name of company:

01June 2016

Date:

2. SCOPE OF WORK

The scope of work for the proposed activity is summarized as follows:

- Characterise the surface water regime in the in the immediate vicinity of the project (quality and flow);
- Characterise and delineate the prevailing surface water features in the area with specific reference to the proximity and sensitivity of wetlands;
- Status of environment: Rivers, catchment boundaries with information on the stream flow, mean runoff, normal dry weather flow, flood peaks and volumes, water quality baseline descriptions and compared with target water guidelines as per legislation
- Drainage density of areas to be disturbed
- Surface water quantity and catchment layout
- Characterise surface water quality surface regime in the area and in the immediate vicinity of the project
- Determine water quality of the prevailing surface water features in the area including wetlands and pans
- Determine areas of potential contamination within the site that could impact on the water resources and transport pathways and potential receptors and the potential impacts on such receptors. Liaison with surface water specialists to get impact zones or routes of potential impact on surface water including waste water discharge, spillages of product and/or other hazardous materials, atmospheric emissions, sedimentation
- Provide recommendations on how potential the development could manage the identified impacts
- Develop a monitoring protocol with details of what to be monitored, frequency and mapped monitoring points.
- Define floodlines for the surface infrastructure (1:100 yr and 1:50 yr floodlines)
- Advise on the various management options and determine how these interventions will impact on the water resources. Recommendations can include but not limited to Storm water management and control and provide the actual designs from pollution containment dams according to applicable regulations

3. LEGAL REQUIREMENTS

For this Hydrological Assessment, the principal act of relevance is The National Water Act, 1998 (Act 36 of 1998) which provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis, upon which to develop tools and means to give effect to the protection of water resources.

The main focuses of the NWA are summarized as follows:

- To evaluate the natural Hydrological conditions for the specific site area and its larger surrounding areas (up and downstream catchments);
- To evaluate Hydrological conditions for the specific project development and its associated processes and infrastructure;
- To evaluate these Hydrological conditions under the following storm events;
    - Normal Dry Weather Flow;
    - 1:50 year 24 hour storm; and
    - 1:100 year 24 hour storm event.
- To ensure that the Hydrological conditions as well as the specific project development and its associated processes and infrastructure are in harmony and that they can both exist and co-exist and operate optimally under all of these environmental conditions;
- To ensure that the natural environment is preserved and protected as far as possible; and
- To ensure that clean and dirty water is separated (collected, contained, and controlled) effectively.

In terms of the Section 40 of the National Water Act, 1998 (Act No 36 of 1998) [NWA], any person proposing water usage, as defined in Section 21 of the Act, must apply to the responsible authority for authorisation before such water use can commence. Attention is drawn to the following Sections of the NWA:

- Section 21 (c) : impeding or diverting the flow of water in a watercourse;
- Section 21 (i) altering the bed, banks, course or characteristics of a watercourse;

4. METHODOLOGY

A holistic approach is followed whereby the project area is analyzed and compared against greater Water Management Areas (WMAs) and Quaternary Catchment Areas.

Desktop Assessment was conducted. During this phase, existing hydrological information was reviewed and assessed for relevance to the study area. A site visit was conducted in order to obtain an understanding of the hydrology in and around the site. Due to the nature of the water resources, flow was observed during the assessment phase. Therefore, water quality samples were collected.

The specific process followed in the assessment is summarized as follows:

- Visual assessment of the site and obtaining an understanding of the hydrological conditions;
- Plotting of spatial data to asses hydrological characteristics;
- Building different computer models (for different applications) that represent the site as accurately as possible; and
- Analysing the models in order to obtain the most desirable outputs and deliverables.

There are different hydrological calculation methods that can be used to calculate flows and drainage in South Africa, the most common being:

- Rational method
- Alternative Rational method
- Unit Hydrograph method
- Standard Design Flood (SDF) method
- Empirical method

The Unit Hydrograph Method was selected as the most reliable method based on the size of the catchment as well as the reliability of input data.

5. CATCHMENT ANALYSIS

5.1. Source of Hydrological Data

The following data, data sources, software, and methods were used in the assessment:

- Design Rainfall Estimation over South Africa computer software utility (Smithers & Shultze, 2002);
- 1:50 000 topographical data (National Surveyor General) including the following;
  - Contours and
  - rivers;
- The Utility Program for Drainage over South Africa (UPD) (SINOTECH, 2007);
  - Unit Hydrograph Method;
- Google Earth;
- Client data in the form of;
  - Total Project boundary;
  - Site specific boundaries; and
  - Survey Data.

5.2. Catchment analysis and hydrology

The existing River systems in relation to the proposed project site are categorized in 3 Tiers as follows:

- Tier 1 : Water Management Area
- Tier 2 : Quaternary Catchment
- Tier 3 : Water Management Unit
- Tier 4 : Site Delineated Catchments

These areas are discussed in detail below.

5.2.1. Water Management Area

The study area falls within WMA 08 – Upper Vaal. The Upper Vaal WMA lies predominantly in the eastern interior of the country, with the major rivers: Wilge, Liebenbergsvlei, and Vaal. From a water resources management perspective it is a pivotal water management area in the country. Large quantities of water are transferred into the area from two neighbouring areas, as well as water sourced from the Upper Orange River via Lesotho. Extensive urbanisation and mining and industrial activity, which relate to the rich gold and coal deposits in the area, occur in the northern part of the water management area.

The sensitive water resource for this WMA is the Vaal River. The Vaal River is the largest tributary of the Orange River in South Africa. The river has its source near Breyten in Mpumalanga province, east of Johannesburg and about 30 km north of Ermelo and only about 240 km from the Indian Ocean. It then flows westwards to its conjunction with the Orange River southwest of Kimberley in the Northern Cape. It is 1,120 km in length, and forms the border between Mpumalanga, Gauteng and North West Province on its north bank, and the Free State on its south

This water management area is divided into three sub-areas: Downstream Vaal Dam, Upstream Vaal Dam and Wilge.

Northern part of the management area is influenced by extensive urbanisation and mining and industry activity. Because of these activities, the water resources in the area are highly developed and regulated (National Water Resource Strategy, 2004)

Climate over the Upper Vaal management area is fairly uniform, and the average rainfall varies between 600 mm and 800 mm per year (National Water Resource Strategy, 2004).

5.2.2. Quaternary catchments

A catchment, in relation to a watercourse means the area from which any rainfall will drain into the watercourse or part of the water course through surface flow to a common point, or points (National Water Act, 1998, Act 36 of 1998).

The site falls within the C22A Quaternary Catchment, with a surface area coverage of 550 km^2. The significant water resource within this quaternary catchment is the Klipspruit River.

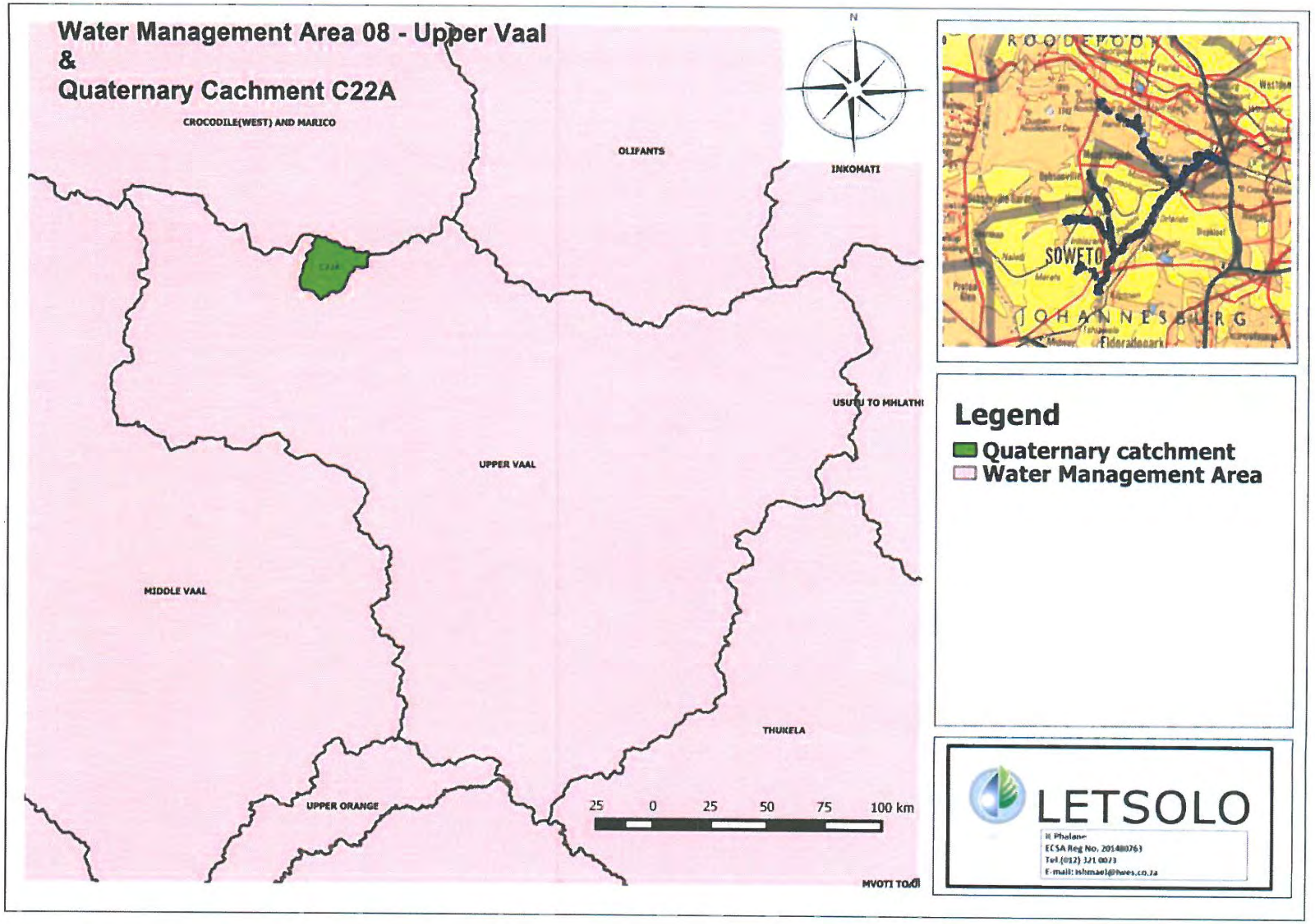


Figure 0-1: DWS Water Management and Quaternary Catchment Area

5.2.3. Water Management Units

Johannesburg City Parks and Zoos (JCPZ) is mandated by the City of Johannesburg (CoJ) to manage the parks and designated public open spaces. According to their website JCPZ currently maintains 22 278 hectares of open space and green areas made up of more than 2 343 parks.

The scope of the project under this report covers one of the identified 18 management units, namely the Klip Middle Soweto WMU.

5.3. Site delineated Catchments

As it can be seen on **Figure 5.3-1**, five (5) site specific catchments were delineated in order to provide site specific storm water management measures. Each delineated catchment is characterised by ta significant stream collecting runoff from the catchment. The delineated catchment areas are summarised as follows:

- **Quaternary catchment C22A –** Geographical Information System of the Department of Water Affairs delineated Quaternary Catchment, was used to identify C22A, DWS Quaternary Catchment. The Klip Middle River (Klipspruit), which is a perennial stream flowing south westerly then south of the Soweto township, is the most significant stream for the C22A Quaternary catchment area, where it discharges to Klip Upper river which then flows into south easterly direction. The Klip River is the main river draining the portion of Johannesburg south of the Witwatersrand, and its basin includes the Johannesburg CBD and Soweto. The mouth of the river is at Vereeniging where it empties into the Vaal River.

- **Effective Catchment –** All other delineated catchment areas are located within the Effective Catchment Area. Therefore, this catchment is the most significant catchment area.

- **Catchment 1-** The stream 1 tributary of the Klip Middle river originates in Catchment 1 flowing from Florida park and traversing through Fleurhof dam to Orlando West. Stream 1 further drains south easterly for approximately 10km before it discharges into the Klip Middle River.

- **Catchment 2-** The stream 2 originates in catchment 2, flowing from Diepkloof to Orlando east and drains north westerly for approximately 5km before it discharges into the Klip middle river.

- **Catchment 3**- The stream 3 tributary of the Klip Middle river originates in Catchment 3, flowing from Meadowlands West to Mofolo South, and drains south easterly for approximately 4km before it discharges into the Klip Middle River wetland system.

- **Catchment 4** - The stream 4 tributary of the Klip Middle river originates in Catchment 4 and drains south easterly for approximately 2km before it discharges into the Klip Middle River wetland system.

- **Catchment 5**- The stream 5 tributary of the Klip Middle river originates in Catchment 5, flowing from Meadowlands East to Orlando West. It drains south easterly for approximately 1km before it discharges into the Klip Middle River

Table 0-1: Site Delineated Catchments

Description	Surface Area (km^2)	Hydraulic Length (km)	Change in height (m)	Significant Water Resource
C22A	550	37	100	Klip Upper River – Perennial
Effective catchment	206	21.7	210	Klip Middle River (Klipspruit) - Perennial
Catchment 1	33.9	10	100	Stream 1, tributary of Klip Middle river on the north western side of the river – Perennial
Catchment 2	10.7	5	120	Stream 2, tributary of Klip middle river on the eastern side of the river. - Perennial
Catchment 3	24	4	160	Stream 3 flowing parallel to stream 1, tributary of Klip Middle river on the north western side of the river - Perennial
Catchment 4	12.3	2	80	Stream 4 flowing parallel to Stream 3, tributary of Klip Middle river on the north western side of the river - Perennial
Catchment 5	5.39	1	100	Perennial stream 3 flowing parallel to stream 1, tributary of Klip Middle river on the north western side of the river.

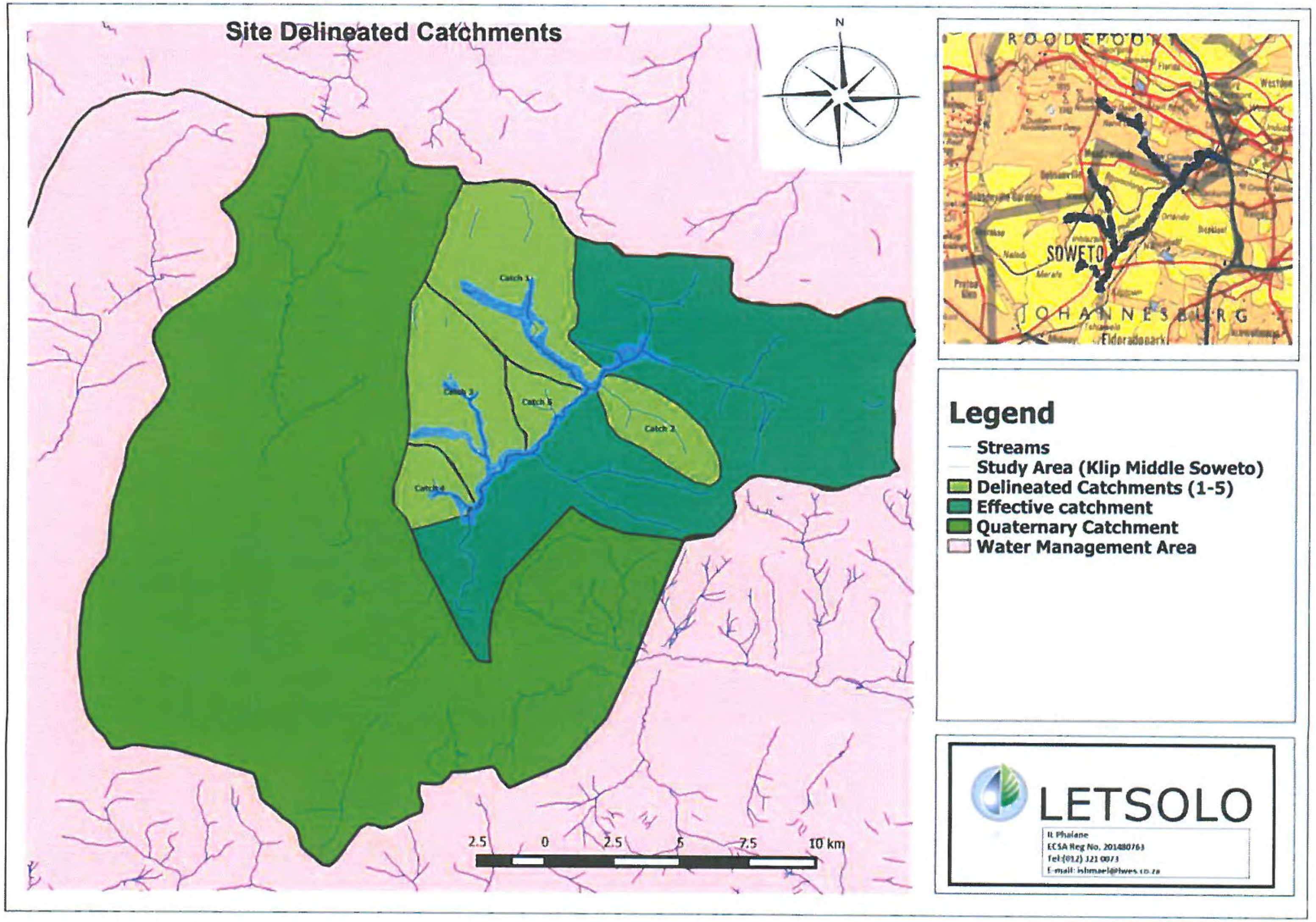


Figure 0-2: Site Delineated Catchments

6. CATCHMENT HYDROLOGY

Catchment hydrology is based on the principal of continuity, which is used to determine the water cycle. The paragraphs below provide details regarding hydrological characteristics of the study area.

6.1. Meteorological Information

The Department of Water and Sanitation (Hydrological Information System) was consulted in order to retrieve Hydrological data. **Table 6.11-1** below provides details regarding other meteorological Stations located in near the study area. Historic data for DWS Station C2E007, which is located approximately 10km south west of the study area, was used for this assessment.

Table 6-1: Meteorological Station in Sub Drainage Region C2

Stations in sub drainage region C2			
Station No	Place	Latitude	Longitude
C2E001	Vaalplaats @ Vaal River Barrage	26.76272	27.68292
C2E003	Makwassie	27.31714	25.99961
C2E004	Potchefstroom	26.73378	27.08297
C2E005	Klipdrift @ Klipdrift Dam	26.61606	27.29217
C2E006	Buffelsvlei @ Boskop Dam	26.563	27.10797
C2E007	Zuurbekom @ Rwr-Pump Station	26.30083	27.81381
C2E008	Eye Of Wonderfontein	26.29633	27.49547
C2E009	Naauwpoort @ Boskop Dam	26.57133	27.118
C2E010	Balkfontein	27.40694	26.50417
C2E011	Eye Of Wonderfontein	26.30053	27.47889
C2E012	Vliegkraal	27.49622	26.06211
C2E013	Heidelberg	26.50472	28.35389
C2E014	Potchefstroom @ Potchefstroom Dam	26.67131	27.09967
C2E015	Klipdrift @ Klipdrift Dam	26.61653	27.29192
C2E016	Elandskuil @ Elandskuil Dam	26.35147	26.77528
C2E017	Klipplaatdrift @ Rietspruit Dam	26.41678	26.79633
C2E018	Klerkskraal @ Klerkskraal Dam	26.24575	27.16208

6.1.1.Rainfall Data

Many different rainfall data sources and consequent data sets exist for rainfall representation over S.A. Each data source and data set has its own unique advantages as well as disadvantages. Different hydrological rainfall-runoff simulation and peak flow estimation models exist as well as different methods for estimations which require different rainfall parameters with specific required detail and accuracy.

Mean Annual Precipitation (MAP) is representative of the average rainfall that occurs over an area during any given year. This rainfall is obtained by taking the total rainfall received over time at a specific point including any extreme periods and/or events and averaging it.

As indicated in **Table 6.1.2-1** and **Figure 6.1.2-1**, the site MAP is estimated at 676.1 mm. During summer seasons, high rainfall is experienced between November and January. However low rainfall amount experienced between June and August is during winter months. The rainfall amount ranges from the average of 2.2 mm in June to an average of 125.5 mm in January.

6.1.2.Evaporation Data

As in the case of rainfall and runoff it is also necessary to analyze the Mean Annual Evaporation (MAE). Much less evaporation data exists than data for rainfall and runoff. Evaporation is measured at dams and mostly stations that are operated by DWS; these stations provide such data.

As indicated in **Table 6.1.2-1** and **Figure 6.1.2-1,** the site MAE is estimated at 1455.4 mm. The highest evaporation months are between October and December with an average of 165.6 mm during December.

Table 0-1: Rainfall and Evaporation Data

Description	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Rainfall (mm)	72.0	98.9	112.5	125.5	87.6	78.5	51.9	13.0	7.3	2.2	7.3	19.4	*676.1*
Evaporation (mm)	162.8	161.3	165.6	160.1	134.5	119.6	94.8	62.3	68.8	75.5	107.1	143.0	*1455.4*

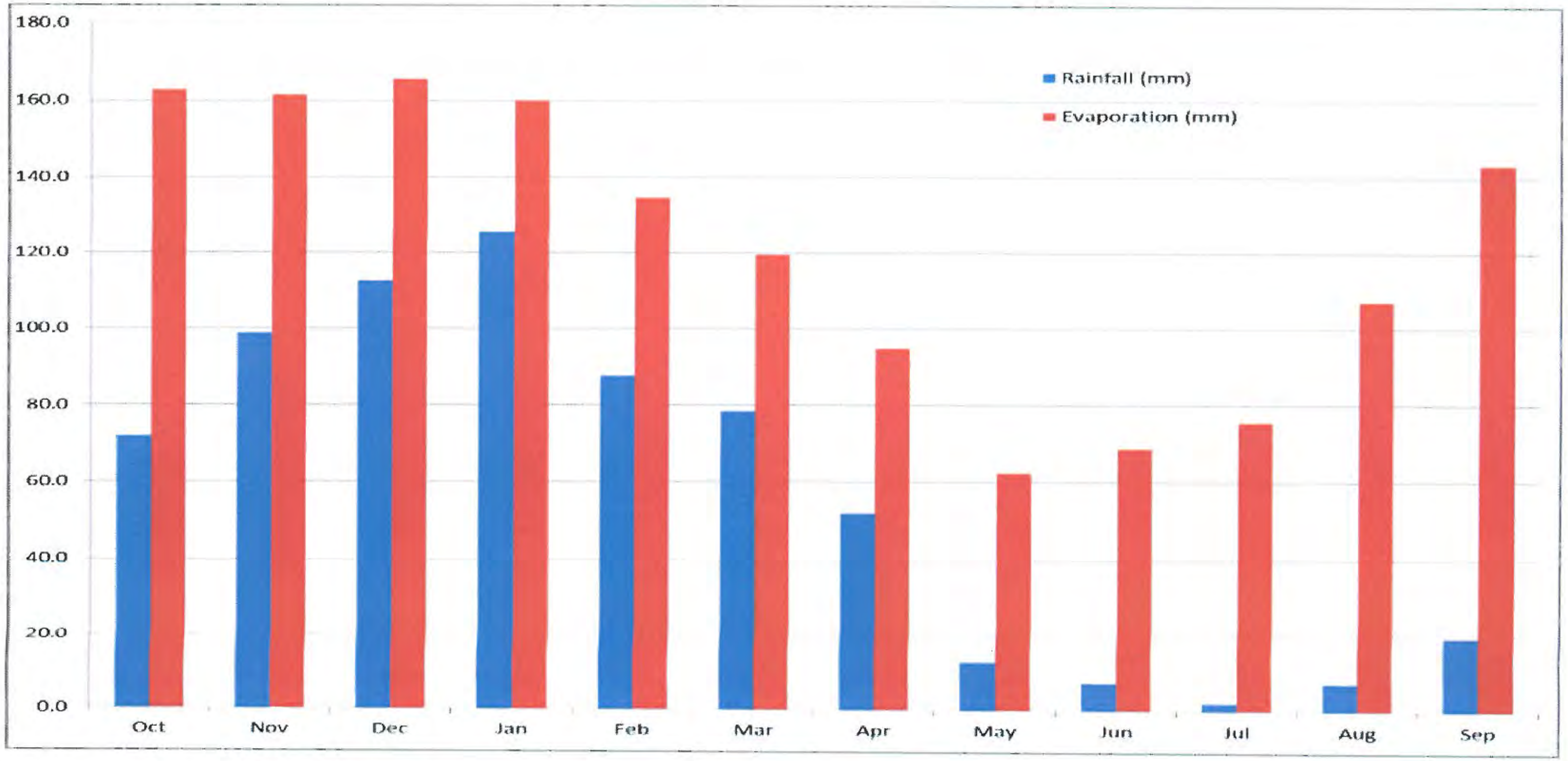


Figure 0-1: Rainfall And Evaporation Data

6.2. Flood Calculations

A Unit Hydrograph (UH) Calculation Method was used to estimate the peak flows. A UH is specific to a particular watershed, and specific to a particular length of time corresponding to the duration of the effective rainfall. Therefore the most critical inputs for UH are Surface Area and Hydraulic Length. The UH technique provides a practical and relatively easy-to-apply tool for quantifying the effect of a unit of rainfall on the corresponding runoff from a particular drainage basin.

UH theory assumes that a watershed's runoff response is linear and time-invariant, and that the effective rainfall occurs uniformly over the watershed.

The approach can be simplified as follows:

- In-stream flow volumes
  - The Unit Hydrograph method was used to calculate in-stream flow volumes for the 1:5, 1:50 and 1:100 24 hours storm events.
  - This information is later used for the delineation of flood lines.
  - The delineated catchment area for which flood calculations were conducted are summarised as follows:
    - Effective Catchment
    - Catchment 1
    - Catchment 2
    - Catchment 3
    - Catchment 4
    - Catchment 5

For in-stream calculations, the following catchment characteristics have an influence on the hydrological yield:

- Area
- Length of watercourse
- Height difference along the slope

- Veld type
- Slope

(Please refer to **Paragraphs 6.2.1** to **6.2.6** below for hydrological characteristics)

6.2.1. Effective catchment

The hydrological characteristics for this area are summarised as follows:

Area of catchment	= 206.0 km²
Length of longest watercourse	= 26.3 km
Height difference along equal area slope	= 210.0 m
Distance to catchment centroid	= 13.15 km
Veld type	= Region 4
Duration interval	= 1 hour
Slope of longest stream	= 0.0080 m/m

6.2.2. Catchment 1

The hydrological characteristics for this area are summarised as follows:

Area of catchment	= 33.9 km²
Length of longest watercourse	= 10.0 km
Height difference along equal area slope	= 100.0 m
Distance to catchment centroid	= 5.0 km
Veld type	= Region 4
Duration interval	= 1 hour
Slope of longest stream	= 0.0100 m/m

6.2.3. Catchment 2

The hydrological characteristics for this area are summarised as follows:

Area of catchment	= 10.7 km²
Length of longest watercourse	= 5.0 km
Height difference along equal area slope	= 120.0 m
Distance to catchment centroid	= 2.5 km
Veld type	= Region 4
Duration interval	= 1 hour
Slope of longest stream	= 0.0240 m/m

6.2.4.Catchment 3

The hydrological characteristics for this area are summarised as follows:

Area of catchment	= 24.0 km²
Length of longest watercourse	= 4.0 km
Height difference along equal area slope	= 160.0 m
Distance to catchment centroid	= 2.0 km
Veld type	= Region 4
Duration interval	= 1 hour
Slope of longest stream	= 0.0400 m/m

6.2.5.Catchment 4

The hydrological characteristics for this area are summarised as follows:

Area of catchment	= 7.45 km²
Length of longest watercourse	= 1.95 km
Height difference along equal area slope	= 80.0 m
Distance to catchment centroid	= 0.973 km
Veld type	= Region 4
Duration interval	= 1 hour

Slope of longest stream = 0.0410 m/m

6.2.6. Catchment 5

The hydrological characteristics for this area are summarised as follows:

Area of catchment	= 5.39 km²
Length of longest watercourse	= 1.0 km
Height difference along equal area slope	= 100.0 m
Distance to catchment centroid	= 0.5 km
Veld type	= Region 4
Duration interval	= 1 hour
Slope of longest stream	= 0.1000 m/m

Table 0-2; Summary of Flood Calculations

Catchment Description	Area (km^2)	Notes	1:50 Peak Flow (Q_{p50}) in m3/s	1:100 Peak Flow (Q_{p100}) in m3/s
Effective catchment	206	The effective catchment area falls within C22A quaternary catchment. Catchments 1 to 5 falls within the Effective Catchment Area. The peak flows for the Effective Catchment area includes the Peak Flows for Catchments 1 to 5.	387.39	521.68
Catchment 1	33.9		124.36	169.14
Catchment 2	10.7		70.51	97.09
Catchment 3	24		178.57	240.55
Catchment 4	7.45		34.13	47.17
Catchment 5	5.39		5.54	7.68

6.3. Mean Annual Runoff

Runoff is the result of precipitation (rainfall) falling on a catchment and eventually running off from the catchment. The amount of rainfall that runs off is dependent on the catchment characteristics.

Modeling this rainfall-runoff effect is complex and requires much detail. Extensive research has been put forward in catchment runoff modeling (Pitman, WR2005). The Pitman model incorporates an enormous amount of rainfall data over S.A. (as explained in (Section 9.1) of this report). The model was furthermore developed especially for S.A. and its unique conditions and characteristics. WMA's and quaternary catchment areas are modeled in great detail (considering many different land use and capability aspects such as irrigation and mining (and industry), soil characteristics, vegetation, and many more). The WR2005 database is considered as a reliable dataset which is proven and tested (verified) to be very accurate and representative of flows in S.A.

Due to the complex nature of rainfall-runoff modeling it is not deemed necessary to set up specific models for small mining catchments (BPGs). Letsolo Water adopts a holistic approach and methodology whereby WR2005 quaternary catchment runoff data is downscaled to site specific runoff data by making use of area and volume relationships as well as a rainfall reduction factor. The formula assumes uniform catchment characteristics as far as possible (the user creates a model of the mine area and groups (categorizes) similar areas). A rainfall reduction factor which compares quaternary catchment rainfall (according to WR2005) with site specific rainfall (according to DRUP) is applied to quaternary catchment runoff (according to WR2005) in order to ultimately obtain site specific runoff (thus also according to WR2005 data).

As indicated in Table 6.3-1 below, The MAR calculations are highly dependent on the surface area.

Table 0-3: Mean Annual Runoff

Description	Surface Area (km^2)	MAR (mm/a)	MAR (m3/a)	Mean Annual Rainfall (MAP) (m/m)
C22A	550	31.5	17 325 000	694.96
Effective catchment	206	31.5	6 489 000	
Catch 1	33.9	31.5	1 067 850	
Catch 2	10.7	31.5	337 050	
Catch 3	24	31.5	756 000	
Catch 4 A	7.45	31.5	234 675	
Catch 5	5.39	31.5	169 785	

6.4. Drainage Density

Drainage Density (DD) is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream channels. As indicated in Table 6.4-1, all delineated catchments are characterised by poor drainage. DD below zero (0) indicates poor drainage characteristics.

Table 0-4: Drainage Density Calculations

Description	Surface Area (km^2)	Hydraulic Length (km)	Drainage Density (km/km^2)
C22A	550	37	0.07
Effective catchment	206	21.7	0.11
Catchment 1	33.9	10	0.29
Catchment 2	10.7	5	0.47
Catchment 3	24	4	0.17
Catchment 4 A	7.45	1.9	0.26
Catchment 5	5.39	1	0.19

7. FIELD INVESTIGATIONS

3 site visits were conducted as follows:

- Initial Site Visit – Project Initiation
- Detailed Investigation
- Ground Truthing for confirmation of findings.

7.1. Initial Site Visit

The initial site visit was conducted on the 10th of February 2016. During this site visit relevant specialists met on site and the project co-ordinators briefed everyone about the purpose of the project. It was during this site visit and the initial scope given that the focus of the project will be on to two WMUs, namely the Klip Middle Soweto and Klip Upper Rietspruit. The focus during this visit was along the Klip River Wetland system in the Lenasia and Soweto area

General weather conditions on the day of the site visit were as follows:

- Sunny;
- No Cloud cover; and
- No precipitation.

7.2. Detailed Site Investigation

After the appointment of Letsolo to conduct a Hydrological study for the proposed project, a detailed site investigation was conducted on the 19th of April 2016. During this site visit there were findings observed which are discussed briefly in **Paragraph 7.2.1** below.

General weather conditions on the day of the site visit were as follows:

- Sunny;
- No Cloud cover; and
- No precipitation.

7.2.1. Findings – Site investigations

In general the area can be described as urban settlement with the main land use being low-density residential housing bordering the city's mining belt in the south. It consists of several townships that are boarded by the main roads, within the townships there are informal settlements. The most dominant land use in Soweto is low-density residential housing and vacant agricultural land to the western edge of the Region. There are several informal settlements as well as constraints to development such as the mine dumps and ridges.

7.2.2. Ground truthing

The well recognized parks, such as Orlando West, Thokoza, and Dorothy Nyembe parks, were observed and they're part of the study area within the Klip Middle Soweto WMU. The maintenance schedule is implemented by City Parks, however domestic waste disposal at these parks remains an ongoing challenge.

Table 7-1: Site Observations

Picture 7-1:Solid Waste Disposal along river near Orlando West Park (1)

Picture 7-2: Solid Waste Disposal at Orlando West Park (2)

Picture 7-3: **Solid waste dumping at stream 3 within Dorothy Nyembe Park**

Picture 7-4: **Solid waste within the residents staying close to the Stream 3 and Dorothy Nyembe**

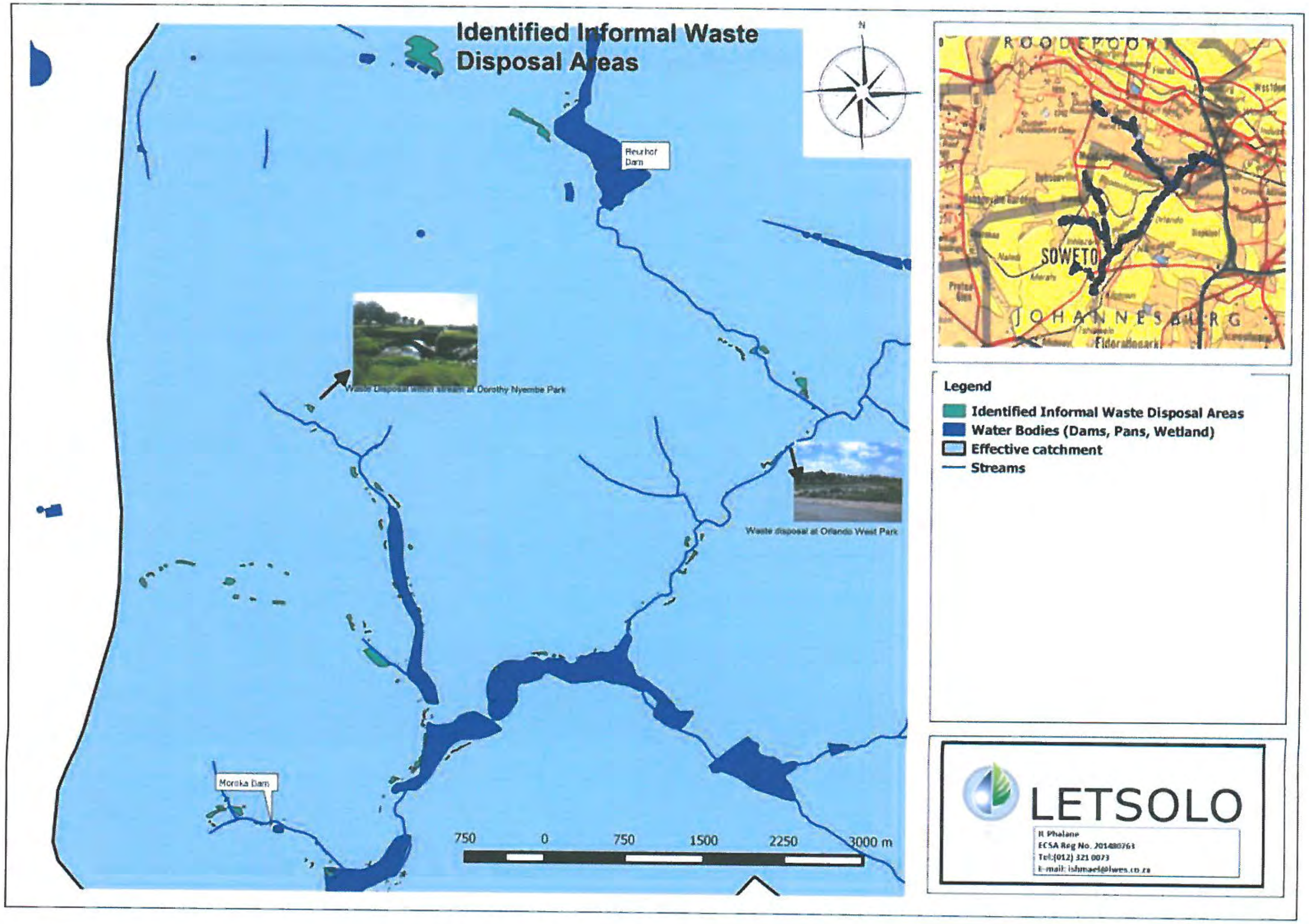


Figure 7-1: Identified Informal Waste Disposal Areas

8. WATER QUALITY MANAGEMENT

8.1. Selection of Water Quality Monitoring Points

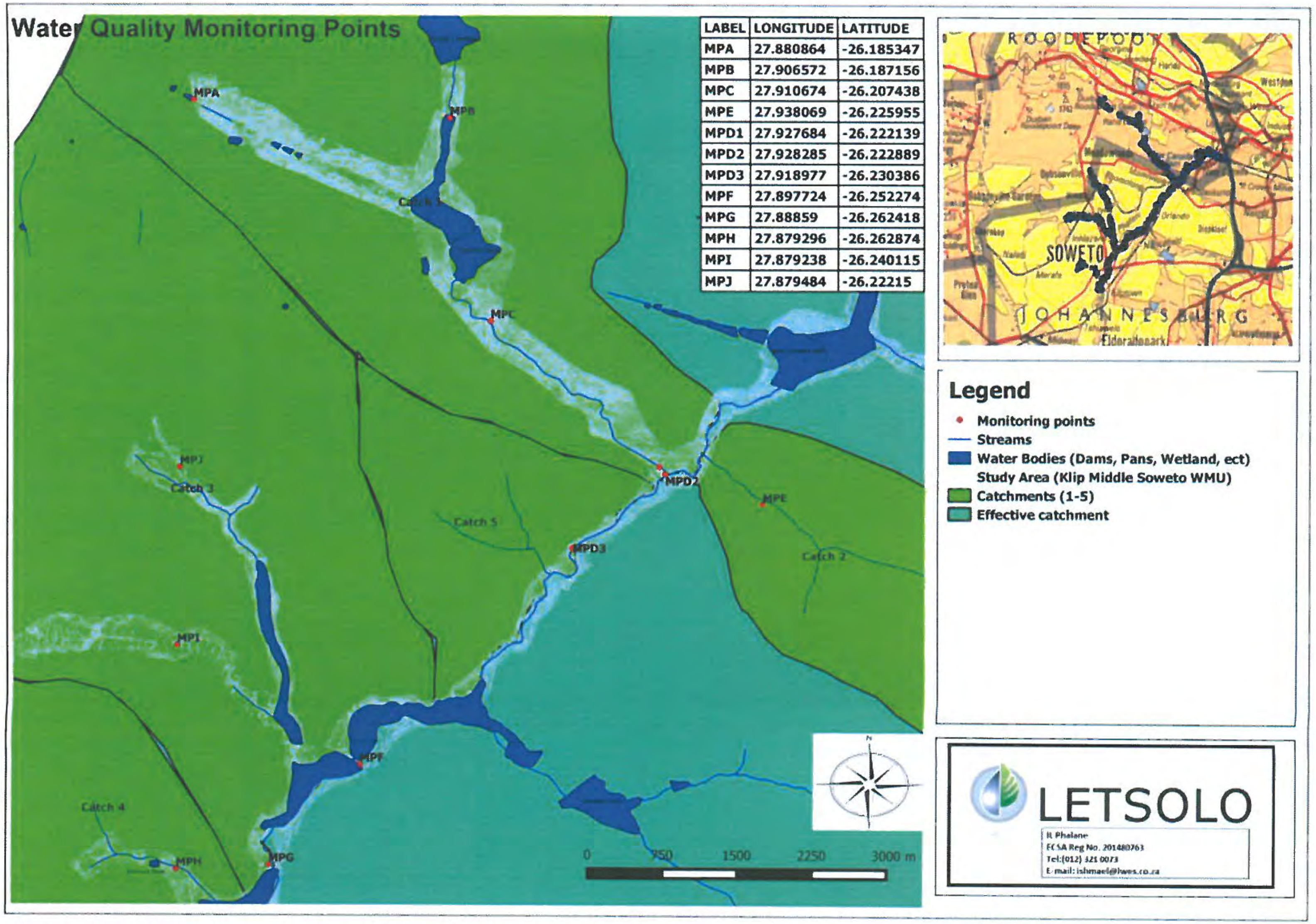
The following points within the study area are recommended for surface water sampling as summarised in the **Table 8.1-1** and shown in Figure 9 below. These are to indicate the overall water quality within the Klip Middle Soweto WMU.

Table 8-1: Water Quality Monitoring points

Klip Middle Monitoring Points					
	Coordinates		Field Observation		
	Latitude	Longitude	Colour	Description	Site pictures
MP A	26° 11' 07.25" S	27° 52' 51.11" E	Reddish brown	Small stream located Downstream of the Mining slime dam. There's little flow at this point as the point is located at the upper reach of the catchment. The source of this polluted water could not be confirmed if it is decant or capillary water from the slimes dam. However, the Laboratory results confirm the presence of mining related indicator variables.	
MP B	26° 11' 13.76" S	27° 54' 23.66" E	Clear	Point located Upstream of the tributary of Klipspruit and Downstream of Florida Dam.	
MP C	26° 12' 26.78" S	27° 54' 38.43" E	Clear	Point located on the Tributary of Klipspruit, Downstream of Fleurhof Dam.	

					
MP D1	26° 13' 19.70" S	27° 55' 39.66" E	Clear	Point located Downstream of the tributary of Klipspruit- Soweto Highway Bridge.	
MP D2	26° 13' 22.40" S	27° 55' 41.83" E	Greyish	Point located on Klipspruit- Upstream of site (Soweto Highway)	
MP D3	26° 13' 49.39" S	27° 55' 08.32" E	Grey	Confluence of two streams indicating the quality of Monitoring points D1 and D3, near Orlando West Stadium.	

MP E	26° 13' 33.44" S	27° 56' 17.05" E	Greyish black with white foam	Point located on Stream 2 at Orland East - Tributary of Klipspruit River.	
MP F	26° 15' 08.19" S	27° 53' 51.81" E	Brown	Point located on Klipspruit Valley road	
MP G	26° 15' 44.70" S	27° 53' 18.92" E	Brown	Point Located on Klipspruit	
MP H	26° 15' 46.35" S	27° 52' 45.47" E	Brown	Point located on Stream 4 at Thokoza Park, downstream of Moroka Dam.	
MP I	26° 14' 24.41" S	27° 52' 45.26" E	Clear	Point Located at Stream 4 at Mshenguville park where the Development of a park is recommended.	
MP J	26° 13' 19.74" S	27° 52' 46.14" E	Clear	Point located on Stream 3 at Dorothy Nyembe Park.	



LABEL	LONGITUDE	LATITUDE
MPA	27.880864	-26.185347
MPB	27.906572	-26.187156
MPC	27.910674	-26.207438
MPE	27.938069	-26.225955
MPD1	27.927684	-26.222139
MPD2	27.928285	-26.222889
MPD3	27.918977	-26.230386
MPF	27.897724	-26.252274
MPG	27.88859	-26.262418
MPH	27.879296	-26.262874
MPI	27.879238	-26.240115
MPJ	27.879484	-26.22215

Figure 8-1: Water Quality Monitoring Points

8.2. Selection of Indicator Variables

The extent of the study area as well as observed activities, were taken into consideration in selection of the indicator variables to assess the surface water quality. The upstream part of the study area is characterised by mining and mining related activities. Slimes dams were observed on site. For this reason, metal were analysed to determine the impact of mining activities on the Klip Middle Soweto WMU. The indicator variables assessed are grouped as follows:

- Physio-Chemical parameters (pH, EC & TDS)
- Metals (Al, Fe, Mn, & Ni)
- Nitrogen-species parameters (NO3, NO2, & Ammonia as N) – Focus given to Ammonia only
- Major Ionic and Phosphorus constituents (SO4 & orthophosphate as P)

8.3. Sampling procedure:

Grab surface water samples were collected, where possible, from the center part of the stream in order to ensure representative samples. The samples were submitted to the accredited analytical laboratory (accredited in terms of the South African National Accreditation System) in a cool, dark insulated container under strict chain-of-custody (CoC) protocols.

8.4. Guidelines

Surface water quality tolerances for drinking / domestic and irrigation water use and for aquatic ecosystem are compared to the following guidelines / standards:

- Department of Water Affairs and Forestry (DWAF) South African Water Quality Guidelines Volume 1 for Domestic Use (1996a) - This category includes primarily human consumption but also bathing and other household uses (washing, laundry, gardening, etc.) and requires a certain set of Target Water Quality Ranges (DWAF 1996a);
- South African Bureau of Standards (SABS) SANS 241-1 2015 Standard Limits for Potable Water- The drinking water guidelines were used as they are the most comprehensive set of standards and provide for a "worst case" scenario where the water is unintentionally used for consumption by humans. Both the DWAF and the SABS standards for drinking water were referred to in this report.

- DWAF South African Water Quality Guidelines Volume 4 for Irrigation (1996b) - Water quality is also important for agriculture use for irrigation and livestock watering. Changes in water quality of irrigation water may reduce crop yield, impair crop quality and soil suitability and damage irrigation equipment (DWAF 1996b). The Target Water Quality Ranges for irrigation water vary slightly and the concentrations are sometimes lower than those for domestic use; and

- DWAF South African Water Quality Guidelines Volume 7 for Aquatic Ecosystems (1996d) - For protecting and maintaining the health of aquatic ecosystems differ from those of other water uses (DWAF 1996d). It is difficult to determine the effects of changes in water quality on aquatic ecosystems as the cause-effect relationships are not well understood. Therefore, water quality criteria have to be derived indirectly through extrapolation of the known effects of water quality on a very limited number of aquatic organisms (DWAF 1996d). Certain quality ranges are required to protect and maintain aquatic ecosystem health. Changes in water quality should be prevented rather than mitigated as it is seldom possible to mitigate the effects of poor water quality for aquatic ecosystems to the same degree as for other uses.

These guideline documents prescribe the recommended concentration of the typical constituents found in water used for human consumption and agricultural use as well as the requirements for the aquatic ecosystem. The recommended concentrations are referred to as "Target Water Quality Range" (TWQR) which is described as the "No Effect Range" and specifies good or ideal water quality (DWAF, 1996a).

8.5. Catchment Based - Water Quality Interpretation

Wetlands can be difficult to define because of their great variation in size and location. In Soweto a prominent wetland system was observed and the CoJ has developed parks along the river wetland systems in Soweto. To name a few that were observed during site visit, the Dorothy Nyembe (MPJ) and Thokoza (MPH) parks being recognized as one of the eco-parks within Soweto. These parks were built to promote the conversation of biodiversity along the rivers through rehabilitation of the wetlands. Another park, Orlando West park (MPD3) facing the Orlando stadium in Soweto was built on a wetland theme to tie in the wetland at the lower end of the park.

As part of CoJ mandate to interlink park nodes or open spaces along the Klip River and Klipspruit, surface water quality is necessary to assess. There are numerous dams and wetland system at Soweto which serve a number of functions in managing freshwater quality and flow. Both the dams and wetlands can act as filters allowing sediments and nutrients (such as nitrogen and phosphorus) to settle down as well as pollutants such as heavy metals which can be trapped by chemical and biological processes (Strydom and King, 2009).

The findings indicate that water quality from the Klipspruit and its tributaries is of poor quality on average and is not suitable for domestic use purposes. Indicator variables of pollutants from various sources where identified in the Laboratory analysis report. Activities which impacts negatively on surface water can be categorised as follows:

- Storm water from urban runoff,
- Sedimentation and siltation,
- Domestic waste disposal along river systems,
- Sewage and mining effluents.

8.5.1.Water Quality Findings – Catchment 1

Looking at catchment 1 water quality monitoring conducted in upstream and downstream of Fleurhof dam along stream 1, reveals that the metals together with Total Dissolved Solids (TDS) are higher downstream than upstream except for Iron (Fe) and Aluminium (Al).

8.5.2.Water Quality Findings – Catchment 2

Catchment 2 is not downstream of Catchment 1, but is located on a different water system upstream of the Klipspruit. There's high concentration of metals, Electrical Conductivity (EC), TDS and Sulphates (SO_4). A distinct difference with catchment 2 is that a unique blackish grey colour was observed during site visit leading to assumption that stream 2 has effluent of sewage though point source of sewage plant was not observed. This assumption was further confirmed by the analysis of Ammonia and Phosphate which showed relatively high concentrations in comparison with other monitoring points.

Similarities between Catchment 1 and 2 is the geographical setting. Both Catchments are characterised by mining and related activities.

8.5.3.Water Quality Findings – Catchment 3

Quality of Catchment 3, 4 and 5 is of better quality compare to catchment 1 and 2 discussed above.

General chemistry of Catchment 3 indicates high concentration of Ammonia. Dorothy Nyembe Park is located in Catchment 3.

8.5.4. Water Quality Findings – Catchment 4

As observed on site, domestic waste is disposed of within the water course at the park itself and there's a brick making facility close to the park. Thokoza Park is located within Catchment 4. When compared to Dorothy Nyembe Park, there are less illegal domestic waste disposal activities at this park. However, negative aesthetic water quality observations (Colour and Odour) were made. The colour of the water sample collected was darker. According to SANS 241-1 2015 only Manganese (Mn), Fe and Ammonia (NH_4) are exceeding the standard limit while the other variables are within the limit in catchment 4.

8.5.5. Water Quality Findings – Catchment 5

Generally, Catchment 5 concerned has the high iron concentration in relation to other catchments (except for MPA located in catchment 1). However, other variables are of lower concentration when compared to other catchments. Orlando West Park falls within Catchment 5. Domestic waste is disposed of at some areas at Orlando West Park. The source of iron (Fe) at this monitoring point is concluded to be from the wash away of sedimentation and siltation at the banks of Klipspruit.

Table 0-1: Water Quality Results

Analyses in mg/ℓ (Unless specified otherwise)				***Sample Identification***												
NB Colouring block Std limit exceeding key: SANS 241-1 2015 DWA (drinking/domestic use) DWA (Irrigation)**	***DWA SAWQTV Irrigation***	***DWA SAWQTV (Drinking/Domestic Use)***	***SANS 241-1 2015 (Standard Limits for Potable Water)***	***MP A***	***MP B***	***MP C***	***MPD 1***	***MPD 2***	***MPD 3***	***MP E***	***MP F***	***MPG***	***MP H***	***MPI***	***MP J***	**Average**
pH – Value at 25°C	6.5 - 8.4	6 – 9	≥ 5 to ≤ 9.7	2.7	6.1	6	6.5	6.4	6.6	6.7	6.8	6.8	7	7.1	7.2	**6.325**
Electrical Conductivity in mS/m at 25°C	<40	<70	≤ 170	1118	22.7	54.2	54.8	71	67.2	84.4	56.7	54.2	34.9	44.2	28.1	**140.8667**
Total Dissolved Solids at 180°C *	NS	<450	≤ 1 200	22314	86	366	344	414	376	436	326	316	214	254	166	**2134.333**
Total Alkalinity as CaCO3	NS	NS	---	<5	44	12	88	136	144	180	140	144	108	144	80	**110.9091**
Chloride as Cl	<100	<100	≤ 300	51	12	22	29	55	49	45	38	37	21	37	17	**34.41667**
Sulphate as SO4	NS	<200	≤ 500 ≤ 250	12994	12	184	140	106	95	171	83	105	40	30	35	**1166.25**
Fluoride as F	<2	<1	≤ 1.5	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	**0.2**
Nitrate as N	NS		≤ 11	<0.1	<0.1	8.4	2.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	1	1.5	**2.68**
Nitrite as N			≤ 0.9	<0.05	<0.05	0.6	0.3	<0.05	<0.05	<0.05	<0.05	<0.05	0.3	0.3	0.2	**0.34**
Ortho Phosphate as P	NS	NS	---	<0.1	<0.1	<0.1	<0.1	0.5	0.6	1.4	0.1	<0.1	0.3	0.3	<0.1	**0.533333**
Free & Saline Ammonia as N	NS		≤ 1,5	8.9	0.1	7.5	5.8	20	20	33	12	10	5.6	37	0.4	**13.35833**
Sodium as Na	<70	<100	≤ 200	65	7	18	25	46	44	48	35	32	21	27	14	**31.83333**
Potassium as K	NS	<50	---	<0.5	2	5.8	6.2	12	10.5	9.5	8.3	7.5	5.5	4.9	2.8	**6.818182**
Calcium as Ca	NS	<32	---	431	13	46	46	37	37	46	33	34	26	30	26	**67.08333**
Magnesium as Mg	NS	<30	---	439	4	15	14	14	14	15	13	13	10	16	9	**48**
Aluminium as Al	<5	<0.15	≤ 0.3	841	1.89	0.214	<0.100	1.66	2.46	1.02	0.627	0.536	0.275	<0.100	<0.100	**94.40911**

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Arsenic as As *	<0.1	<0.01	≤ 0.01	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.01**
Barium as Ba *	NS	NS	≤ 0.7	<0.025	0.029	0.032	0.034	0.077	0.082	0.049	0.05	0.052	0.07	0.052	0.053	**0.052727**
Beryllium as Be *	<0.10	NS	---	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	**#DIV/0!**
Boron as B *	<0.5	NS	≤ 2.4	0.488	<0.025	0.049	0.05	0.097	0.089	0.048	0.074	0.07	0.05	0.034	0.028	**0.097909**
Cadmium as Cd	<0.01	<0.005	≤ 0.003	0.399	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**0.201**
Chromium as Cr	NS	0.05	≤ 0.05	0.663	<0.025	<0.025	<0.025	<0.025	0.036	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	**0.3495**
Cobalt as Co	<0.05	NS	---	18	<0.025	0.054	<0.025	0.087	0.089	0.117	0.044	0.04	<0.025	<0.025	<0.025	**2.633**
Copper as Cu	<0.2	<1	≤ 2	1.53	<0.010	<0.010	<0.010	0.031	0.012	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.524333**
Iron as Fe	<5	<0.1	≤ 2 ≤ 0.3	3350	10	1.38	0.384	9.83	14	5.4	5.73	5.05	0.535	0.451	0.238	**283.5873**
Lead as Pb	<0.2	<0.01	≤ 0.01	0.186	<0.010	<0.010	<0.010	0.016	0.017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.073**
Manganese as Mn	<0.02	<0.05	≤ 0.4 ≤ 0.1	101	0.146	3.26	2.92	2.32	2.28	4.96	1.64	1.61	0.709	0.147	0.202	**10.0995**
Molybdenum as Mo *	<0.01	NS	---	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	**#DIV/0!**
Nickel as Ni	<0.20	NS	≤ 0.07	26	<0.025	0.149	<0.025	0.164	0.194	0.118	0.076	0.068	<0.025	<0.025	<0.025	**3.824143**
Strontium as Sr *	NS	NS	---	0.438	0.05	0.125	0.196	0.189	0.194	0.15	0.165	0.17	0.132	0.157	0.123	**0.174083**
Vanadium as V *	<0.10	<0.1	---	0.169	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	**0.169**
Zinc as Zn	<1	<3	≤ 5	35	<0.025	0.093	<0.025	0.397	0.471	0.128	0.117	0.086	0.028	<0.025	<0.025	**4.54**
% Balancing *			---	95.1	95.5	97.1	95	98	97.1	98.7	97.3	90.7	99.5	94.2	97	**96.26667**

8.6. Site specific / Monitoring Point Based - Water Quality Interpretation

The results presented in Table 8.5-1, were used to provide more information on the chemical composition of the samples collected. Detailed Water Quality Findings were simplified as follows:

- Physio-Chemical parameters
- Metals
- Nitrogen-species parameters
- Major Ionic and Phosphorus constituents

8.6.1. Physico-Chemical Parameters

The following Indicator Variables were assessed:

- pH;
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)

8.6.1.1. pH

The overall average pH of the study area is 6.3 and falls within the SANS 241-1 2015 limit. There is gradual increase of the ph value further downstream of MPA (see **Figure 8.6.1.1-1** below) and because of other tributaries influencing the main river system of the study area.

MPA has acidic water because of the mining related impacts and MPJ is more basic water (alkaline) as the quality gets diluted.

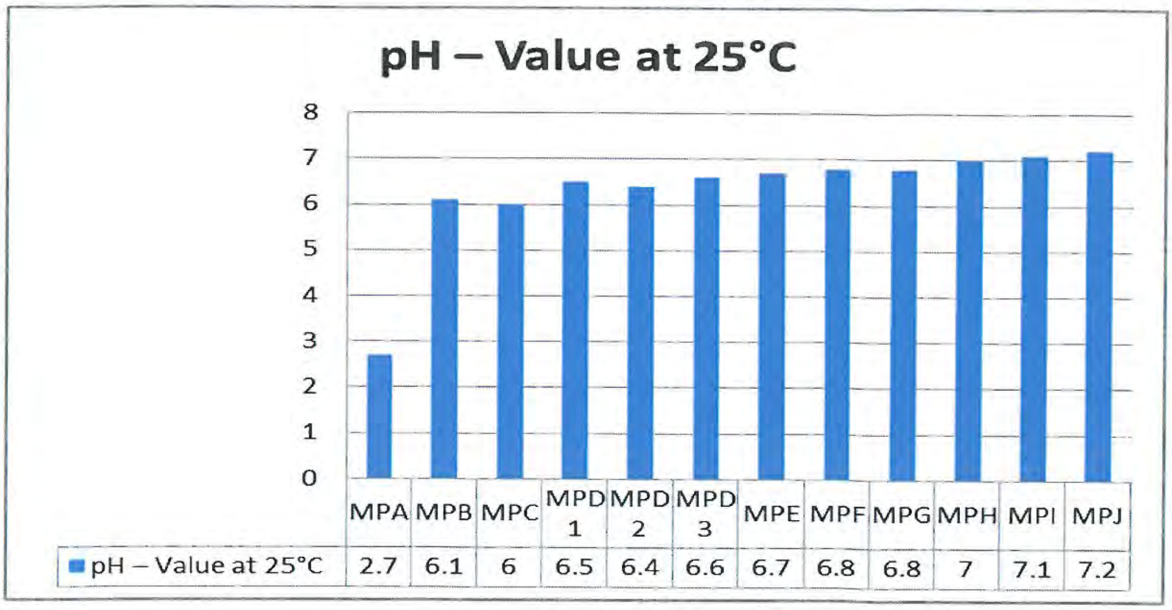


Figure 0-1: pH comparison throughout all the monitoring points

8.6.1.2. EC Profile

The electrical conductivity of water estimates the total amount of solids dissolved in water –TDS (Total Dissolved Solids). TDS is any form of minerals, metals, salts, cations or anions present in water other than pure water molecule and suspended solids (HM Digital, 2008-2012), The electrical conductivity of the water depends on the water temperature: the higher the temperature, the higher the electrical conductivity would be. This directly proportional relationship was observed within the effective catchment and Catchment 1. It is therefore concluded that higher concentration of EC result in higher TDS within the water quality of these catchments.

EC Profile was produced for the following Riverine Systems

- Effective Catchment Area
- Catchment 1

(See details in Paragraphs 8.6.1.2.1 and 8.6.1.2.2 below)

8.6.1.2.1. EC Profile for Effective Catchment Area

The table below indicates the lab results of the physical determinants (pH, electrical conductivity (EC), and total dissolved solids (TDS)) of the water within the respective monitoring points along the Klipspruit, of which is the main river within the catchment of the study area. The results are interpreted in the profile of EC in figure 8.6.1.2.1-1 below.

Table 0-2: Lab results of the physical determinants along the Klipspruit

EC profile for Effective catchment			
	pH – Value at 25°C	*Electrical Conductivity in mS/m at 25°C*	*Total Dissolved Solids at 180°C **
SANS 241-1 2015	≥ 5 to ≤ 9.7	≤ 170	≤ 1 200
MPD2	6.4	71	414
MPD3	6.6	67.2	376
MPF	6.8	56.7	326
MPG	6.8	54.2	316
EC Average	**6.65**	**62.275**	**358**

According to SANS 241, electrical conductivity in water quality has the standard of 170mg/l. From the monitoring points in table 8.6.1.2.1-1 above, it is clearly that most of the samples are relatively below the average EC of 62.3 mS/m. The highest concentration is seen in the monitoring point – MPD2 with a value of 71 mS/m. The lowest concentration is downstream of the Klipspruit at monitoring point MPG with a value of 54.2 mS/m at 25^{0}C.

The observation between the monitoring points in Klipspruit within the effective catchment as figure 8.6.1.2.1-1 illustrate a decrease of EC and TDS, and an increase of the pH from upstream to downstream of Klipspruit. Klipspruit has lot of tributaries that could influence an increase of pH which is observed in the water quality results in paragraph 8.6.1.1. The impacts of other tributaries contributing to the water quality of the Klipspruit could explain the change in colour of the water of the stream from being grey to brown, as observed in the field. This indicates dilution of the total dissolved solids within the water. All the physical parameters of the stream within the effective catchment are within the SANS 241-1 2015 limit standards as seen in table 8.6.1.2.1-1 above.

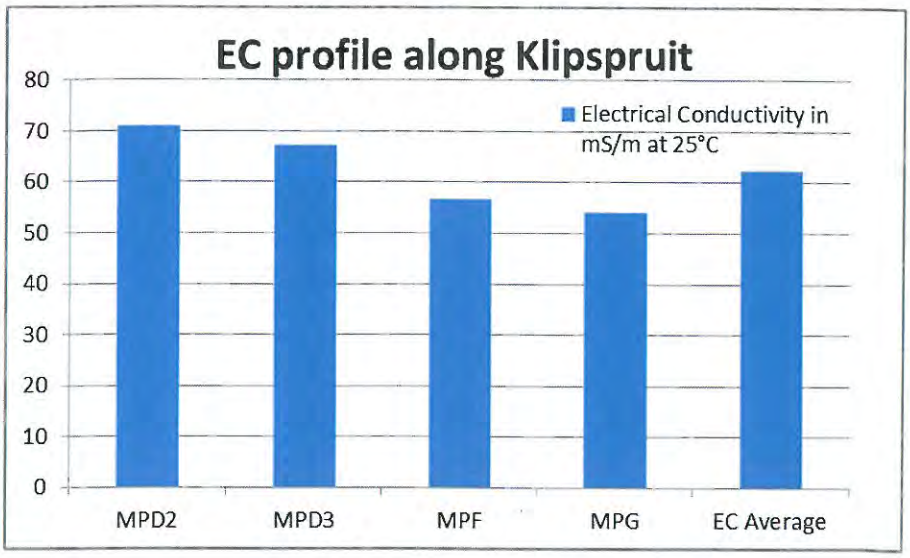


Figure 0-2: EC profile along Klipspruit

8.6.1.2.2. EC Profile for Catchment 1

The table below indicates lab results showing the physical determinants (pH, EC, & TDS) within catchment 1 with its respective monitoring points. From the monitoring points in table 2 below, it is clearly that the highest concentration of the EC is seen in the monitoring point (MPA) with a value of 1 118 mS/m, this value exceeds the standard limit. Highest concentration of the TDS also observed in MPA with value of 22 314 mg/L is above the limit according to SANS 241-1 2015.

Table 0-3: Physical determinants within catchment 1

EC profile for catchment 1			
	pH – Value at 25°C	Electrical Conductivity in mS/m at 25°C	Total Dissolved Solids at 180°C *
SANS 241-1 2015	≥ 5 to ≤ 9.7	≤ 170	≤ 1 200
MPA	2.7	1118	22314
MPB	6.1	22.7	86
MPC	6	54.2	366
MPD1	6.5	54.8	344
Average	4.9	312.4	5777.5

According to SANS 241-2015, electrical conductivity in water quality has the standard of 170mg/l. However it is observed that most of the samples have relatively low concentration of the EC, with the lowest value of 22.7 mS/m observed in MPB.

Within catchment 1 the main stream, called stream 1, has relatively three monitoring points which are MPB (Upstream), MPC, and MPD1 (Downstream). **Figure 8.6.1.2.2-1** below which summarizes the change in EC concentrations along the stream. There is an increase in the concentration of EC from upstream to downstream of stream 1.

MPA is located within a non-perennial stream that discharges into Stream 1 after MPB. MPB had low flow during the date of monitoring. MPA had an impact on the quality of the water within the catchment 1 as the average of the EC & TDS is above the limits of SANS 241-1 2015.

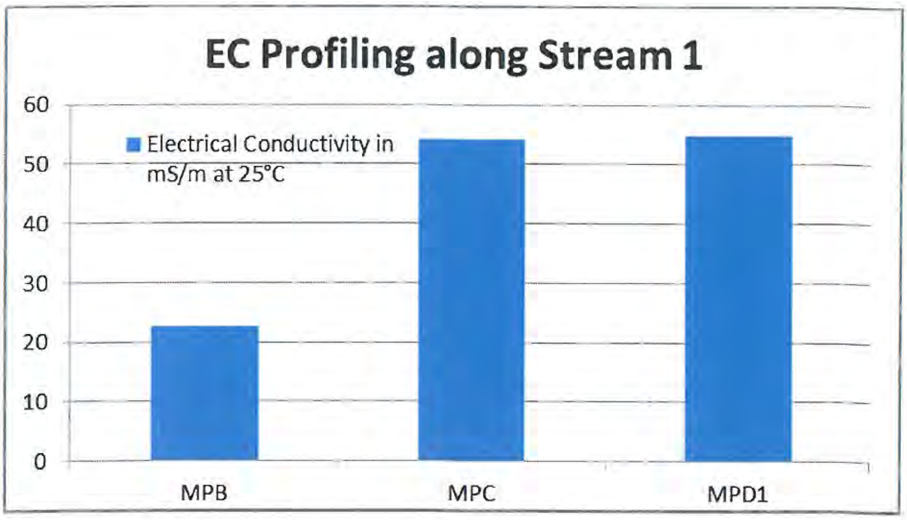


Figure 0-3: EC profiling along stream 1

8.6.2.Metalloids

The results for the metals that are of concern within the study area are given in the table below. Because of proximity to the old mines, traces of metals were expected to be pragmatic in lab results. This was to confirm the field observations of high concentration of metals especially in MPA which has relatively high amounts of metals (see figure (a) &(b) below), and to investigate the impact this stream has in the overall water system of the study area.

The table below indicates that the water quality from the water systems has traces of the metals that can be confirmed to be from the mines. All four variables of concern are above the SANS 241-1 2015 standard limit in terms of their average within the monitoring points.

In summary of the table and figure below, metals in catchment 1 are higher exceeding the respective SANS 241-1 2015 limits except for the Mg and Ni being low at MPB. This concentrations influence the quality of the water in Klipspruit as stream 1 discharges after the MPD1 upstream of the Klipspruit in the effective catchment. This controlled the metals concentration found in MPD3 being higher than all the other monitoring points within this catchment. Moving downstream of the Klipspruit there are many tributary streams that dilute the concentration of the metals hence a decrease is observed.

Table 8.6.2-1: Results of Metalloids

Metalloids constituents	SANS 241-1 2015 (Standard Limits for Potable Water)	MPA	MPB	MPC	MPD1	MPD2	MPD3	MPE	MPF	MPG	MPH	MPI	MPJ	Average
Iron as Fe	≤2 ≤0.3	3350	10	1.38	0.384	9.83	14	5.4	5.78	5.06	0.535	0.451	0.238	283.587
Aluminium as Al	≤0.3	841	1.89	0.214	<0.100	1.66	2.46	1.02	0.627	0.536	0.275	<0.100	<0.100	94.4091
Manganese as Mn	≤0.4 ≤0.1	101	0.146	3.26	2.92	2.32	2.28	4.96	1.64	1.61	0.709	0.147	0.202	10.0995
Nickel as Ni	≤0.07	26	<0.025	0.149	<0.025	0.164	0.194	0.115	0.076	0.068	<0.025	<0.025	<0.025	3.82414

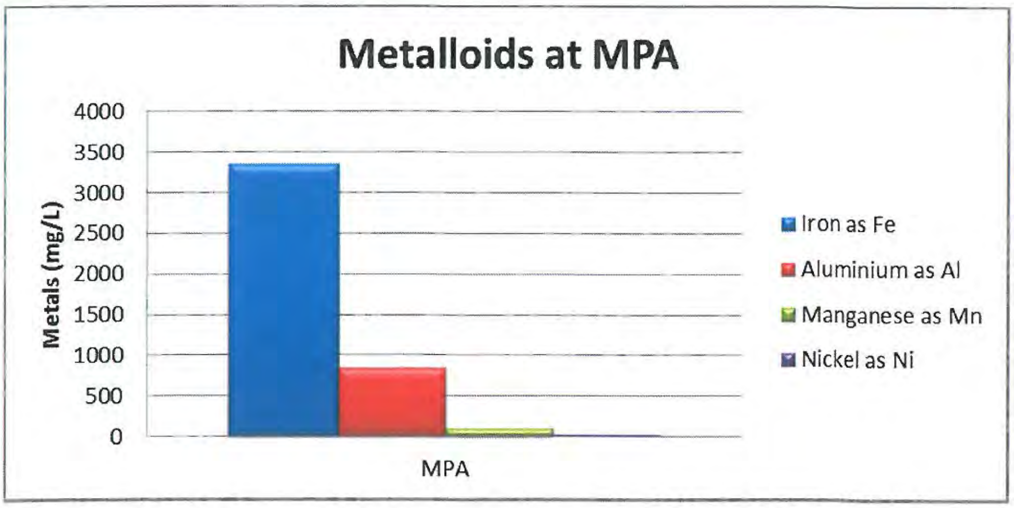


Figure 8.6.2-1: Metals at MPA exceeding SANS 241-1 2015.

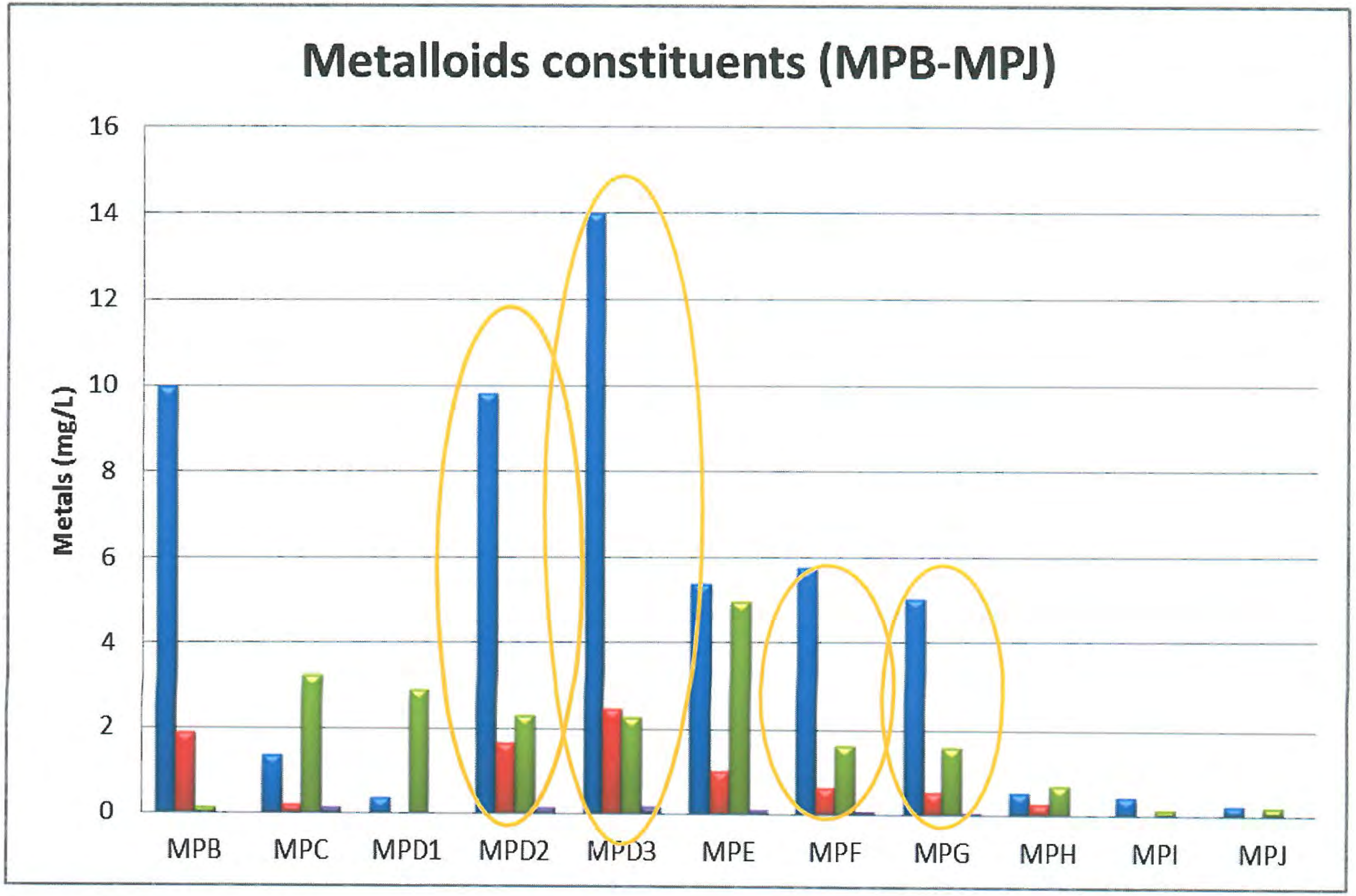


Figure 8.6.2-2: Comparison of metals between MPB & MPJ (circled monitoring points are within Klipspruit).

- Fe

The iron concentration is relatively high for MPA with a value of 3 350 mg/L and low at MPJ with a value of 0.238 mg/L. An average of the monitoring points within the water systems of the study area is 283.6 mg/L which is above the SANS 241-1 2015 limit of 2 mg/L for chronic health or 0.3 mg/L for aesthetic.

- Mn

The Mn concentration is relatively high in MPA with a value of 101 mg/L, followed by MPE with a value of 4.96 mg/L, and low at MPB with a value of 0.146 mg/L. Overall Mn average is 10.1 mg/L which is high than the SANS 241-1 2015 standard limit of 0.4 for chronic health and 0.1 for aesthetic. MPA and MPE are in different water systems contributing to the effective catchment.

- Al

Aluminium concentration is high at MPA with a value of 841 mg/L followed by MPD3 with a value of 2.46 mg/L. there's less traces of Al at MPD1, MPI & MPJ with a value of <0.1 mg/L. An average of 94.4 mg/L value is observed because of the influence from MPA.

- Ni

Nickel concentration has high concentration at MPA as seen in figure (a), and severely low at MPB, MPD1 and MPJ with a value of <0.25 mg/L. Because of MPA the average value of 3.8 mg/L for Ni is above the SANS 241-1 2015 limit of 0.7 mg/L.

8.6.3. Nitrogen- species parameters

The figure below indicates the concentration of ammonia within the monitoring points. According to SANS 241-1 2015 the standard limit for Ammonia has to be less than 1.5 mg/L, meaning for the study area only MPB and MPJ are within that limit. The other monitoring points are above the limit with the highest value of 37 mg/L observed at MPI followed by MPE with a value of 33 mg/L. The average ammonia for the entire study area is 13.3 mg/L which is above the limit. The logic understanding for high concentration at MPI is because of animal excretion and waste dumping at that area while at MPE it could be because of the sewage system.

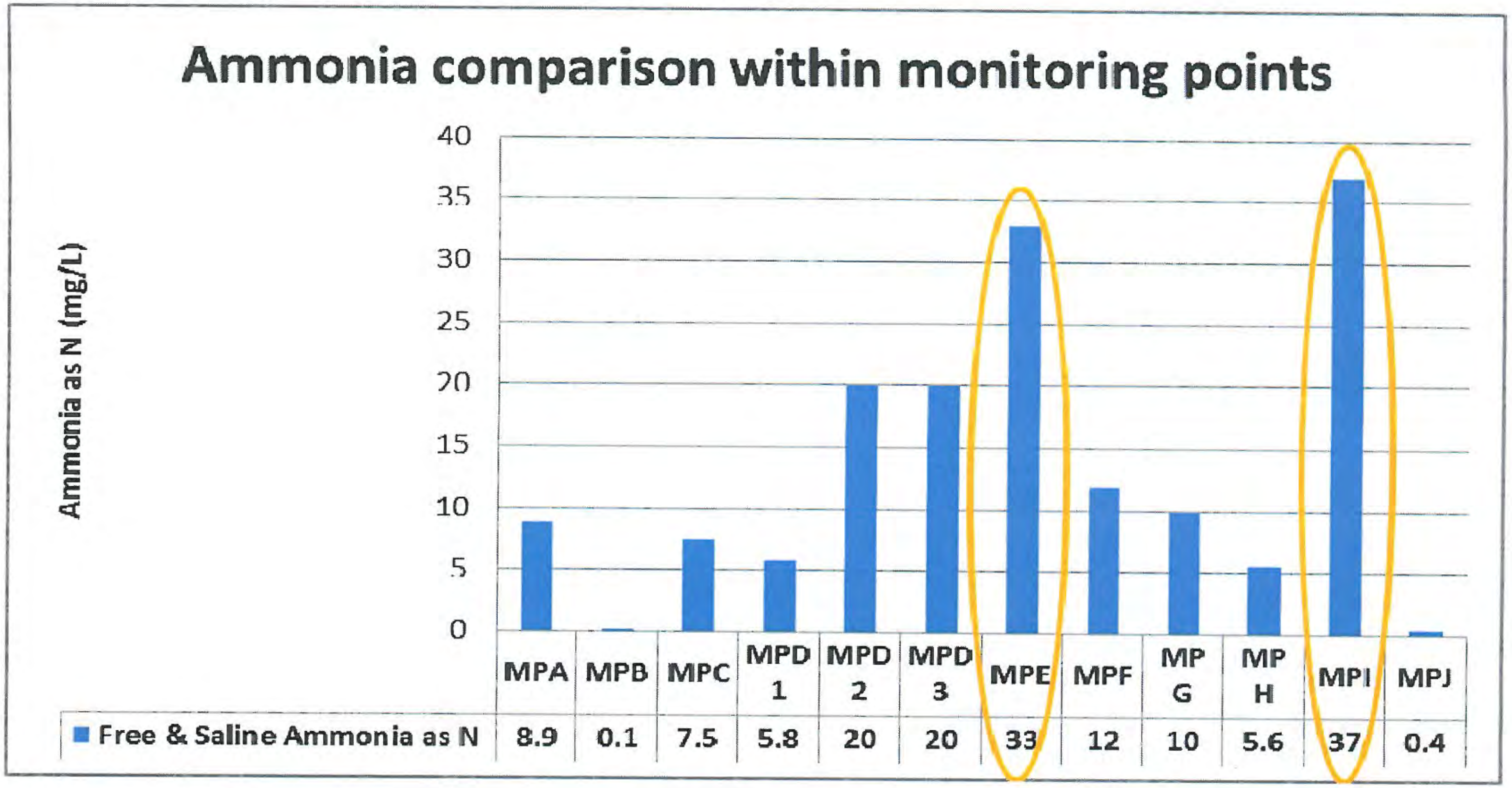


Figure 8.6.2-3:: Comparison of Ammonia concentration along the monitoring points (observable high values at MPE & MPI).

Analysis of chemical constituents such as SO_4, NO_3, NO_2 & P

Sulphate occurs naturally in numerous minerals and its salts of sulfuric acid and many are prepared from that acid. Higher levels of sulphate in any water source can be indicative of some form of pollution. High sulphate concentrations in water can accelerate corrosion of metals, especially iron.

Table 8.6.2-2: Analysis of chemical constituents such as SO_4, NO_3, NO_2 & P.

Analyses in mg/ℓ				*Sample Identification*												
NB** Colouring block key: Red- SANS 241-1 2015 Green - DWA (drinking/domestic ue) Blue - DWA (Irrigation)	*DWA SAWQTV Irrigation*	*DWA SAWQTV (Drinking/Domestic Use)*	*SANS 241-1 2015 (Standard Limits for Potable Water)*	*MPA*	*MPB*	*MPC*	*MPD1*	*MPD2*	*MPD3*	*MPE*	*MPF*	*MPG*	*MPH*	*MPI*	*MPJ*	Average
Total Dissolved Solids at 180°C *	NS	<450	≤1 200	22314	86	366	344	414	376	436	326	316	214	254	166	2134.333
Chloride as Cl	<100	<100	≤300	51	12	22	29	55	49	45	38	37	21	37	17	34.41667
Sulphate as SO4	NS	<200	≤500 ≤250	12994	12	184	140	106	95	171	83	105	40	30	35	1166.25
Fluoride as F	<2	<1	≤1.5	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nitrate as N	NS		≤11	<0.1	<0.1	8.4	2.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	1	1.5	2.68
Nitrite as N			≤0.9	<0.05	<0.05	0.6	0.3	<0.05	<0.05	<0.05	<0.05	<0.05	0.3	0.3	0.2	0.34
Ortho Phosphate as P	NS	NS	---	<0.1	<0.1	<0.1	<0.1	0.5	0.6	1.4	0.1	<0.1	0.3	0.3	<0.1	0.533333

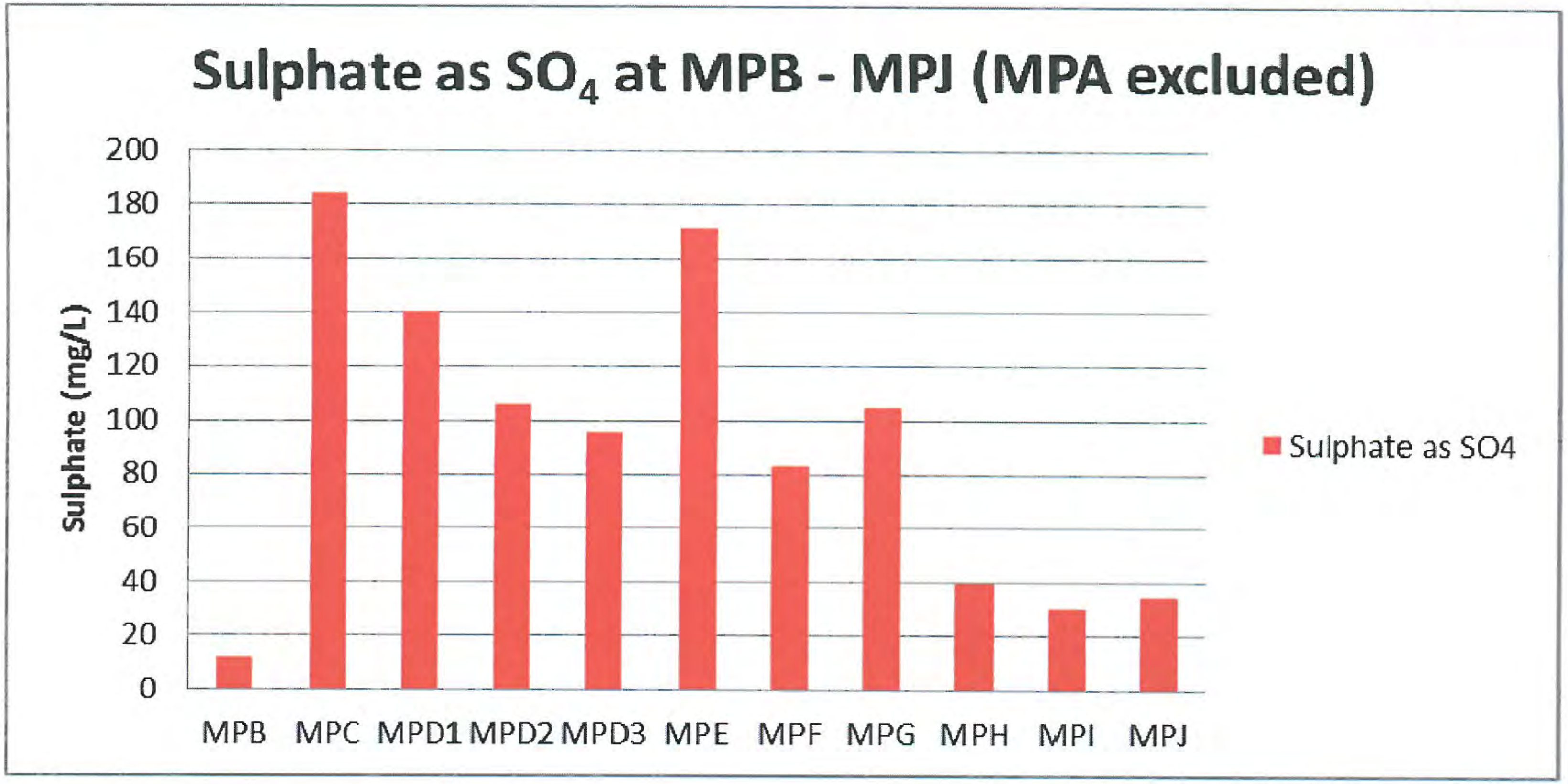
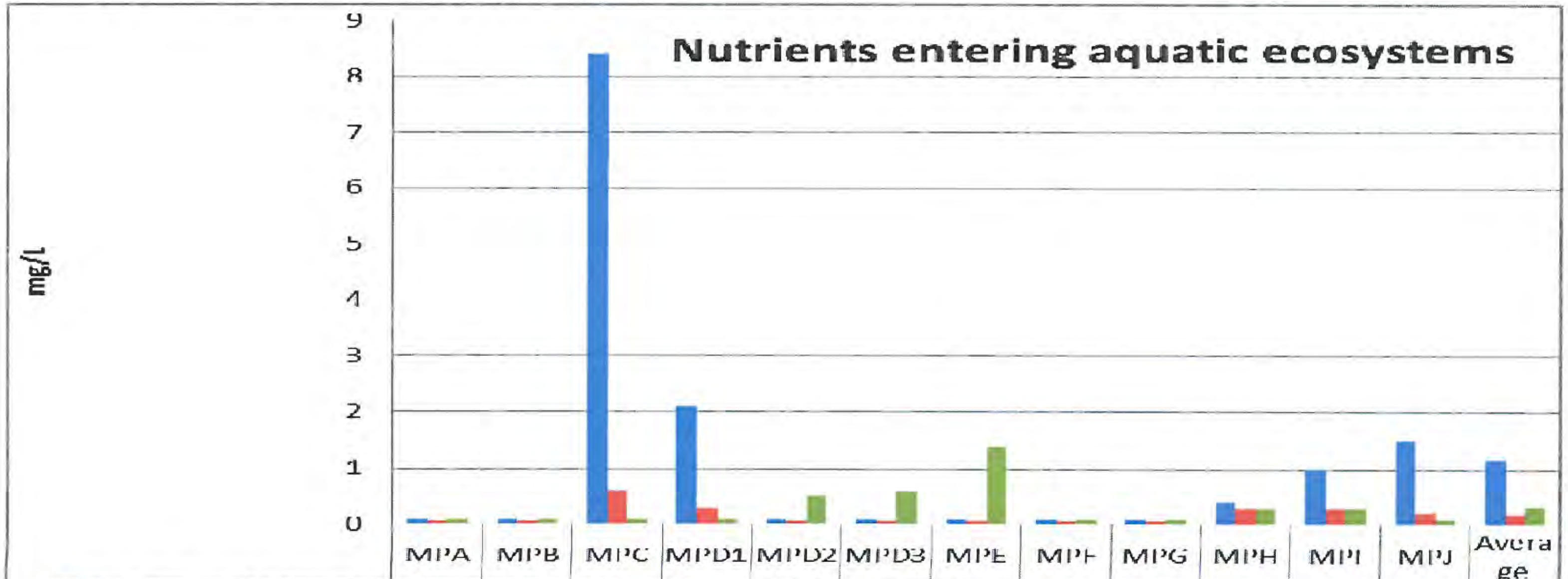


Figure 8.6.2-4 Sulphate concentrations for all monitoring points excluding MPA

According to SANS 241-1 2015, SO4 has a limit value of 500 mg/L for acute health and 250 mg/L for aesthetic, MPA exceptionally exceed these values with a value of 12 934 mg/L. Because of extraordinarily high SO_4 concentration at MPA, its results are not shown in the figure above. Comparison of the remaining monitoring points is shown with the highest value at MPC with a value of 184 mg/L, followed by MPE with a value of 171 mg/L. the lowest value is at MPB with a value of 12 mg/L, indicating unpolluted water. Sulphate at MPB to MPJ are within the SANS 241-1 2015 standard limit. On average the SO4 value is at 1 166.25 mg/L which exceed the SANS 241-1 2015, indicating that the source around



	MPA	MPB	MPC	MPD1	MPD2	MPD3	MPE	MPF	MPG	MPH	MPI	MPJ	Average
Nitrate as N	0.1	0.1	8.4	2.1	0.1	0.1	0.1	0.1	0.1	0.4	1	1.5	1.175
Nitrite as N	0.05	0.05	0.6	0.3	0.05	0.05	0.05	0.05	0.05	0.3	0.3	0.2	0.1708
Ortho Phosphate as P	0.1	0.1	0.1	0.1	0.5	0.6	1.4	0.1	0.1	0.3	0.3	0.1	0.3167

Figure 8.6.2-5: Nutrients such as NO_3, NO_2 & orthophosphate as P.

The figure above indicates results of chemical constituents commonly referred to as nutrients, which are nitrate, nitrite and phosphorus. According to Strydom and King (2009), these nutrients are considered as pollutants because they encourage the growth of nuisance plants and algae, and systems suffering from excessive additions of nutrients are said to be eutrophic. Nutrients enter aquatic ecosystems mostly from agricultural and urban run-off, as well as in both untreated sewage and in purified, treated, sewage effluent (Strydom and King, 2009).

Although all the monitoring points are within the SANS 241-1 2015 standard limits, the Nitrate and Nitrite are both high at MPC downstream of Fleurhof dam. Because of the development taking place at this area and easily accessibility to the stream, human activities could alter the nitrogen of the water.

Phosphorus is high at MPE, a different water system (catchment 2) to the significant water resource. According to SANS 241-1 2015 there is no detection limit given for phosphorus. The source of this high concentration is assumed to be from the treated sewage effluent because of the actual colour of the water observed during site visit. Other monitoring points seem to be relatively having low concentrations.

9. FLOOD LINE DELINEATION

The run-off that is generated within a catchment through precipitation will depend on the following Characteristics:

- Characteristics of the storm event;
- The response characteristics of the catchment; and
- The influence of temporal storage on the run-off.

The temporal distribution of the run-off is reflected in a hydrograph. The flood peak (QP) is reached as soon as the entire catchment contributes to the flood, which is also referred to as the time of concentration (T_C).

Flood lines are usually determined for areas where proposed infrastructure could be influenced by in-stream flood volumes and their respective levels. Streams A, B and C were modelled and based on flow technical data, flood lines were delineated.

9.1. Survey data

Survey data was provided in the following format:

- 1m height difference contours;
- TIFF Files.

9.2. Roughness parameters

In order to accurately model the flow in the river the roughness parameters along each cross section had to be defined. The river was divided into three sections i.e. the left bank, main channel and right bank. The positioning of the main channel was based on the anticipated flow in the river (low flows). The Manning n roughness values used for each of the three sections were 0,05 m/s1/3, 0,035 m/s1/3 and 0,05 m/s1/3 respectively.

Manning equation:

$$Q = \frac{1}{n} \frac{A^{\frac{5}{3}}}{P^{\frac{2}{3}}} S_0^{\frac{1}{2}}$$

...

Where:

Q	=	flow rate (m3/s)
n	=	Manning value (s/m1/3)
A	=	flow area (m2)
P	=	wetted perimeter (m)
S0	=	slope (m/m)

The following guidelines were used for the selection of the suitable Manning Coefficient:

Table 9-1: Manning Roughness Coefficient

d Description	Minimum	Normal	Maximum
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.03	0.033
b. same as above, but more stones and weeds	0.03	0.035	0.04
c. clean, winding, some pools and shoals	0.033	0.04	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.05
e. same as above, lower stages, more ineffective			
slopes and sections	0.04	0.048	0.055
f. same as "d" with more stones	0.045	0.05	0.06
g. sluggish reaches, weedy, deep pools	0.05	0.07	0.08
h. very weedy reaches, deep pools, or floodways			
with heavy stand of timber and underbrush	0.075	0.1	0.15
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.03	0.04	0.05
b. bottom: cobbles with large boulders	0.04	0.05	0.07
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.03	0.035
2. high grass	0.03	0.035	0.05
b. Cultivated areas			
1. no crop	0.02	0.03	0.04
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.03	0.04	0.05
c. Brush			
1. scattered brush, heavy weeds	0.035	0.05	0.07
2. light brush and trees, in winter	0.035	0.05	0.06
3. light brush and trees, in summer	0.04	0.06	0.08
4. medium to dense brush, in winter	0.045	0.07	0.11
5. medium to dense brush, in summer	0.07	0.1	0.16
d. Trees			
1. dense willows, summer, straight	0.11	0.15	0.2
2. cleared land with tree stumps, no sprouts	0.03	0.04	0.05
3. same as above, but with heavy growth of sprouts	0.05	0.06	0.08
4. heavy stand of timber, a few down trees, little			
undergrowth, flood stage below branches	0.08	0.1	0.12
5. same as 4. with flood stage reaching branches	0.1	0.12	0.16

9.3. Flow data

Flood calculations were conducted and the peak flows are summarised in Table below:

Table 9-2: Summary of Flood Calculations (1:50 and 1:100 years)

Catchment Description	Peak Flow in m3/s Qp50	Peak Flow in m3/s Qp100
Effective catchment	387.39	521.68
Catchment 1	124.36	169.14
Catchment 2	70.51	97.09
Catchment 3	178.57	240.55
Catchment 4	34.13	47.17
Catchment 5	5.54	7.68

9.4. Hydraulic model

The public domain and internationally accepted software package HEC-RAS (version 3.1.3) developed by the US Army Corps of Engineers was used to hydraulically model the river system. The system consists of three components i.e. flow data, geometric data and simulation options. These components are described in more detail below.

The software provides graphical output of the flow in the river as well as tabulated output of the calculated results. A list of errors and warnings are also provided as an output in order to carefully evaluate and interpret the obtained results.

9.5. Cross section data

As indicated in the map on figure 9.5-1 below, Cross section were delineated at 100m intervals using survey data provided by CADMAP.

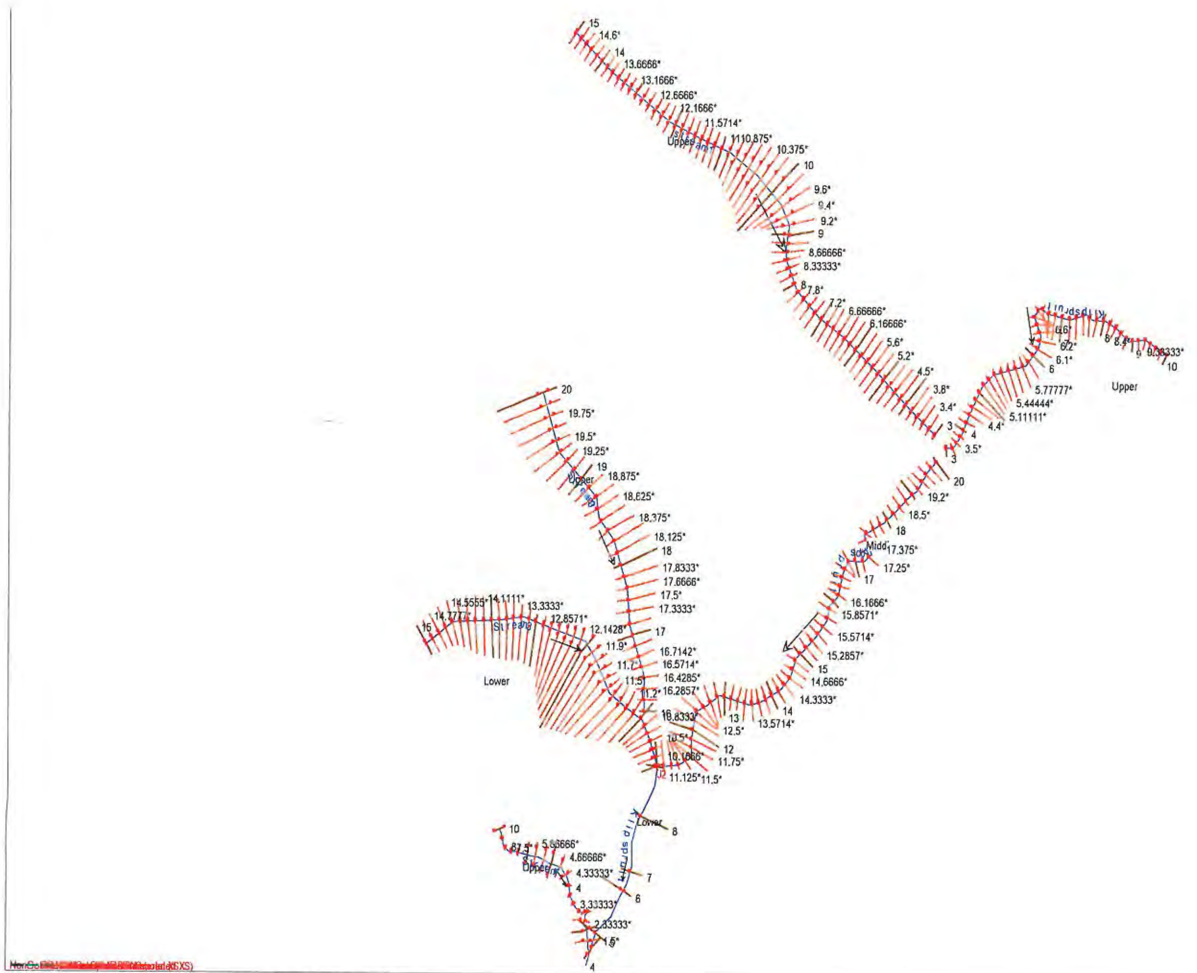


Figure 9-1: Cross section data

9.6. Description of flood line output data

The 1:100 year flood-line restriction is the internationally accepted norm for the placement of anything that may be in danger of failing or have a potential safety hazard. This norm is also reflected in section 144 of the National Water Act in respect of the locality of townships.

The purpose of this paragraph is to summarise the output from a surface water assessment. The output variables can be defined as follows:

- E.G. Elev: Energy Grade line for calculated WS elevation
- Flow Area: Total Area of cross section active flow.
- Froude # Chnl: Froude Number for the main channel.
- Min Ch El: Minimum main channel elevation.
- Q total: Total flow in cross section
- Top W Chnl: Top Width of the main channel.
- Vel Chnl: Average Velocity of flow in main channel.

The following tables indicate the details relating to each river system:

Table 9-3: **Hecras output table (Klipspruit Upper Reach)**

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Klipspruit	Upper	10	1 in 50	387.39	1643	1645.91	1645.91	1649.82	0.04886	11.18	49.69	37.48	2.16
Klipspruit	Upper	10	1 in 100	521.68	1643	1647.34	1647.34	1647.93	0.006413	5.36	174.45	120.57	0.84
Klipspruit	Upper	9	1 in 50	387.39	1641	1643.91	1643.91	1646.9	0.026218	9.09	56.21	32.12	1.7
Klipspruit	Upper	9	1 in 100	521.68	1641	1645	1645	1645.57	0.004735	4.78	189.01	129.5	0.76
Klipspruit	Upper	8	1 in 50	387.39	1637	1639.61	1639.61	1640.46	0.007824	4.65	101.5	56.22	0.92
Klipspruit	Upper	8	1 in 100	521.68	1637	1639.38	1639.98	1641.46	0.021584	7.25	88.39	55.99	1.51
Klipspruit	Upper	7	1 in 50	387.39	1634	1637.28	1637.28	1638.67	0.009839	5.92	76.65	30.69	1.05
Klipspruit	Upper	7	1 in 100	521.68	1634	1638.01	1638.01	1639.47	0.008552	6.31	100.88	34.31	1.01
Klipspruit	Upper	6	1 in 50	387.39	1632	1634.76	1634.76	1635.52	0.00703	4.57	109.11	66.52	0.89
Klipspruit	Upper	6	1 in 100	521.68	1632	1635.2	1635.2	1636.03	0.006539	4.88	141.85	81.29	0.88
Klipspruit	Upper	5	1 in 50	387.39	1628	1629.92	1629.92	1630.73	0.012231	4.82	103.83	86.37	1.12
Klipspruit	Upper	5	1 in 100	521.68	1628	1630.43	1630.43	1631.07	0.007256	4.36	159.07	118.85	0.89
Klipspruit	Upper	4	1 in 50	387.39	1623	1626.9	1626.9	1627.81	0.008407	5.34	95.81	51.96	0.89
Klipspruit	Upper	4	1 in 100	521.68	1623	1627.48	1627.48	1628.23	0.008883	6.06	142.78	87.31	0.94
Klipspruit	Upper	3	1 in 50	387.39	1616	1617.5	1618.56	1621.52	0.072192	9.9	48.53	53.67	2.59
Klipspruit	Upper	3	1 in 100	521.68	1616	1617.77	1618.83	1621.91	0.061893	10.23	63.08	55.41	2.46

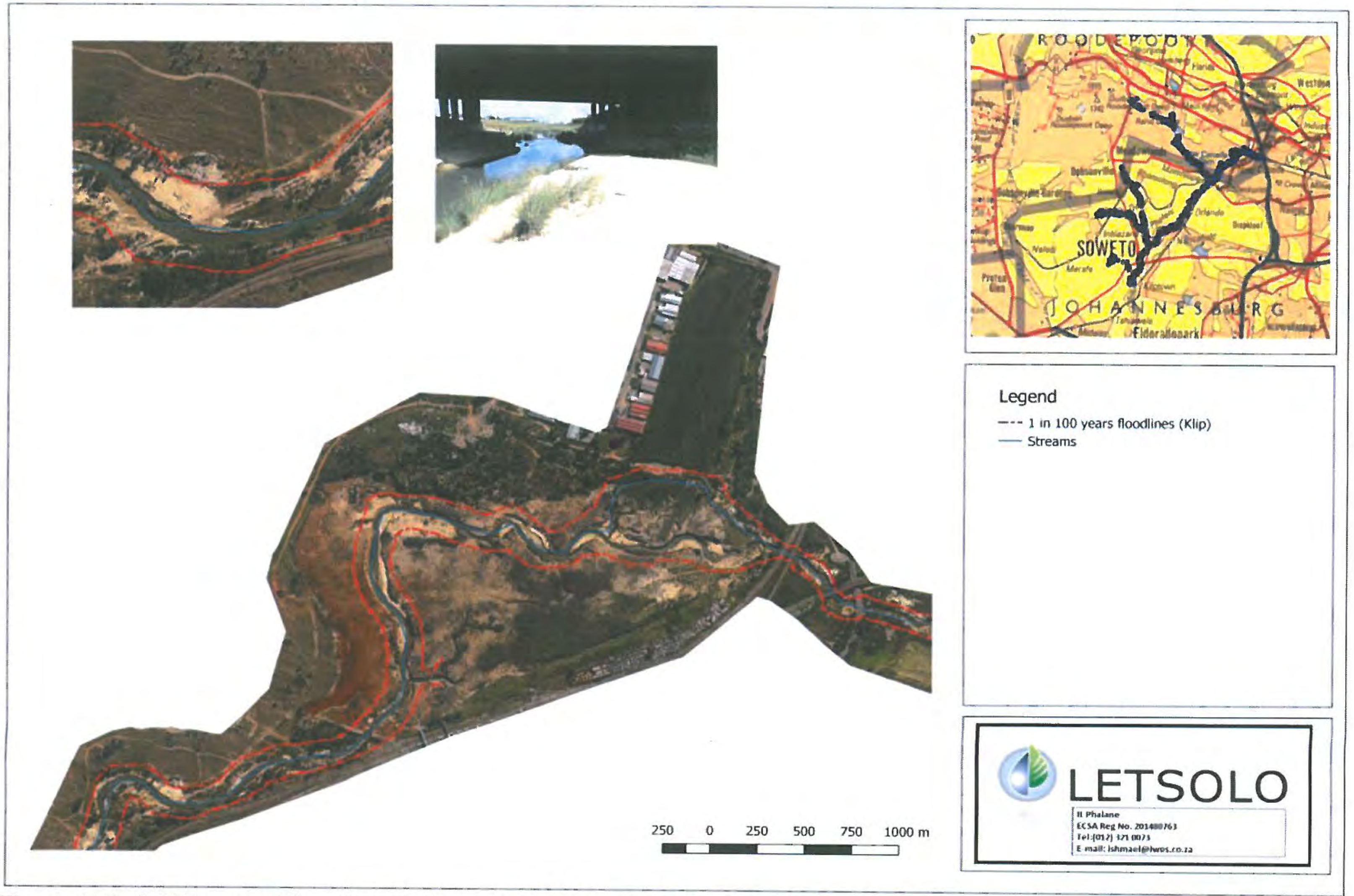


Figure 9-2: 1:100 years Floodlines (Klipspruit Upper Reach)

Table 9-4: Hecras Output Table (Klipspruit Middle Reach)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Klipspruit	Middle	20	1 in 50	387.39	1609	1612.85	1612.85	1613.5	0.008591	5.64	114.73	78.63	0.93
Klipspruit	Middle	20	1 in 100	521.68	1609	1613.25	1613.25	1613.92	0.008749	6.09	153.26	106.34	0.95
Klipspruit	Middle	19	1 in 50	387.39	1606	1608.9	1608.9	1611.8	0.0324	9.97	55.38	35.17	1.88
Klipspruit	Middle	19	1 in 100	521.68	1606	1610	1610	1611.16	0.009715	6.78	117.83	60.47	1.09
Klipspruit	Middle	18	1 in 50	387.39	1602	1605.34	1605.4	1606.2	0.006696	5.22	107.88	61.87	0.91
Klipspruit	Middle	18	1 in 100	521.68	1602	1605.35	1605.77	1606.88	0.011953	6.99	108.46	61.88	1.22
Klipspruit	Middle	17	1 in 50	387.39	1594	1597.31	1597.72	1598.7	0.01627	7.21	83.14	63.06	1.29
Klipspruit	Middle	17	1 in 100	521.68	1594	1597.94	1597.95	1598.97	0.009078	6.08	123.27	64.02	1
Klipspruit	Middle	16	1 in 50	387.39	1591	1593.92	1593.92	1595.14	0.011106	6.06	85.2	47.19	1.13
Klipspruit	Middle	16	1 in 100	521.68	1591	1594.66	1594.66	1595.66	0.006966	5.59	126.38	56.7	0.93
Klipspruit	Middle	15	1 in 50	387.39	1589	1591.94	1591.94	1592.71	0.009885	4.91	101.32	63.34	0.97
Klipspruit	Middle	15	1 in 100	521.68	1589	1592.42	1592.42	1593.02	0.009083	5.28	158.93	128.53	0.96
Klipspruit	Middle	14	1 in 50	387.39	1586	1587.73	1587.73	1588.43	0.010168	4.03	107.94	75.16	0.99
Klipspruit	Middle	14	1 in 100	521.68	1586	1588.19	1588.19	1588.86	0.007962	4.17	150.19	118.47	0.91
Klipspruit	Middle	13	1 in 50	387.39	1584	1585.82	1585.82	1586.21	0.008952	3.92	149.39	165.24	0.93
Klipspruit	Middle	13	1 in 100	521.68	1584	1585.97	1585.97	1586.48	0.010036	4.37	174.09	166.91	1
Klipspruit	Middle	12	1 in 50	387.39	1581	1582.53	1582.53	1582.79	0.011576	4.09	183.34	330.19	1.05
Klipspruit	Middle	12	1 in 100	521.68	1581	1582.64	1582.64	1582.95	0.011715	4.3	219.46	330.98	1.07
Klipspruit	Middle	11	1 in 50	387.39	1578	1579.84	1579.84	1580.2	0.013289	3.75	145.33	199.2	0.97
Klipspruit	Middle	11	1 in 100	521.68	1578	1580	1580	1580.44	0.013172	3.99	178.41	211.18	0.98

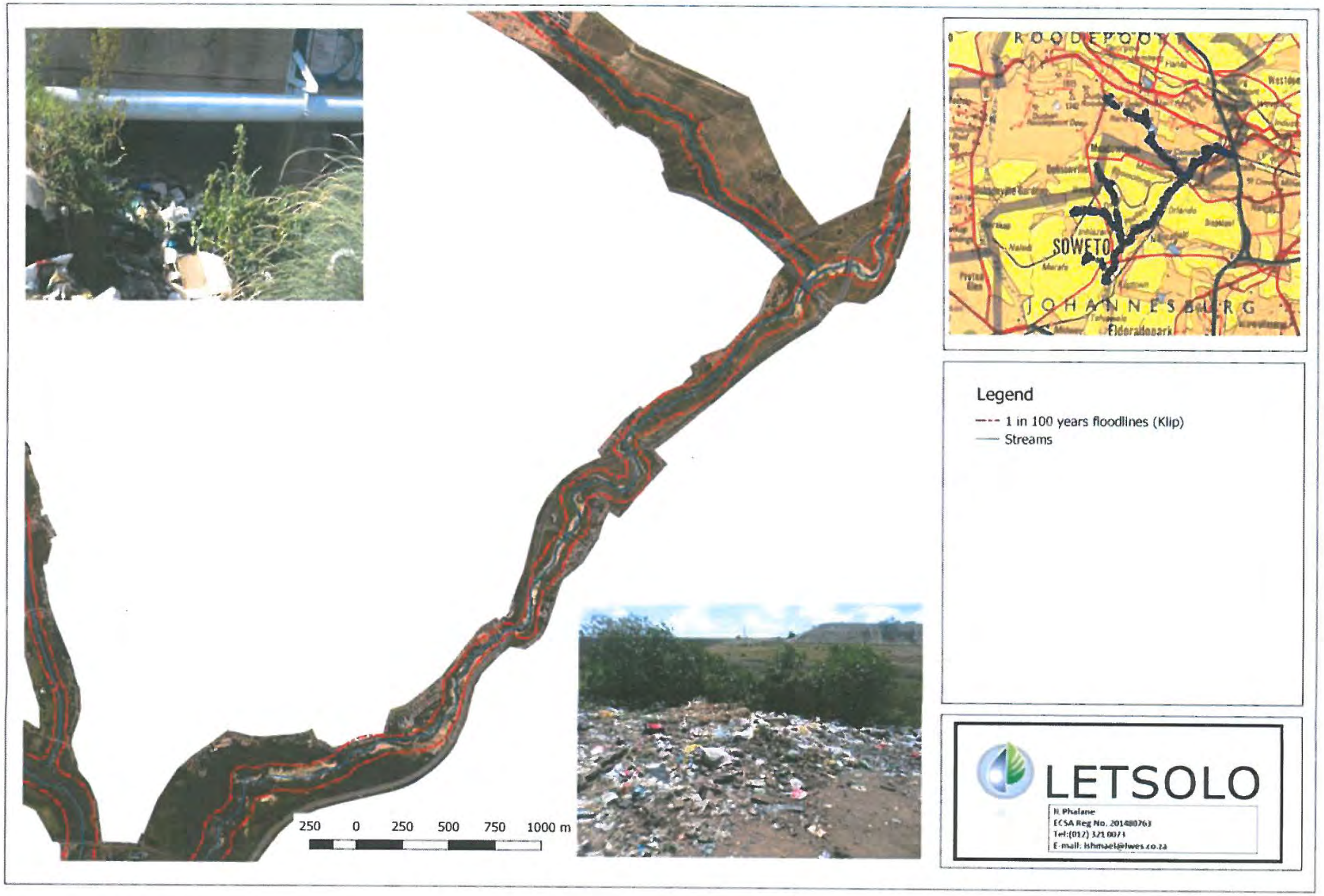


Figure 9-3: 1:100 years Floodlines (Klipspruit Middle Reach Reach)

Table 9-5: Hecras Output Table (Klipspruit Lower Reach)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Klipspruit	Lower	9	1 in 50	387.39	1575	1575.81	1576.66	1579.84	0.146582	9.49	44.87	66.64	3.37
Klipspruit	Lower	9	1 in 100	521.68	1575	1576.05	1576.93	1580.08	0.107702	9.67	61.3	76.43	3.02
Klipspruit	Lower	8	1 in 50	387.39	1573	1574.83	1574.83	1575.24	0.010892	3.88	139.04	155.58	0.99
Klipspruit	Lower	8	1 in 100	521.68	1573	1574.99	1574.99	1575.52	0.011621	4.27	163.8	156.52	1.04
Klipspruit	Lower	7	1 in 50	387.39	1572	1573.87	1573.87	1574.3	0.011565	4.2	135.27	150.74	1.02
Klipspruit	Lower	7	1 in 100	521.68	1572	1574.13	1574.13	1574.57	0.011214	4.55	181.85	199.57	1.03
Klipspruit	Lower	6	1 in 50	387.39	1572	1572.96	1572.96	1573.45	0.012904	3.16	124.84	132.9	1.03
Klipspruit	Lower	6	1 in 100	521.68	1572	1573.3	1573.3	1573.67	0.009126	3.24	204.29	251.91	0.91
Klipspruit	Lower	5	1 in 50	387.39	1570.44	1571.32	1571.32	1571.6	0.011551	1.51	171.68	294.69	0.77
Klipspruit	Lower	5	1 in 100	521.68	1570.44	1571.43	1571.43	1571.78	0.011873	1.82	205.73	295.02	0.82

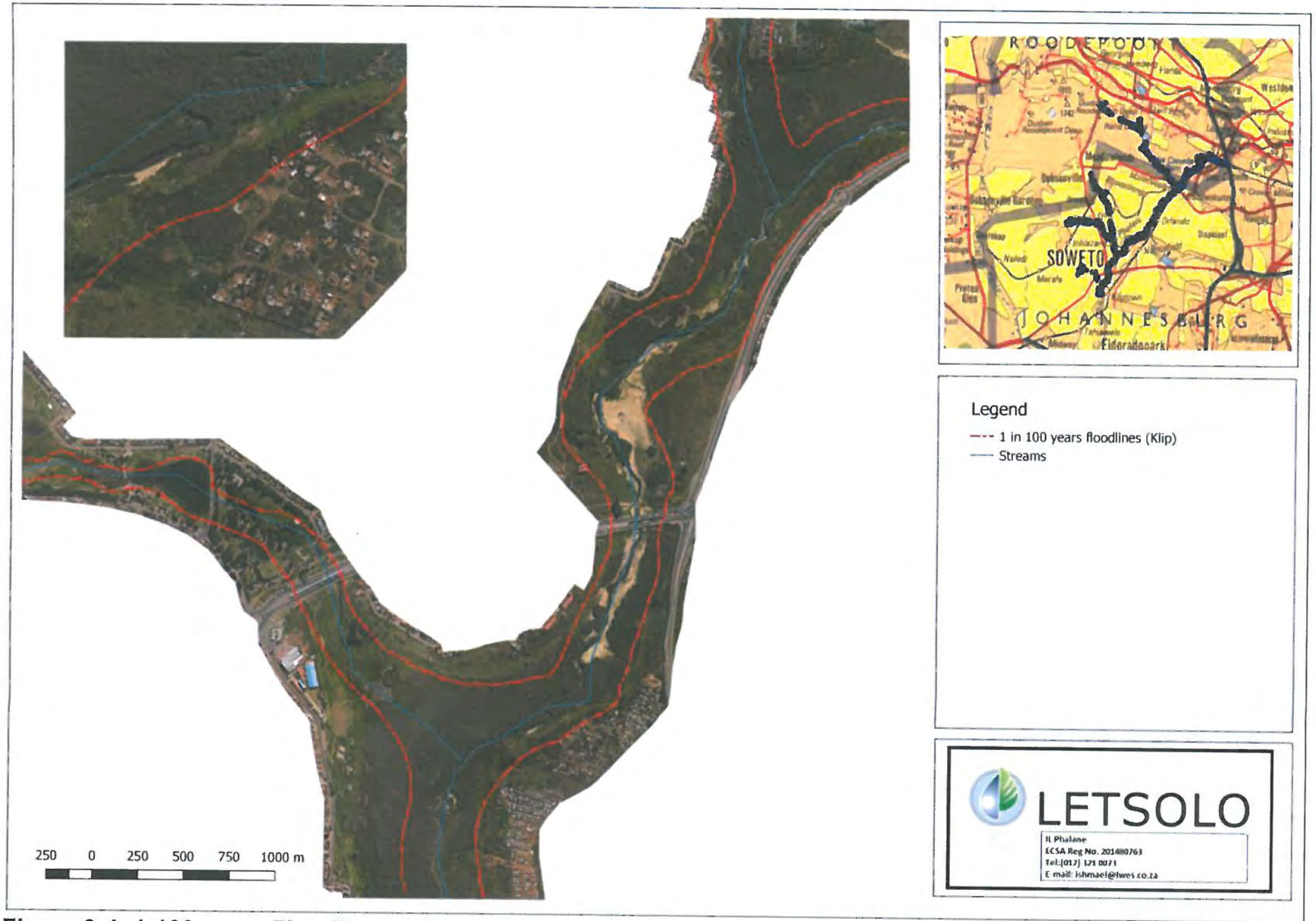


Figure 9-4: 1:100 years Floodlines (Klipspruit Upper Reach)

Table 9-6: **Hecras output table (Stream 1) Upper Reach**

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
stream1	Upper	15	1 in 50	124.36	1700	1700.92	1700.92	1701.36	0.012889	3	42.22	47.55	1.01
stream1	Upper	15	1 in 100	169.14	1700	1701.24	1701.24	1701.65	0.008803	3.05	64.94	77.41	0.88
stream1	Upper	14	1 in 50	124.36	1689	1690.25	1690.53	1691.54	0.051085	7.48	35.18	112.29	2.14
stream1	Upper	14	1 in 100	169.14	1689	1690.25	1690.63	1692.64	0.094376	10.16	35.19	112.29	2.91
stream1	Upper	13	1 in 50	124.36	1680	1680.71	1680.71	1681.06	0.013705	2.65	47.33	67.9	1.01
stream1	Upper	13	1 in 100	169.14	1680	1680.87	1680.87	1681.3	0.012728	2.93	58.34	68.34	1
stream1	Upper	12	1 in 50	124.36	1671	1671.72	1671.78	1672.18	0.017049	3.01	41.74	58.36	1.13
stream1	Upper	12	1 in 100	169.14	1671	1671.85	1671.95	1672.46	0.018358	3.47	49.17	58.57	1.2
stream1	Upper	11	1 in 50	124.36	1664	1664.98	1664.98	1666.18	0.032528	4.95	25.75	27.85	1.61
stream1	Upper	11	1 in 100	169.14	1664	1665.56	1665.56	1665.99	0.007653	3.28	63.81	67.84	0.85
stream1	Upper	10	1 in 50	124.36	1660	1660.2	1660.2	1660.31	0.020488	1.42	87.73	429.8	1
stream1	Upper	10	1 in 100	169.14	1660	1660.25	1660.25	1660.38	0.019258	1.57	107.5	429.9	1
stream1	Upper	9	1 in 50	124.36	1648	1648.57	1648.69	1649.07	0.025306	3.14	39.87	70.17	1.32
stream1	Upper	9	1 in 100	169.14	1648	1648.68	1648.85	1649.33	0.026119	3.58	47.56	70.43	1.38
stream1	Upper	8	1 in 50	124.36	1644	1645.65	1645.65	1646.22	0.008557	3.61	39.55	33.11	0.9
stream1	Upper	8	1 in 100	169.14	1644	1645.9	1645.9	1646.61	0.008775	4.03	48.16	33.62	0.93
stream1	Upper	7	1 in 50	124.36	1640	1641.42	1641.42	1642.03	0.009734	3.54	37.38	30.95	0.95

stream1	Upper	7	1 in 100	169.14	1640	1641.7	1641.7	1642.44	0.009472	3.93	45.97	31.41	0.97
stream1	Upper	6	1 in 50	124.36	1635	1636.15	1636.18	1636.66	0.010475	3.2	41.13	49.01	0.95
stream1	Upper	6	1 in 100	169.14	1635	1636.33	1636.44	1636.98	0.011163	3.64	50.6	54.2	1.01
stream1	Upper	5	1 in 50	124.36	1628	1628.69	1628.84	1629.32	0.025778	3.53	35.38	52.34	1.37
stream1	Upper	5	1 in 100	169.14	1628	1628.85	1629.12	1629.61	0.023622	3.89	43.78	52.73	1.36
stream1	Upper	4	1 in 50	124.36	1621	1621.79	1621.81	1622.21	0.014099	2.89	43.4	55.7	1.04
stream1	Upper	4	1 in 100	169.14	1621	1621.93	1621.98	1622.49	0.015127	3.34	51.2	55.97	1.11
stream1	Upper	3	1 in 50	124.36	1615	1615.96	1615.96	1616.42	0.013393	3.13	41.6	47.66	1.03
stream1	Upper	3	1 in 100	169.14	1615	1616.22	1616.22	1616.71	0.011385	3.38	55.66	56.73	0.99

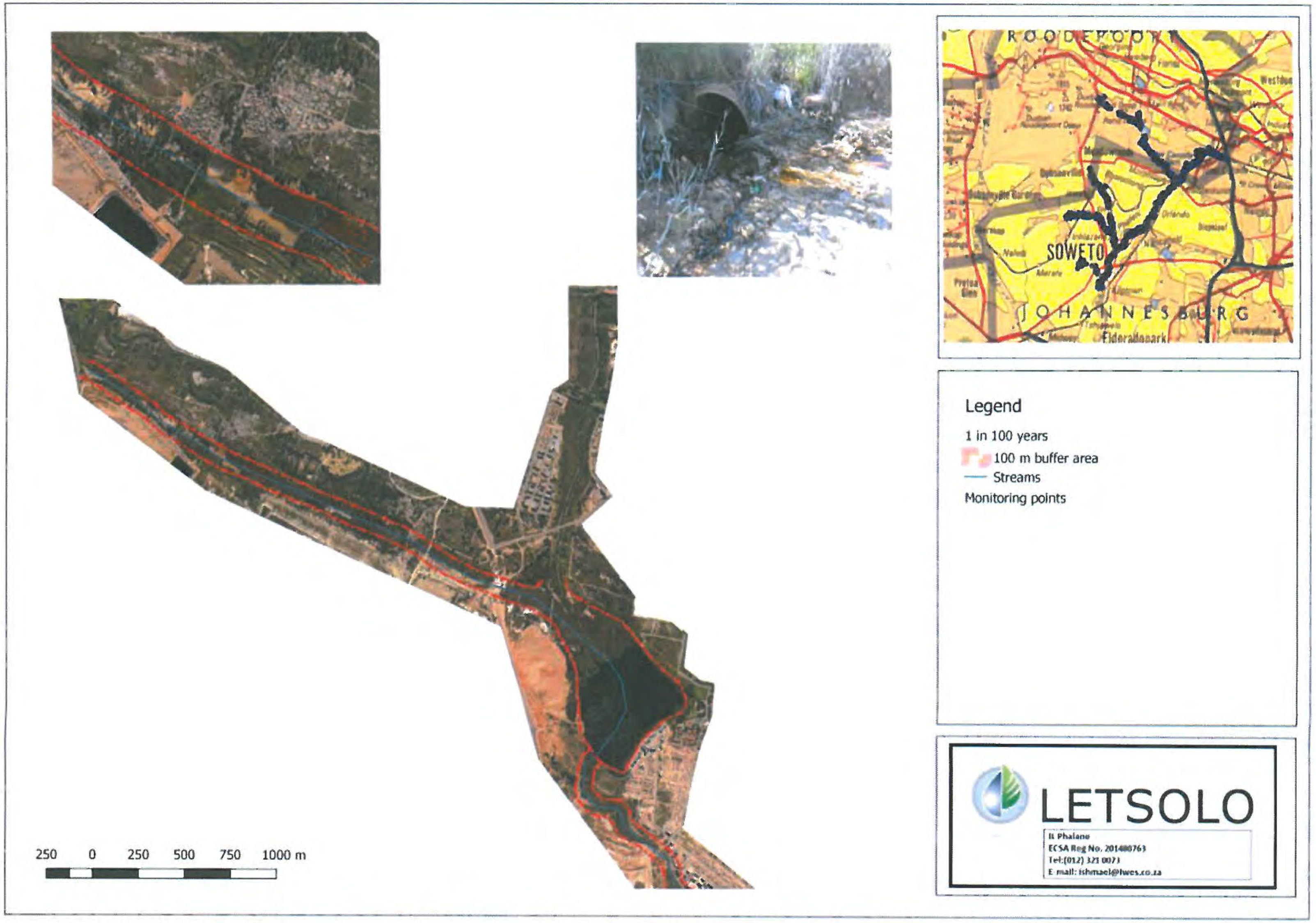


Figure 9-5: 1:100 years Floodlines (Stream 1 Upper Reach)

Table 9-7: Hecras output table (Stream 3)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Stream3	Upper	20	1 in 50	89.29	1627	1627.42	1627.42	1627.63	0.016226	2.03	44.18	106.43	1
Stream3	Upper	20	1 in 100	120.28	1627	1627.51	1627.51	1627.76	0.015163	2.23	53.96	106.62	1
Stream3	Upper	19	1 in 50	89.29	1620	1621.85	1621.85	1622.43	0.008191	3.65	28.56	23.66	0.88
Stream3	Upper	19	1 in 100	120.28	1620	1621.95	1621.95	1622.83	0.011707	4.53	31.02	24.03	1.07
Stream3	Upper	18	1 in 50	89.29	1604	1605.28	1605.99	1608.18	0.06565	8	12.37	13.49	2.33
Stream3	Upper	18	1 in 100	120.28	1604	1605.75	1605.96	1608.02	0.034711	7.24	18.9	14.51	1.79
Stream3	Upper	17	1 in 50	89.29	1599	1600.44	1600.44	1600.67	0.009472	3.55	46.67	86.23	0.94
Stream3	Upper	17	1 in 100	120.28	1599	1600.54	1600.54	1600.82	0.010054	3.83	55.36	86.64	0.98
Stream3	Upper	16	1 in 50	89.29	1592	1593.43	1593.55	1593.86	0.013696	4.06	37.38	72.33	1.09
Stream3	Upper	16	1 in 100	120.28	1592	1593.56	1593.67	1594	0.012825	4.16	46.75	72.49	1.07
Stream3	Lower	15	1 in 50	89.29	1627	1627.82	1627.82	1628.24	0.013091	2.86	31.58	39.07	1.01
Stream3	Lower	15	1 in 100	120.28	1627	1627.95	1627.95	1628.51	0.014869	3.34	36.54	40.36	1.1
Stream3	Lower	14	1 in 50	89.29	1614	1615.21	1615.31	1615.54	0.016101	4.08	50.24	190.86	1.19
Stream3	Lower	14	1 in 100	120.28	1614	1615.28	1615.38	1615.59	0.015072	4.1	63.65	191.85	1.16
Stream3	Lower	13	1 in 50	89.29	1607	1607.47	1607.47	1607.71	0.015867	2.03	41.53	89.41	0.97
Stream3	Lower	13	1 in 100	120.28	1607	1607.57	1607.57	1607.86	0.014897	2.24	50.72	89.88	0.97

Stream3	Lower	12	1 in 50	89.29	1599	1599.14	1599.14	1599.21	0.023416	1.16	76.78	559.47	1
Stream3	Lower	12	1 in 100	120.28	1599	1599.17	1599.17	1599.25	0.021643	1.28	94.02	559.69	1
Stream3	Lower	11	1 in 50	89.29	1584	1585.26	1585.26	1585.6	0.009898	3.3	36.15	60.39	0.94
Stream3	Lower	11	1 in 100	120.28	1584	1585.43	1585.43	1585.8	0.009757	3.56	46.51	60.92	0.95
Stream3	Lower	10	1 in 50	89.29	1580	1580.74	1580.74	1581.12	0.013341	2.71	33.23	45.35	1
Stream3	Lower	10	1 in 100	120.28	1580	1580.91	1580.91	1581.36	0.012435	2.99	40.69	45.8	1

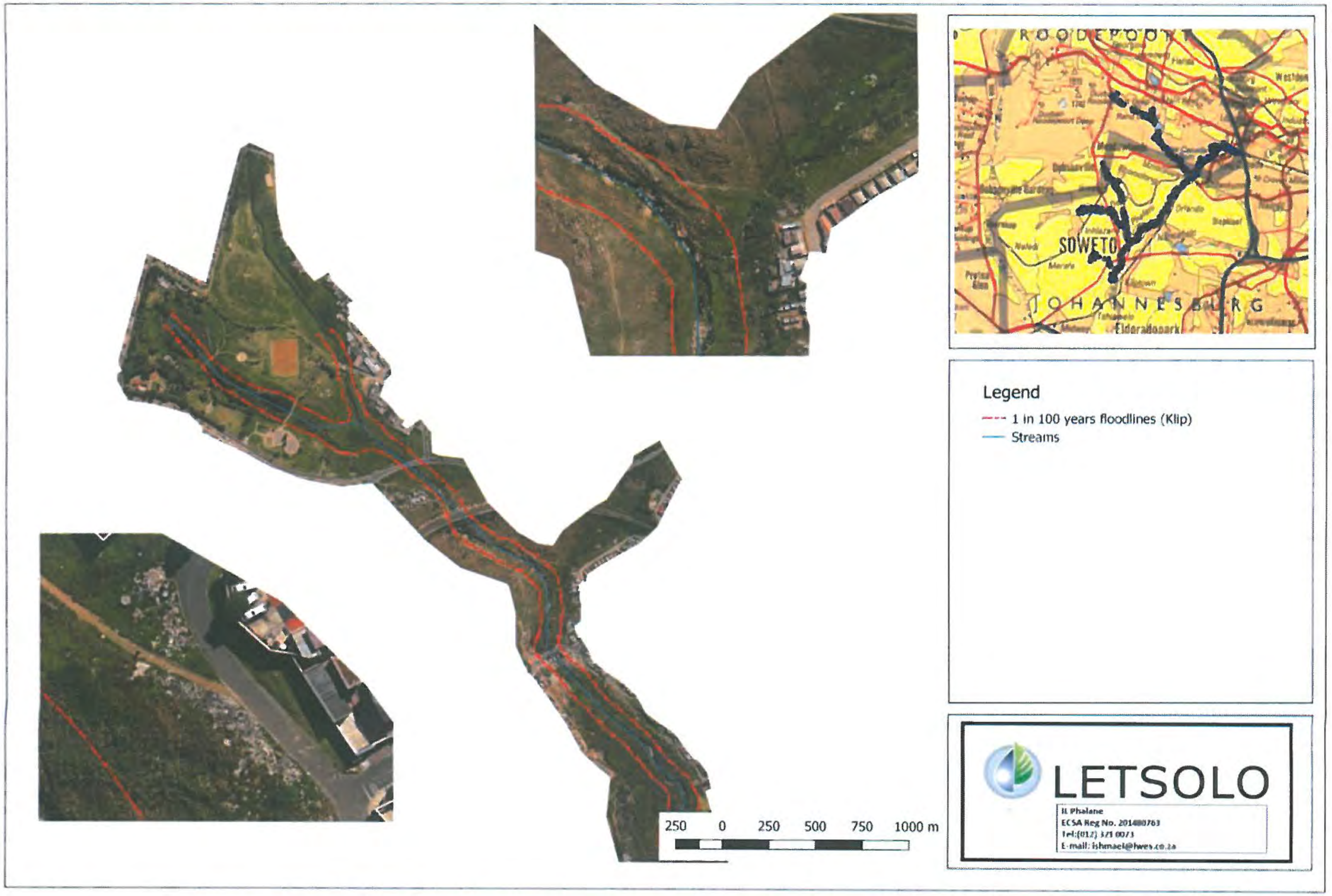


Figure 9-6: 1:100 years Floodlines (Stream 3 Upper Reach)

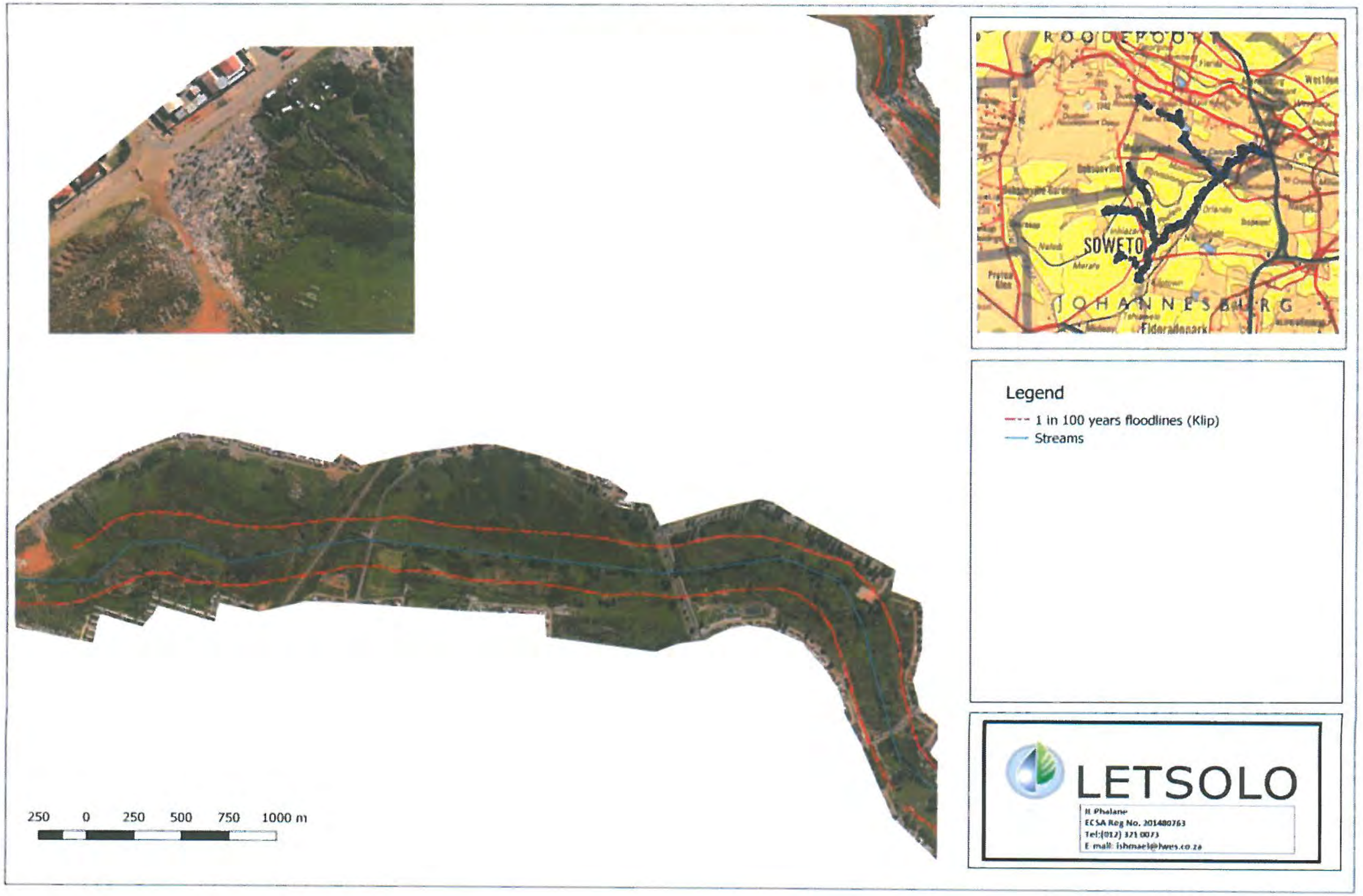


Figure 9-7: 1:100 years Floodlines (Stream 3 Lower Reach)

Table 9-8: Hecras output table (Stream 4)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Stream4	Upper	10	1 in 50	34.13	1593	1593.22	1593.22	1593.33	0.020081	1.46	23.38	107.74	1
Stream4	Upper	10	1 in 100	47.17	1593	1593.27	1593.27	1593.4	0.018806	1.63	28.96	107.78	1
Stream4	Upper	9	1 in 50	34.13	1592	1593.11	1593.11	1593.61	0.011041	3.17	11.33	11.7	0.97
Stream4	Upper	9	1 in 100	47.17	1592	1593.35	1593.35	1593.96	0.010532	3.54	14.15	11.7	0.98
Stream4	Upper	8	1 in 50	34.13	1589	1589.78	1589.96	1591.58	0.066997	6.12	5.85	7.93	2.22
Stream4	Upper	8	1 in 100	47.17	1589	1589.97	1589.99	1592.17	0.062163	6.81	7.36	8.3	2.22
Stream4	Upper	7	1 in 50	34.13	1587	1587.5	1587.5	1587.74	0.015383	2.22	15.55	31.8	1.01
Stream4	Upper	7	1 in 100	47.17	1587	1587.6	1587.61	1587.92	0.015612	2.53	18.84	32.19	1.05
Stream4	Upper	6	1 in 50	34.13	1587	1587.2	1587.2	1587.3	0.021542	1.43	23.97	121.04	1.02
Stream4	Upper	6	1 in 100	47.17	1587	1587.25	1587.25	1587.37	0.019285	1.57	30.09	121.15	1
Stream4	Upper	5	1 in 50	34.13	1585	1585.16	1585.16	1585.23	0.021983	1.23	27.76	177.49	0.99
Stream4	Upper	5	1 in 100	47.17	1585	1585.19	1585.19	1585.29	0.020573	1.37	34.39	177.57	1
Stream4	Upper	4	1 in 50	34.13	1576	1577.02	1577.35	1578.29	0.030794	5.08	8.07	38.25	1.61
Stream4	Upper	4	1 in 100	47.17	1576	1577.13	1577.46	1578.47	0.032083	5.54	12.2	38.51	1.67
Stream4	Upper	3	1 in 50	34.13	1574	1574.96	1574.96	1575.44	0.012447	3.11	11.46	12.8	1.01
Stream4	Upper	3	1 in 100	47.17	1574	1574.96	1574.96	1575.87	0.024027	4.31	11.42	12.8	1.4
Stream4	Upper	2	1 in 50	34.13	1572	1572.27	1572.27	1572.4	0.018979	1.63	20.91	78.37	1.01
Stream4	Upper	2	1 in 100	47.17	1572	1572.33	1572.33	1572.5	0.017493	1.82	26.04	78.47	1
Stream4	Upper	1	1 in 50	34.13	1571	1571.17	1571.17	1571.27	0.022521	1.34	25.62	147.69	1.02
Stream4	Upper	1	1 in 100	47.17	1571	1571.22	1571.22	1571.33	0.019906	1.47	32.31	147.93	1

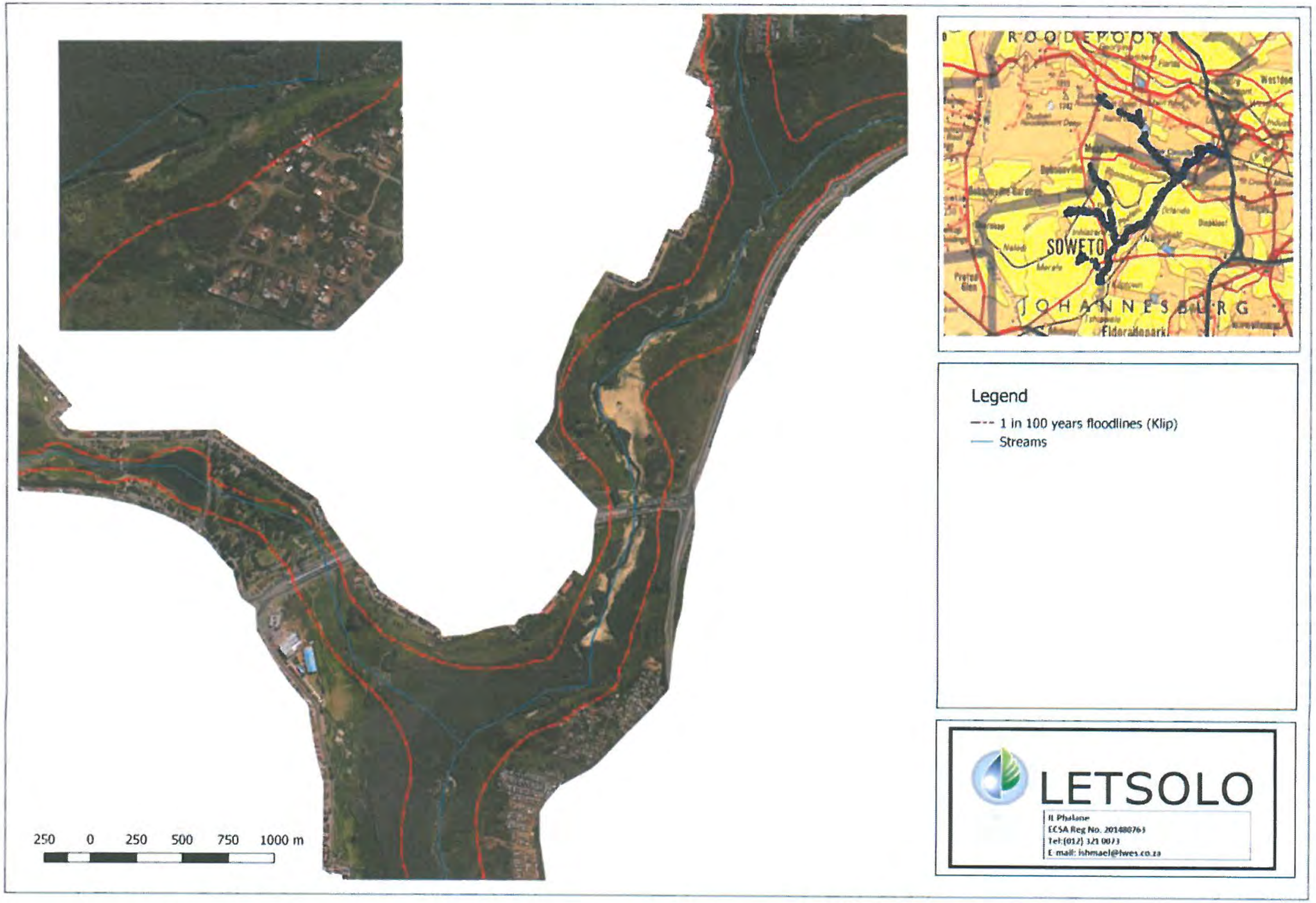


Figure 9-8: 1:100 years Floodlines (Stream 4)

10. RISK ASSESSMENT AND RATING

10.1. Approach

10.1.1. Establishment of Parks

Existing open spaces may be developed as parks. City Parks identified several areas which may be developed to parks. The purpose of the paragraphs below is to indicate the potential impacts associated with the development of parks.

The activities associated with the development of parks are summarized as follows:

- Clearing of Vegetation in close proximity to a watercourse;
- Installation of fence around the perimeter of the park;
- Erosion Control and Re-vegetation of bare surface areas;
- Maintenance of Culvert crossing upstream and downstream of the proposed park area;
- Storm Water and Flood Management;
- Generation and management of waste;

Please refer to the paragraphs below for aspects relating to the above-mentioned activities.

10.1.1.1. Clearing of vegetation in close proximity to a watercourse

The establishment of parks results in urbanization. In this instance, the establishment of infrastructure like ablution facilities and car parks areas will result in the removal of vegetation. The Aspects associated with vegetation clearance are as follows:

- Ripping/ loosening of soils
    - The impact associated with loosening of soil is sediment transport. Loose particles may be washed away during storm events.

  - The proposed mitigation for sedimentation is that bare surfaces must be managed as minimum as possible. Re-vegetation of bare areas must be implemented after the construction phase.

- Material Stockpile
  - Vegetation roots will be removed with topsoil. This material will be stockpiled close to the establishment area.
  - The side slopes of the topsoil must be at a slope less than 1:3 (v:h) in order to avoid the formation of erosion gullies at the stockpile area.
- Grading, leveling of the landscape
  - Some of the removed topsoil may be used as fill material.
  - The impact associated with landscaping is the formation of ponding areas. The final landscape must blend with the surrounding topography to avoid water ponding.

10.1.1.2. Installation of fencing and gates

Fence and gates are required to restrict and control access to the parks. The aspects associated with the installation of fencing and gates are as follows:

- Excavation for poles
  - The excavation of poles is usually shallow and covers small surface areas. However, the length of the area to be fenced off may result in cumulative impacts as the number of poles is directly proportional to the length of the barricade.
- Casting for foundation of poles
  - Concrete mix will be required for casting support of poles.
  - During the construction phase, construction waste will be generated due to the need for concrete casting.
- Delivery of material

- Construction camp may be required for the storage of construction material.

- Vegetation will be cleared for the establishment o contractor camp. This camp can be established as close as possible to the infrastructure area.

10.1.1.3. Erosion Control and Re vegetation of bare areas

Bare areas which were created during the construction phase must be rehabilitated. The aspects associated with Erosion Control are as follows;

- Re-vegetation of bare areas;
    - After completing the construction phase, it is necessary to re-vegetate the bare areas.
    - This aspect is deemed a positive impact as vegetation provides support for loose material.
- Construction of Berms Storm water Structures.
    - Water from external catchment areas like adjacent residential dwellings, must be controlled by storm water channels.

10.1.1.4. Storm Water and Flood Management

Due to the close proximity of the proposed parks to the riverine systems, Storm water and flood management is deemed necessary. The following aspects are associated with Storm water and flood management:

- Location of infrastructure.
    - Floodlines were delineated for the entire WMU in order to highlight the risks associated with activities taking place within the 1:100 year flood areas. There are some residential areas which fall within the 1:100 year flood area.
    - Flood protection berms are recommended in order to protect the existing infrastructure.

- Maintenance of hydraulic structures
    - Silted up culverts result in poor drainage as the design capacities are compromised.
    - The culvert crossings located upstream and downstream of the proposed park area must be maintained in order to avoid water attenuation and/or ponding at the park area.

10.1.1.5. Deterioration of water Quality

Most artificial activities may result in the deterioration of water quality if not properly managed. The following aspects are associated with the Deterioration of water quality:

- Water pollution from industrial activities like mining and related activities;
    - Defunct mines may result in the deterioration of water quality. Water quality results for a sample collected at Monitoring Point A indicates mining related impacts.
    - Water quality control measures must be implemented from the source of pollution.
- Water pollution from failing waste water treatment plants.
    - Blockages of the sewer lines and poorly managed sewage treatment plant pose a risk to the receiving water body.
    - The sewage treatment facilities must be designed and managed in such a manner that the final effluent complies to the receiving water quality objectives.
- Water pollution from dense settlements
    - Dense settlements are associated with unofficial waste disposal areas.
    - Waste collecting and sorting measures must be implemented at dense settlement.
- New residential developments

- New residential development sites were identified. These activities are still at the construction phase. Construction activities are associated with the generation of dust.

- Dust suppression measures must be in place at residential development sites.

10.1.1.6. Generation and management of waste

Waste will be generated during the construction and operational phases. The aspects associated with the generation and management of waste are as follows;

- Generation of waste;
  - Construction waste will be generated during the establishment of parks
  - Waste management at source - Waste must be temporarily stored in properly marked/colour coded bins.
- Collection of Waste
  - Spillages may occur between collection, transportation and disposal.
  - Waste must be collected by a competent entity for safe disposal. Spillages must be remediated as soon as possible.
- Disposal of waste.
  - Several illegal waste disposal sites were identified.
  - Waste must be disposed of at registered water disposal sites.
- If waste is not properly managed, storm water which gets in contact with waste will be contaminated. Hazardous waste like grease and oil may impact on surface runoff during storm events.

10.1.2. Rehabilitation of Wetlands

10.1.2.1. Activities

The activities associated with the rehabilitation of wetlands parks are summarized as follows:

- Clearing of silt in close proximity to a watercourse;
- Change in flow regimes
- Installation of fence around the perimeter of the park;
- Erosion Control and Re-vegetation of bare surface areas;
- Maintenance of Culvert crossing upstream and downstream of the proposed park area;
- Generation and management of waste;

Please refer to the paragraphs below for aspects relating to the above-mentioned activities.

10.1.2.2. Clearing of silt in close proximity to or in a watercourse

During storm events, Fine particles are washed off to the riverine system. Incidents such as failing dams also result in sedimentation. The aspects associated with the removal of silt are summarized as follows:

- Laydown Areas
  - Laydown areas are required for the temporary storage of silt.
  - The laydown areas must be as close as possible to the rehabilitated area. The footprint of the laydown areas must be managed as small as possible.
- Stockpiles
  - Silt will be temporarily stockpiled before off site disposal.
  - The side slopes of the topsoil must be at a slope less than 1:3 (v:h) in order to avoid the formation of erosion gullies oat the stockpile area.

- Impeding the flow
  - The removal of silt will result in the widening of the water course.
  - The widening of the water course will result in the reduction of flow velocity and the reduction of the potential for soil erosion.

10.1.2.3. Change in flow regimes

Changes in flow Regime may result in inter basin transfers. The following aspects are associated with the potential impact of change in flow:

- The removal of silt will result in the widening of the water course.
- Vegetation cover reduces hydrological yield. Vegetation will be removed. Due to an increased percentage of bare surfaces, there is a higher potential for hydrological yield.
- The widening of the water course will result in the reduction of flow velocity and the reduction of the potential for soil erosion.

10.1.2.4. Installation of fencing and gates

Fence and gates are required to control access. The aspects associated with the installation of fencing and gates are as follows:

- Excavation for poles
  - The excavation of poles is usually shallow and covers small surface areas. However, the length of the area to be fenced off may result in cumulative impacts as the number of poles is higher.
- Casting for foundation of poles
  - Concrete mix will be required for casting support of poles.
  - During the construction phase, construction waste will be generated due to the need for concrete casting.
- Delivery of material

- Construction camp may be required for the storage of construction material.
- Vegetation will be cleared for the establishment of contractor camp. This camp can be established as close as possible to the infrastructure area.

10.1.2.5. Erosion Control and Re vegetation of bare areas

Bare areas which were created during the construction phase must be rehabilitated. The aspects associated with Erosion Control are as follows;

- Re-vegetation of bare areas;
    - After completing the construction phase, it is necessary to re-vegetate the bare areas.
    - This aspect is deemed a positive impact as vegetation provides support for loose material.
- Construction of Berms Storm water Structures.
    - All catchment areas like adjacent residential dwellings, must be controlled by storm water channels.

10.1.2.6. Deterioration of water Quality

Most artificial activities may result in the deterioration of water quality if not properly managed. The following aspects are associated with the Deterioration of water quality:

- Water pollution from industrial activities like mining and related activities;
    - Defunct mines may result in the deterioration of water quality. Water quality results for a sample collected at Monitoring Point A indicates mining related impacts.
    - Water quality control measures must be implemented from the source of pollution.
- Water pollution from failing waste water treatment plants.

- Blockages of the sewer lines and poorly managed sewage treatment plant pose a risk to the receiving water body.
- The sewage treatment facilities must be designed and managed in such a manner that the final effluent complies to the receiving water quality objectives.

- Water pollution from dense settlements
    - Dense settlements are associated with unofficial waste disposal areas.
    - Waste collecting and sorting measures must be implemented at dense settlement.
- New residential developments
    - New residential development sites were identified. These activities are still at the construction phase. Construction activities are associated with the generation of dust.
    - Dust suppression measures must be in place at residential development sites.

10.1.2.7. Generation and management of waste

Waste will be generated during the construction and operational phases. The aspects associated with the generation and management of waste are as follows;

- Generation of waste;
    - Construction waste will be generated during the establishment of parks
    - Waste management at source - Waste must be temporarily stored in properly marked/colour coded bins.
- Collection of Waste
    - Spillages may occur between collection, transportation and disposal.
    - Waste must be collected by a competent entity for safe disposal. Spillages must be remediated as soon as possible.

- Disposal of waste.
    - Several illegal waste disposal sites were identified.
    - Waste must be disposed of at registered water disposal sites.
- If waste is not properly managed, storm water which gets in contact with waste will be contaminated. Hazardous waste like grease and oil may impact on surface runoff during storm events.

10.2. Risk Rating Criteria

A risk assessment refers to the documented risk of environmental impact(s) due to a change in the receiving environment by an activity either intentionally or unintentionally. For section 21 (c) and (i) water uses it will refer to changes in the resource quality. The formula used to determine risk is indicated hereunder.

RISK = CONSEQUENCE x LIKELIHOOD

CONSEQUENCE = SEVERITY + SPATIAL SCALE + DURATION

LIKELIHOOD = FREQUENCY OF THE ACTIVITY + FREQUENCY OF THE IMPACT +LEGAL ISSUES + DETECTION

Risk is based on the likelihood of occurrence and the consequence it poses to the characteristics of a watercourse. The likelihood is a factor of the mechanisms in place to detect failure, the frequency that the activity is undertaken, legal implications of failure and the frequency of impact occurrence on the watercourse(s). The consequence is measured in terms of severity, duration and spatial scale. The amount of risk involved will trigger the requirement of certain measures to be implemented in order to reduce the risk, like an EMP, and a subsequent rescoring of the risk assessed. The process is illustrated in Figure 10.1-1, based on International Organization for Standardization (ISO) standard ISO14001 (2004).

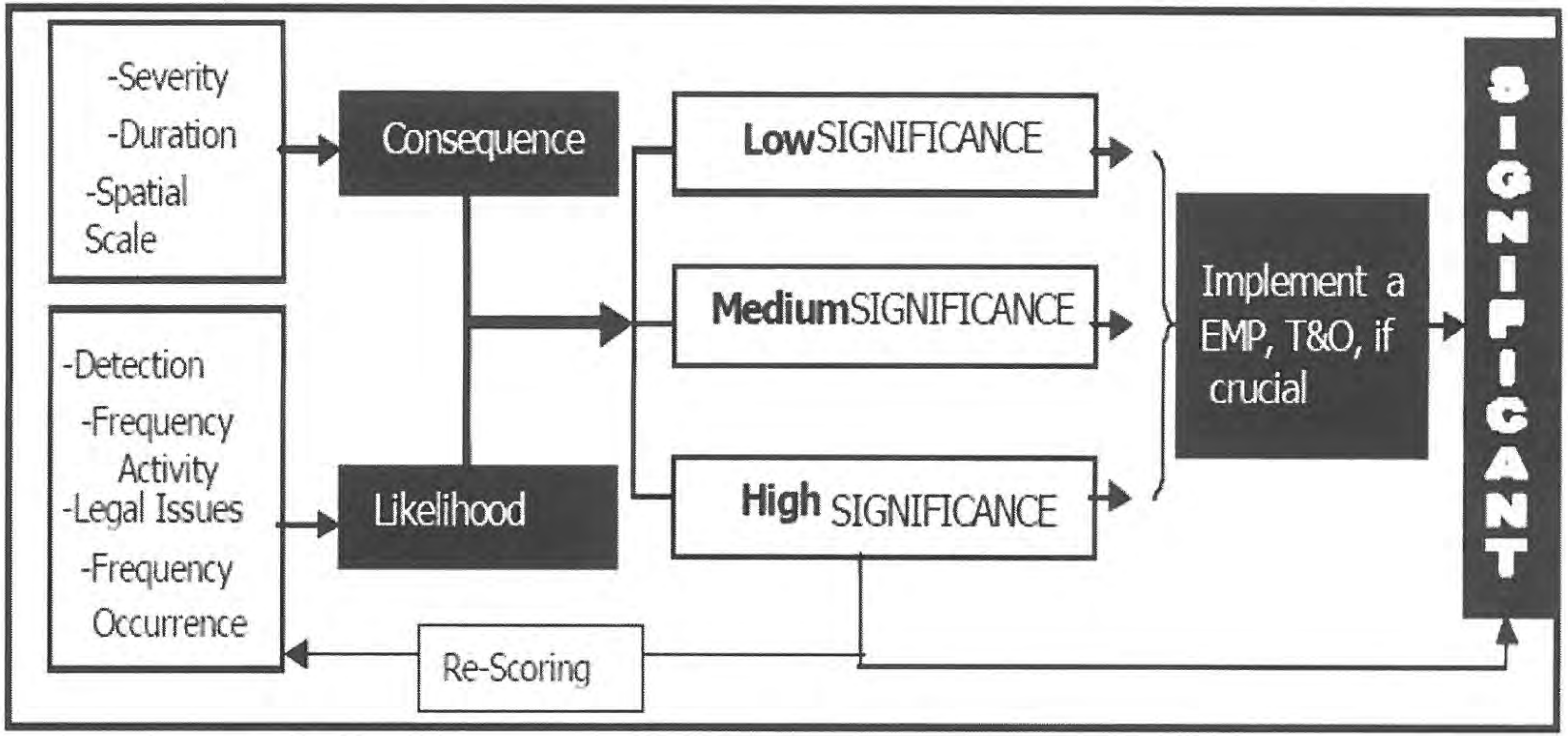


Figure 10-1:- The risk assessment process (based on International Organization for Standardization (ISO) standard ISO14001 (2004)).

Table 10-1: Risk Rating tables according to DWS.

RISK ASSESSMENT KEY (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

TABLE 1- SEVERITY

How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, habitat) ?

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.	

TABLE 2 – SPATIAL SCALE

How big is the area that the aspect is impacting on?

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighboring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

TABLE 3 – DURATION

How long does the aspect impact on the resource quality?

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5
PES and EIS (sensitivity) must be considered.	

TABLE 4 – FREQUENCY OF THE ACTIVITY

How often do you do the specific activity?

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

TABLE 5 – FREQUENCY OF THE INCIDENT/IMPACT

How often does the activity impact on the resource quality?

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

TABLE 6 – LEGAL ISSUES

How is the activity governed by legislation?

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5
Located within the regulated areas	

TABLE 7 – DETECTION

How quickly/easily can the impacts/risks of the activity be observed on the resource quality, people and property?

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

TABLE 8: RATING CLASSES		
RATING	**CLASS**	**MANAGEMENT DESCRIPTION**
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

A low risk class must be obtained for all activities to be considered for a GA

TABLE 9: CALCULATIONS

Consequence = Severity + Spatial Scale + Duration
Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection
Significance\Risk = Consequence X Likelihood

Table 10-2: Risk Rating (Rehabilitation of the Klip Middle Soweto WMU)

Rehabilitation of the wetlands							
No.	**Phases**	**Activity**	**Aspect**	**Impact**	**Risk Rating**	**Confidence level**	**Control Measures**
1		Clearing of silt on the river banks and inlet to wetland	Ripping/loosening of soil	Impact posed by Damage to bank due to sediment transport.	**M**		Bare surfaces must be managed as small as possible. The side slopes of topsoil must be less than 1:3 (v:h). The landscape must blend with the surrounding areas to avoid water ponding.
			Material Stockpile		M		
			Grading/leveling of the landscape		M		
2		Installation of fencing and gates	Excavation	Damage to top soil; Siltation; Compaction of soil / rutting	L		Material required for fencing must be stored at a clearly demarcated area like the contractor camp. This camp must be located close to the area earmarked for infrastructure like ablution facilities in order to centralize the impacted area.
			Casting of foundations for poles		L		
			Delivery of material		L		
3		Erosion Control	Construction of berms	Altering of banks. Impeding the flow. Changing the water course. Siltation & sedimentation	M		Activities within 500m measured from the center of the stream are deemed water uses in line with Section 21(c) of the NWA. Berms and storm water channels must be considered during the construction phase in order to divert clean runoff from the external catchment away from the disturbed areas.
			Storm water structures				
			revegetation of bare areas				

4		Storm Water and Flood Management	Location of infrastructure in the flood lines Maintenance of hydraulic structures Infilling of excavation	Houses located within the 1:100 years flood lines pose a risk. Reduction in design capacity of the culvert due to silted up culvert crossings	M		A maintenance schedule for clearing silt at the culvert crossing must be designed and implemented. Flood protection structures like attenuation walls must be designed and constructed for residential dwellings located within the flood risk areas.
5		Deterioration of water quality	Mine related water quality impacts Blocked Sewer lines and Waste Water treatment plants. Illegal Waste Disposal Residential Development Activities	Acid Mine Drainage from defunct Mines. Raw sewage flowing to the streams. Storm Water Pollution due to illegal domestic waste disposal sites. Use of machinery during construction - Dust generation.	M		Ensure Proper water resource protection measures Enforce Section 19 of NWA which places a duty on everyone to avoid pollution and degradation of water resources. Conduct public awareness educating people about importance and function of water resources i.e. wetland Ensure Proper Waste Management Measures.
6		Disposal of domestic waste and building rubbles	Waste Sorting Waste Transportation Waste Disposal	Water Quality deterioration due to disposal of waste at water resources.	M		Implement Waste collection and sorting from the source. Ensure Proper Waste Management Measures. Public Awareness regarding importance and function of water resource

Table 10-3 Risk Rating (Development of Parks)

Development of parks							
No.	**Phases**	**Activity**	**Aspect**	**Impact**	**Risk Rating**	**Confidence level**	**Control Measures**
1		Clearing of vegetation in close proximity to or in a watercourse	Ripping/loosening of soil	Impact posed by Damage to bank due to sediment transport.	**M**		Bare surfaces must be managed as small as possible.
			Material Stockpile		M		The side slopes of topsoil must be less than 1:3 (v:h).
			Grading/levelling of the landscape		M		The landscape must blend with the surrounding areas to avoid water ponding.
2		Installation of fencing and gates	Excavation	Damage to top soil; Siltation; Compaction of soil / rutting	L		Material required for fencing must be stored at a clearly demarcated area like the contractor camp. This camp must be located close to the area earmarked for infrastructure like ablution facilities in order to centralise the impacted area.
			Casting of foundations for poles		L		
			Delivery of material		L		
3		Erosion Control	Construction of berms	Altering of banks. Impeding the flow. Changing the water course. Siltation & sedimentation	M		Activities within 500m measured from the center of the stream are deemed water uses in line with Section 21(c) of the NWA. Berms and stormwater channels must be considered during the construction phase in order to divert clean runoff from the external catchment away from the disturbed areas.
			Stormwater structures				
			revegetation of bare areas				

4		Storm Water and Flood Management	Location of infrastructure in the flood lines	Houses located within the 1:100 years flood lines pose a risk.	M		A maintenance schedule for clearing silt at the culvert crossing must be designed and implemented.
			Maintenance of hydraulic structures	Reduction in design capacity of the culvert due to silted up culvert crossings			Flood protection structures like attenuation walls must be designed and constructed for residential dwellings located within the flood risk areas.
			Infilling of excavation				
5		Deterioration of water quality	Mine related water quality impacts	Acid Mine Drainage from defunct Mines. Raw sewage flowing to the streams. Storm Water Pollution due to illegal domestic waste disposal sites. Use of machinery during construction - Dust generation.	M		Proper water resource protection measures like "Polluter Pays Principles" must be enforced.
			Blocked Sewer lines and Waste Water treatment plants.				
			Illegal Waste Disposal				
			Residential Development Activities				

6		Generation of domestic waste and building rubble.	Waste Sorting Waste Transportation Waste Disposal	Water Quality deterioration due to disposal of waste at water resources.	M		Endurage Waste collection and sorting from the source. Proper Waste Management Measures.
		May not be authorized under GA					

The tables above (table 10.2 and table 10.3) give a summary of the risks assessment associated with the rehabilitation of the Klip Middle Soweto Water Management Unit as well as development of parks within the WMU. For further information on the impact assessment ratings and scores, the reader is referred to Appendix C of this document. Additional information, in the form of the original impact assessment model spreadsheets (Microsoft Excel), can be made available by Letsolo personnel on request.

11. CONCLUSION

The hydrological Impact Assessment Study was conducted in line with the requirements of the National Water Act, 1998 (Act 36 of 1998) which provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis, upon which to develop tools and means to give effect to the protection of water resources.

The specific process followed in the assessment is summarized as follows:

- Visual assessment of the site and obtaining an understanding of the hydrological conditions;
- Plotting of spatial data to asses hydrological characteristics;
- Building different computer models (for different applications) that represent the site as accurately as possible; and
- Analysing the models in order to obtain the most desirable outputs and deliverables.

The Unit Hydrograph Method was selected as the most reliable Flood Calculations method based on the size of the catchment as well as the reliability of input data.

11.1. Status Quo

The findings indicate that water quality from the Klipspruit and its tributaries is of poor quality on average and is not suitable for domestic use purposes. Indicator variables of pollutants from various sources where identified in the Laboratory analysis report. Activities which impacts negatively on surface water can be categorised as follows:

- Illegal Domestic Waste Disposal;
- Illegal Disposal of building rubbles (glasses, bricks, tar road etc.);
- Stormwater from urban areas and Sedimentation;
- Industrial Activities like mining;
- Informal settlements without services like Sewage and Domestic Waste Disposal Systems;

- Blocked sewer lines and failing waste water treatment plants;

- Illegal Sand Winning activities from the tailings and proximity to the watercourse i.e MPA;

- Existing of distorted erosion control measures such as gabions at tributary of stream 3 (upstream of MPI) .

11.1.1. Development of Parks

The CoJ has developed parks, which are recognized as eco parks, along the river wetland systems in Soweto. Eco parks promote the conservation of biodiversity along the rivers. To mention a few, these parks include the following:

- Dorothy Nyembe Park;

- Thokoza Park;

- Orlando West Park.

The illegal disposal of waste at open spaces and parks, defeats the original purpose of the parks.

11.1.2. Rehabilitation of Wetland Systems

The major impact on the wetland system is a change in flow regimes as a result of blocked culverts. Siltation at the culvert crossings result in a change of flow velocities and peak flows as the original design capacity is compromised.

Wetlands can be difficult to define because of their great variation in size and location. As part of CoJ mandate to interlink park nodes or open spaces along the Klip River and Klipspruit, surface water quality is necessary to assess. There are numerous dams and wetland system at Soweto which serve a number of functions in managing freshwater quality and flow. Both the dams and wetlands act as filters allowing sediments and nutrients (such as nitrogen and phosphorus) to settle down as well as pollutants such as heavy metals which can be trapped by chemical and biological processes. However due to negative impacts on the systems, rehabilitation is needed to maintain and sustain the Klip Middle Soweto WMUs especially the wetland systems.

11.2. Flood calculations

The effective catchment area falls within C22A quaternary catchment. The peak flows for the effective catchment includes the peak flows for Catchments 1 to 5. The peak flow for the 1:100 year storm event, 24 hour storm event, is approximately 521.68 m^3/s. The floodlines just before the outlet of the effective catchment area are based on this value.

11.2.1. Drainage Density

The Drainage Density which is a measure of how well or how poorly a watershed is drained by stream channels, have the value of 0.11 for the effective catchment. It is therefore concluded that the effective catchment drains poorly.

11.2.2. Mean Annual Runoff

The Mean Annual Runoff (MAR), which is the result of precipitation (rainfall) falling on a catchment and eventually running off from the catchment, has a volume of 6 489 000 m3/a for the entire effective catchment.

The catchment is characterised by low-lying areas that are close to the wetland and river system in Soweto. The area is always wet due to continuous flows which typically increase the flood risk in time of a storm event.

11.2.3. Location of houses within the 1:100 years floodline

The public domain and internationally accepted software package HEC-RAS (version 3.1.3) developed by the US Army Corps of Engineers was used to hydraulically model the river system.

Delineated floodlines indicates that some of the residential developments are located within the 1:100 years flood lines. These properties are at risk of being washed away during the significant storm events.

Due to proximity of the flood lines (1:50 and 1:100) only the 1:100 flood have been considered as a worst case scenario for the rehabilitation of the Klip Middle Soweto WMU.

Preventative measures need to be taken to prevent flooding risk, especially on the new development area at Fleurhof.

11.3. Risk Rating

The Klip Middle Soweto WMU is within the urbanized area of Soweto that is affected by expansion of urban development's having some negative impacts on the riverine systems. Potential Impacts from Klip Middle Soweto wetland system along the Klipspruit and its tributaries are summarised as follows:

- Deterioration of water quality
- Change in flow regime
- Increase in Hydrological Yield
- Erosion/sediment transport

11.4. Sensitivities

The study area falls within WMA 08 – Upper Vaal. The Upper Vaal WMA lies predominantly in the eastern interior of the country, with the major rivers: Wilge, Liebenbergsvlei, and Vaal. This water management area is divided into three sub-areas: Downstream Vaal Dam, Upstream Vaal Dam and Wilge.

The site falls within the C22A Quaternary Catchments.

Site Specific Delineated catchments are as follows:

- Effective Catchment
- Catchment 1
- Catchment 2
- Catchment 3
- Catchment 4
- Catchment 5

11.5. Water Quality

Water quality finding are summarised as follows:

- Catchment 1 – Industrial related impacts were observed;
- Catchment 2 – Industrial related impacts were observed;
- Catchment 3 – Urban Activities like disposal of waste and sewage impacts were observed.
- Catchment 4– Urban Activities like disposal of waste and sewage impacts were observed.
- Catchment 5– Urban Activities like disposal of waste and sewage impacts were observed.

12. RECOMMENDATIONS

Reasonable measures as recommended in this report must be implemented in order to reduce the impact on surface water resources. In view of the above conclusions, the following recommendations are made:

- Removing the siltation in blocked culverts;
- Regular maintenance of the culverts crossing the river system;
- Maintenance of distorted existing erosion control measures
- The silted up river banks must be restored to mimic the original cross sections;
- Removal of sedimentation/siltation at the river banks in such a manner that it blends with the surrounding natural area. This will reduce soil erosion and improve natural re-vegetation;
- Improvement of waste collection and disposal at the communities to alleviate illegal disposal of waste;

- Construction of flood protection berms at areas located close to the water resource;
- Continuous Water quality monitoring must be undertaken and action/corrective measures must be implemented in order to protect the water resources;
- Conduct audit to assess the sewage design capacity and treatment plants infrastructure if they are suitable for the current population Soweto is having;
- Implement an educational programme for the people of Soweto about importance and value of wetlands and riverine systems;
- Actively enforce restrictions on dumping in wetlands and riverine systems; and
- Establish wetland monitoring programme to assess the wetland state after rehabilitation;
- Application of GN 704 (1999) should be taken into consideration for the Sand winning activities. Where GN 704 under Regulation 10 (1) (a) (i) – (iii) state that:

"(1) No person may-

(a) extract sand, alluvial minerals or other materials from the channel of a watercourse or estuary, unless reasonable precautions are taken to-

i. ensure that the stability of the watercourse or estuary is not affected by such operations;

ii. prevent scouring and erosion of the watercourse or estuary which may result from such operations or work incidental thereto;

iii. prevent damage to in-stream or riparian habitat through erosion, sedimentation, alteration of vegetation or structure of the watercourse or estuary, or alteration of the flow characteristics of the watercourse or estuary;"

Proposed rehabilitation of the wetland within the WMU should not commence prior the grant of WUL from the Department of Water and Sanitation. Whereby section 21 (c) & (i) are triggered - S21(c) denotes diverting the flow of water and 21(i) denotes altering a water course.

13. SCHEDULE OF REFERENCE

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APPENDICES