

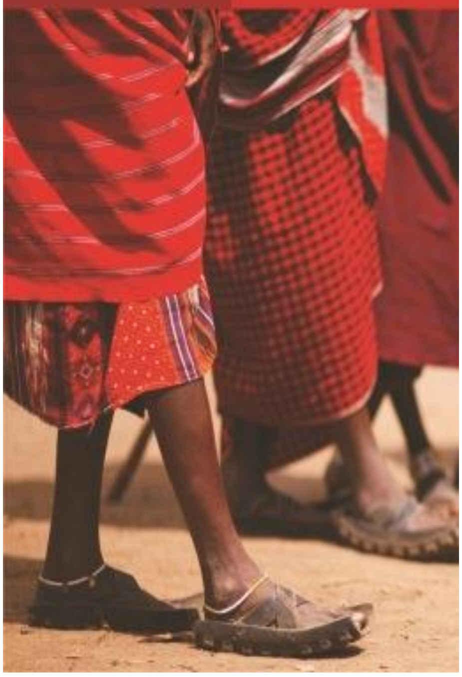

DIGBY WELLS ENVIRONMENTAL

Proposed Open Cast Coal Mine on Portions Farm Palmietkuilen 241 IR, near Springs in the Gauteng Province

Surface Water Assessments Report

Project Number:

CNC4065

Prepared for:

Canyon Coal (Pty) Ltd

March 2017

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This document has been prepared by Digby Wells Environmental.

Report Type:	Surface Water Assessments Report
Project Name:	Proposed Open Cast Coal Mine on Portions Farm Palmietkuilen 241 IR, near Springs in the Gauteng Province
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EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Pandospan (Pty) Ltd, a subsidiary of the Canyon Group which is in contract with Anglo Operations (Pty) Ltd to undertake surface water assessments relating to the proposed development and operation of a new open cast coal mine and associated infrastructure on Portions 1, 2, 4, 9, 13 and 19 of the Farm Palmietkuilen 241 IR, near Springs in the Gauteng Province of South Africa. The proposed Project Area falls within the Sedibeng District Municipality and borders of the Mpumalanga Province.

The aim of this surface water study was to:

- Undertake baseline assessments in terms of water quality and quantity;
- Undertake floodlines assessments for a 1:50 and 1:100 year flood peaks on the Aston Lake and feeder streams (Dwars-in-die-wegvlei and the Verdrietlaagte);
- Prepare a conceptual Storm Water Management Plan (SWMP); and
- Develop a mine wide water balance.

The study also involved undertaking an impact assessment that identifies significant impacts on the Aston Lake and nearby streams as a result of the proposed activities and provide mitigation measures for implementation to prevent and/or reduce the identified potential surface water impacts together with a monitoring plan.

The surface water study in conducted in line with the National Water Act, 1998. Act 36 of 1998 (NWA)'s Government Notice of Regulation 704 (GN 704) (for environmental purposes only) and Department of Water and Sanitation (DWS) Best Practise Guidelines (BPG) Guidelines G1 and G2 on Storm Water Management and Water Balance respectively (DWS, 2006);

The proposed Palmietkuilen Coal Mine is located within the Aston Lake catchment, surrounded by wetlands and drained by the Dwars-in-die-wegvlei and the Verdrietlaagte stream on either side. The Aston Lake discharge flows into the Blesbokspruit. The Project Area is situated within the Vaal Water Management Area (WMA 5), within quaternary catchments C21E.

The identified infrastructure areas amount to approximately 10.72 km^2 as measured on the provided infrastructure layout. The Infrastructure is approximately 3.1% of total catchment area for the Aston Lake (344 km^2) and this would imply a loss of only 3.1 % catchment runoff to the Aston Lake.

A site visit was conducted on the 23 August 2016 to collect water samples from the three selected points: one upstream, one downstream on the Verdrietlaagte stream and one from the Aston Lake.The Dwars-in-die-wegvlei was found dry and some other sections of the Verdrietlaagte had stagnant water. August is considered a dry season in South Africa and

due to that streams were predominantly dry with other sections having stagnant water however three (3) water samples were collected.

The water quality was benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996) and South African Water Quality Guidelines for Agricultural Use: Domestic Use. It was also benchmarked against the Blesbokspruit catchment water quality guidelines/ objectives (WQO) and the South African National Standards (SANS) 241-1:2015 drinking water standards.

The water quality results indicated that the pH exceeded the SWQG Agriculture irrigation limit in all samples, which has high possibility of affecting yield decreasing marketable products for farmers and is within the range for other limits. When compared against the SWQG Agriculture: Domestic Use, all samples exceeded standards in Turbidity and at SW01 in EC, Ca, Mg, Na, Cl, and Total Hardness. The irrigation limit was exceeded for Cl.

Turbidity exceeded limit of the SANS 241-2015 drinking water quality standards in all samples.

The water quality at Aston Lake had elevated Al and Fe exceeding SWQG Domestic Use, Turbidity exceeding beyond both SANS 241-2015 drinking water quality standards and SWQG: Domestic Use limit with SS exceeding SWQG: Agriculture (Irrigation) Limit.

The result of the flood elevations shows that none of the proposed infrastructure is within the determined Dwars-in-die-wegvlei floodlines except the proposed haul road which crosses the floodlines. It is important to note that the floodlines delineation methodology used is conservative and should be considered a worst case scenario given up to the 1:50 and 1:100 year flood peak.

Based on the conceptual SWMP, proposed infrastructure included installation of clean water diversion berms and dirty water conveyance channels towards a PCD. The following recommendations were made:

- Management measures which include vegetating the stockpiles, cleaning the dirty water collection trenches regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows;
- Installation of sediment control and erosion control through impeding structures and silt traps were also recommended as well as monitoring of the water quality and quantity; and .
- Construction of an emergency dam or toe paddocks adjacent to the PCD, preferably downstream to hold overflows and bypass in times when the primary PCD is being cleaned.

From the impacts assessments undertaken; the results indicated the following:

Minor Negative Impacts

- Sedimentation of surface water resources resulting in deteriorated water quality; and

- Reduced surface water infiltration as well as an alteration in surface water drainage patterns as a result of soil compaction from the movement of heavy machinery and vehicles.

Moderate Negative Impacts

- Reduced surface water infiltration, alteration in surface water drainage patterns and increased velocity in surface water runoff leading to possible erosion and sedimentation and less runoff reporting to the Blesbokspruit;
- Alteration in surface water drainage patterns and a reduction in the amount of water reaching the Aston Lake and reduced flow to Blesbokspruit; and
- Water contamination leading to deterioration of water quality from carbonaceous material and eroded soil material.

Mitigation measures include implementation of the SWMP and additional measures such as:

- To ensure that the topography of disturbed areas is returned to a pre-mining state to allow free draining topography;
- Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration
- Roads should be maintained regularly to ensure that surface water drains freely off the road preventing erosion; and
- Re-vegetation of disturbed areas.

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LIST OF ABBREVIATIONS AND ACCRONYMS

Abbreviation	Description
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GN704	Government Notice 704 in Government Gazette 20119
ha	hectares
km	Kilometre
LIDAR	Light Detection And Ranging
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act, 1998 (Act No. 36 of 1998)
m	Metre
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
Mg/l	Milligrams per litre
MRA	Mining Right Application
mg/L	milligrams per litre
mm	Millimetre
mS/m	Milli Siemens per metre
m^3	Cubic metre
PCD	Pollution Control Dam
RoM	Run of Mine
SANAS	South African National Accreditation System
SAWQG	South African Water Quality Guidelines
SDF	Standard Design Flood
SOP	Standard Operation Procedures
TDS	Total Dissolved Solids
UPD	Utilities Programme for Drainage
WARMS	Water Authorisation and Registration Management System
WRC	Water Research Commission
WMA	Water Management Area

1 Introduction

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Pandospan (Pty) Ltd, a subsidiary of the Canyon Group which is in contract with Anglo Operations (Pty) Ltd to undertake surface water assessments relating to the proposed development and operation of a new open cast coal mine and associated infrastructure on Portions 1, 2, 4, 9, 13 and 19 of the Farm Palmietkuilen 241 IR, near Springs in the Gauteng Province of South Africa. The proposed Project Area falls within the Sedibeng District Municipality and borders of the Mpumalanga Province.

1.1 Project Description

The Palmietkuilen project involves the development of a new open pit coal mine and supporting infrastructure. The raw coal, once extracted, will be transported to a processing plant for crushing, screening and washing. The coal product will either be transported via haul roads from the product stockpile area to the existing Welgedacht siding for distribution by rail or directly to prospective clients by road. The proposed mine will require supporting infrastructure such as water storage, sewage treatment, power supply, fuel storage, haul roads etc.

The current resource is estimated at 125.98 Mt. The life of mine for the project is 53 years including a 2 year ramp-up period. Once the mine has been established, a full production rate of 200 000 t / month will be maintained for 51 years.

2 Terms of Reference

This report serves to provide the details of the baseline surface water conditions prior to the commencement of the proposed mining project, and assess the potential impacts on the surface water resources that could emanate from the project and its associated activities. It will also provide the recommended mitigation measures to prevent or reduce the identified potential impacts. This will be limited to the project area and associated infrastructure illustrated in Figure 2-1.

The surface water impact assessment was conducted in line with the Department of Water and Sanitation (DWS) Best Practice Guideline for Impact Prediction and the following legislative requirements:

- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA);
- National Water Act (Act 36 of 1998) (NWA); and
- NWA amendment of Regulation 704 (GN R 704) of 1999.

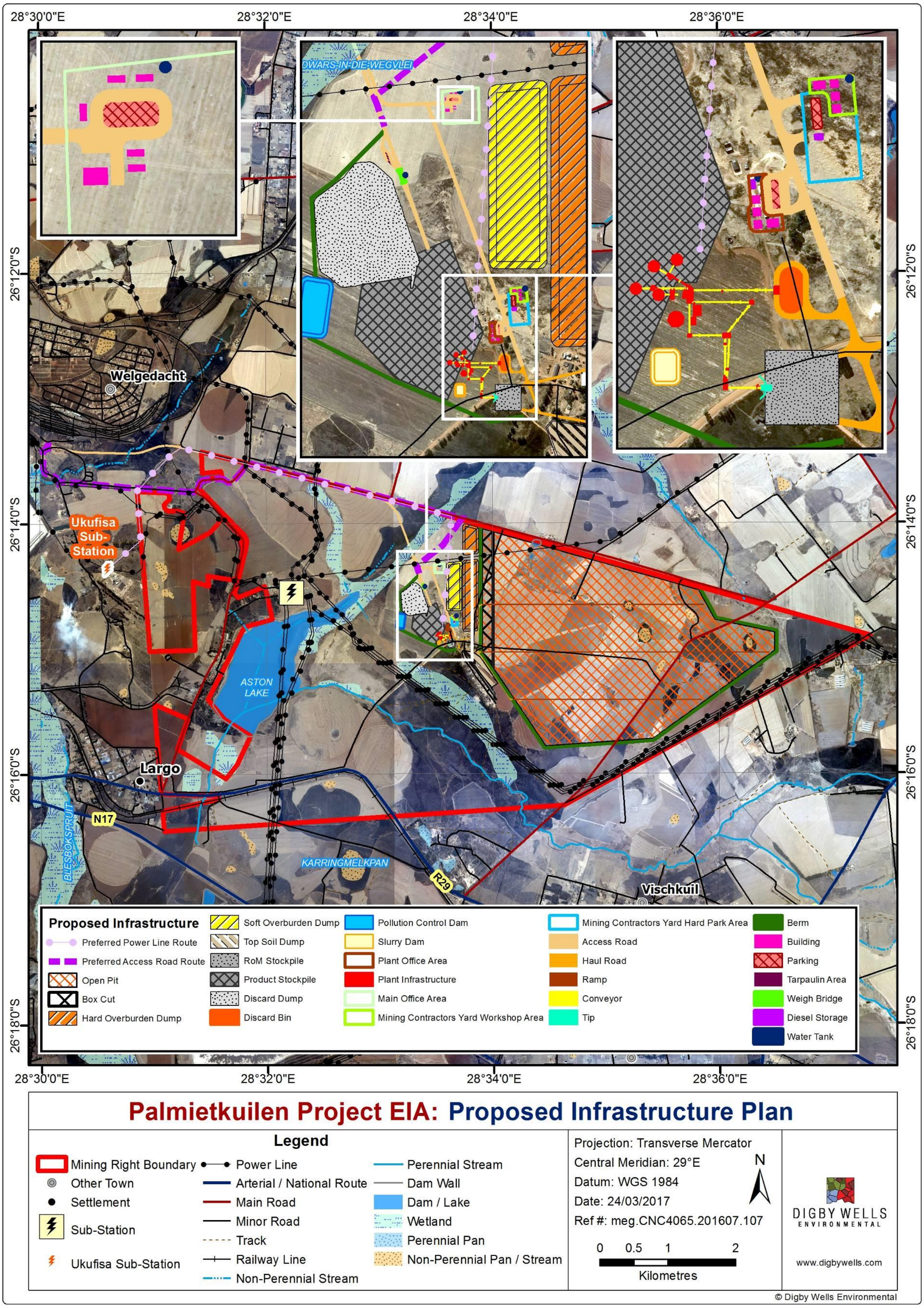


Figure 2-1 : Proposed Infrastructure

3 Details of the Specialist

The relevant expertise of the specialists involved in the surface water assessments. Chenai Makamure undertook the hydrological modelling and report writing and Zinhle Shongwe was part of the site assessments and water quality data manipulation for the report. A summary of their credentials and experience is detailed in Table 3-1.

Table 3-1: Expertise of specialists

Chenai E. Makamure (Pr. Sci. Nat) 400150/16 Water Institute of Southern Africa WISA (No. 25046)	A holder of an MSc in Geo-Information Science and Earth Observation for Watershed Modelling and Management (Surface Hydrology). Chenai is a seasoned Surface Water Consultant (Hydrologist) with over nine years work experience. Her experience ranges from Mining, quasi-government and consulting environment; focused specifically in the mining industry. Chenai had completed numerous hydrology specialist studies including, baseline hydrology assessments, water quality assessments, data collection and analysis for surface water quality and quantity, surface water quality input into EIA/EMP, integrated water and waste management plans, water balances, storm water management plans assessments and development, flood modelling and floodlines determination within Iron Ore, Coal, Gold and Platinum mining, power stations and infrastructure development projects in Africa (South Africa, Ghana, Mali, Liberia, Sierra Leone, Cameroon, Malawi and Democratic Republic of Congo).
Zinhle Shongwe	Zinhle Shongwe is a Hydrology Intern at Digby Wells Environmental specialising in Surface Water Assessments within the Water Geosciences Department. She holds a Bachelor of Geography and Hydrology (Double Major) and Honours Degree in Hydrology both obtained from the University of Zululand. Zinhle joined Digby Wells in 2015 (June and December) as a bursar student doing her vacation work and became an Intern in January 2016. Her work experience includes data collection, capture and analysis of surface water quality and quantity, surface water specialist studies for EIA/EMPs, and Integrated Water and Waste Management Plans (IWWMP) and has been involved in Geophysical and Hydrocensus Surveys.

4 Study Objectives

The objectives of this study are to:

- Provide a baseline description of the hydrology of the project area in terms of the hydrological setting, climate and water quality and quantity;
- Conduct an assessment that identifies impacts on the Aston Lake and nearby streams (Dwars in die wegvlei and Verdrietlaagte) as a result of the proposed activities;
- Provide mitigation measures for implementation to prevent and/or reduce the identified potential surface water impacts together with a monitoring plan;

- Determine the 1:50 year and 1:100 year floodlines or the nearby sections of the Dwars in die wegvlei and the Verdrietlaagte as well as the Aston Lake; and
- Prepare a conceptual Storm Water Management Plan (SWMP) in line with the location of infrastructure. All recommendations will be in line with the GN 704. The measures provided in the SWMP have been developed in accordance with the principles of BPG G1: Storm water management (DWS, 2006), with the objective of keeping clean and dirty water separate, as defined by the following:
  - Collect all storm water that is of poor quality in a dirty water trench and contain it within the storage facilities (i.e. Pollution Control Dam (PCD) for reuse;
  - Ensure that all storm water structures that are designed to keep dirty and clean water separate can accommodate a defined precipitation event. The magnitude of the precipitation event used in this assessment is the 1:50 year, 24-hour event;
  - Route all clean storm water directly to natural watercourses without increasing the risk of a negative impact on safety and infrastructure, e.g. loss of life or damage to property due to an increase in the peak runoff flow;
  - Ensure that the maximum volume of clean water runoff is diverted directly to watercourses;
  - The SWMP must be sustainable over the life cycle of the mine and over different hydrological cycles and must incorporate principles of risk management; and
  - The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

5 Methodology

5.1 Desktop Based Literature Review

A review of documents including existing surface water reports (Digby Wells Environmental, 2015) and other water resources study such as the Water Resources of South Africa, 2012 Study (WR2012) was undertaken. Background information for the project area was obtained and the relevant information extracted for compiling this report.

5.2 Field Assessments and Sampling

A site visit was conducted on 23 August 2016 to collect water samples from the selected points, The selection of water sampling locations aims at collection of samples upstream of the proposed mining activities, within the mining activities (mid-stream) and downstream of mining activities/infrastructure.

The upstream site will indicate the inflow water quality into the proposed Project area which represents the water quality from all upstream activities not related to the proposed Project activities. The midstream points will indicate the immediate mine site's point and diffuse sources of water quality pollution, whilst the downstream points will detect how far reaching the water quality impacts are, and is most cases can prove the water course's self-cleaning capability through dilution or biological activities.

The surface water points locations are summarised below in Table 5-1.

Table 5-1: Surface Water Sampling Points

Point Name	Latitude*	Longitude*	Description
AECSW06	-26.269461	28.523228	Downstream monitoring point : downstream of Aston Lake on unnamed Stream
SW1	-26.274339	28.572975	Upstream on Verdrietlaagte a feeder stream to the Aston Lake
SW2	-26.231863	28.55844	Upstream sampling point on the Dwars-in-die-wegvlei was found dry
Aston Lake	-26.253233	28.527422	Located within the Lake downstream of infrastructure area

*Geographic Coordinate System WGS84 Datum

Sampling photos taken of the sampling locations are represented on Figure 5-2

SW1

SW2

AECSW06

Aston Lake

Figure 5-1: Sampling Location Pictures

The location of the three sampling sites relative to the project area is indicated in Figure 5-2.

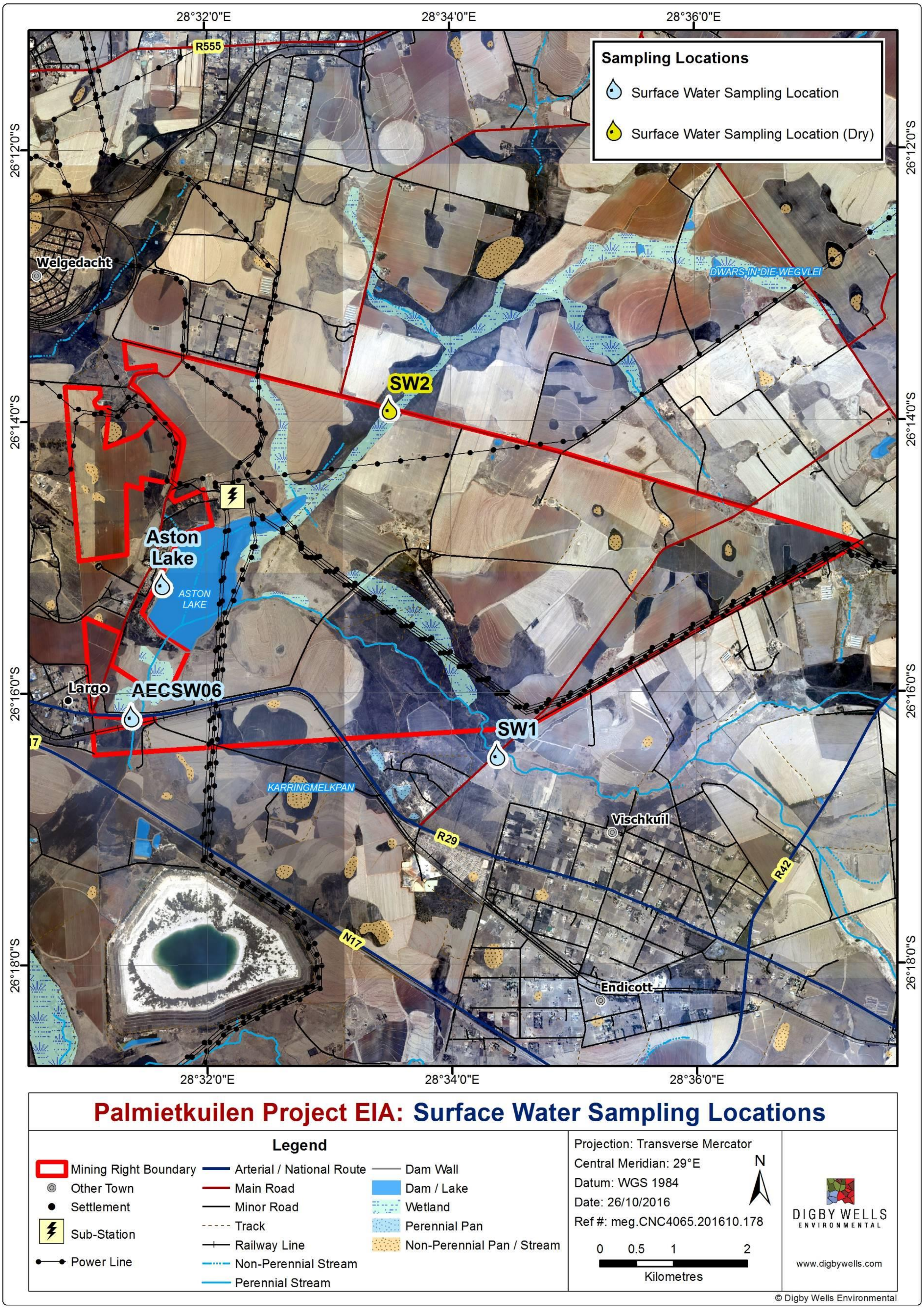


Figure 5-2 : Surface Water Sampling Locations

5.3 Baseline Water Quality

Surface water samples were submitted to Aquatico Laboratory (Pty) Ltd, a South African National Accreditation System (SANAS) accredited laboratory, in Pretoria for analyses of physical and chemical water quality parameters. Based on the site survey water use around the project area is predominantly for irrigation, livestock watering and domestic water use (with most farmers having their own water treatment plants). For that reason the results were benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996) and South African Water Quality Guidelines for Agricultural Use: Domestic Use.

The water quality data was also benchmarked against the Blesbokspruit catchment water quality objectives (WQO)[1] as the project area is located within the catchment and there are no standards in the Aston Lake.

Water quality results have also been benchmarked against the South African National Standards (SANS) 241-1:2015 drinking water standards. SANS 241 specifies the quality of acceptable drinking water, defined in terms of microbiological, physical, aesthetic and chemical determinants. Water that complies with SANS 241 is deemed to present an acceptable quality for human consumption (this implies an average consumption of 2 L of water per day for 70 years by a person that weighs 60 kg).

[1] (http://reservoir.co.za/forums/vaalbarrage/blesbok_forum/blesbok_documents/BF_WQGuidelines.pdf

5.4 Storm Water Management Plan

A conceptual SWMP has been developed in accordance to the Best Practice Guideline G1: Storm Water Management Plan (DWS, 2006); for implementation throughout the Life of Mine (LoM). All recommendations in the SWMP ensure compliance with NWA Government Notice of Regulation (GN R) 704 GN 704.

The following was completed:

- The mine plan indicating the conceptual placement of clean and dirty water structures; and provision of recommendations for SWMP measures;
- Calculation of the 1:50 year 24 hour peak flows for the dirty water catchments namely;
  - Soft and hard stockpiles
  - Plant area
  - Workshop
  - Open pit
- Recommendations of storm water control, management and erosion control measures to be put in place as part of the SWMP; and
- Technical Report defining the SWMP.

5.5 Floodlines Determination

The initial desktop assessment shows that the Aston Lake is within the project area. The GN704 requires that:

No person in control of a mine or activity may-

(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked;

(b) except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest;

As such the 1:50 and the 1:100 floodline were delineated on the unnamed stream flowing east-west draining to Aston Lake. This section provides the methodology and inputs used to determine the 1:50 year and 1:100 year floodlines and the model results.

5.5.1 Topography Data Sources

The topography of the project area and surrounds is undulating with hills and valleys. The Digital Elevation Model (DEM) was created by merging two contour datasets.

- The first contour dataset was provided by the client and only covers the extent of the project area. The contour interval of this dataset is 1 m; and
- The second contour dataset was obtained from the July 2012 Topographical Map Data. The contour interval of this dataset is 5 m and covers an extent of 8 km outside the project boundary.

The DEM was modelled using ArcGIS version 10.2.1 3D Analyst Extension from the combined contour datasets. The resolution of the final DEM is a 2 m by 2 m cell size.

5.5.2 Land Uses and Soils Characterisation

Land use and soil in the project area is adopted from the Digby Wells, 2016 – Soils Assessment Report studies. The soil can be described as texturally variable, containing a mixture of sandy clay loam, loamy sand and sandy loam (Soil Classification Working Group, 1991).

The identified soils were also classified in terms of permeability and as listed the following were available on the project site:

- Sandy loams and sandy clay loams Hutton and Clovelly Forms with moderate to good infiltration and drainage characteristics;
- The Arcadia, Westleigh soil, Kroonstad soil, Katspruit soil and Glencoe soil have a low permeability. These low permeability soils are associated with wetland / flood plain areas; and
- The Mispah soil which is almost impermeable and pose a high erosion hazard.

Based on the soil delineations undertaken for the project area, approximately, 100% semi permeable (meaning moderate to low permeability) and the area covered by impermeable soils is almost negligible.

The most dominant land use is cultivated areas followed by grasslands, shrubland and woodlands. This shows that the area has been developed into agriculture over years.

5.5.3 Subcatchment Delineation

Subcatchments were delineated to cover the streams within the project boundary and were utilised to determine the flood peaks for the 1: 50 and 1: 100 year extreme events. The delineated subcatchments are highlighted in Figure 5-3.

The subcatchments were characterised for the peak flows calculations as detailed in the Drainage Manual (SANRAL, 2007). The values of each of these model parameter classes were then determined by professional subjective judgement/ discretion, and visual inspection on the terrain and fraction of the catchment. The most important parameters are:

- Area distribution – which is estimated based on the catchment area and respective areas covered by the rural, urban and reservoirs;
- Rural area surface slope – which was characterised based on the respective slope (%) classifications to define flat areas from hilly areas and steep area;
- Rural area permeability – which is estimated from the a qualitative guide of soil texture for the classification of the soil permeability as in the Drainage Manual (SANRAL, 2007) and soil maps (1:250 000 interactive map from Agricultural Research Council) and estimation of percentage area by visual inspection;
- Vegetation – which was estimated from site inspections observations and satellite imagery visual classification;
- Urban area parameters – which were based on site observations and inspections;
- The number of days on which thunder was heard – obtained from the WRC Report and the SAWS;
- Dolomitic areas – the percentage dolomitic area was determined based on the geology map and using visual inspection and estimation; and
- Overland or defined water course flow – where the average slope of a catchment greater than 5% and catchment larger than 5 km^2 assumes that defined water courses exist.

The delineated catchments as used in the floodlines modelling are as follows

Catchment	Catchment Area (km^2)	Comment
C1	62	Dwars in die wegvlei
C2	69	Verdrietlaagte
C3	13	Downstream of Aston Lake
Catchment for Aston Lake (C1 + C2)	131	Catchment upstream of Aston Lake

5.5.4 Peak Flow Methodology

Alternative rational (AR) and standard design flood (SDF) methods were used to calculate the 1:50 and the 1:100 year peak flows and are described below. The Utilities Programme for Drainage (UPD) software which contains the AR and the SDF was used to perform calculations.

5.5.4.1 Alternative Rational Method

This method is based on the rational method with the point precipitation being adjusted using the Design Rainfall Estimation Methodology developed by Smithers and Schulze (2003) to take into account local South African conditions. This method can work for large catchments without any limitation.

5.5.4.2 Standard Design Flood

The standard design flood method (SDF) was developed to address the uncertainty in flood prediction under South African conditions. It is based on historical data to adequately describe the flood frequency relationships. The runoff or discharge coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 29 regions of WMAs. This method can work for large catchments without any limitation.

Four classes of surface slope (< 3, 3 - 10, 10 - 30 and > 30 %) were identified, which were used in the determination of their respective coverage areas and enabled the calculation of the slope component of the C (discharge) factor.

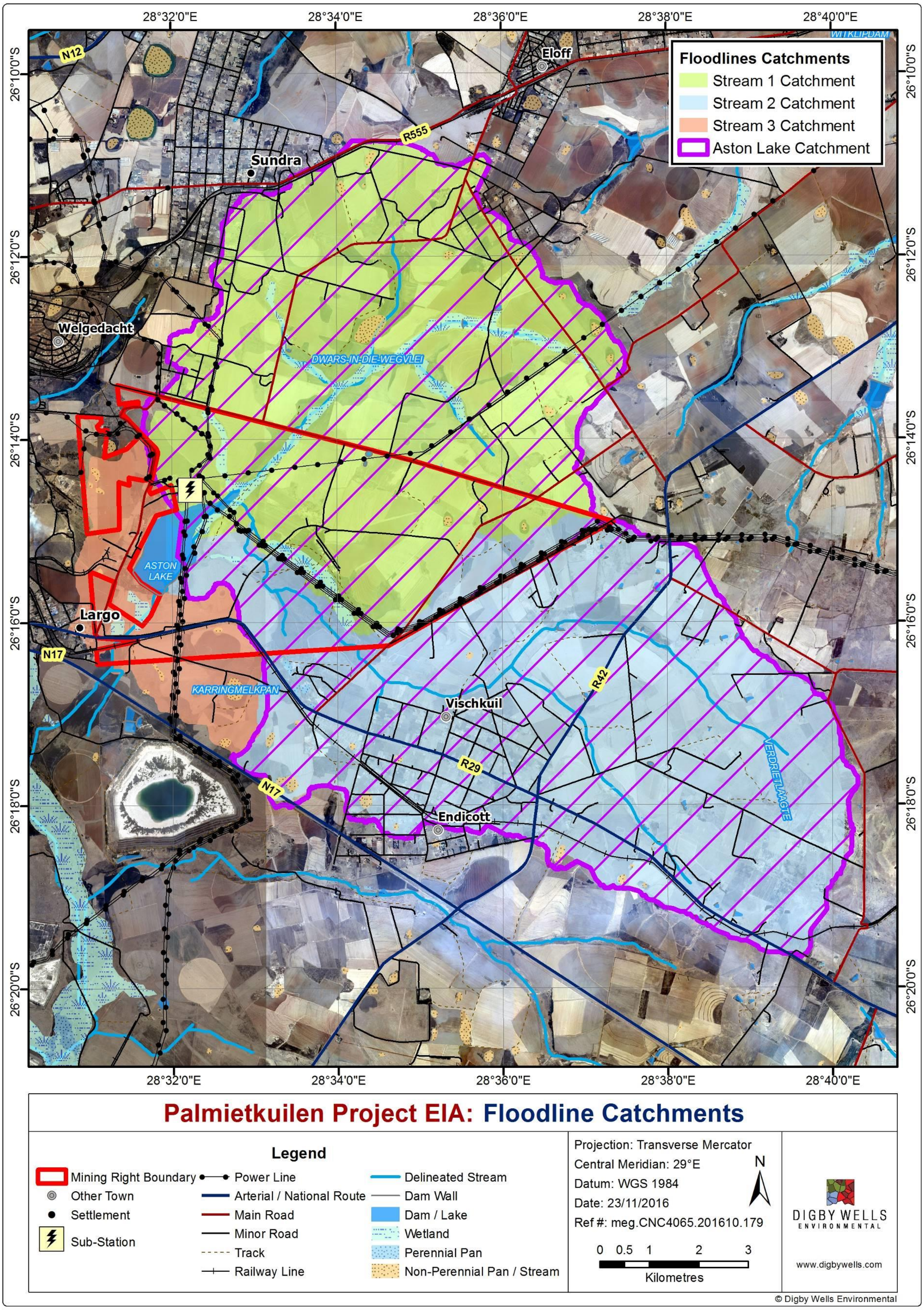


Figure 5-3: Delineated sub-catchments

5.5.5 Manning's Roughness Coefficients

Manning's roughness factor (n) is used to describe the channel and adjacent floodplains resistance to flow. Based on a site visit conducted on 23 August 2016, where the channel and floodplain were assessed, it was observed that the left and right banks of most of the affected watercourses were densely covered by grass. Therefore a Manning factor of 0.05 for Catchment 1 and 0.045 for Catchment 2 were assigned to best represent the frictional characteristics of both the channel and floodplain areas.

The Manning's roughness coefficients were estimated from Chow (1959). Figure 5-4 indicates the Vlei channel and the Stream channel for Catchments 1 and Catchment 2 respectively.

A: River channel for the Dwars-in-die-wegvlei in Catchment 1 taken at location -26.231863; 28.55844 (n=0.05)

B: River channel for the unnamed river in Catchment 2 taken at location -26.274339; 28.572975 (n=0.045)

Figure 5-4: Photographs of the Floodplains and River Channels for Catchments 1 & 2

5.5.6 Choice of Software

ArcMap 10.2 is a GIS software programme used to view, edit, create and analyse geospatial data. ArcMap was used to view spatial data and to create maps. Its extension 3D Analyst was used for terrain modelling purposes, for converting the survey data into a DEM grid format.

HEC-GeoRAS is an extension of HEC-RAS in the ArcGIS environment. is used to extract the cross-sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-

RAS for modelling. It is further used in post processing to import HEC-RAS results back into ArcMap, to perform flood inundation mapping.

HEC-RAS version 5.03 (Brunner, 2016) was used for the purpose of modelling the flood elevation profile for the 1:50 and 1:100 year flood event. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels.

5.5.7 Model Development

Development of the hydraulic model included the following steps:

- Creation of a DEM from the contour data;
- Digitising the stream centre lines and flow paths using HEC-GeoRAS;
- Generating cross-sections approximately 100 m apart through the watercourses using HEC-GeoRAS;
- Importing geometric data into HEC-RAS;
- Entering the Manning's values, peak flows, and upstream and downstream slope boundary conditions in HEC-RAS;
- Performing steady, mixed-flow regime hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections; and
- Importing flood levels and projecting levels onto the DEM using HEC-GeoRAS to determine the flood inundation areas.

5.5.7.1 Reservoir Routing

Reservoir routing through the Aston Lake was undertaken using the principle of mass conservation which forms the basis of flood attenuation to determine the Lake floodlines. Reservoir routing considers the modulation effect of a flood wave when it passes through a water reservoir and results in an outflow hydrograph with attenuated peaks and enlarged time basis whereby the peak flow occurs at a later time.

The reservoir routing was undertaken using level pool procedure which is performed by the following:

- Use hydrological calculations to obtain inflows hydrograph for the contributing catchment that is handled by the reservoir over a 50 and 100 year design period;
- Use dimensions of the reservoir and determine a head /discharge relationship for such a controlled conditions;
- A graph is plotted showing the relationship between outflow and the auxiliary function determined by the relationship of change in storage volume over a selected time increments, for example time increments of 0.005 hours from the start of the inflow to the peak inflow (Time of Concentration (Tc)). Successive auxiliary functions are calculated and the corresponding outflows can be read; and

- The maximum outflow discharge will then coincide with maximum energy head, which can then be calculated. This will then determine the attenuated flood elevation at the spillway.

A rectangular sharp crested weir spillway was used of the analysis and the applicable outflow stage relationship was adopted as follows (SANRAL, 2016):

$$Q=C_dLH^{1.5}$$

Where:

Q	=	discharge (m^3/s)
C_d	=	Discharge Coefficient
L	=	Length of Spillway (m)
H	=	Total energy head (measured above spillway level) (m)

5.6 Impact Assessment

An impact assessment was undertaken to:

- Identify the impacts on the surface water resources due to implementation of the proposed activities. Once impacts have been identified, a significance rating system adopted by Digby Wells will be used to rate the impacts. The system takes into consideration the intensity, duration, spatial scale and probability of the impacts;
- Develop mitigation measures for implementation to reduce the significance of the surface water impacts; and
- Develop surface water monitoring plan prepared in line with the DWA BPG: G3 Water Monitoring indicating monitoring points located up and downstream of the site and the frequency of monitoring.

6 Assumptions and Limitations

The following defines the assumptions and limitations applicable to this study:

- The surface water impact assessment was done based on the provided mine layout plans and the proposed mining activities. Any changes to the mine plans after completion of this report may require an update of this report; and
- The determined floodlines and SWMP should only be used for indicative and environmental purposes, and not for detailed engineering design. Should they need to be used for designs, civil engineering drawings will need to be undertaken based on these;
- It should be noted that the sizing and design of the PCD and channels as well as dirty water sumps within the open pits do not form part of this conceptual SWMP;

- Part of this hydrological study was the development of a mine wide water balance , due to the limited information at compilation of this study, the water balance will only be carried out once all designs have been finalised and capacities and alternatives of water discharge and sources have been finalised during the Water Use Licence Application phase; and
- In line with the development of the floodlines the following specific assumptions were made:
  - The flood extents were determined for environmental purposes only and not for engineering design;
  - It is assumed that the survey data provided by the client is an accurate and up-to-date representation of the terrain of the modelled streams and floodplains;
  - Calibration of the hydrological and hydraulic models was not possible as there was no existing information available for the modelled streams. Conservative guideline values for parameters have been used based on observed site conditions. This is a standard approach for determining indicative flood lines
  - No abstractions from the river section or discharges into the river section were taken into account during the modelling;
  - The Aston Lake was modelled using level pool routing approach, which uses an elevation versus volume curve to define a storage area instead of the use of cross sections as elevation information was not immediately available for the Aston Lake itself (it was excluded in the 1m contour surveys);
  - The vertical wall effect was prevented by extending the cross sections long so as to and prevent the flood water elevation falling outside the cross sections;
  - Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate; and
  - A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model.

7 Baseline Environment

7.1 Hydrological Setting

This section provides the hydrological baseline description. This includes description of the water management areas (WMAs), rivers and drainages, climate (rainfall and evaporation), and water quality status within or around the project area.

7.1.1 Regional Hydrology

South Africa is divided into 9 WMAs which have been published in the Government gazette number 40279 of 19/09/16 (Notice no 1056, DWS, 2016), managed by their own water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A to X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment; A2 for example will represent the secondary catchment; A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the WRM2012 manual. Each of the quaternary catchments has associated hydrological parameters.

The Project Area is situated within the Vaal Water Management Area (WMA 5), within the C21E quaternary catchment (Figure 7-1).

7.1.2 Local Hydrology

The proposed Mine is within the Aston Lake catchment, surrounded by wetlands and drained by the Dwars-in-die-wegvlei and the Verdrietlaagte streams on either side as depicted in Figure 7-2. The Aston Lake discharge flows into the Blesbokspruit.

The Blesbokspruit is a perennial second-order stream which is a tributary of the Suikerbosrand River, which in turn flows into the Vaal River. The Blesbokspruit originates in the northern part of the catchment with perennial and non-perennial streams contributing to its flow; it is a National Freshwater Ecosystem Priority Areas (NFEPA) recognised wetland and is also a Ramsar site. Aston Lake is best known as a fishing destination thus giving is a local recreational importance.

7.1.3 Climate

This section provides the climatic conditions (temperature, rainfall and evaporation) of the Palmietkuilen Project area.

7.1.3.1 Rainfall

The MAP (mean annual precipitation) (obtained from the WR2012 manual) for quaternary catchment C21E is 691 mm. The average monthly rainfall for this catchment is present in Table 7-1.

Table 7-1 Summary of Rainfall Data Extracted from the WR2012

Month	Monthly mean rainfall
January	122.7
February	91.8
March	82.9
April	43.3
May	19.1

Month	Monthly mean rainfall
June	7.4
July	6.4
August	8.1
September	23.4
October	70.7
November	105.4
December	110.1
MAP	**691**

Based on the data, the average driest months for quaternary catchment C21E are June, July and August whilst the average wettest months are November, December and January. These are considered as the winter and summer season respectively in South Africa, the results further explains why the streams were found dry during the site visit conducted on the 23 August.

7.1.3.2 Evaporation

Monthly evaporation data was obtained from the WR2012 database (WRC, 2012) manual (WR2005, 2012) an indicated a MAE of 1625. Table 7-2 is a summary of the monthly evaporation from the WR2005 for the C21E quaternary catchment.

Table 7-2: Summary of Evaporation Data

Months	Symons Pan Evaporation (mm)	Lake Evaporation Factor	Lake Evaporation (mm)
January	184.60	0.84	155.06
February	152.26	0.88	133.99
March	142.35	0.88	125.27
April	107.58	0.88	94.67
May	87.26	0.87	75.92
June	70.85	0.85	60.22
July	76.54	0.83	63.53
August	110.99	0.81	89.90
September	149.18	0.81	120.83
October	176.31	0.81	142.81
November	176.80	0.82	144.98
December	190.29	0.83	157.94
Total	**1625**	**N/A**	**1365**

The obtained mean annual lake evaporation is 1 365 mm as presented on the data. The monthly evaporation data shows the highest lake evaporation rate of 144.98 mm, 157.94 mm and 155.06 mm which was recorded in November, December and January respectively. The recorded monthly minimum lake evaporation rate is 60.22 mm, 63.53 mm and 75.92 mm for months June July and May respectively.

7.1.1 Mean Annual Runoff

The C21E quaternary catchment has a net area of 629 km^2 and has a MAR of 18.02 million cubic metres (Mm^3). Runoff emanating from this quaternary catchment drains in a south-westerly direction towards the Blesbokspruit.

According to GN704 requirements pertaining to mine water use, all runoff emanating from dirty water areas such as mine infrastructures, operational areas and ROM stockpiles need to be contained within these areas, so as not to mix with the downstream clean water

The proposed mining project will be an open pit coal mine. However, there will be surface infrastructure including a crushing, screening and washing plant, conveyors, PCD and offices. The identified infrastructure areas amount to approximately 10.72 km^2 as measured on the provided infrastructure layout. The percentage loss in MAR for the C21E quaternary catchment due to the project is approximately 1.7% of the total MAR. The Infrastructure is approximately 3.1% of total catchment area for the Aston Lake (344 km^2) and this would imply a loss of only 3.1 % catchment runoff are to the Aston Lake.

The MAR attributes of the C21E quaternary catchment are summarised in Table 7-3. This includes the as obtained from the Water Resources of South Africa 2012 Study (WR2012).

Table 7-3 : Summary of the Surface Water Attributes of the C21D Quaternary Catchment

Quaternary Catchment	Total Area (km^2)	MAR (Mm^3*	Infrastructure Area (km^2)	Percentage decrease in MAR (%)	Loss in MAR (Mm$^{3)*}$
C21E	629	18.02	10.72	1.70	0.307

*Mm^3 refers to a Million cubic metres

7.1.2 Storm Rainfall Depths

The closest weather stations to the project area defined by a location of 26° 14' S; 28° 37'E are presented in Table 7-4. The data was used to estimate the 24-hour design rainfall using the Design Rainfall Estimation (DRE) in South Africa (Smithers and Schulze, 2003).

Table 7-4 : Summary of the Closest Rainfall Stations

Station Name	SAWS Number	Distance from Project Centre (km)	Record Length (years)	Lat (°) (')	Long (°) (')	MAP (mm)	Altitude (m)
STRYDPAN	0477224_W	5.4	46	26° 14'	28° 37'	683	1603
DROOGEFONTEIN	0477191_W	6.5	61	26° 11'	28° 36'	664	1617
RIETFONTEIN	0476737_W	10.2	48	26° 18'	28° 30'	702	1580
SPRINGS-OLYMPIA PARK	0476766_W	16.3	80	26° 15'	28° 25'	711	1622
SPRINGS (RWB)	0476736_W	16.6	96	26° 16'	28° 25'	709	1610
DELMAS (POL)	0477309_W	16.6	92	26° 8'	28° 41'	661	1555

Table 7-5 presents the estimated rainfall depths for a 24-hour rainfall event for various return periods based on a weighted average for the stations mentioned in Table 7-4

Table 7-5 : Estimated 24 Hour Design Rainfall Depth

Design rainfall return period (yrs)	1:2	1:5	1:10	1:20	1:50	1:100	1:200
24 Hr design peak rainfall (mm)	62.5	86.3	104.3	123.4	151.4	174.8	200.6

7.2 Topography Description

The elevation of the Palmietkuilen project area ranges from 1637 metres above mean sea level (mamsl) on the eastern side to 1600 mamsl on the western side of project boundary. The slope gradient is relatively flat, ranging from 0.9% to 1.1%; influenced by the streams, wetlands and pans surrounding the area.

The quaternary catchment and local setting are illustrated in Figure 7-1 and Figure 7-2 respectively.

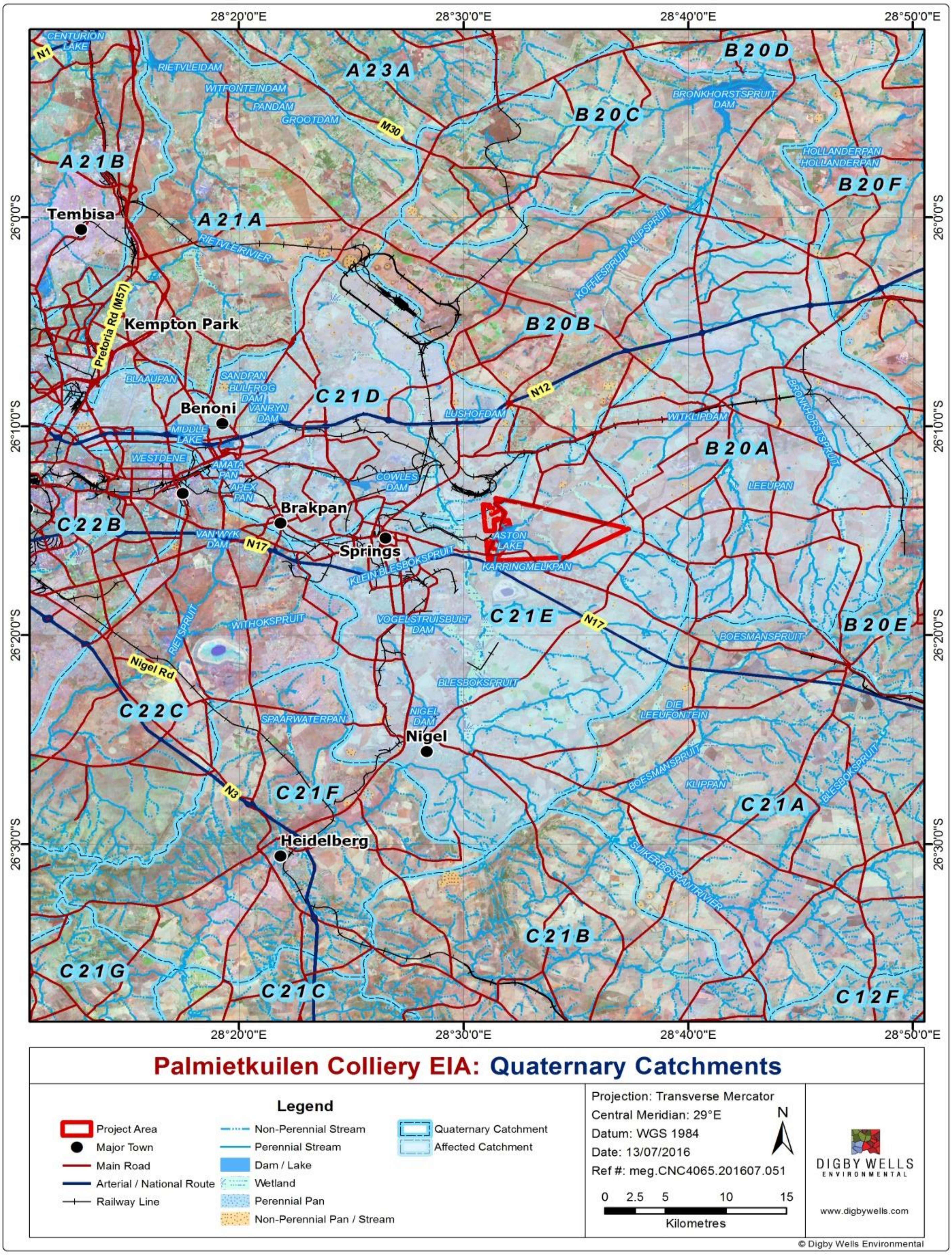


Figure 7-1 : Quaternary Catchments of the Study Area

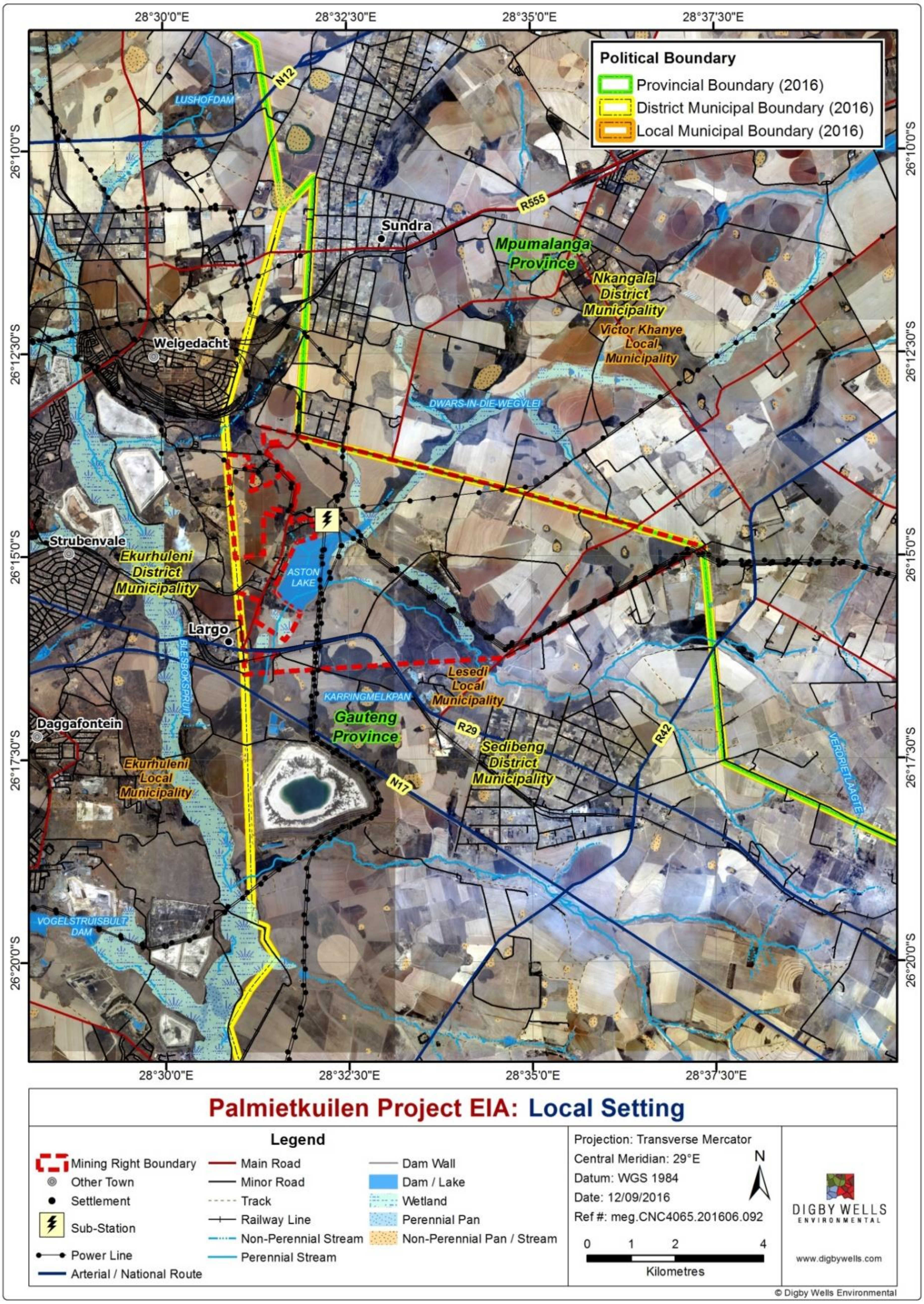


Figure 7-2 : Local Setting of the Project Area

7.3 Catchment Water Uses

The Water Authorisation Registration and Management System (WARMS) (DWS, 2013) database pertaining to surface water use was consulted on the 20 July 2016. The surface water uses determined for quaternary catchment C21E included industrial use (urban and non-urban), irrigation, watering livestock and mining. This information is summarised in Table 7-6.

Table 7-6: Summary of Surface Water Uses for Quaternary Catchment C21E

Quaternary Catchment	Registered Water Use	No. of Registered Users	Registered Volumes (m^3/year)	Sources of Water Used
C21E	Agriculture: Irrigation	17	5,568,809	Dam, Borehole, River/Stream
C21E	Agriculture: Watering livestock	2	60,225	Borehole
C21E	Mining	2	960,000	Scheme and River/Stream
C21E	Industry (Urban)	4	104,441	Boreholes and Scheme
C21E	Industry (Non-Urban)	4	71,896	Borehole and River/Stream

There are 29 registered water users in this quaternary catchment sharing 6 765 371 m^3 of water per year with agriculture (irrigation) being the highest water user sector. These water uses were confirmed during the site visit conducted by a surface water specialist for water sampling.

7.4 Water Quality

The results of the surface water quality analysis are presented in Table 7-7 and Table 7-8.

Table 7-7 :Water Quality Results benchmarked against the SANS 241-1:2015 and SWQG: Irrigation and Domestic Use Guidelines

Sample ID		pH-Value at 25° C	Conductivity at 25° C in mS/m	Total Dissolved Solids	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Chlorides as Cl	Sulphate as SO_4	Nitrate NO_3 as N	Fluoride as F	Aluminium as Al	Iron as Fe	Free and Saline Ammonia as N	Total Hardness	Turbidity	Orthophosphate as P	Suspended Solids as SS	Total Alkalinity as $CaCO_3$
SANS 241:2015 Limits	**(Aesthetic)**	-	≤ 170	≤ 1 200	-	-	≤ 200		≤ 300	≤ 250	-	-	-	≤ 300	≤ 1.5	-	≤ 5	-	-	-
	Operational	≥ 5 to ≤ 9.7	-	-	-	-	-	-	-	-	-	-	≤ 300	-	-	-	≤ 1	-	-	-
	Chronic Health	-	-	-	-	-	-	-	-	-	-	≤ 1.5	-	≤ 2000	-	-		-		
	Acute Health	-	-	-	-	-	-	-	-	≤ 500	≤ 11	-	-	-	-	-	-	-	-	-
SWQG: Domestic Use (Target water quality range)	**Target Water Quality Range**	6.0 – 9.0	-	0 - 450	0 - 32	0 - 30	0 - 100	0 - 50	0 - 100	0 - 200	-	0 - 1.0	0 - 0.15	0 - 0.1	0 - 1.0	50 - 100	0 - 1	-	-	-
South Africa Water Quality Guidelines: Agriculture Irrigation	**Target Water Quality Range**	6.5 - 8.4	-	40	-	-	70	-	100	-	-	2.0	5.0	5.0	-	-	-	-	50	-
AECSW06	26/08/2016 00:00	8.5	26	146	30	13	9	11	8	51	0.313	0.386	BDL	BDL	0.077	127	15	0.05	11	92
SW01	26/08/2016 00:00	8.8	119	692	80	52	127	33	178	109	0.272	0.348	BDL	BDL	0.091	414	28	0.10	42	300
Aston Lake	26/08/2016 00:00	8.6	30	222	19	12	35	12	21	29	0.298	0.565	0.744	0.429	0.065	97	222	0.08	204	119

N:B:

BDL = Below Detection Limit; and

(-) = No Specified Guidelines Value

Manganese as Mn ; Co Cadmium as Cd; Cobalt as Co ; Total Chromium as Cr; Copper as Cu; Nickel as Ni ; Lead as Pb; and Zinc as Zn have been excluded as they were all BDL

Table 7-8 : Water Quality Results benchmarked against the Blesbokspruit Catchment Water Quality Objectives

Sample ID		Nitrate NO_3 as N	Chlorides as Cl	Sulphate as SO_4	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Iron as Fe	Conductivity at 25° C in mS/m	pH-Value at 25° C	Aluminium as Al	Free and Saline Ammonia as N	Fluoride as F
Water Quality Guidelines for the Blesbokspruit Catchment														
Ideal Catchment Background		<0.5	<80	<150	NS	<8	<70	NS	<0.1	<45	6.5 - 8.5	NS	<0.1	<0.19
(Acceptable Management Target)		0.5 - 3.0	80 - 150	150 - 300	NS	8 - 30	70 - 100	NS	0.1 - 0.5	45-70	NS	< 0.3	0.1 - 1.5	0.19 - 0.70
(Tolerable Interim Target)		3.0 - 6.0	150 - 200	300 - 500	NS	30 - 70	100 - 150	NS	0.5 - 1.0	70-120	NS	0.3 - 0.5	1.5 - 5.0	0.70 - 1.00
(Unacceptable)		> 6.0	> 200	> 500	NS	> 70	> 150	NS	> 1.0	>120	<6.5 >8.5	> 0.5	> 5.0	> 1.00
AECSW06	26/08/2016 00:00	0.31	7.7	50.8	29.9	12.6	9.3	10.80	BDL	26.0	8.47	BDL	0.08	0.39
SW01	26/08/2016 00:00	0.27	178.0	109.0	79.9	52.1	127.0	32.90	BDL	119.0	8.75	BDL	0.09	0.35
Aston Lake	26/08/2016 00:00	0.30	20.8	28.6	19.1	12.1	34.9	12.30	0.43	30.0	8.56	0.74	0.07	0.57

N:B:

BDL = Below Detection Limit; and

(NS) = No Specified Guidelines Value

Manganese as Mn has been excluded as they were all BDL

7.4.1 Water Quality Results

Recent water quality results presented in Table 7-7 and Table 7-8 can be summarised as follows:

- pH exceeded the SWQG Agriculture: Irrigation limit in all samples but is within the range for other limits;
- Turbidity exceeded SWQG Agriculture: Domestic Use limit and the SANS 241-2015 drinking water quality standards in all samples;
- SW01 has elevated levels of EC, Ca, Mg, Na, Cl, Total Hardness and Turbidity beyond the SWQG: Domestic Use limit. Cl found in this sample also exceeds SWQG: Agriculture (Irrigation) Limit. The elevated levels of salts could be attributed to the concentration of these elements due to evaporation in the dry season;
- The water quality at Aston Lake had elevated Al and Fe exceeding SWQG Domestic Use, Turbidity exceeding beyond both SANS 241-2015 drinking water quality standards and SWQG: Domestic Use limit with SS exceeding SWQG: Agriculture (Irrigation) Limit; and
- When benchmarked against the Blesboksporuit WQO, the pH at Aston Lake and SW01 as well as the Aluminium at Aston Lake exceeds the limits. The Aluminium levels in Aston Lake can be attributed to the slightly elevated pH levels as Aluminium levels in dissolved state increase at higher and lower pH than 5.5-9.0 (WHO, 2003) Aluminium naturally occurs in waters in very low concentrations.

The water samples collected should be considered to be a representative of a low flow period water quality where the constituents are more concentrated resulting in higher salt concentrations. During project operational phase, water quality monitoring should be undertaken as prescribed in the proposed monitoring plan most preferably monthly to establish an extensive water quality records database.

8 Floodlines Modelling

A key component of the floodlines delineation is the mapping of the flood extent of the Aston Lake and the Dwars-in-die-wegvlei and the Verdrietlaagte streams feeding the lake. The floodlines will be based on a 1:50 and 1: 100 year rainfall events.

8.1 Model Inputs

8.1.1 Catchment Characteristics

A summary of the catchment characteristics for the Aston Lake Inflow Rivers is provided in Table 8-1.

Table 8-1: Catchment Characteristics

Catch ment	Catchment Area (km^2)	Length of Longest Course (km)	Height Difference (the 10-85- method) m	Average Rainfall (mm)
C1	62	9.7	22	691
C2	69	16	39	691
C3	13	2.9	2.28	691

Percentage Slope for the catchments used to determine the catchments runoff coefficients is the slopes less than 3% and 3-10%. In terms of the catchments souls characteristic also used in peak flow determination, all catchments bare considers 100% semi permeable.

These inputs are applied in the modelling using SDF and AR methods in the UPD

8.1.2 Flood Peak Calculations

The output from the UPD software for the 3 catchments is provided in Appendix A. A summary of the peak flows calculated is depicted in Table 8-2.

Table 8-2: Predicted Peak Flow (m^3/s) based on the UPD Model

Catchment	1:50 (m^3/s)	1:100 (m^3/s)	Tc hours	River channel Average slope m/m	Combined C(runoff coefficient)
C1	233	290	3.56	0.003	0.36
C2	196	244	5.09	0.003	0.36
C3	73	91	2.1	0.001	0.31
Aston Lake C12 + C2)	298	362	5.55	0.00253	0.37

8.1.3 Hydraulic Structures

One of the key objectives of the site visit undertaken on 23 August 2016 was to determine the existence of any hydraulic structures. A spillway was identified at the Aston Lake as a necessary hydraulic structure. A spillway serves as a control on the flow through the lake. This implies a controlled release downstream thus also controlling the flood levels downstream. The measurements of the spillway were undertaken for the flood routing in the lake to be undertaken. The spillway is located on the south eastern corner of the lake crest similar to the spillway depicted in Figure 8-1.

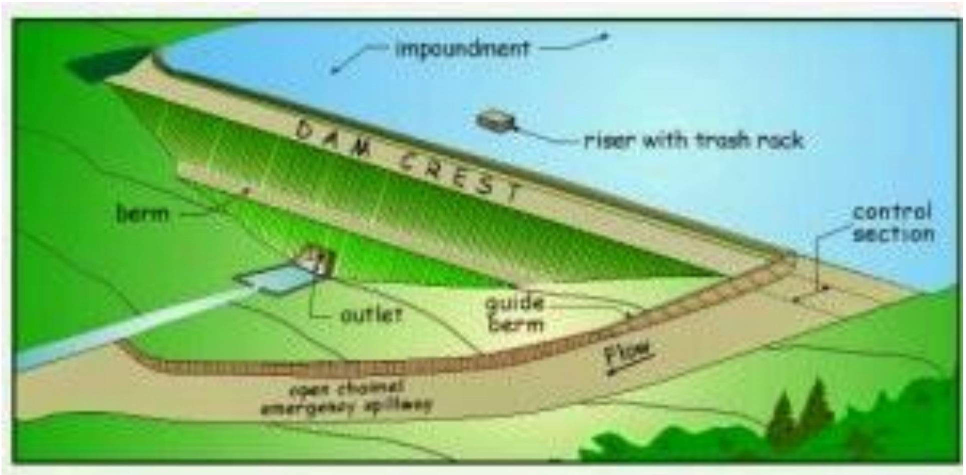


Figure 8-1: Example of Spillway Location similar to that of Aston Lake

(Source: http://www.strukts.com)

The measurements of the spillway are depicted in Figure 8-2 below:

Figure 8-2: Measurement taken at the Aston Lake

Where:

- A is 100 m;
- B is 25 m;
- C is 20 m;
- D is 335 m; and
- E is 350 m.

A to E make up the crest of the Lake;

A depicts the spillway of the Lake used in the routing.

The lake properties were that were determined for input into the level pool reservoir routing procedure are detailed below in Table 8-3.

Table 8-3: Summary of Aston Lake Characteristics

Input	Unit	Value
1:50 peak flow	m^3/s	298
1:100 peak flow	m^3/s	362
Slope		0.00253
Tc	hours	5.55
Lake surface area	km^2	1.6578
Spillway L	m	100
Spillway H	m	1.15
Total L of Dam wall / Crest	m	830
Lake Capacity	m^3	3 500 000

The Aston Lake capacity is estimated from the Area of the Lake and an average depth of at least 2 m on average. This will need to be verified if any bathymetric data is made available.

8.2 Results

The results of the flood elevations in HEC-RAS output table are presented in Appendix B.

As can be seen in Figure 8-3, none of the infrastructure proposed in the immediate future is within the determined Dwars-in-die-wegvlei floodlines except the proposed haul road which crosses the floodlines. The proposed future development site, falls within the floodlines for the Verdrietlaagte.

The flood height on the Aston Lake will range between 1.07 and 1.12 m above the dam water level for the 1:50 and 1:100 year flood peaks respectively indicates. It is important to note that the floodlines determination methodology used is conservative and considered a worst case scenario given up to a 1:100 year flood peak. The 1:50 and 1:100 year floodlines are indicated on Figure 8-3.

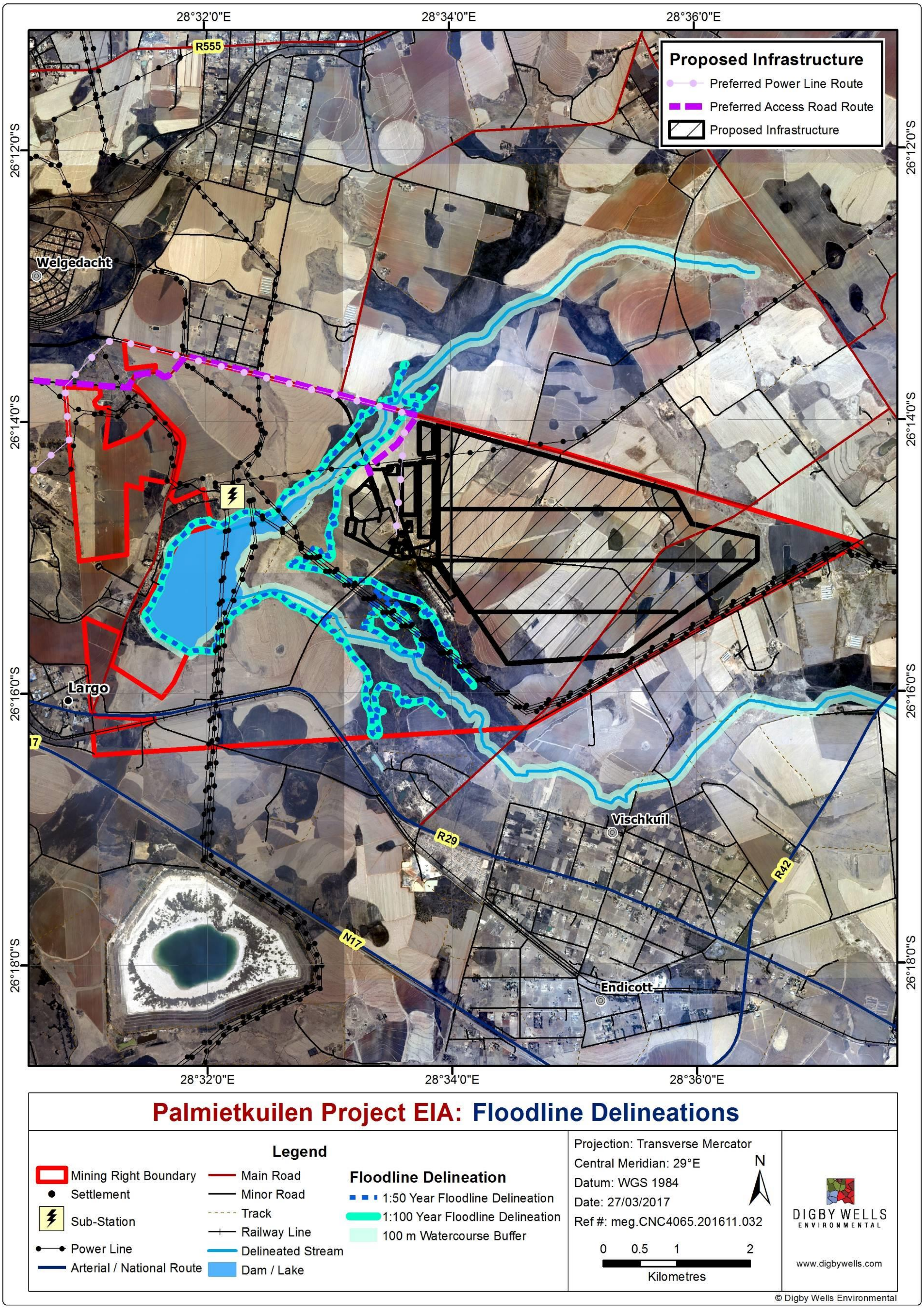


Figure 8-3: The 1:50 and 1:100 Year Floodlines

9 Storm Water Management Plan

Storm water management and drainage planning are critical for the management of water and waste at mining sites. As a best practise for a mining entity in South Africa, a Storm Water Management Plan (SWMP) needs to be developed under the guidance of the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPG) (DWS, 2006) focusing on storm water management (BPG: G1).

9.1 Storm Water Management Principles

Mining operations have the potential to have a negative impact on the natural water quality of an area in the following ways:

- Bulk earthworks will strip vegetation and expose topsoil and sub-soils. Storm water will contribute to erosion thereby increasing levels of suspended solids within local watercourses and water features;
- Earthworks and mineral processing operations may expose elements naturally occurring within soils and geology, mobilising them into local watercourses and water features;
- Storage and use of process specific chemicals and vehicular related pollutants which, if not properly managed, may be washed by storm water into local watercourses and water features; and
- Discharge of polluted or improperly treated storm water, process water and sewage water into local watercourses or water features may occur.

A negative impact on the baseline water quality by mining operations will likely affect local aquatic ecosystems within the Blesbokspruit or the Aston Lake feeder streams, and the local community who use the water for drinking, washing, irrigating or livestock watering. In addition to the above, storm water may pose a risk of flooding to a proposed development, if not managed correctly. The aim of this SWMP is to mitigate the above impacts by fulfilling the requirements of the NWA and more particularly GN 704.

The following definitions from GN 704 are appropriate to the classification of catchments and design of SWMP for the proposed project:

- **Clean water system:** includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;
- **Dam:** includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);
- **Dirty area:** means any area at a mine or ***activity*** which causes, has caused or is likely to cause pollution of a water resource;

- **Dirty water system:** This includes any dirty water diversions bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and
- **Activity:** means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

The storm water management outlined in this section serves to ensure that surface water risks within the upstream catchments of the Aston Lake; namely the Dwars-in-die-wegvlei and the Verdrietlaagte stream catchments (Catchments 1 and 2 in Figure 5-3) where the project is located, are minimised.

This SWMP section will provide conceptual inputs into the management of the proposed storm water structures outlined in the mine plan design and make recommendations for additional erosion controls and placement of storm water management structures.

9.2 Proposed Storm Water Management Measures

A mine infrastructure layout has been proposed, and consequently the SWMP has been based on the proposed layout with dirty and clean areas as indicated in Table 9-1.

Table 9-1: Clean and Dirty Area Classification

Area Classification	Mine Areas
Clean runoff areas	Plant offices and mine offices
	Areas within the mine but upstream and downstream of the dirty areas
	Mining contractors yard (paved areas)
Dirty Areas	Overburden stockpiles and product stockpiles
	Pollution Control Dam (PCD)
	Open pit (a source of dirty water through dewatering)
	Haul road and weigh bridge
	Diesel storage
	Mining Contractor's yard vehicle workshop
	Plant infrastructure, conveyors and slurry dam
	Discard dump

In order to meet the design principles detailed in the GN704 and the BPG G1, the following storm water management measures are proposed:

- Clean water diversion berms to divert clean water to the downstream environment or nearby watercourse away from the infrastructure area;
- Dirty water channels and berms around all stockpile areas, waste rock dump areas, contractors camp areas and plant areas, such that all dirty water is captured and contained in respective PCD's;
- A PCD which will capture and contain dirty water runoff from the afore mentioned dirty areas; and
- 2 proposed silt traps/sumps to collect water before it is conveyed to the PCD. This controls siltation of the PCD.

9.2.1 Peak Flows Catchment Characteristics

A summary of the catchment characteristics together with the estimated peak flows required to size the proposed clean water diversion channels, the dirty water channels and the river diversions are presented in Table 9-2.

Table 9-2 Summary of Catchment Characteristics and Peak Flows

Dirty catchments areas	Area km^2	Longest watercourse (km)	Height difference dz (m)	1:50 year peak flow (m^3/s)	1:100 year peak flow (m^3/s)	Time of Concentration Tc (hr)
Soft and hard stockpiles	0.598	1	8	5.085	6.586	1.06
Plant area	0.672	1.25	13	5.523	7.153	1.1
Workshop	0.002	0.125	1	0.041	0.053	0.24
Open pit	9.103	3.75	33	71.55	92.26	1.15

Figure 9-1 below indicates some examples of trenches for dirty water with berms to ensure clean and dirty water separation occurs.

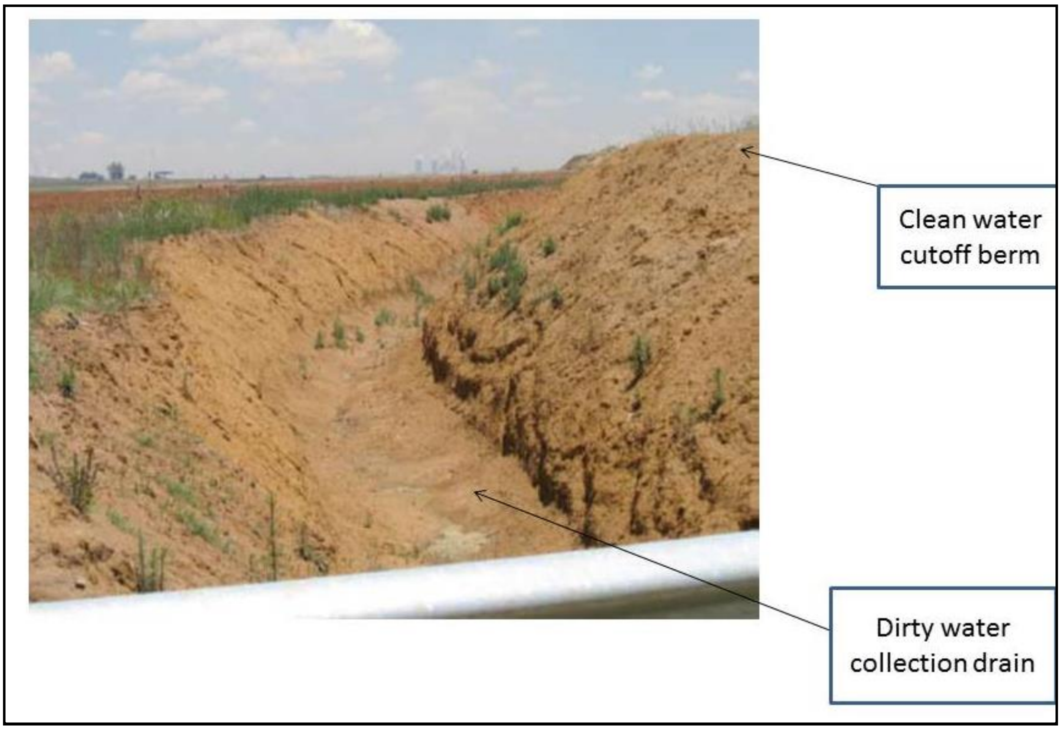


Figure 9-1: Examples of a Dirty Water Trenches and Clean Water Berms

9.2.2 SWMP

A layout showing the proposed storm water controls mentioned above is presented in Figure 9-2 and the proposed SWMP measures and operational management measures per infrastructure type are presented in Table 9-3.

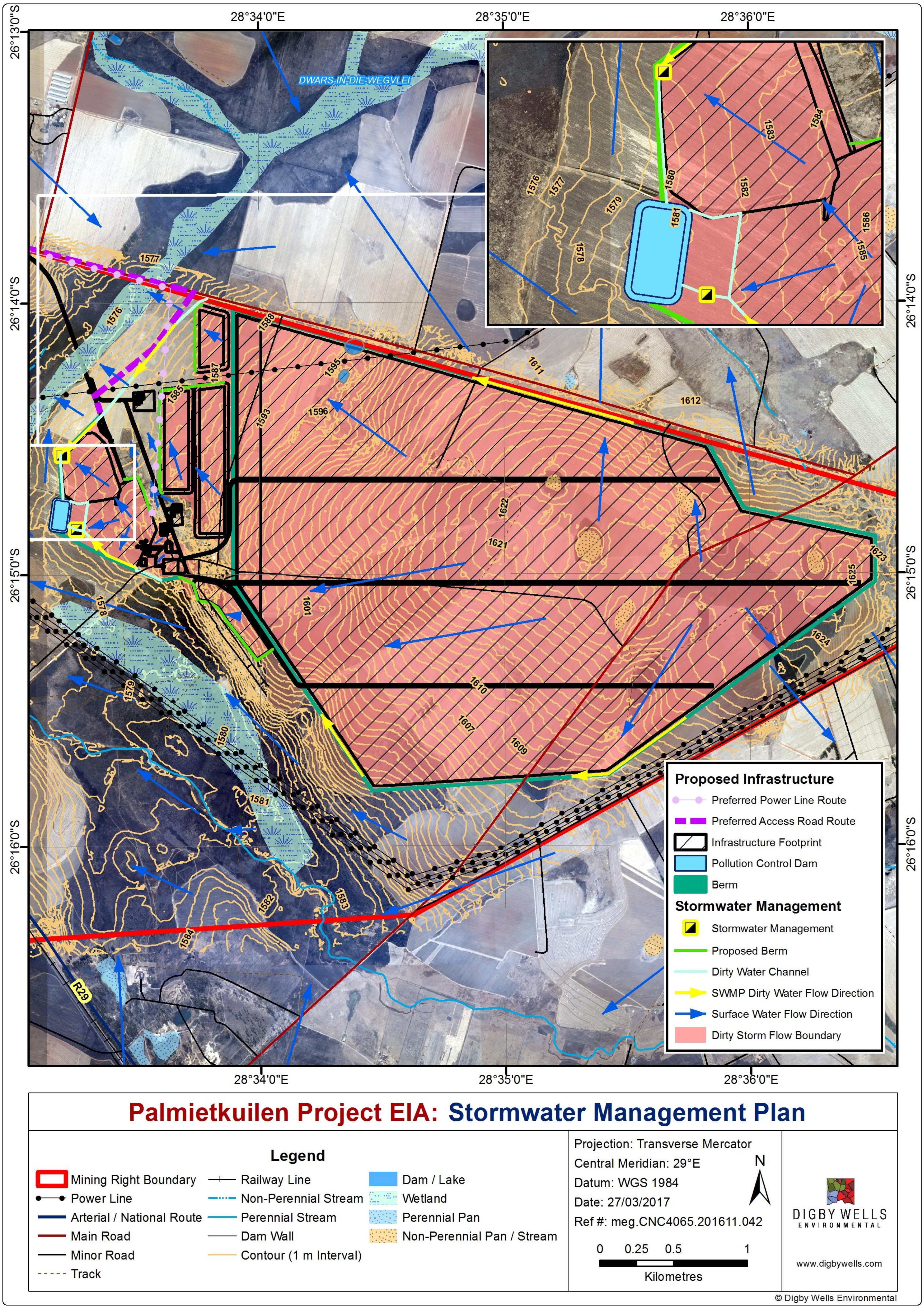


Figure 9-2: Proposed Storm Water Management Plan

Table 9-3: General Recommended SWMP Operational Management Measures per Infrastructure Type

SWMP Aspect Infrastructure	Storm Water Management measures
PCD	▪ The PCDs should have elevated downstream embankment /walls on flat ground so that water can be contained within and not overflow to the downstream clean water receiving environment and the nearby watercourse. ▪ PCDs should be designed and constructed to contain the daily operational volume, the runoff during a storm event and have a freeboard of 0.8m.The PCD should be operated as empty as possible to allow for it to hold runoff from the dirty areas in the event of a 1:50 year storm event. The PCD should not spill more than once in 50 years. ▪ The PCDs should be design in such a way that all water entering the dam will go through a silt trap first. ▪ It is further recommended that an emergency PCD should be constructed to ensure that one is always operational while the other one is cleaned out. ▪ The PCDs should be desilted when siltation occurs; however the presence of silt traps at the dirty water runoff collection points (for example where water from the stockpiles is collected) should ensure limited siltation. ▪ The volumes of water flowing into and abstracted from the PCDs and water levels should be recorded for understanding the water balance on site. ▪ The water quality in the PCDs should also be tested and records analysed monthly to help with the mine site water and salt balance.
Overburden stockpile areas	▪ Berms are recommended to control the runoff and contain eroded material. A trench can be dug on the inside around the foot of the stockpiles leading to a small sump that can hold the 1:50 year storm of runoff of about ▪ Storm water channels should be maintained and cleaned regularly to ensure that their capacities to convey contaminated runoff from the stockpiles are not compromised and it can still convey the 1:50 year peak flows. ▪ All overburden stockpile areas should be vegetated as soon as possible to prevent erosion.

SWMP Aspect Infrastructure	Storm Water Management measures
Haul roads	▪ No formal diversions are recommended; rather normal roadside drainage, culverts with downstream dissipaters should be constructed. ▪ Where the proposed haul road crosses the water courses and the floodlines, culverts should be constructed to accommodate the 1:100 flood. ▪ The necessary erosion protection measures will be implemented to prevent the erosion of the beds and banks once the culverts are constructed. ▪ At the culverts, scour and erosion damages should be periodically assessed and repaired by means of measures approved by SANRAL such as the use of riprap, or Reno Mattresses downstream if the outlet aprons at bridges and culverts
Product stockpile areas, Discard dump and ROM Stockpiles	▪ Contaminated storm water runoff from this area will be routed through trenches to silt trap sumps at the bottom of the stockpiles ▪ Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles. ▪ Contaminated storm water runoff from the sump will be routed through channels to the PCDs. ▪ Clean water from clean upstream catchments will be diverted around the sides of the stockpiles to stop it becoming contaminated. ▪ The conveyor transfer points should be contained in paved areas with some small bund walls. ▪ The construction of small size masonry or concrete bund walls around the stockpile areas to prevent material falling into the trenches.
Topsoil stockpile areas	▪ The sides of the top soil stockpiles will be vegetated to control erosion of sediment materials to surface water resources. ▪ Regular inspections will be undertaken to ensure that erosion is addressed as soon as it occurs to prevent the loss of topsoil.

SWMP Aspect Infrastructure	Storm Water Management measures
Dust suppression of areas and erosion control	▪ Dust suppression should be applied in such a way that it does not runoff from the area and cause secondary pollution. ▪ Ponding of the water should be prevented. ▪ Storm water dissipation is important so as to keep erosion in check, such include geotechnical innovations, optimization of slopes, use of plants and application of riprap. ▪ In addition to the control of storm water, water quality monitoring should form part of this system where water in the PCDs is monitored for quality. This ensures that pollution sources are monitored during the mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to monitor should include but not limited to Total Suspended Solids (TSS, pH, SO4, Salinity, EC and other metals);
Open pit	▪ Surface water runoff ingress into pit should be prevented by ensuring the pit periphery has a berm. ▪ Water pumped from open pit mine dewatering to allow for mining will be collected in the surface PCDs or pit sumps for immediate reuse for dust suppression

9.2.3 Hydraulic Design Standards

This section describes the standards in place for the design of PCD and channels in the SWMPs.

- GN704 requires that dirty water facilities are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. GN704 also requires that as a minimum, the 1:50 year design volume and a 0.8 m freeboard allowance should always be available; and
- GN704 requires that the clean water systems are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. Therefore, proposed clean water channels should be sized to accommodate the 1:50 year peak flows.

The PCD's should be operated such that they are empty; this is to ensure that a 1 in 50 year storm event for which they are sized can be adequately contained if it occurs. It is therefore recommended that the 1 in 50 year volume be pumped out from the PCD over a decent interval period, in case another storm event occurs

9.2.4 Site Inspections and Administrative Requirements

Site inspections at the mining site should be implemented as prescribed in the BPG G1 (DWS, 2006). For a transparent and effective system, the SWMP inspections at the proposed Mine are carried out in line with the Standard Operation Procedures (SOPs) at the Mine. The plan and procedure is recommended as detailed in Table 9-4.

Table 9-4: Site Inspection and Maintenance Plan and Procedure

Maintenance and operation aspect	Comments
Inspection Frequency	Regular visual site inspections of the storm water structures should be carried out – once every month and weekly at the areas near stockpiles. Inspection frequency may be reduced if runoff is limited due to winter conditions.
Scope of Inspections	Inspections should cover the entire mine site, particularly ensuring that the storm water infrastructure is operating well. Maintenance of infrastructure ensures that erosion, blockages, overflows and pollution are prevented by maintaining design capacities of the facilities. The maintenance of the facilities includes desilting of dams and conveyances, clearance of vegetation in canals and descaling of pipelines. Desilting of dams should be done when necessary or at least during annual maintenance.

Maintenance and operation aspect	Comments
Inspection Reporting	Very short and concise inspection reports should be detailed and should include details on the measures observed to be inadequate, as well as corrective actions and responsible personnel.
Follow up actions	Follow up actions should be prioritized by the Mine where some of the interventions need to be carried out before the next storm events or as soon as is practical. An annual review is recommended setting up new actions and continually improving the storm water system.
Record keeping	All records should be kept on site for the life of Mine so that they are available for regulatory inspections.

10 Sensitivity Analysis and No-Go Areas

This study included floodlines delineation as part of the hydrological assessment. Floodlines delineation was done to understand the risk of flooding on the proposed mine infrastructure, and in accordance with GN 704 regulations, where it is states that infrastructure should not be placed within the floodlines, or a horizontal distance of 100 m from a watercourse (whichever is greater).

The 1:50 and 1:100 year floodlines were delineated for the streams and drainage lines within close proximity to infrastructure areas. This is considered as a very sensitive area and no infrastructure with potential to impact water resources should be placed within the delineated floodlines.

This is with the exception of the proposed haul roads, in which the recommendation is to design and construct in a manner that it will withstand a 1:100 year flood and ensure measures are available to prevent erosion and ensure free flow of water to the Aston Lake.

The perennial streams, dams and pans with the potential to be impacted by the proposed mining activities have been classified as high sensitive whilst the non-perennial and perennial streams, dams and pans that are not likely to be impacted are classified as moderately sensitive.

11 Surface Water Impact Assessment and Management Planning

11.1 Methodology

The impacts are assessed based on the impact's magnitude, as well as the receiver's sensitivity, culminating in an impact significance which identifies the most important impacts that require management.

Based on international guidelines and South African legislation, the following criteria are taken into account when examining potentially significant impacts:

- Nature of impacts (direct/indirect, positive/ negative);
- Duration (short/medium/long-term, permanent(irreversible) / temporary (reversible), frequent/seldom);
- Extent (geographical area, size of affected population/habitat/species);
- Intensity (minimal, severe, replaceable/irreplaceable);
- Probability (high/medium/low probability); and
- Possibility to mitigate, avoid or offset significant adverse impacts.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 11-1. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this EIA / EMP Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 11-3, which is extracted from Table 11-2. The description of the significance ratings is discussed in Table 11-1.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 11-1: Impact Assessment Parameter Ratings

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

Rating	Intensity / Replicability		Spatial Scale	Duration	Probability
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment.	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational life span of the Project.	Likely The impact may occur.
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	Municipal Area Will affect the whole municipal area.	Long term 6-15 years to reverse impacts.	Probable Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem functions. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements.	Medium term 1-5 years to reverse impacts.	Unlikely Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur.

<table>
<tr><th rowspan="2">Rating</th><th colspan="2">Intensity / Replicability</th><th rowspan="2">Spatial Scale</th><th rowspan="2">Duration</th><th rowspan="2">Probability</th></tr>
<tr><th>Negative Impacts
(Type of Impact = -1)</th><th>Positive Impacts
(Type of Impact = +1)</th></tr>
<tr><td>2</td><td>Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants.
Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.</td><td>Low positive impacts experience by very few of population.</td><td><u>Limited</u>
Limited to the site and its immediate surroundings.</td><td><u>Short term</u>
Less than 1 year to completely reverse the impact.</td><td><u>Rare/ improbable</u>
Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.</td></tr>
<tr><td>1</td><td>Limited damage to minimal area of low significance that will have no impact on the environment. No irreplaceable loss of a significant aspect to the environment.
Minimal social impacts, low-level repairable damage to commonplace structures.</td><td>Some low-level social and environmental benefits felt by very few of the population.</td><td><u>Very limited</u>
Limited to specific isolated parts of the site.</td><td><u>Immediate</u>
Less than 1 month to completely reverse the impact.</td><td><u>Highly unlikely/None</u>
Expected never to happen.</td></tr>
</table>

Table 11-2: Probability/Consequence Matrix

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

Table 11-3: Significance Rating Description

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

11.2 Project Activities

A list of project activities to be assessed for the project is presented in Table 11-4.

Table 11-4: Description of Project Activities

Project Phase	Project Activity
Construction	Site establishment;
	Site clearing, including the removal of topsoil and vegetation;
	Construction of mine related infrastructure, including haul roads, pipes, dams;
	Construction of washing plant;
	Relocation of Infrastructure;
	Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts; and
	Temporary storage of hazardous products, including fuel and explosives, as well as waste and sewage.
Operations	Stripping topsoil and soft overburden
	Removal of overburden, including drilling and blasting of hard overburden
	Loading, hauling and stockpiling of overburden
	Drilling and blasting of coal
	Load, haul and stockpiling of RoM coal
	Use and maintenance of haul roads for the transportation of coal to the washing plant
	Water use and storage on-site
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste
Mine Decommissioning and Closure	Demolition and removal of all infrastructure, including transporting materials off site
	Rehabilitation, including spreading of soil, re-vegetation and profiling or contouring
	Environmental monitoring of decommissioning activities
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste
	Post-closure monitoring and rehabilitation

11.3 Impact Assessment

The surface water impacts are assessed and presented below. The list of project activities can be found in Table 11-4. Only project activities that are likely to result in a surface water impact are assessed below. Project activities that may pose a risk and not an impact are discussed under section 12.

11.3.1 Construction Phase

11.3.1.1 Project Activities Assessed

The following project activities are likely to cause an impact to surface water during the construction phase:

- Site clearing, including the removal of topsoil and vegetation;
- Construction of mine related infrastructure, including haul roads, pipes, dams;
- Construction of washing plant;
- Relocation of Infrastructure;
- Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts;

Table 11-5 provides the activity interaction and the resultant impact during the construction phase.

Table 11-5: Interactions and Impacts during the Construction Phase

Interaction	Impact
Removal of vegetation and exposure of soils	Sedimentation of surface water resources leading water siltation of water to deteriorated water quality
Movement of heavy machinery and vehicles during the construction phase	Reduced surface water infiltration and baseflow as a result of soil compaction
	Alteration in surface water drainage patterns
Lay down of impenetrable surfaces such as concrete roads	Reduced surface water infiltration and baseflow as a result of impervious surfaces
	Alteration in surface water drainage patterns
	Increased velocity in surface water runoff leading to erosion and consequent sedimentation of surface water resources
Alteration to the natural topography for the new boxcut	Alteration in surface water drainage patterns

11.3.1.1.1 Impacts Description

The removal of vegetation for site clearance and for the development and establishment of infrastructure will expose soils to erosion elements. Eroded material may cause sedimentation in the Aston Lake downstream. The movement of heavy machinery and vehicles during the construction phase may cause compaction of soils resulting in reduced infiltration of surface water and reduced baseflow. A further impact as a result of this interaction is the alteration in current surface water drainage patterns. This is also applicable to areas where impermeable surfaces such as offices and workshops will be developed. Increased runoff velocity as a result of impermeable surfaces and compaction may further result in erosion and sedimentation of the Aston Lake. The development of the new boxcut will further alter the onsite drainage patterns.

11.3.1.1.2 Management Objectives

To minimise or prevent potential surface water impacts on water quality and/or quantity during construction on the Aston Lake and its tributaries.

11.3.1.1.3 Management/ Mitigation Measures

The following mitigation measures are recommended:

- Development of the storm water management structures to ensure that sediment generated during the construction phase is conveyed to the silt trap, and clean water is diverted away from the boxcut and dirty water areas
- Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration
- Roads should be maintained regularly to ensure that surface water drains freely off the road preventing erosion
- Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events.

11.3.1.2 Construction Phase Impact Ratings

Table 11-6: Potential Impacts during the Construction Phase

Activity & Interaction: Site clearing for the development of surface infrastructure through the removal of vegetation exposing soil to erosion			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Sedimentation of surface water resources resulting in the deterioration of water quality			
Prior to mitigation/ management			
Duration	Medium term (3)	More sediment deposition may occur during rainy months	Minor (negative) – 40

<table>
<tr><th colspan="4">Activity & Interaction: Site clearing for the development of surface infrastructure through the removal of vegetation exposing soil to erosion</th></tr>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td>Extent</td><td>Local (3)</td><td>Sedimentation may potentially affect nearby downstream water users on the Palmietkuilen Farm.</td><td rowspan="3"></td></tr>
<tr><td>Intensity x type of impact</td><td>Medium term - negative (4)</td><td>Serious loss to moderately sensitive environment limiting ecosystem function</td></tr>
<tr><td>Probability</td><td>Probable (4)</td><td>It is probable that the impact may occur</td></tr>
<tr><td colspan="4">Mitigation/ Management actions</td></tr>
<tr><td colspan="4">
Development of the storm water management structures to ensure that sediment generated during the construction phase is conveyed to the silt trap, and clean water is diverted away from the boxcut and dirty water areas
Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration
Roads should be maintained regularly to ensure that surface water drains freely off the road preventing erosion
Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events.
The silt trap and storm water management structures should be inspected after large storm events to ensure that there are no blockages or breaches. Should blockages or breaches occur, then immediate action should be undertaken to remove debris or to repair breached areas; and
Vegetation clearing should be limited as much as possible to areas where it is absolutely needed.
</td></tr>
<tr><td colspan="4">Post- mitigation</td></tr>
<tr><td>Duration</td><td>Short term (2)</td><td>Less than a year to reverse the impact if mitigation measures are applied.</td><td rowspan="4">Negligible (negative) – 18</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>Storm water management structures will limit sedimentation of the lake and its tributaries.</td></tr>
<tr><td>Intensity x type of impact</td><td>Minor - negative (2)</td><td>Minor effects on the environment</td></tr>
<tr><td>Probability</td><td>Unlikely (3)</td><td>Unlikely but may happen even when mitigation measures are implemented</td></tr>
</table>

Activity & Interaction: Movement of heavy machinery and vehicles for site clearing and for the development of surface infrastructure during the construction phase			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduced surface water infiltration as well as an alteration in surface water drainage patterns as a result of soil compaction from the movement of heavy machinery and vehicles			
Prior to mitigation/ management			
Duration	Medium term (3)	Impacts will occur during the construction phase and can be reversed during this time	Minor (negative) – 60
Extent	Local (3)	Reduced baseflow may have a minor impact on local streamflow within the Palmietkuilen Farm extending beyond the site	
Intensity x type of impact	Medium term - negative (4)	Environmental damage can be reversed in less than a year	
Probability	Highly Probable (6)	It is highly probable that the impact may occur	
Mitigation/ Management actions			
▪ Vegetation clearing should be limited as much as possible to areas where it is absolutely needed; ▪ Implementation of the storm water management plan to capture sediment and convey it to the silt trap; and ▪ Compact soils can be loosened through soil ripping in areas where compact areas are not in use post construction.			
Post- mitigation			
Duration	Short term (2)	Less than a year to reverse the impact	Negligible (negative) – 24
Extent	Limited (2)	Limited to the site	
Intensity x type of impact	Minor - negative (-2)	Minor effects on the environment	
Probability	Unlikely (3)	Unlikely to take place after mitigation	

<table>
<tr><th colspan="4">Activity & Interaction: Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts resulting in the alteration of the natural topography</th></tr>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Impact Description: Alteration in surface water drainage patterns and a reduction in the amount of water reaching the Aston Lake and reduced flow to Blesbokspruit.</td></tr>
<tr><td colspan="4">Prior to mitigation/ management</td></tr>
<tr><td>Duration</td><td>Permanent (7)</td><td>The boxcut will remain permanent therefore the impacts will occur beyond the life of the project</td><td rowspan="4">Moderate (negative) – 98</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>Limited to the two subcatchments of the Aston Lake</td></tr>
<tr><td>Intensity x type of impact</td><td>Long term - negative (-5)</td><td>Environmental damage will be long term, as there will be reduced storm flow to the Aston Lake used by the surrounding communities.</td></tr>
<tr><td>Probability</td><td>Certain (7)</td><td>The impact will occur</td></tr>
<tr><td colspan="4">Mitigation/ Management actions</td></tr>
<tr><td colspan="4">Implementation of the storm water management plan to prevent clean water from flowing into the boxcut. Unfortunately, there are no mitigation measures for direct rainfall falling into the boxcut.
As much as is possible, water should be reused and any treated storm flows released downstream
Backfilling and rehabilitation of old boxcuts as mining progresses</td></tr>
<tr><td colspan="4">Post- mitigation</td></tr>
<tr><td>Duration</td><td>Medium term (3)</td><td>Impacts will occur only until the boxcut areas are backfilled</td><td rowspan="4">Minor (negative) – 63</td></tr>
<tr><td>Extent</td><td>Very Limited (1)</td><td>Limited to an isolated part of the site</td></tr>
<tr><td>Intensity x type of impact</td><td>Long term - negative (-5)</td><td>Environmental damage will be long term</td></tr>
<tr><td>Probability</td><td>Certain (7)</td><td>The impact will occur</td></tr>
</table>

11.3.2 Operational Phase

11.3.2.1 Project Activities Assessed

The following project activities are likely to cause an impact to surface water during the operation phase:

- Stripping topsoil and soft overburden;
- Removal of overburden, including drilling and blasting of hard overburden;

- Loading, hauling and stockpiling of overburden;
- Drilling and blasting of coal;
- Load, haul and stockpiling of RoM coal;
- Use and maintenance of haul roads for the transportation of coal to the washing plant; and
- Water use and storage on-site.

Table 11-7 provides the activity interaction and the resultant impact during the construction phase.

Table 11-7: Interactions and Impacts of Activity

Interaction	Impact
Runoff from the dirty water areas (waste water dams, crushing plant, conveyors and product stockpile)	Runoff reporting into the Aston Lake and the unnamed streams flowing to it resulting in water contamination or the deterioration of the water quality
Development and operation of surface infrastructure (pollution control dams, stockpiles, workshops & offices, crushing and screening plant)	Reduction of Catchment Yield as dirty water runoff within the mine will be contained in the PCD.

11.3.2.1.1 Impact Description: Water contamination leading to deterioration of water quality

Dirty water runoff laden with carbonaceous material from the contaminated surfaces and the infrastructure within the mine (ROM stockpiles, crushing plant, conveyors and product stockpile) has the potential to contaminate and silt up the natural water resources or streams, should it not be contained within the mine. This impact will therefore deteriorate the water quality in both the Aston Lake and the Blesbokspruit.

Containment of dirty water runoff from within the mining area will reduce the amount of runoff reporting to the Aston Lake. A decrease in the catchment yield may have an impact on the flow required for the ecological reserve. However, the total infrastructure footprint area amounts to approximately 10.72 km^2 which approximates to 3.1% of the total catchment area of the Aston Lake of 344 km^2. The percentage decrease in MAR reporting to Aston Lake will result from the capture of dirty water as the mine develops. This decrease of 3% is not considered to be significant in light with the mitigation measures prescribed.

11.3.2.1.2 Management Objectives

To minimise or prevent potential surface water impacts on water quality and/or quantity during operation on the Aston Lake and its tributaries.

11.3.2.1.3 Management/ Mitigation Measures

This section provides the necessary management measures to prevent and/or reduce the identified impacts:

- Ensure that all the dirty water emanating from the dirty water areas be collected via silt traps before entering the PCD for re-use within the mine, to prevent unnecessary discharge into the environment;
- The dirty water collection trenches should be cleaned regularly to reduce the build up of washed off coal fines and ensurFse they are able to accommodate and convey the 1:50 year peak flows. This material should be disposed to an appropriate licenced facility.
- Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels;
- In addition to the control of storm water, water quality monitoring should form part of the system where water in the PCD's are monitored for quality. This ensures that pollution sources are monitored during the mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to check would be the TSS, EC, Salts and some chemical parameters that such as (pH, SO_4 and other metals.)

11.3.2.2 Operational Impact Ratings

Table 11-8: Impact Rating for the Operation Phase

Dimension	Rating	Motivation	Significance
Impact: Water contamination leading to deterioration of water quality			
Pre-Mitigation			
Duration	Project Life (5)	Due to the nature of the mining activities the contamination of water resources may occur over the project life if mitigation measures are not in place.	Moderate - negative (90)
Extent	Region (5)	The impacts may affect the Aston Lake	
Intensity	Serious - negative (-5)	This may have serious impacts on the water quality that will be made available to the downstream water users (agricultural- livestock watering and crop irrigation)	
Probability	Almost Certain (6)	Without appropriate mitigation, the probability of the impact occurring is almost certain	

Dimension	Rating	Motivation	Significance
Mitigation Measures			
▪ Ensure that all the dirty water emanating from the dirty water areas be collected via silt traps before entering the PCD for re-use within the mine, to prevent unnecessary discharge into the environment; ▪ The dirty water collection trenches should be cleaned regularly to reduce the build up of washed off coal fines and ensure they are able to accommodate and convey the 1:50 year peak flows. This material should be disposed to an appropriate licenced facility ▪ Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels; ▪ In addition to the control of storm water, water quality monitoring should form part of the system where water in the PCD's are monitored for quality. This ensures that pollution sources are monitored during the mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to check would be the TSS, EC, Salts and some chemical parameters that such as (pH, SO4 and other metals).			
Post-Mitigation			
Duration	Medium term (5)	Impact may occur over the project life even if if mitigation measures are t in place however at a different scale	Minor (negative) (60)
Extent	Region (5)	The impacts may affect the flow in the Aston Lake and possibly contributes to the Blesbokspruit.	
Intensity	Moderate - negative (-5)	This may have serious impacts on the downstream agricultural water users	
Probability	Probable (4)	Has occurred here or elsewhere and could therefore occur. The severity will be minimal with mitigation.	

11.3.3 Decommissioning and Post Closure Phase

11.3.3.1 Project Activities Assessed

The following project activities listed in Table 11-4 are likely to cause an impact to surface water during the decommissioning and post closure phase:

- Demolition and removal of all infrastructure, including transporting materials off site;
- Rehabilitation, including spreading of soil, re-vegetation and profiling or contouring

Table 11-9 provides the activity interaction and the resultant impact during the decommissioning and post Closure phase.

Table 11-9: Interactions and Impacts during the Decommissioning and Post Closure Phase

Interaction	Impact
Movement of heavy machinery and vehicles compacting soils during demolition of infrastructure and rehabilitation processes	Alteration of natural surface water drainage patterns and reduced infiltration
Loosening of soil during demolition of infrastructure and rehabilitation processes	Sedimentation of surface water resources leading to deteriorated water quality
Restoration of topography to a pre-mining state and re-vegetation of disturbed areas	Return of natural drainage patterns as a result of freely draining topography

11.3.3.1.1 Impact Description

The movement of heavy machinery and vehicles during the decommissioning phase may cause compaction of soils resulting in reduced infiltration of surface water. A further impact as a result of this interaction is the alteration in current surface water drainage patterns. Increased runoff velocity as a result of compaction may further result in erosion and sedimentation of the Aston Lake.

11.3.3.1.2 Management Objectives

- To ensure that rehabilitation is undertaken strictly according to the rehabilitation and closure study undertaken as part of the EIA.

11.3.3.1.3 Management Actions and Targets

The following actions and targets are required:

- Leaving the storm water management structures in place during the decommissioning and post closure phase until the rehabilitation process is completed. This will ensure that sediment generated during this phase is captured.
- Storm water management structures should be inspected after large storm events to ensure that there are no blockages or breaches. Should blockages or breaches occur, then immediate action should be undertaken to remove debris or to repair breached areas.
- Soils compacted by heavy machinery can be ripped to allow infiltration.
- Rehabilitation processes such as restoring the topography to a pre-mining state, and re-vegetation of disturbed areas will assist in returning natural surface water drainage patterns.

11.3.3.2 Decommissioning and Post Closure Phase Impact Ratings

Table 11-10: Potential Impacts during the Decommissioning Phase

Activity & Interaction: Movement of heavy machinery during the decommissioning and rehabilitation phases resulting in soil compaction			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduced surface water infiltration as well as an alteration in surface water drainage patterns as a result of soil compaction from the movement of heavy machinery and vehicles			
Prior to mitigation/ management			
Duration	Medium term (3)	Impacts will occur during the decommissioning phases and can be reversed during this time	Minor (negative) – 36
Extent	Limited (2)	Compacting will be confined to the access roads thus only small areas will be affected within the catchment of the Dwars-in-die-wegvlei	
Intensity x type of impact	Medium term - negative (-4)	Environmental damage can be reversed in less than a year	
Probability	Probable (4)	The impact may occur	
Mitigation/ Management actions			
▪ Compact soils can be loosened through soil ripping.			
Post- mitigation			
Duration	Short term (2)	Less than a year to reverse the impact	Negligible (negative) – 18
Extent	Limited (2)	Limited to the site	
Intensity x type of impact	Minor - negative (-2)	Minor effects on the environment	
Probability	Unlikely (3)	Unlikely but may happen if mitigation measures are not implemented	

<table>
<tr><th colspan="4">Activity & Interaction: Loosening of soil during rehabilitation processes</th></tr>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Impact Description: Sedimentation of surface water resources resulting in reduced water quality</td></tr>
<tr><td colspan="4">Prior to mitigation/ management</td></tr>
<tr><td>Duration</td><td>Medium term (3)</td><td>Seasonal high flows are likely to disperse sediment build up</td><td rowspan="4">Minor (negative) – 40</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>Sedimentation may potentially affect the storage capacity of Aston Lake.</td></tr>
<tr><td>Intensity x type of impact</td><td>Medium term - negative (-4)</td><td>Environmental damage can be reversed in less than a year</td></tr>
<tr><td>Probability</td><td>Probable (4)</td><td>It is probable that the impact may occur</td></tr>
<tr><td colspan="4">Mitigation/ Management actions</td></tr>
<tr><td colspan="4">Storm water management structures should be left in place until rehabilitation is complete; and
Storm water management structures should be inspected after large storm events to ensure that there are no blockages or breaches. Should blockages or breaches occur, then immediate action should be undertaken to remove debris or to repair breached areas.</td></tr>
<tr><td colspan="4">Post- mitigation</td></tr>
<tr><td>Duration</td><td>Short term (2)</td><td>Less than a year to reverse the impact</td><td rowspan="4">Negligible (negative) – 18</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>Storm water management structures will limit sedimentation to the infrastructure site and silt trap</td></tr>
<tr><td>Intensity x type of impact</td><td>Minor - negative (-2)</td><td>Minor effects on the environment</td></tr>
<tr><td>Probability</td><td>Unlikely (3)</td><td>Unlikely but may happen if mitigation measures are not implemented</td></tr>
</table>

12 Cumulative Impacts

Negative water quality impacts result in the deterioration of surface water resources. All runoff from the project area drains to the Aston Lake, and when it overspills or seeps, flows downstream to the Blesbokspruit. The baseline water quality indicated poor quality with parameters of concern being pH, EC, Ca, Mg, Na, Cl, and Turbidity at SW01 and Al, Fe, Turbidity and pH for Aston Lake when benchmarked against the SWQG Agriculture: Irrigation, SWQG Agriculture: Domestic Use limit, the SANS 241-2015 drinking water quality standards and Blesboksporuit WQO. These impacts could spread downstream to the Blesbokspruit which is already deteriorated in water quality based on the scoping report findings (Digby Wells, 2016). The report concluded that the overall water quality in the Blesbokspruit and its tributaries has been contaminated and the pollution sources are likely to be anthropogenic activities.

Mining has been attributed to increase in turbidity and salts in the surface water resources and cumulative surface water quality impacts will be anticipated in the Aston Lake and potentially the Blesbokspruit. The deteriorated water quality could then imply further restricted water use for domestic, agricultural and drinking water purposes and increased costs of treatment should there be no option but to use the water.

13 Unplanned Events and Low Risks

Project activities that may pose a risk (an impact at low probabilities) are discussed under this section in Table 13-1.

Table 13-1: Unplanned events, low risks and their management measures

Potential Project Risk (Unplanned Occurrences)	Aspect Potentially Impacted	Mitigation / Management / Monitoring
Hydrocarbon spills from vehicles and heavy machinery or hazardous materials or waste storage facilities. Spills during decommissioning and removal of infrastructure will also add to water contamination	Hydrocarbon contamination of surrounding surface water resources through surface water runoff.	▪ Hydrocarbons and hazardous materials must be stored in bunded areas and refuelling should take place in contained and paved areas; ▪ Ensure that oil traps are well maintained; ▪ Vehicles and heavy machinery should be serviced and checked on a regularly basis to prevent leakages and spills; ▪ Decommissioning should be undertaken by accredited contractors with proven track records in environmental management

Potential Project Risk (Unplanned Occurrences)	Aspect Potentially Impacted	Mitigation / Management / Monitoring
Spills / leaks from the dewatering pipeline.	Contamination of surrounding surface water resources through surface water runoff.	▪ Regular inspections of the pipeline for any leaks; and ▪ Ensure that storm water management structures are put in place to capture all spills and to convey to the PCD.
Blockage of storm water management structures and silt trap.	Overflow of dirty water into the clean water environment.	▪ Inspect storm water management structures and silt trap after large storm events; and ▪ Regular inspections of the silt trap.
Contamination from the ROM and overburden dump.	Runoff from the ROM and overburden dump has the potential to pollute the surface water environment if not contained.	▪ Ensure that storm water management structures are put in place to capture all runoff from the ROM and overburden dumps and to convey to the PCD. ▪ Ensure that storm water structures are monitored as per as per section 9.2.

14 Surface Water Monitoring Plan

A monitoring programme is essential as a tool to assist any management plan and to detect negative impacts as they arise and to ensure that the necessary mitigation measures are operating effectively. It also ensures that storm water management structures are in working order. Monitoring should be implemented throughout the life of the mine.

The impacts on water quality will be determined by comparing the monitoring data against the mine water use license, when issued.

Water quality monitoring is recommended at the locations provided in Table 14-1

Table 14-1: Proposed water quality monitoring sites

Point Name	Latitude*	Longitude*
AECSW06	-26.269461	28.523228
SW1	-26.274339	28.572975
SW2	-26.231863	28.55844
Aston Lake	-26.253233	28.527422

The surface water monitoring plan is detailed in Table 14-2.

Table 14-2 : Surface Water Monitoring Programme

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Ensure that monitoring is implemented to cover all mining activity areas. Recommended monitoring sites are shown in Table 14-1 Water quality parameters that need to be analyzed are shown in Table 14-3.	-Monthly during construction. - Reduce to quarterly on rehabilitated areas. - This can further be reduced to biannually (wet and dry season). -Monitoring needs to carry on after the project has ceased and the results depict a steady state, as is standard practice to detect residual impacts.	Specialist Environmental Quality

Monitoring Element	Comment	Frequency	Responsibility
Water quantity	Flow monitoring should be carried out in channels and pipelines and at facilities on site. Monitoring water levels in dams and channels. Records of Pit dewatering	-Instantaneous where automatic flow meters are in place for real time measurements. -Where there are no automatic flowmeters weekly monitoring needs to be done. -In operational areas, daily records need to be kept	Specialist Environmental Quality
Physical structures and SWMP performance	Personnel should have a walk around facilities to determine the facilities conditions and pick out any anomalies such as leaks or overflows and system malfunctions. Dams are inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.	Continuous process and yearly formal report	Specialist Environmental Quality
Meteorological data	Measure rainfall	Real time measurement system if in place. Alternatively install a rain gauge and measure storm depths after rainfall events	Environmental Officer

The constituents in Table 14-3 are recommended to be analysed to determine the water quality. Where applicable, the analysis results were compared to compliance standards to be specified in the WUL. Where standards are not specified by the regulator, results were compared to the SANS 241:2011 South African National Standards for Drinking Water (SANS).

Table 14-3: Constituents Recommended In Water Quality Analysis

pH Value @ 20°C	Bicarbonate, HCO_3
Sodium, Na	Sodium Absorption Ratio (SAR)
Conductivity mS/m @ 25°C	Chloride, Cl
Potassium, K	Aluminium, Al
Total Dissolved Solids	Sulphate, SO_4
Free and Saline Ammonia as NH_4	Manganese, Mn
Calcium, Ca	Nitrate, NO_3
Magnesium Hardness as $CaCO_3$	Iron, Fe
Calcium Hardness as $CaCO_3$	Fluoride, F
Total Hardness as $CaCO_3$	Chromium, Cr
Langelier Saturation Index (pH-pHs)	Total Suspended Solids
Total Alkalinity as $CaCO_3$	Phosphorus, P
Dissolved Metals using Inductive Coupled Plasma Scan	

15 Consultation Undertaken

During the surface water site visit for sample collection, Digby Wells communicated with the landowners and community people to gain access to their land. No stakeholder engagement took place during the study.

16 Comments and Responses

Comments received during the public comment period on the Draft EIA Report will be included into this report, and submitted to the DMR as the final report.

17 Conclusions

The following is concluded:

The proposed Mine is within the Aston Lake catchment, surrounded by wetlands and drained by the the Dwars-in-die-wegvlei and the Verdrietlaagte stream on either sides. The Lake discharge flows into the Blesbokspruit. The Project Area is situated within the Vaal Water Management Area (WMA 5), within quaternary catchments C21E and it falls within the Sedibeng District Municipality and borders of the Mpumalanga Province.

The identified infrastructure areas amount to approximately 10.72 km^2 as measured on the provided infrastructure layout. The percentage loss in MAR for the C21E quaternary catchment due to the project will amount to approximately 1.7% of the total MAR. The Infrastructure is approximately 3.1% of total catchment area for the Aston Lake (344 km^2) and this would imply a loss of only 3.1 % catchment runoff are to the Aston Lake.

A site visit was conducted on the 23 August 2016 to collect water samples where there samples were collected at points one downstream of Aston Lake on an unnamed stream, upstream, one downstream on the Verdrietlaagte stream the surrounding streams and on Aston Lake. However, the Dwars-in-die-wegvlei was found dry.

The water quality results indicated the following:

- pH exceeded the SWQG Agriculture: Irrigation limit in all samples, which has high possibility of affecting yield, decreasing marketable products for farmers but is within the range for other limits;
- Turbidity exceeded SWQG Agriculture: Domestic Use limit and the SANS 241-2015 drinking water quality standards in all samples;
- SW01 has elevated levels of EC, Ca, Mg, Na, Cl, Total Hardness and Turbidity beyond the SWQG: Domestic Use limit. Cl found in this sample also exceeds SWQG: Agriculture (Irrigation) Limit. The elevated levels of salts could be attributed to the concentration of these elements due to evaporation in the dry season;
- The water quality at Aston Lake had elevated Al and Fe exceeding SWQG Domestic Use, Turbidity exceeding beyond both SANS 241-2015 drinking water quality standards and SWQG: Domestic Use limit with SS exceeding SWQG: Agriculture (Irrigation) Limit; and
- When benchmarked against the Blesboksporuit WQO, the pH at Aston Lake and SW01 as well as the Aluminium at Aston Lake exceed the limits. The Aluminium levels in Aston Lake can be attributed to the slightly elevated pH levels as Aluminium levels in dissolved state increase at higher and lower pH than 5.5 - 9.0 (WHO, 2003) Aluminium naturally occurs in waters in very low concentrations. Higher concentrations derived from mining waste may negatively affect aquatic communities. Aluminium is toxic to fish in acidic, unbuffered waters starting at a concentration of 0.1 mg/L.

The water samples collected may not be considered to be representative of the rivers water quality during low flow period.

The results of the flood elevations none of the infrastructure proposed in the immediate future is within the determined Dwars-in-die-wegvlei floodlines except the proposed haul road which crosses the floodlines. The proposed future development site, falls within the floodlines for the Verdrietlaagte. It is important to note that the floodlines methodology used is conservative and considered a worst case scenario given up to the 1:50 and 1:100 year flood peak.

In order to meet the design principles detailed in the GN704 and the BPG G1, the following storm water management plan measures are proposed:

- Clean water diversion berms to divert clean water to the downstream environment or nearby watercourse away from the infrastructure area;
- Dirty water channels and berms around all stockpile areas, waste rock dump areas, contractors camp areas and plant areas, such that all dirty water is captured and contained in respective PCD's;
- A PCD which will capture and contain dirty water runoff from the afore mentioned dirty areas; and
- 2 proposed silt traps/sumps to collect water before it is conveyed to the PCD. This controls siltation of the PCD.

From the Impacts assessments undertaken; the results indicated the following

Minor negative Impacts

- Sedimentation of surface water resources resulting to deteriorated water quality; and
- Reduced surface water infiltration as well as an alteration in surface water drainage patterns as a result of soil compaction from the movement of heavy machinery and vehicles

Moderate Negative Impacts

- Reduced surface water infiltration, alteration in surface water drainage patterns and increased velocity in surface water runoff leading to possible erosion and sedimentation and less runoff reporting to the Blesbokspruit;
- Alteration in surface water drainage patterns and a reduction in the amount of water reaching the Aston Lake and reduced flow to Blesbokspruit; and
- Water Contamination leading to deterioration of water quality from carbonaceous material and eroded soil material

18 Recommendations

This section described the recommendations that could be derived from the assessments results.

The Baseline water quality should be sampled in wet months before construction can commence to ensure that the baseline water quality can be captured for all streams, in both seasons.

Based on the determined floodlines, adequate designs need to be implemented for the haul road that crosses the floodlines through the use of well-constructed culverts to allow flood flow through and to minimise or avoid erosion. To improve the accuracy of the flood model, it is recommended that the use of measured flood levels and discharge over the spillway be undertaken to calibrate the determined discharge through the level pool reservoir routing method and the flood peaks.

A summary of the recommendations associated with the SWMP is listed below:

- Overburden and topsoil stockpiles should be vegetated to prevent erosion of occurring;
- The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows;
- Stockpiling of materials should be monitored so that the side slopes do not encourage erosion of the slopes, resulting in silt transported into the trenches from the stockpiles, allowing silt to settle on the dirty water site rather than in the channels;
- Sediment control is necessary during the process and this could be achieved by setting up flow impeding structures such as silt traps on the downstream of the potential silt generating infrastructure like stockpiles;
- In addition to the control of storm water, water quality monitoring should form part of this system where water in the PCDs is monitored for quality. This ensures that pollution sources are monitored during the mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to monitor should include but not limited to Total Suspended Solids (TSS, pH, SO_4, Salinity, EC and other metals); and

An emergency dam is recommended adjacent to the PCD, preferably downstream to hold overflows and bypass in times when the primary PCD is being cleaned.

Mitigation measures include Implementation of the SWMP and additional measures such as

- To ensure that the topography of disturbed areas is returned to a pre-mining state to allow free draining topography;
- Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration
- Roads should be maintained regularly to ensure that surface water drains freely off the road preventing erosion; and
- Re-vegetation of disturbed areas.

19 References

Brunner G.W. 2016. HEC-RAS – River Analysis System Hydraulic Reference Manual Version 5.0, US Army Corps of Engineers Hydrologic Engineering Center (HEC).

Chow V.T. 1959. Open channel hydraulics. McGraw-Hill, New York.

Department of Water and Sanitation (DWS). 2013. National Water Resource Strategy 2, page 64.

DIGBY WELLS. 2016. Scoping Report for the Proposed Reclamation of the Grootvlei Tailings Storage Facilities Cluster, Near Springs, Gauteng.

DWS 2015. Water Authorisation Registration and Management System data extracted on 13 June 2016. Department of Water and Sanitation, Pretoria.

Department of Water Affairs and Forestry (DWAF), 1996. South African Water Quality Guidelines (second edition). Volume 1: Agriculture: Irrigational Use.

Department of Water Affairs (DWA), 2006. Best Practice Guidelines series. BPG:G1 Storm Water Management

DWA, 2006. Best Practice Guidelines series

Geoterraimage. 2015. The 2013 – 2014 South African National Land-Cover Dataset. Data User Report and MetaData.

http://www.reservoir.co.za/forums/vaalbarrage/blesbok_forum/blesbok_chemical_2013 Accessed 18/07/2016.

In-stream Water Quality Guidelines for the Blesbokspruit Catchment Effective: June 2003. http://reservoir.co.za/forums/vaalbarrage/blesbok_forum/blesbok_documents/BF_WQGuidelines.pdf

National Water Act, 1998. Act 36 of 1998 (NWA).

NWA Government Notice of Regulation (GN R) 704, 1999. Regulation of Water Use in Mining

Smithers J.C. and Schulze R.E. 2002. Design Rainfall and Flood Estimation in South Africa. WRC Project No: K5/1060

South African Bureau of Standards (SABS). 2011. South African National Standard: SANS 241-1:2011: Drinking Water.

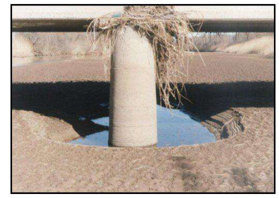
South African National Roads Agency (SANRAL), 2013. Drainage Manual Aplication Guide 6th Edition (www.sanral.co.za)

Utility Programs for Drainage (UPD). 2007. Version 1.1.0. Developed by Sinotech cc. Available online: www.sinotechcc.co.za/software

WR2005, 2012, Water Resources of South Africa, 2005 Study (WR2005), Revised up to 2012. WRC Report No. TT380/08, Water Research Commission, Pretoria.

World Health Organisation (WHO, 2003) Aluminium in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality

Appendix A: UPD Peak Flow Modelling Results



Sinotech

Utility Programs for Drainage
Flood calculations

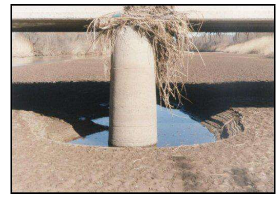
Project name: CNC4065
Analysed by: C. Maka
Name of river: Aston Lake Inflow 2
Description of site: C2
Filename: C:\CEM_1\PORTABLE\Projects\CANYON RESOURCES\CNC4065\Modelling\Floodlines\UPD C2.fld
Date: 26 October 2016

Summary of peak flows (m³/s)

Method	1:2	1:5	1:10	1:20	1:50	1:100	1:200	Design year
Rational	45.36	65.51	87.61	113.80	154.60	198.27		90
Alternative rational	38.31	68.94	95.82	125.35	165.65	200.92	227.47	90
Unit hydrograph								
Standard design flood	18.24	64.05	106.58	154.73	226.59	286.95	351.01	100
Empirical								
Statistical: LN								
Statistical: LEV1								
Statistical: LP3								
Statistical: EV1								

Class of road = Class 1 Primary Distributors

Utility Programs for Drainage
Flood calculations



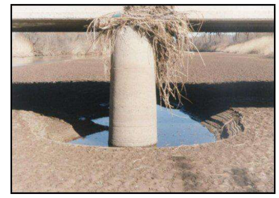
Sinotech

Project name: CNC4065
Analysed by: C. Maka
Name of river: Aston Lake Inflow 1
Description of site: C1
Filename: C:\CEM_1\PORTABLE\Projects\CANYON RESOURCES\CNC4065\Modelling\Floodlines\UP D C1.fld
Date: 26 October 2016

Summary of peak flows (m³/s)

Method	1:2	1:5	1:10	1:20	1:50	1:100	1:200	Design year
Rational	54.71	78.90	105.33	136.57	184.97	236.49		100
Alternative rational	45.48	81.85	113.75	148.81	196.65	238.52	270.03	100
Unit hydrograph								
Standard design flood	21.65	76.04	126.53	183.69	268.99	340.65	416.70	100
Empirical								
Statistical: LN								
Statistical: LEV1								
Statistical: LP3								
Statistical: EV1								

Class of road = Class 1 Primary Distributors



Utility Programs for Drainage
Flood calculations

Sinotech

Project name: CNC4065
Analysed by: C. Maka
Name of river: Aston Lake
Description of site: Aston Lake Catchment
Filename: C:\CEM_1\PORTABLE\Projects\CANYON RESOURCES\CNC4065\Modelling\Floodlines\UPD Aston Lake.fld
Date: 27 October 2016

Summary of peak flows (m³/s)

Method	1:2	1:5	1:10	1:20	1:50	1:100	1:200	Design year
Rational	84.00	121.16	161.80	209.84	284.36	363.74		100
Alternative rational	69.06	124.27	172.71	225.93	298.58	362.14	409.99	100
Unit hydrograph								
Standard design flood	31.33	110.02	183.08	265.79	389.22	492.91	602.95	100
Empirical								
Statistical: LN								
Statistical: LEV1								
Statistical: LP3								
Statistical: EV1								

Class of road = Class 1 Primary Distributors

Appendix B: HecRAS Model Results

Catchment 2												
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)	
Main Reach	3977.314	1:50	196	1581.48	1582.26	1581.87	1582.28	0.002073	0.57	314.73	563.58	0.26
Main Reach	3977.314	1:100	244	1581.48	1582.34	1581.96	1582.36	0.002163	0.64	357.29	573.6	0.27
Main Reach	3613.948	1:50	196	1580.73	1581.29		1581.31	0.003547	0.56	295.59	769.42	0.32
Main Reach	3613.948	1:100	244	1580.73	1581.36		1581.38	0.003419	0.63	350.4	814.88	0.32
Main Reach	3303.924	1:50	196	1579.21	1580.59		1580.6	0.001607	0.62	405.15	1029.55	0.24
Main Reach	3303.924	1:100	244	1579.21	1580.65		1580.67	0.001672	0.67	471.95	1094.14	0.25
Main Reach	3016.852	1:50	196	1578.99	1580.05		1580.07	0.002149	0.78	377.03	1102.44	0.28
Main Reach	3016.852	1:100	244	1578.99	1580.12		1580.14	0.002034	0.77	455.67	1150.41	0.28
Main Reach	2633.283	1:50	196	1578.02	1579.42		1579.43	0.00132	0.62	396.44	777.04	0.22
Main Reach	2633.283	1:100	244	1578.02	1579.5		1579.51	0.001328	0.65	460.42	805.96	0.23
Main Reach	2297.148	1:50	196	1577.99	1578.74		1578.77	0.003177	0.75	268.23	633.42	0.33
Main Reach	2297.148	1:100	244	1577.99	1578.81		1578.84	0.003275	0.82	314.29	703.22	0.34
Main Reach	1963.952	1:50	196	1577.14	1578.14		1578.16	0.001184	0.6	421.97	870.02	0.21
Main Reach	1963.952	1:100	244	1577.14	1578.23		1578.24	0.001117	0.62	497.51	871.33	0.21
Main Reach	1553.364	1:50	196	1577.11	1577.75		1577.76	0.000795	0.36	448.94	665.73	0.16
Main Reach	1553.364	1:100	244	1577.11	1577.84		1577.85	0.000826	0.4	507.34	668.98	0.17
Main Reach	1204.412	1:50	196	1576.52	1577.33		1577.34	0.00204	0.57	331	628.74	0.26
Main Reach	1204.412	1:100	244	1576.52	1577.41		1577.43	0.001957	0.61	382.74	630.79	0.26
Main Reach	795.6317	1:50	196	1575.81	1576.43		1576.46	0.002295	0.49	261.35	399.17	0.26
Main Reach	795.6317	1:100	244	1575.81	1576.53		1576.57	0.002289	0.54	301.83	412.14	0.26
Main Reach	379.5837	1:50	196	1574.98	1575.66		1575.68	0.00156	0.55	352.24	595.07	0.23
Main Reach	379.5837	1:100	244	1574.98	1575.74		1575.75	0.001658	0.61	395.62	599.56	0.24
Main Reach	75.2766	1:50	196	1574.38	1575.02	1574.76	1575.03	0.003002	0.52	332.8	932.36	0.29
Main Reach	75.2766	1:100	244	1574.38	1575.07	1574.8	1575.09	0.003003	0.58	386.6	1043.16	0.3

Catchment 1

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)	
Main	3733.647	1:50	233	1578.57	1579.96	1579.27	1579.99	0.001067	0.82	328.83	440.36	0.24
Main	3733.647	1:100	290	1578.57	1580.11	1579.36	1580.14	0.001038	0.87	397.93	508.94	0.24
Main	3621.018	1:50	233	1578.42	1579.87		1579.89	0.000679	0.68	401.02	457.51	0.19
Main	3621.018	1:100	290	1578.42	1580.02		1580.04	0.000678	0.73	469.43	483.73	0.2
Main	3533.126	1:50	233	1578.32	1579.8		1579.83	0.000858	0.76	364.16	464.73	0.22
Main	3533.126	1:100	290	1578.32	1579.95		1579.98	0.000831	0.8	434.91	496.92	0.22
Main	3449.27	1:50	233	1578.19	1579.69		1579.74	0.001359	0.9	272.35	301.09	0.27
Main	3449.27	1:100	290	1578.19	1579.83		1579.88	0.001424	1	318.72	420.32	0.28
Main	3356.02	1:50	233	1578.11	1579.09	1579.09	1579.38	0.023804	2.39	97.33	166.82	1
Main	3356.02	1:100	290	1578.11	1579.19	1579.19	1579.52	0.02349	2.53	114.52	178.6	1.01
Main	3274.476	1:50	233	1577.11	1577.98	1577.51	1578.06	0.003468	0.66	189.84	232.12	0.35
Main	3274.476	1:100	290	1577.11	1578.11	1577.61	1578.21	0.003689	0.56	223.77	304.1	0.35
Main	3182.976	1:50	233	1576.34	1577.85		1577.88	0.001109	0.74	327.48	350.26	0.24
Main	3182.976	1:100	290	1576.34	1577.98		1578.01	0.001179	0.82	372.55	364.31	0.25
Main	3091.456	1:50	233	1576.25	1577.66		1577.71	0.003637	1.04	236.9	385.65	0.4
Main	3091.456	1:100	290	1576.25	1577.79		1577.85	0.002967	1.06	290.41	398.17	0.37
Main	3003.334	1:50	233	1576.01	1577.54		1577.57	0.000831	0.74	360.6	416.32	0.21
Main	3003.334	1:100	290	1576.01	1577.69		1577.71	0.000824	0.79	422.22	433.96	0.21
Main	2908.977	1:50	233	1575.99	1577.46		1577.49	0.000851	0.72	372.99	437.64	0.21
Main	2908.977	1:100	290	1575.99	1577.61		1577.64	0.000818	0.76	438.64	455.67	0.21
Main	2807.218	1:50	233	1575.97	1577.39		1577.41	0.000709	0.68	393.81	436.99	0.2
Main	2807.218	1:100	290	1575.97	1577.53		1577.56	0.000707	0.73	460.94	465.36	0.2
Main	2682.499	1:50	233	1575.88	1577.3		1577.32	0.000678	0.6	413.18	438.65	0.19
Main	2682.499	1:100	290	1575.88	1577.45		1577.47	0.000652	0.64	480.27	450.85	0.19
Main	2507.409	1:50	233	1575.46	1577.16		1577.19	0.000837	0.7	360.44	369.89	0.21
Main	2507.409	1:100	290	1575.46	1577.32		1577.34	0.000845	0.75	418.11	387.46	0.21
Main	2344.436	1:50	233	1575.06	1577.04		1577.06	0.000683	0.71	365.79	362.19	0.2
Main	2344.436	1:100	290	1575.06	1577.19		1577.21	0.00071	0.78	420.85	380.61	0.2
Main	2192.468	1:50	233	1575.37	1576.93		1576.95	0.000752	0.74	351.96	351.7	0.2
Main	2192.468	1:100	290	1575.37	1577.07		1577.1	0.000796	0.81	403.45	375.87	0.21
Main	1909.407	1:50	233	1575.32	1576.55		1576.6	0.002372	1.06	237.83	312.15	0.34
Main	1909.407	1:100	290	1575.32	1576.68		1576.74	0.002281	1.13	280.45	329.74	0.34
Main	1706.187	1:50	233	1574.97	1576.29		1576.32	0.000861	0.74	340.52	346.26	0.21
Main	1706.187	1:100	290	1574.97	1576.42		1576.45	0.000929	0.82	384.37	356.15	0.23
Main	1398.748	1:50	233	1574.99	1576.11		1576.13	0.000469	0.51	506.71	569.09	0.16
Main	1398.748	1:100	290	1574.99	1576.23		1576.24	0.000506	0.56	571.35	587.37	0.16
Main	1238.442	1:50	233	1574.89	1576.04		1576.05	0.000495	0.47	546.76	722.07	0.16
Main	1238.442	1:100	290	1574.89	1576.15		1576.16	0.000501	0.51	626.11	737.42	0.16
Main	1055.03	1:50	233	1574.75	1575.95		1575.96	0.000426	0.43	588.98	746.52	0.14
Main	1055.03	1:100	290	1574.75	1576.06		1576.07	0.000442	0.47	669.65	766.72	0.15
Main	898.1475	1:50	233	1574.7	1575.83		1575.85	0.001518	0.79	382.74	706.38	0.27
Main	898.1475	1:100	290	1574.7	1575.93		1575.95	0.001523	0.84	461.31	822.26	0.27
Main	818.4186	1:50	233	1574.5	1575.69		1575.71	0.001802	0.78	343.59	582.85	0.29
Main	818.4186	1:100	290	1574.5	1575.8		1575.82	0.00172	0.82	406.84	617.57	0.29
Main	561.048	1:50	233	1573.99	1575.5		1575.51	0.000432	0.51	549.76	750.28	0.15
Main	561.048	1:100	290	1573.99	1575.6		1575.61	0.000469	0.56	624.5	772.92	0.16
Main	320.3267	1:50	233	1574.05	1575.24	1574.87	1575.29	0.003	1.05	264.28	585.01	0.37
Main	320.3267	1:100	290	1574.05	1575.32	1574.97	1575.37	0.003001	1.12	314.12	617.98	0.38