MINETEK RESOURCES (PTY) LTD

NEWCASTLE COAL PROJECT

HYDROLOGICAL IMPACT ASSESSMENT

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Disclaimer	

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Revision History		
Reviewed by	Date	Summary of changes
Lelani Claassen	26 May 2023	Changes to pit WB calculations following groundwater ingress.

Lebohang Makola	13 July 2023	Revision of trapezoidal channels liner

LIST OF ABBREVIATIONS

Abbreviation	Description
BPG	Best Practice Guidelines
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
GN	Government Notice
LoM	Life of Mine
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NCP	Newcastle Coal Project
NEMA	National Environmental Management Act
NWA	National Water Act, 36 of 1998
SWMP	Storm Water Management Plan
RSA	Republic of South Africa
WMA	Water Management Area

DECLARATION

I, Lebohang Makola declare that I am an independent specialist working under Letsolo Water and Environmental Services. I, Lebohang Makola, and Letsolo Water and Environmental Services do not benefit in any way from our client Cabanga Environmental whether directly or indirectly apart from the consultation work we conduct based on their requests. I further declare that I, and Letsolo Water and Environmental Services have no interest and are not in business, have personal investments and other forms of benefits with regards to the proposed Newcastle Mining Project in Newcastle, Kwa Zulu Natal of Minetek Resource (Pty) Ltd.

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EXECUTIVE SUMMARY

Letsolo Water and Environmental Services was appointed by Cabanga Environmental to undertake a Hydrological Impact Assessment for a Water Use Licence Application (WULA) and for Environmental Impact Assessment for the proposed Newcastle Coal Project (NCP) in the Kwa Zulu Natal Province. Minetek Resources (Pty) Ltd (The Applicant) proposes the mining of coal from two seams of the Klip Rivier Coalfield near Newcastle in the KwaZulu Natal Province. Proposed operations will involve both opencast and underground mining methods, with an onsite crushing, screening, and sorting plant on farm Craig 2989-HS. Currently, the site is on greenfield, and the dominant land use is farming.

The proposed project falls within the primary catchment (V) and quaternary catchment V31J of the Pongola-Mtamvuna Water Management Area (WMA 4) found in the eastern part of South Africa. The regional topography is considered hilly, consisting of undulating landscapes and broad valleys. Drainage within the study area occurs from the iNguduma River located directly north of the mining area and flows eastwards where it confluences with the Ncandu River.

Water quality assessment was conducted from the Ncandu river and iNguduma river with their tributaries on the 19th of January 2023 to determine the baseline water quality of the area before proposed mining activity commences as well for the understanding of the general characterisation of the site. Water samples were collected from seven sampling points, namely Ncandu (ND) 01 and ND 02, iNguduma (IGM) 01 to 03, iNguduma tributary 01 (IGMT 01), and After Confluence (AC). ND 01 and ND 02 are located on the main system (Ncandu River). IGM 01 and IGM 02 are located on the iNguduma River, the main tributary of the Ncandu River, while IGMT 01 is located on a tributary of the iNguduma River.

The water quality results indicate that the majority of the chemical parameters such as the EC, TDS, SO_4, as well the cations i.e., Ca, Mg, and Na, were higher in the tributary (IGM 01 – IGMT 01) when compared to the main system (ND 01 and ND 02). Five selected chemical parameters (TDS, SO_4, Cl, K, and Na) were averaged and used to determine salt distribution in the area of interest. The salt load calculation revealed that salt retention in the Ncandu River decreases from the upstream point to the downstream point (influenced by dense vegetation between the two points which serves as a natural rehabilitation system), indicating an improvement in water quality. Salt retention in the iNguduma River increase from the upstream to the downstream point, the farming activity adjacent to the river is a likely source of salts in the river.

A Conceptual Stormwater Management Plan (SWMP) was prepared following BPG 1: Stormwater Management to ensure the separation of the clean and dirty catchments associated with the proposed mine. Dirty catchments include all the areas where coal is proposed to be handled such as opencast pits, overburden dumps, sorting and stockpiling areas. Clean catchments are areas not directly affected by mining or associated activities. It is proposed that berms should be built around the dirty catchments and to construct vegetated trapezoidal channels inside the berms to convey dirty runoff into dirty water containment facilities such as the Pollution Control Dams (PCDs) and in-pit sumps. The location of the PCDs was assessed according to surface water drainage and it was found that the main PCD is located upstream of the drainage and would not be able to collect dirty runoff from the hosting dirty catchment. The location of the PCD named 'Potential Future PCD' is suitable for dirty water collection, therefore, the main PCD should be moved to this location.

Floodlines were delineated on the iNguduma River and its tributaries that drain the study area to check compliance with Condition 4 of the GN 704 regulations and to assess the risk of flooding to the proposed mine infrastructures. The proposed infrastructure which is within the 1:100-year inundation boundary and the 100 m watercourse buffer include the PCDs, Overburden 1 and Overburden 4+6, Pit 1, Pit D1, Pit 4, Pit 5, and Pit 6. GN 704 Condition 4 restricts mining activity to occur within these boundaries, therefore, it is recommended that the mine applies for an exemption from the Department of Water and Sanitation (DWS). Additionally, Section 21c and i water uses should be applied for and should include the overburden stockpiling and opencast pits that are within the inundation boundary and the 100 m buffer in the Water Use License Application (WULA). Alternatively, the extent of the pits and overburden dumps must be reduced to refrain from establishing an infrastructure area within the floodline area. In line with the Best Practice Guidelines, as discussed in more detail in this report, the PCDs should not be located within the inundation boundary.

The purpose of this report is to assess the impact of the proposed mine on the hydrological components of the area of interest. An impact assessment was conducted to determine the potential impact of the overburden stockpiles, dirty water infrastructures, open cast pits, and the conveyor belt on surface water bodies. The proposed infrastructures (excluding open cast pits) have medium impacts before mitigation and would remain medium after mitigation, except for the conveyor belt and dirty water infrastructures. The common impact these infrastructures has is the deterioration of water quality through siltation (runoff from overburden stockpiles and coal particles falling from the conveyor belt), overflow of PCDs, and decanting contaminated water from the in-pit sumps. These impacts can be mitigated by putting in place stormwater infrastructures to contain dirty water.

GLOSSARY OF TERMS

Applicant	Any person who applies for an authorisation to undertake an activity or to cause such activity to be undertaken as contemplated in the National Environmental Management Act (Act 107 of 1998), as amended, and the Environmental Impact Assessment Regulations, 2014. In this report, Applicant refers to Minetek Resources (Pty) Ltd.
Borehole	A generic term used for any drilled or hand-dug hole used to abstract or monitor groundwater, irrespective of diameter or construction.
Catchment	The area from which any rainfall will drain into the watercourse or watercourses or part of the water course, through the surface flow to a common point or common points.
Contamination	The introduction into the environment of any substance by the action of man.
Environment	All physical, chemical, and biological factors and conditions that influence an object and/or organism; the surroundings within which humans exist and are made up of the land, water, atmosphere, plant, and animal life (micro and macro), the interrelationship between the factors and the physical or chemical conditions that influence human health and well-being.
Environmental Impact Assessment	An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting, and assessing the potential positive and negative social, economic, and biophysical impacts of any proposed project, plan, programme, or policy that requires authorisation of permission by law and which may significantly affect the environment. The EIA includes an evaluation of alternatives, as well as recommendations for appropriate mitigation measures for minimising or avoiding negative impacts, measures enhancing the positive aspects of the proposal, and environmental management and monitoring measures.
Environmental Management Plan	A legally binding working document, which stipulates environmental and socio-economic mitigation measures that must be implemented by responsible parties throughout the proposed project.
Hydrological	The study of movement, distribution, and quality of surface water
Study Area	Refers to the entire study area compassing the total area of the land parcels as indicated on the study area map of Newcastle Coal Project.
Sustainable Development	Development that has integrated social, economic, and environmental factors into planning, implementation, and decision-making, to ensure that it serves present and future generations.
Topography	The study and description of the physical features of an area.
Water quality	This means the physical, chemical, toxicological, biological (including microbiological), and aesthetic properties of water that determine sustained (1) healthy functioning of aquatic ecosystems and (2) fitness for use (e.g., domestic, recreational, agricultural, and industrial). Water quality is therefore reflected in (a) concentrations or loads of substances (either dissolved or suspended) or micro-organisms, (b) physio-chemical attributes (e.g., temperature), and (c) certain biological responses to those concentrations, loads, or physio-chemical attributes.
Water Use License	An authorisation from the Department of Water and Sanitation to a designated water user to use water. The authorisation will provide details on the time-frames and conditions for the designated water use.

Water Resource	A water resource includes any watercourse, surface water, estuary, or aquifer. Watercourses include rivers, springs, and natural perennial and non-perennial channels. Wetlands, lakes, dams, or any collection identified as such by the Minister in the Government Gazette.

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1. INTRODUCTION AND OVERVIEW

1.1. Introduction

The proposed Newcastle Coal Project (hereafter referred to as NCP) is owned by Minetek Resources (Pty) Ltd who is the applicant for the required permissions including the Water Use Licence Application (WULA). The applicant applied for a Mining Right for coal over multiple farms (approximately 3250 hectares) west of Newcastle, the application reference number is KZN30/5/1/2/2/10122MR.

Letsolo Water and Environmental Services cc. (referred to herein as Letsolo) was appointed by Cabanga Environmental to conduct Hydrological Impact Assessment (HIA) for WULA and EIA for the proposed Newcastle Coal Project. The principal aim for the HIA is to predict and quantify the potential impacts on surface water resources as well as to recommend reasonable mitigation measures. In order to fulfil this principal aim, this assessment covers site specific aspects such as:

- Flood calculations;
- Stormwater management;
- Floodlines delineation;
- Water quality monitoring;
- Water and salt balance; and
- Impact Assessment.

1.2. Purpose of the study

The Hydrological Impact Assessment is required to predict and quantify the potential impacts on surface water resources as well as to recommend reasonable mitigation measures. This assessment is fundamental to the discipline of environmental management and is a requirement of the environmental authorisation, the Environmental Impact Assessment (EIA)/Environmental Management Programmes (EMPr), and IWULA. In each instance, there is a need to understand the future impact of a proposed activity and then determine whether the management measures applied to that activity are appropriate or whether they should be modified. The legal purpose of this Hydrological Assessment is to ensure that:

- The effect is given to the objectives of the National Water Act (NWA) 36 of 1998 and National Environmental Management Act (NEMA) 107 of 1998.

- The hydrological regime applicable to the Newcastle Coal Project is understood.
- Systems are in place to enable effective management of impacts on the water resources.
- Consistent and sustainable implementation of water management hierarchy at the proposed facilities that have the potential to impact on the water resource.

1.3. Scope of work

The scope of work for the Hydrological Impact Assessment allows for the following:

- Analysis of the physical hydrological conditions for the Quaternary Catchment and its larger surrounding areas with a specific focus on the area of influence (AoI). The physical hydrological conditions include defining the flow as high/low/pond/dam/pumped and recording physical parameters including water temperature and electrical conductivity (EC);
- Evaluation of the physical hydrological conditions such as slope, permeability, and vegetation cover, for delineated site-specific catchment areas. These physical characteristics were used to calculate the peak flows for the 1:50-year and 1:100-year storm events;
- Delineation of surface water catchments in the proposed mining area;
- To undertake the baseline Hydrological impact assessment and baseline Water and Salt Balance and to propose management measures as well as stormwater management;
- To propose management and mitigating measures that will ensure that the natural environment is preserved and protected as far as possible;
- Design stormwater facilities to separate clean and dirty water according to the BPG1: Stormwater Management; and
- Floodlines were delineated to assess the location of the proposed infrastructure in detail. GN 704 provides regulations for the location of dirty water infrastructure (and mine infrastructure). In instances where dirty water or mining infrastructure is located within the 100m buffer or the 1: 100 years flood area mitigation and management were proposed;

1.4. Background

Coal mining in the Klip Rivier coalfields stretches around many pockets in Mpumalanga and KZN, on various top and bottom seams, giving the mineral resource at different depths. The proposed NCP targets both top and bottom coal seams for opencast and underground mining.

The coal is planned to be processed onsite through crushing, screening, and sorting targeting a primary export thermal product and a middling product for potential sale to market. The other proposed site infrastructure includes overburden stockpiles, pollution control dams (PCDs), haul roads, admin office block, workshop, stockpiling area, and conveyor belt. Figure 1-1 below illustrates the location of the proposed infrastructure.

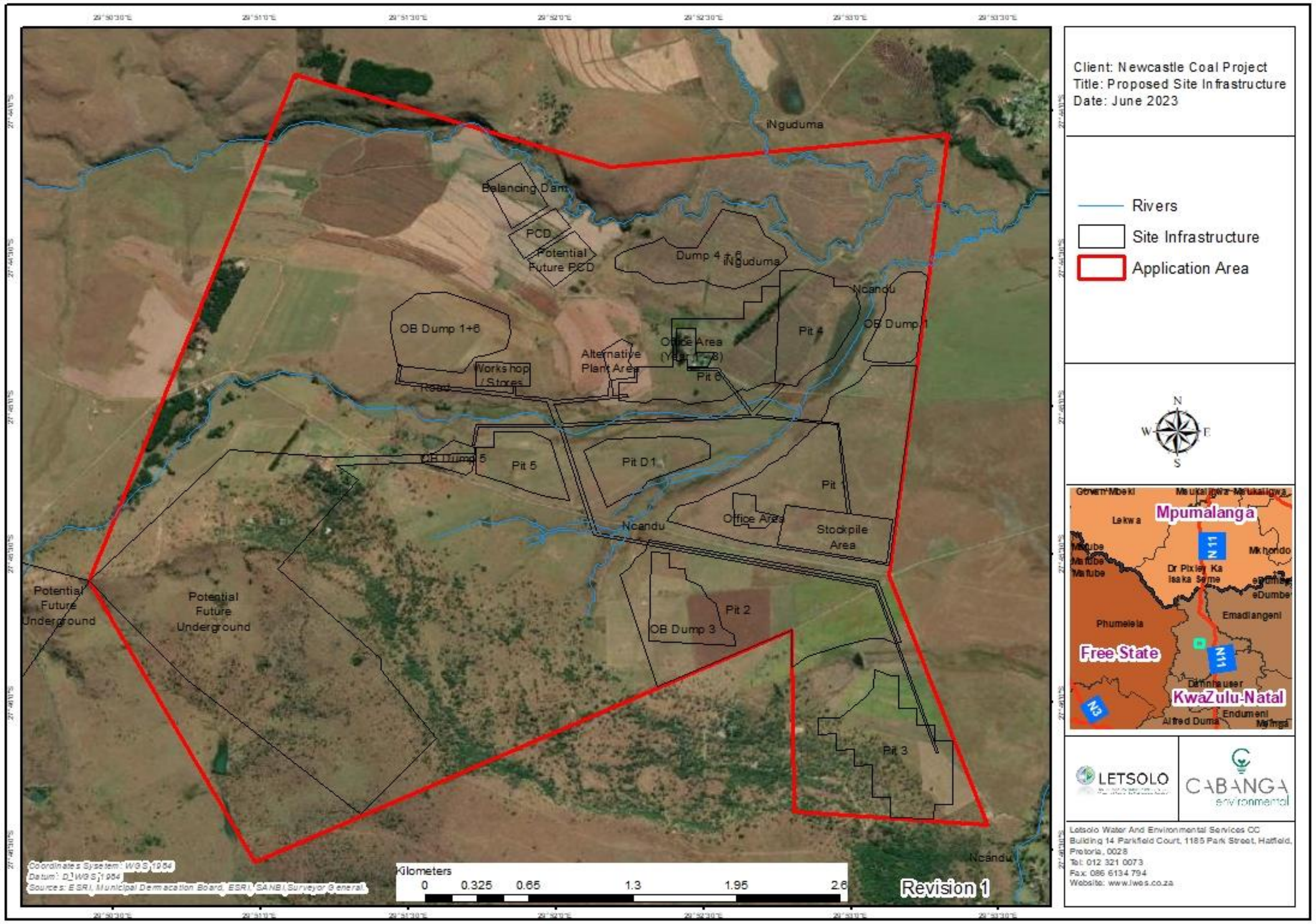


Figure 1-1: Location of the proposed site infrastructure

1.5. Date and season of the site investigation

The site visit was conducted on the 19th of January 2023 to conduct further investigations. The site investigation made allowance for the following:

- Records of the current state which is still a greenfields area;
- Identification of areas that may be hydrologically affected by the proposed mining activity;
- Logging of areas of interest for mapping purposes;
- Identification of nearby streams; and
- Characterisation of tributaries in terms of their perennial or non-perennial nature; and
- Collect water samples for baseline water quality assessment.

1.6. Site Location

The project site is located within Newcastle Local Municipality of the Amajuba District Municipality. The NCP project site is located approximately 5 km west-northwest of the town of Newcastle in the KwaZulu-Natal Province of South Africa. The site is accessed through D96 road that is linked to R34 regional road. The application area includes portions of the farms Craig, Dumblane, Glen Ashton, and Waterfall. Table 1-1 gives more description of the farm portions. The extent of the study area is shown on the Site Location Map (Figure 1-2).

Table 1-1: Detailed description of the farm portion

Farm Portion	Planned Activity	SG Code
Subdivision 1 of Craig No 2989-HS	Surface	N0HS00000000298900001
The remainder of Craig No 2989-HS	Surface	N0HS00000000298900000
Subdivision 3(of 1) Glen Ashton No 8589-HS	Underground	N0HS00000000858900003
Harwarden No 8915-HS	Underground	N0HS00000000891500000
Mineral Area 1 on Remainder of Subdivision 4 of Waterfall No 3335-HS	Surface	N0HS00000000333500004
Portion 1 of Waterfall No 3335-HS	Surface	N0HS00000000333500001
Subdivision 2 of Dumblane No 3317-HS.	Underground	N0HS00000000331700002
Subdivision 3 of Dumblane No 3317-HS.	Underground	N0HS00000000331700003

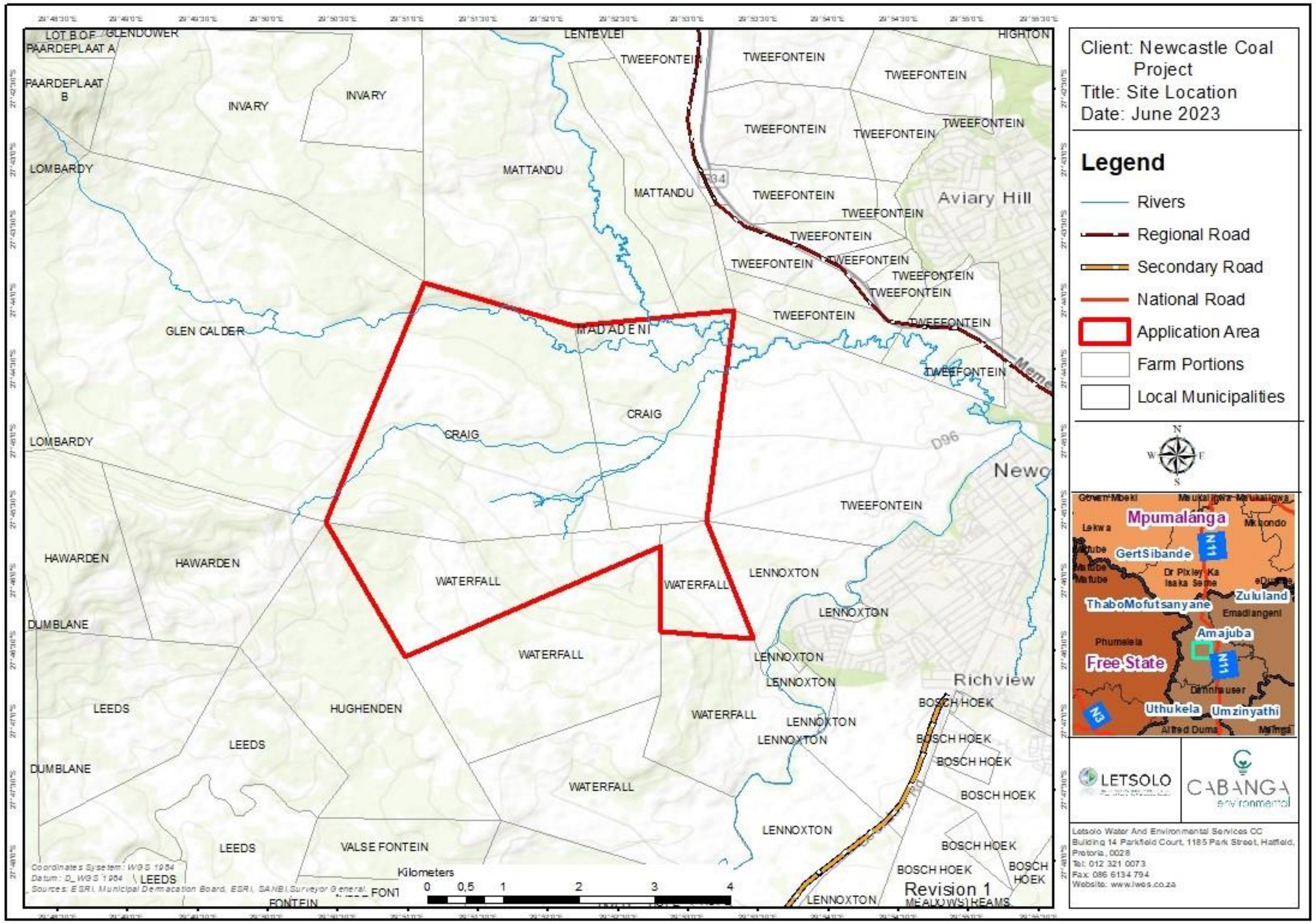


Figure 1-2: Site Location map.

2. LEGAL REVIEW

The Bill of Rights in the Constitution of the Republic of South Africa, 1996 (Act 108 of 1996) enshrines the concept of sustainability, specifying rights regarding the environment, water, access to information, and just administrative action. These rights and other requirements are further legislated through the National Water Act (NWA), 1998 (Act 36 of 1998). The latter is the primary statute providing the legal basis for water management in South Africa and has to ensure ecological integrity, economic growth, and social equity when managing and using water. The use of water for mining and related activities is also regulated through regulations that were updated after the promulgation of the NWA (Government notice No. GN704 dated 4 June 1999).

2.1. Constitution of South Africa, 1996 (Act 108 of 1996)

The Bill of Rights contained in the Constitution of the Republic of South Africa, 1996 (Act 108 of 1996) states that everyone has a right-

a) to an environment that is not harmful to their health or wellbeing; and
b) to have the environment protected for the benefit of the present and future generations through reasonable legislative and other measures that –
   i. prevent pollution and ecological degradation
   ii. promote conservation and
   iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development

Water management at mines is primarily controlled by the following legislation:

- National Water Act, 1998 (Act 36 of 1998) (NWA) and its regulations;
- National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA).

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

The NWA introduced the concept of Integrated Water Resource Management (IWRM), comprising all aspects of the water resource, including water quality, water quantity, and the aquatic ecosystem quality (quality of the aquatic biota and in-stream and riparian habitat). The IWRM approach provides for both resource-directed and source-directed measures. Resource-directed measures aim to protect and manage the receiving environment.

The NWA, therefore, provides for the protection, usage, development, conservation, management, and control of the country's water resources in an integrated manner. The Act provides the legal basis upon which to develop tools and means to give effect to the said activities.

One of these tools is the authorisation of water use as defined in Chapter 4 of the National Water Act. Section 21 of the National Water Act lists 11 water uses that can only be legally undertaken through the water use authorisation issued by the Department of Water and Sanitation (DWS).

2.3. Government Notice 704

Government Notice 704 (GN704) regulates the use of water by mines and related activities and aim to protect water resources. The protection is governed by Restriction 4 which states 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 floodline 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 (pertaining to sand mining), 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.*

3. METHODOLOGY

The following sub-sections describe the methodologies used:

- Flood calculations;
- Stormwater management;
- Floodlines delineation;
- Water quality monitoring;
- Water and salt balance; and
- Impact Assessment.

3.1. Flood calculations

The common hydrological methods for flood calculation that were applied are rational methods and the standard design flood method (SDF).

3.1.1. Rational Methods

The Rational method is based on a simplified representation of the law of conservation of mass. Rainfall intensity is an important input in the calculations; because uniform aerial and time distributions of rainfall must be assumed, therefore, the method is suitable for catchments that have a surface area smaller than 15 km^2 (SANRAL, 2013). The Rational method was selected as the most reliable method for the site-specific catchments, based on their surface area as well as the reliability of input data. It was also used to calculate site-specific peak flows.

Field observation data were used to calculate the runoff coefficient (c). The runoff coefficient represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception; all of which affect the time distribution and peak rate of runoff.

The runoff coefficient is the variable of the Rational method, least susceptible to a precise determination, and requires judgment and understanding on the part of the designer. This coefficient differs from site to site as it depends on site conditions, as observed during the site visit (SANRAL, 2013). The conditions that have an impact on the runoff coefficient are slope, vegetation cover, and permeability. The 1085 m (10% and 85% of the hydraulic length) height difference refers to the difference between elevation height at 10% and 85% of the length of the watercourse. This height difference is then divided by the length of the watercourse to determine the 10-85 slope (SANRAL, 2013).

3.1.2. Standard Design Flood Method (SDF)

The SDF method is applied/used on calibrated discharge coefficients for recurrence periods between 2 and 100 years (SANRAL, 2013). The method is suitable for catchments with large surface areas and was used to conduct flood calculations for catchments IGM 02, IGM 03, ND 01, ND 02, and AC.

3.2. Stormwater management

The Utility Programs for Drainage software was used to calculate peak flows for site conditions pre- and post-development. The peak flows were then used to design suitable channels, culverts, and sumps that will manage the increased runoffs post-development.

3.3. Floodlines delineation

The public domain and internationally accepted software package HEC-RAS developed by the US Army Corps of Engineers was used to hydraulically model the river system. Floodlines were delineated to assess the risk of flooding to the proposed infrastructure and compliance with GN 704 Condition 4. The system consists of three components i.e., flow data, geometric data, and simulation options. These components are described in more detail below.

3.3.1. Survey data

A topographical survey was conducted February 2023 to get the latest survey information. A Topographical Survey is a 2-D representation of what is happening in the real world (3-D). The characteristics of a topographical survey can vary, but some of the most common elements include:

- Contours - A contour line shows the peaks and the valleys of the land. The smaller the cumulative drop, the more detailed the survey becomes.
- Vegetation and physical attributes - The streams and creeks as well as any easily identified area, were captured in the imagery. These attributes were identified by the land surveyor after the aerial survey and details regarding the location of those attributes were obtained and used for other specialists' studies.
- Utilities - Any artificial infrastructure was identified and shown on the topographical survey. Overhead utility lines, streetlights, electric boxes, pipeline markers, and any visible evidence can be shown on the drawing.

When the survey was conducted, four standard items were key deliverables and were produced from each cross-section with each surveyed section.

- The baseline is a two or three-point line feature. Baseline features with only one point were ignored. The acceptable and defined baseline feature had a minimum of three points, chainages and those to the right positive.
- The left bank was used to identify the left bank point on the river cross-section. A single point is expected.

- The right bank was used to identify the right bank point on the river cross-section. A single point is expected.
- The water level identifies the water level of the river at the time of the survey.

3.3.2. Cross-sections

The survey was used to generate and extract river cross-sections from a model. When selected, a property sheet like that shown in Figure 3-1 below, was produced. HEC RAS model was used to superimpose profiles from the Digital Terrain Model (DTM) onto the river cross-sections.

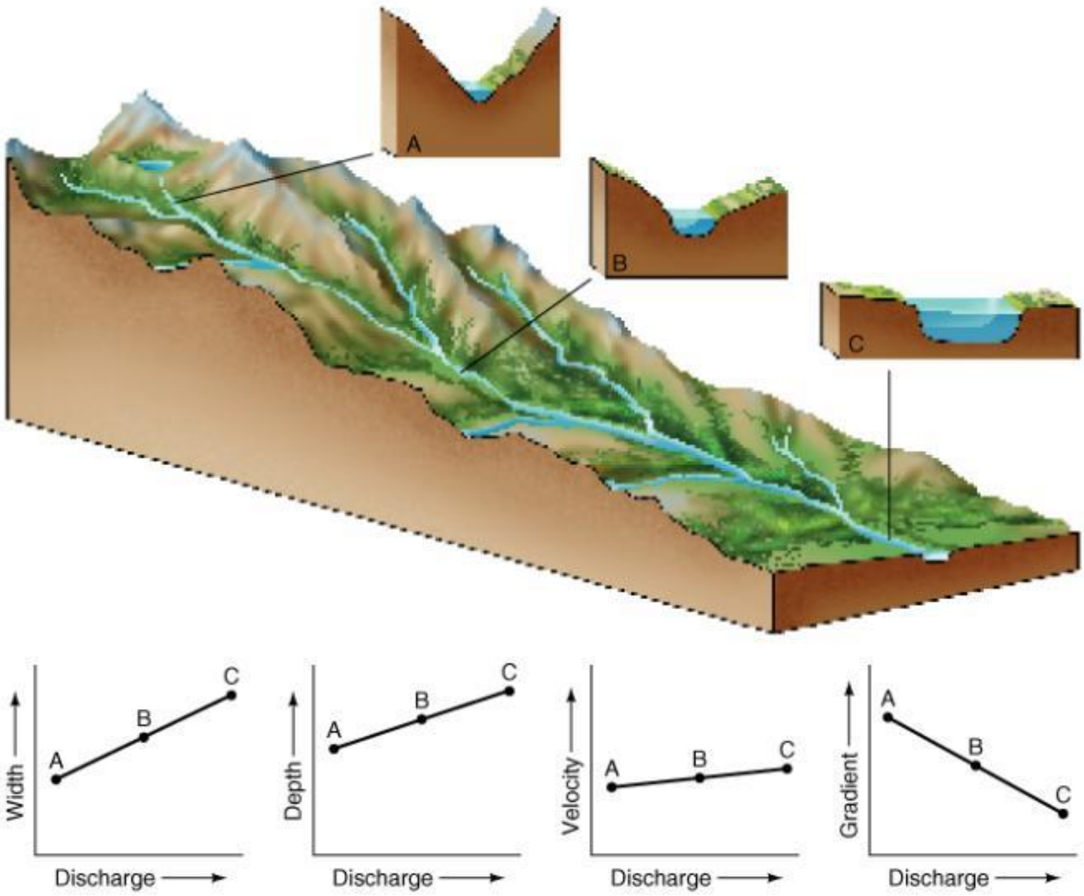


Figure 3-1: Typical River Cross Section

Cross-sections were drawn perpendicular to the stream, from left to right, and from the upstream point to the downstream point. They were labelled with the highest number from the upstream point to the lowest number at the downstream point (Figure 3-2).

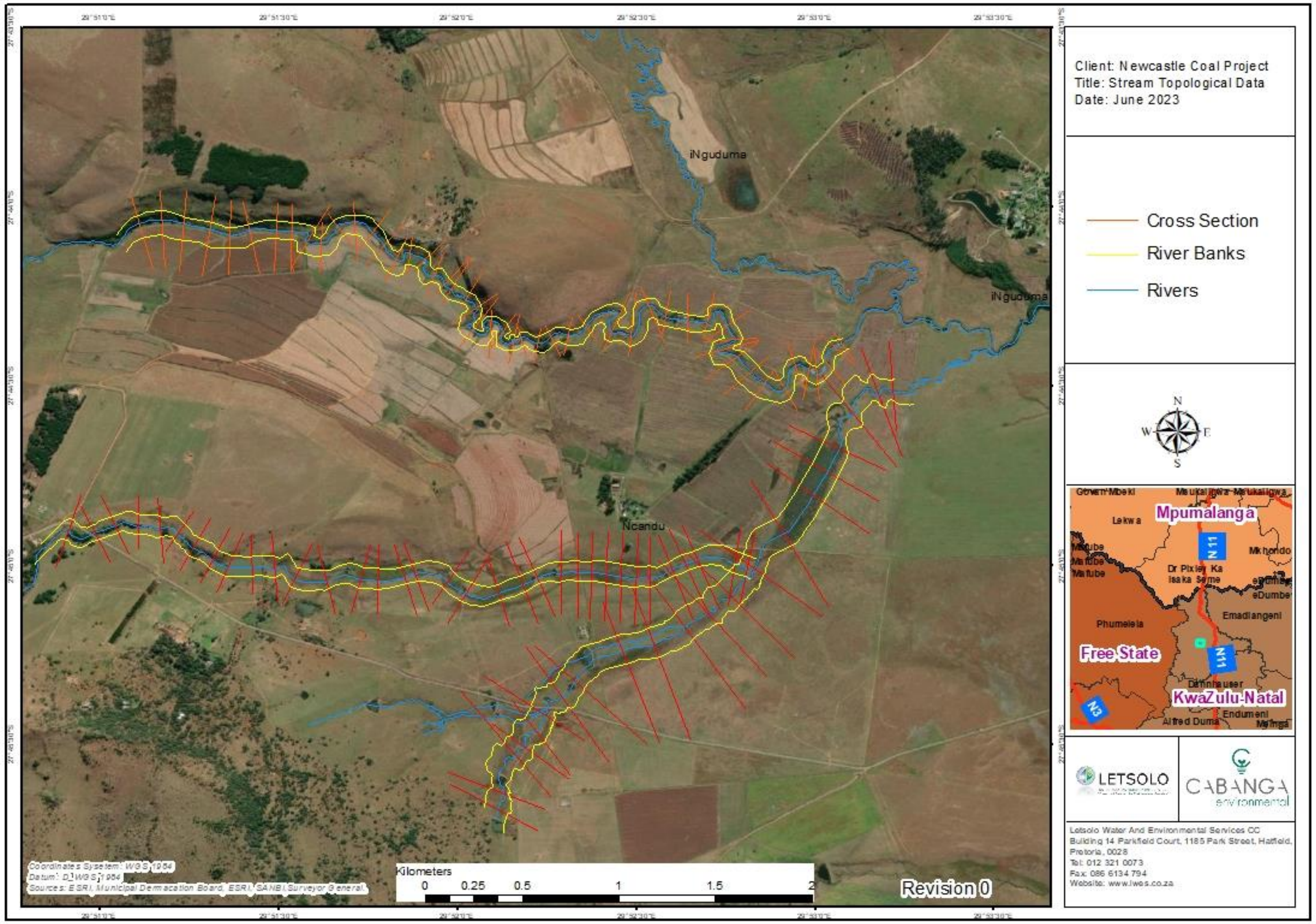


Figure 3-2: Floodlines topological data

3.4. Baseline water quality

The following instruments were used on site:

- Hand held pH/EC/TDS meter for measuring field physical parameters, including temperature;
- GPS for digitizing the location of points;
- Camera for site pictures;
- Water bottles for storing water samples, and
- Cooler box for preserving samples.

3.4.1. Water sampling

All fieldwork was conducted based on the protocols and specifications and code of practice contained in the SABS ISO 5667. These international standards address all aspects of the sampling methods as well as sample preservation and related aspects. The sampling and sample preservation were undertaken according to the following guidelines:

- SABS ISO 5667-2: 1991 Guidance on sampling techniques;
- SANS 5667-3 Part 3: Guidance on the preservation and handling of water samples;
- SANS 5667-14:2016 (Edition 2) on Water quality sampling, part 14: Guidance on quality assurance and quality control of environmental water sampling and handling; and
- SANS 5667-6, Part 6: Guidance on sampling of rivers and streams.

All samples were collected using sterilised bottles. Before a sample was collected, a prescribed sampling bottle was labelled in correspondence with the monitoring point from which sampling was done. Grab sampling method was used to sample the surface water along the streams. A hand-held pH/EC/TDS meter was used to record the following in-situ parameters: pH, EC, TDS, and temperature. A hand-held GPS was used to mark the geographic coordinates of the sampled sites. As recommended in SANS 5567-3, after samples have been collected, sampling bottles were stored in a cooler box at a temperature below 4^0C and then transported to the laboratory within 48 hours of sampling for analysis.

3.5. Water and Salt Balance

Spreadsheet-based water and salt balances methodology was applied. The advantages of these types of balances are:

- Calculations are done automatically.

- Data and results can be viewed relatively easily in various ways, e.g., graphs or tables.
- Data transfer is easy.
- Updates are easily effected when necessary.

The Water and Salt Balance were conducted following the Best Practice Guidelines, BPG 2- Water and Salt Balance (BPG, 2006). The calculations were based on the basic principle of mass conservation, which forms the foundation of mass balances. The principle can be simplified to the basic equation for a mass of species x and a processing unit: (rate of x into process unit) = (rate of x out of process unit).

NOTE: The salt loads were converted to Kilogrammes per annum as follows

Salt load	*= Concentration*Mean annual Runoff*	
	$= mg/l * m^3/a$	
	$= 0.001 g/l * m^3/a$	*(Convert mg to g)*
	$= 0.000001 kg/l * m^3/a$	*(Convert g to kg)*
	$= 0.001 kg/m3 * m^3/a$	*(convert l to m^3)*

3.6. Impact assessment methodology

An aspect and impact matrix were used to assist in identifying potential interactions between surface water bodies and project activities. Where interactions were deemed likely, the interactions were further rated to determine if impacts could potentially be created which require the development and implementation of management and mitigation measures beyond standard best-practice. The matrix made provision for the identification of potential interactions for all phases of the project (either positive or negative).

3.6.1. Impact rating

The identification of potential impacts also made provision for the identification of potential:

- Direct impacts – interactions and impacts which could be caused by an activity or action and occur at the same time and place (e.g., direct footprint of project infrastructure locations);
- Indirect impacts – interactions and impacts caused by an action and occur later or farther removed in distance, or which may cause an impact on another environment or water body but are still reasonably foreseeable, e.g., soil erosion due to exposure of surfaces is the

direct impact and siltation of surface water as a result of the erosion, is the indirect impacts; and

- Cumulative impacts - impact on the environment, which results from the incremental impact of the action when added to other past, present, associated, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Where cumulative impacts can be expected, to ensure consistency, similar Impact Rating Definitions were applied for current and future activities.

The following aspects are used to assess the impact of the activity on the environment:

- Severity – How severe does the aspect impact the environment and water quality characteristics (Table 3-1).
- Spatial scale – How big is the area that the aspect is impacting on (Table 3-2).
- Duration – How long does the aspect impact the environment and water quality (Table 3-3).
- Frequency of activity – How often is the specified activity being done (Table 3-4).
- Frequency of incident/impact – How often does the activity impact the environment (Table 3-5).
- Legal issues – How is the activity governed by legislation (Table 3-6).
- Detection – How quickly can the impacts of the activity be observed on the environment, people, and property.

Ratings were based on the following scoring scheme:

Table 3-1: Severity

1 = Insignificant	2 = Small	3 = Significant	4 = Great	5 = Disastrous.
The impact is non-harmful.	The impact is potentially harmful.	The impact is slightly harmful.	The impact is harmful.	The impact is extremely harmful and/or wetland(s) involved

Table 3-2: Spatial scale

1 = Localised	2 = Confined to site	3 = Wider area of Influence	4 = National	5 = Global
Localised to a specific area of activities.	Confined to the whole site.	The extent of the impacts will be regional.	Importance of the impact is of provincial or national importance	Importance of the impact is of global importance

Table 3-3: Duration

1 = Short term	2 = Short to medium Term	3 = Medium Term	4 = Long Term	5 = Permanent
Possible to immediately or within a short period mitigate / immediate or fairly quick progress with management implementation. One day to one month.	One month to one year. Areas impacted will have no change in status.	One year to 10 years, impacted area to a lower environmental value status but can be improved over this period through mitigation.	Life of the activity, environmental importance permanently lowered.	More than the life of the mine/operation.

Table 3-4: Frequency of the activity

1 =Annually	2 = 6 months	3 = Monthly	4 = Weekly	5 = Daily
The activity will be done once off on an annual basis.	The activity will be done twice after six months.	The activity will be done on a monthly basis.	The activity will be done on a weekly basis.	The activity will be done on a daily basis.

Table 3-5: Frequency of the incident/impact

1 = Almost never	2 = Very seldom	3 = Infrequent	4 = Often	5 = Daily
It is almost impossible for the activity to	It is highly unlikely for the activity to impact on the	It is unlikely for the activity to impact on the	The activity regularly impacts on the environment >80%.	The activity definitely impacts on the

impact on the environment >20%.	environment >40%	environment >60%.		environment >100%.

Table 3-6: Legal issues

1 = No legislation	5 = Covered by legislation
No legislation governs the activity.	The activity is fully covered by legislation.

Table 3-7: Detection

1 = Immediately	2 = Without much effort	3 = Need some effort	4 = Remote and difficult to observe	5 = Covered
Impact can be detected immediately.	**Impact can be detected without much effort.**	**Impact needs some effort like water quality testing to detect.**	**Impact is remote and difficult to observe**	**Covered**

Table 3-8: Significance

RATING	CLASS	MANAGEMENT DESCRIPTION
1 - 55	(L) Low Risk	Acceptable as is or consider a requirement for mitigation. The impact on the environment is small and easily mitigated. Wetlands may be excluded.
56 - 169	(M) Moderate Risk	Risk and impact on the environment are notable and require mitigation measures on a higher level, which costs more and affects sensitive areas.
170 - 300	(H) High Risk	Always involves sensitive environments. The impacts of the activity are such that they impose a long-term threat on a large scale and lowering of the Natural Reserve.

4. PHYSICAL CHARACTERISTICS

The Newcastle Weather Station which is the nearest weather station (approximately 7 km from the site) to the study area, is not functional and has no recent meteorological data. The mesoscale model fifth generation (MM5) was used to interpolate weather conditions in the study area. This data was obtained from Rayten Engineering Solutions (RES). Rainfall data was sourced from the Water Research Commission database (WR2012).

4.1. Temperature

The temperature in Newcastle fluctuates across different months of the year. Minimum day and night temperatures are noted in June and July. Maximum day temperatures are noted from November to February. Maximum night temperatures are noted from November to January (RES, 2023). Maximum day temperature in summer (December to February) reaches an average of 34°C and night temperature reaches an average of 11°C. Maximum day temperature in winter (June to August) reaches an average of 23°C and night temperature reaches an average of 1°C (Figure 4-1). Minimum day temperature reaches an average of 30°C and 20°C in summer and winter periods respectively. Minimum night temperature reaches an average of 8°C and -1°C in summer and winter periods respectively (RES, 2023)

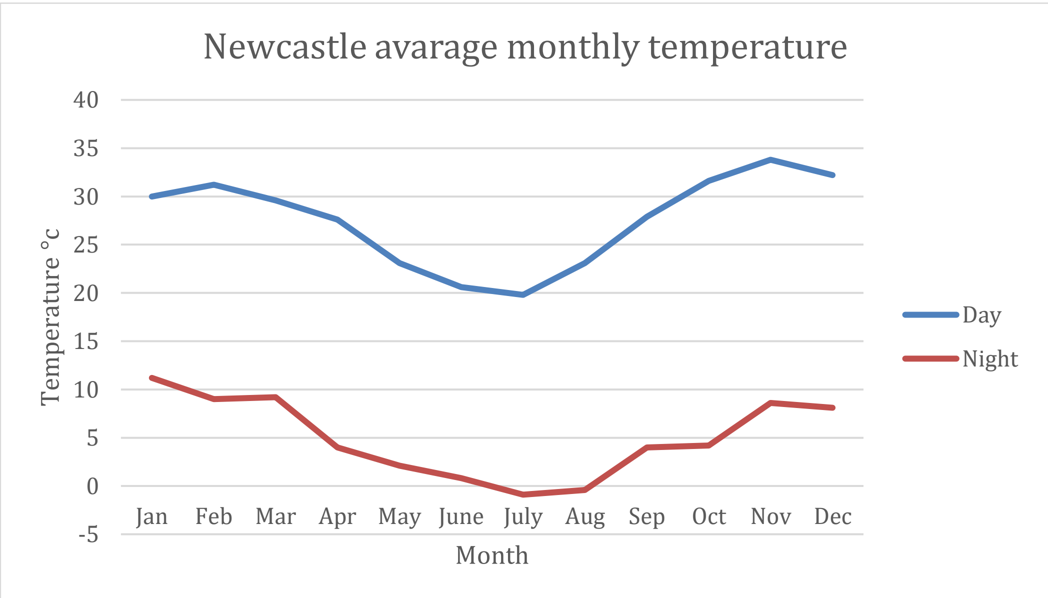


Figure 4-1: Average temperature for Newcastle, KZN

4.2. Rainfall and evaporation

In Newcastle, the highest rainfall is received in the summer period, with December receiving the most rainfall (163 mm) (WR, 2012). Minimum precipitation is noted in winter (with June receiving the least rainfall at 11mm) as this is the driest period in Newcastle (Figure 4-2). This means that precipitation is not uniform across a year, thus some months receive more precipitation than others. The calculated Mean Annual Precipitation (MAP) for the site is 895 mm/a which is the sum of the annual rainfall. The Mean Annual Evaporation (MAE) used for peak flow, water and salt balance calculations was also sourced from the WR2012. The average catchment MAE is 1800 mm/a. The MAE is larger than the MAP showing that the area has water deficit.

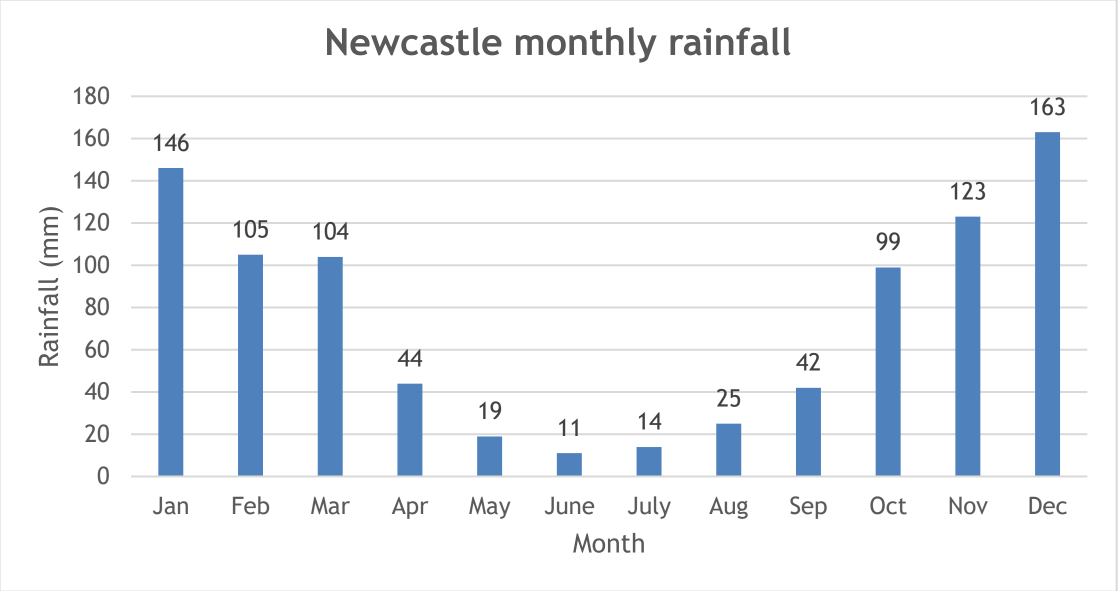


Figure 4-2: Monthly average precipitation for Newcastle, Kwa Zulu Natal

4.3.Mean Annual Runoff

The Mean Annual Runoff (MAR) calculations are highly dependent on the surface area. Runoff figures were analysed statistically in a similar manner as rainfall. Surface runoff often occurs because impervious areas (such as roofs and pavement) do not allow water to soak into the ground. The MAR is not constant throughout the country. However, smaller catchment areas were delineated, and the MAR was determined for smaller catchment areas. The MAR for the study area was also sourced from the WR2012. The average MAR is 129.2 mm/a. The calculated catchment-based mean annual runoffs are presented in Table 4-1 and site-specific mean annual runoffs are presented in Table 4-2.

Table 4-1: Catchment-specific MAR

M.P	Area (m^2)	MAR (m/a)	MAR (m^3/a)
IGM 01	51002000	0.1292	6589458.4
IGM 02	98926000	0.1292	12781239.2
IGM 03	121470000	0.1292	15693924
IGMT 01	32266000	0.1292	4168767.2
ND 01	298000000	0.1292	38501600
ND 02	305150000	0.1292	39425380
AC	446230000	0.1292	57652916

Table 4-2: Site-specific MAR

Site catchments	Area (m^2)	MAR (m/a)	MAR (m^3/a)
C1	3826003	0.1292	494320
C2	4153000	0.1292	536568
C3	943141	0.1292	121854
C4	5469439	0.1292	706652
C5	2152168	0.1292	278060
C6	1780102	0.1292	229989

4.4. Topography

Steep topography results in higher flow velocities and affects the resultant flood volumes under various associated conditions as infiltration is minimised. The potential flood is the source of the water, generally, an unusual amount of rainfall, which may be characterised by great water more than that which can be absorbed by the ground or evaporated into the air directly or through vegetation collects in the stream channels that drain the area.

Once in the stream system, the runoff flows to the outlet through channels that, like the trunk of a network of streams, progressively increase in size as contributions are received from tributary streams. Topography plays a vital role in flood events; steep slopes increase peak flows at a given point during heavy rainfalls. The surface topography on site varies between 1193 and 1423.5 mamsl with average topographic slopes of around 1V:5H (Figure 4-3).

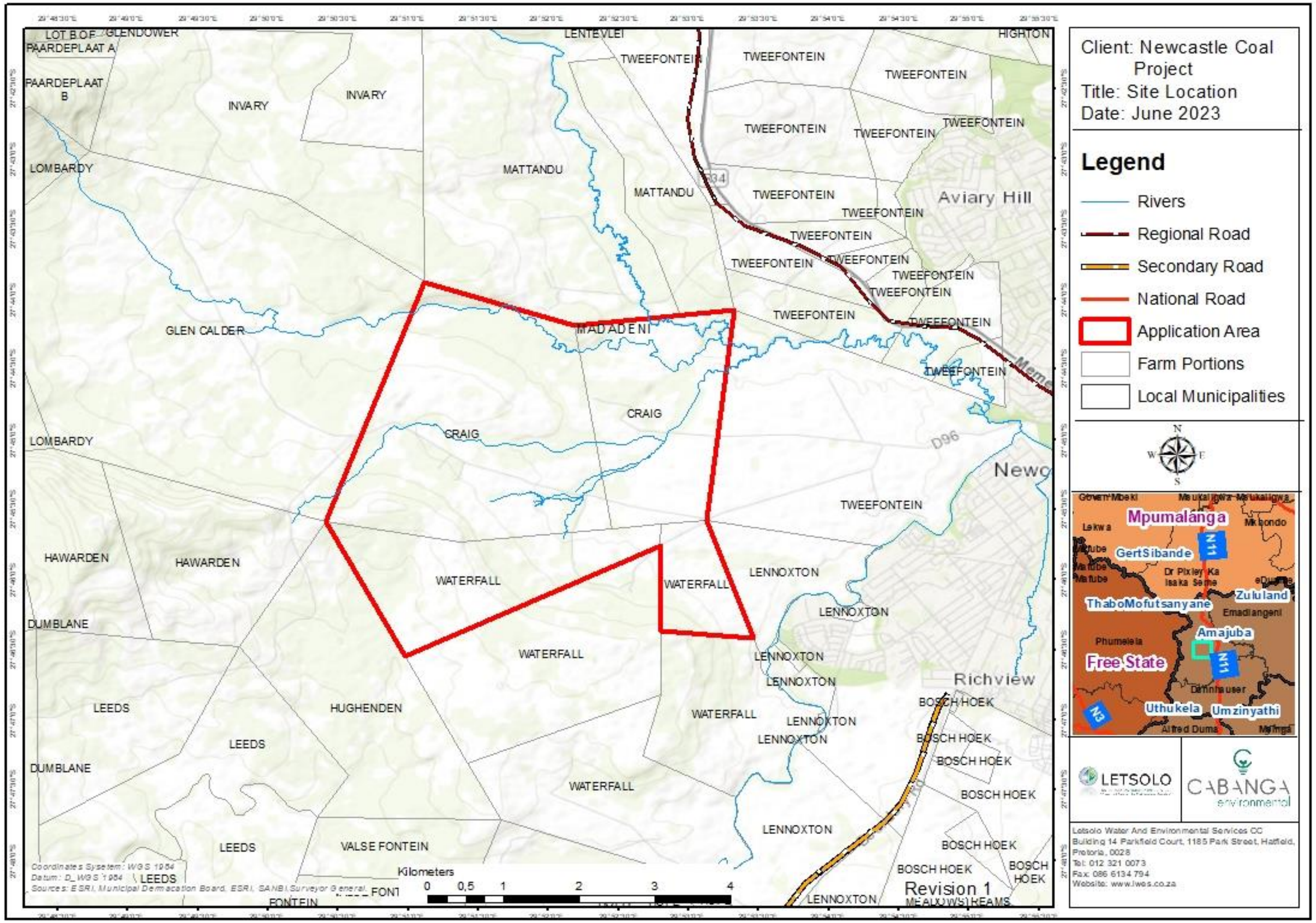


Figure 4-3: Topographic map of the study area

4.4.1. Relevance of topography to the hydrological patterns at NCP

Topography was considered for the catchment delineation and location of infrastructure. The channel system is a relatively permanent characteristic of a drainage basin throughout the life of the mine. Some influential changes may take place in this system; for example, variations in seasonal vegetation along the banks may affect the hydraulic conveyance, floods may scour or deposit sediments and old bends may be cut through and new ones created. Therefore, a maintenance program must be in place to ensure the longer life of the infrastructure.

5. SURFACE HYDROLOGY

The hydrological analysis is simplified in the subsections below.

5.1. Water Management Area

The water management areas were revised in line with Government Gazette No. 35517, regulations 547 of 16 September 2016. The study area falls within the Buffalo sub-catchment of the Pongola-Mtamvuna Water Management Area (WMA 4). The WMA 4 lies in the eastern part of South Africa (National Water Resources Strategy, 2016). The uThukela River is the major river system in the WMA 4 and has seven major tributaries namely the; Bloukrans, Buffalo, Bushmans, Klip, Little Thukela, Mooi, and Sundays Rivers.

5.2. Drainage and Quaternary Catchment

A catchment or watershed is derived from the topographical landscape. It is sectioned by a water divide, a high land separating two or more water systems. A quaternary catchment is the land and water surface area that contributes to the discharge at the system outlet. The Ncandu River, which is the major river in the study area, drains two quaternary catchments which are V31H and V31J. The study area falls within the primary catchment (V) and quaternary catchment V31J. Only V31J will be discussed because the proposed site is located in it.

Drainage within the study area occurs from the iNguduma River located directly north of the mining right application area. There are multiple small tributaries of the iNguduma River draining the study area (Figure 5-1). The iNguduma River is a perennial river that originate from the mountains northwest of the study area.

It flows in an easterly direction and is a tributary of the Ncandu River located southeast of the study area, which is a larger tributary of the iNguduma River. The iNguduma River drains into the Buffalo River which drains into the uThukela River.

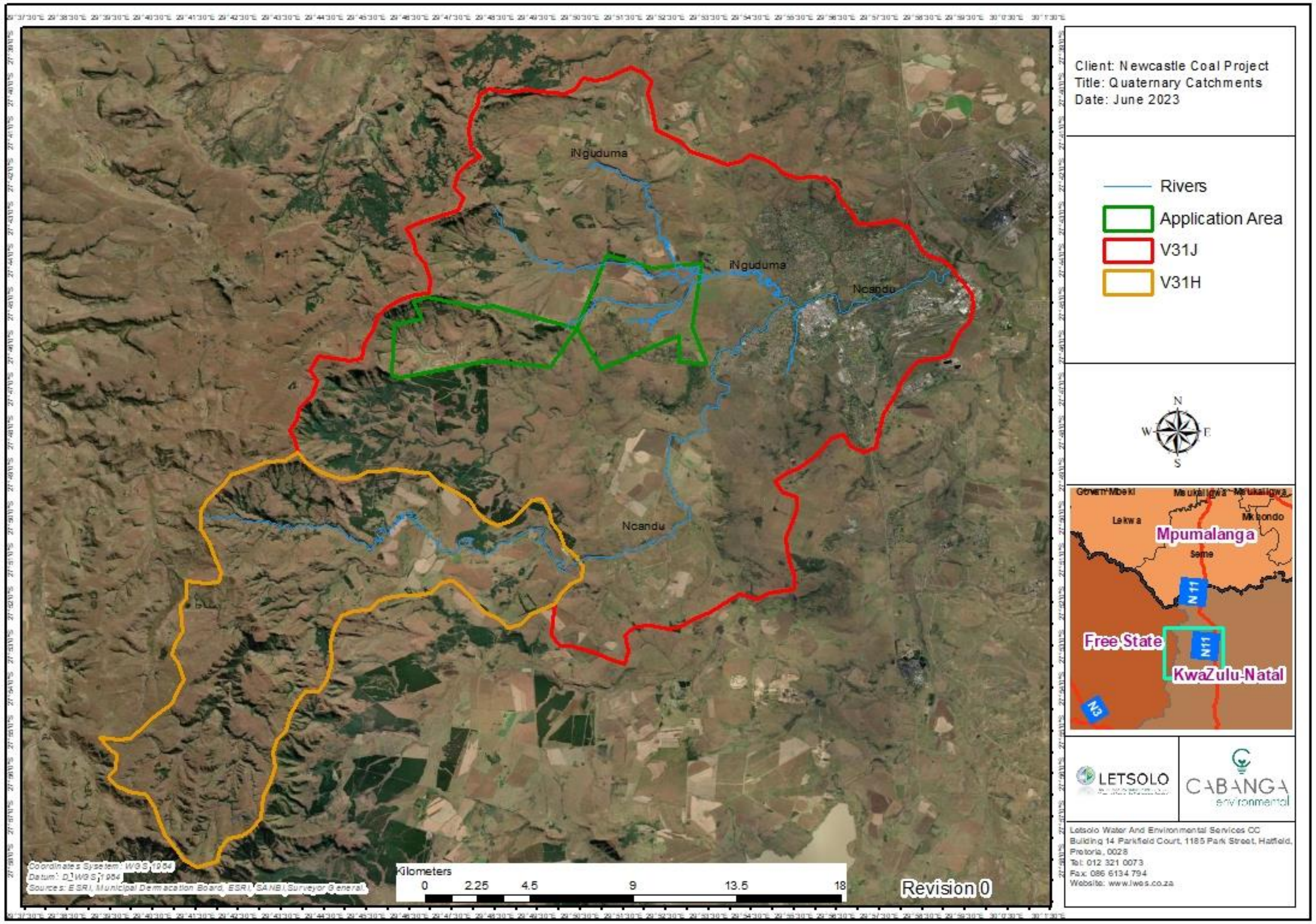


Figure 5-1: Quaternary catchments V31J and V31H

5.3. Delineated Catchments

Seven sub-basins (Figure 5-2) were delineated for stream flood calculations and for modelling purposes. To systematise the necessary tabulations, the sub-basins were named in accordance with the system illustrated (iNguduma -IGM and Ncandu – ND) in Table 5.1. The sub-basins of the tributary system (iNguduma Tributary – IGMT) are then named in the same manner as those of the mainstream, down to the sub-basin immediately above the confluence (After Confluence – AC) of the tributary with the mainstream.

Table 5-1: Delineated river-based catchments

Catchment	Area (km^2)	Length of longest watercourse (km)	Hight difference (m)	Slope
IGM 01	51.005	10.38	628	0.061
IGM 02	98.936	16.704	633	0.038
IGM 03	121.46	24.223	638	0.026
IGMT 01	32.266	7.78	546	0.070
ND 01	298	41.028	749	0.018
ND 02	305.15	45.194	752	0.017
AC	446.23	47.88	755	0.016

Runoff collects at the lowest area of a catchment, being the drainage line, and continues to flow downstream. Until this water discharges to the receiving catchment or at sea. Several factors affect the hydrological characteristics of a catchment. These include the Hydraulic Length and Height difference. The stream or drainage density is the ratio between the total length of all streams within the drainage basin and the total area of the basin and is an indication of the drainage development.

For hydrological calculations, the length of the longest streams and/or reaches were measured to determine the stream density and the area-distance distribution. The number of small headwater streams shown on the topographic maps would vary with the season and the wetness of the particular year during which the survey was made. This length, when divided by the mean velocity of flow will give the time of concentration as used in the rational formula for the computation of flood volume at discharge points.

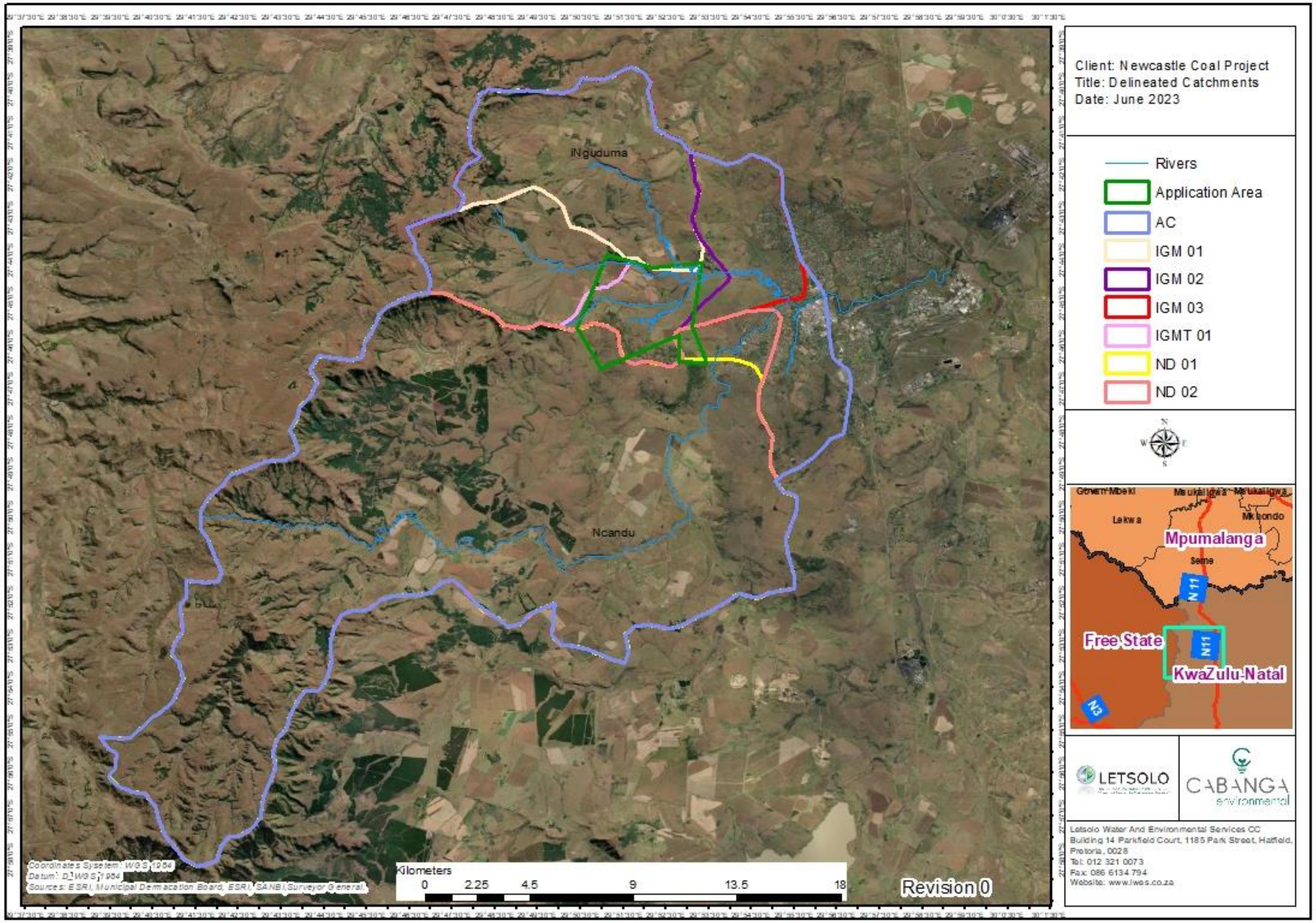


Figure 5-2: Delineated catchments

5.4. Site-specific Catchments

Site-specific catchments (Figure 5-3) were delineated around the study area to determine the drainage line and discharging point for stormwater management. As indicated in Table 5-2, to produce site-specific hydrological yields, six catchments were separated from each other, and the relevant runoff coefficients were applied for accurate peak flows.

Table 5-2: Site-specific catchments

Catchment	Area (km^2)	Length (km)	Hight difference (m)	Slope
C1	3.83	4.51	121.29	0.027
C2	4.15	5.57	37.50	0.007
C3	0.94	2.13	40.05	0.019
C4	5.47	3.30	73.57	0.022
C5	2.15	2.07	91.728	0.044
C6	1.78	0.75	31.56	0.042

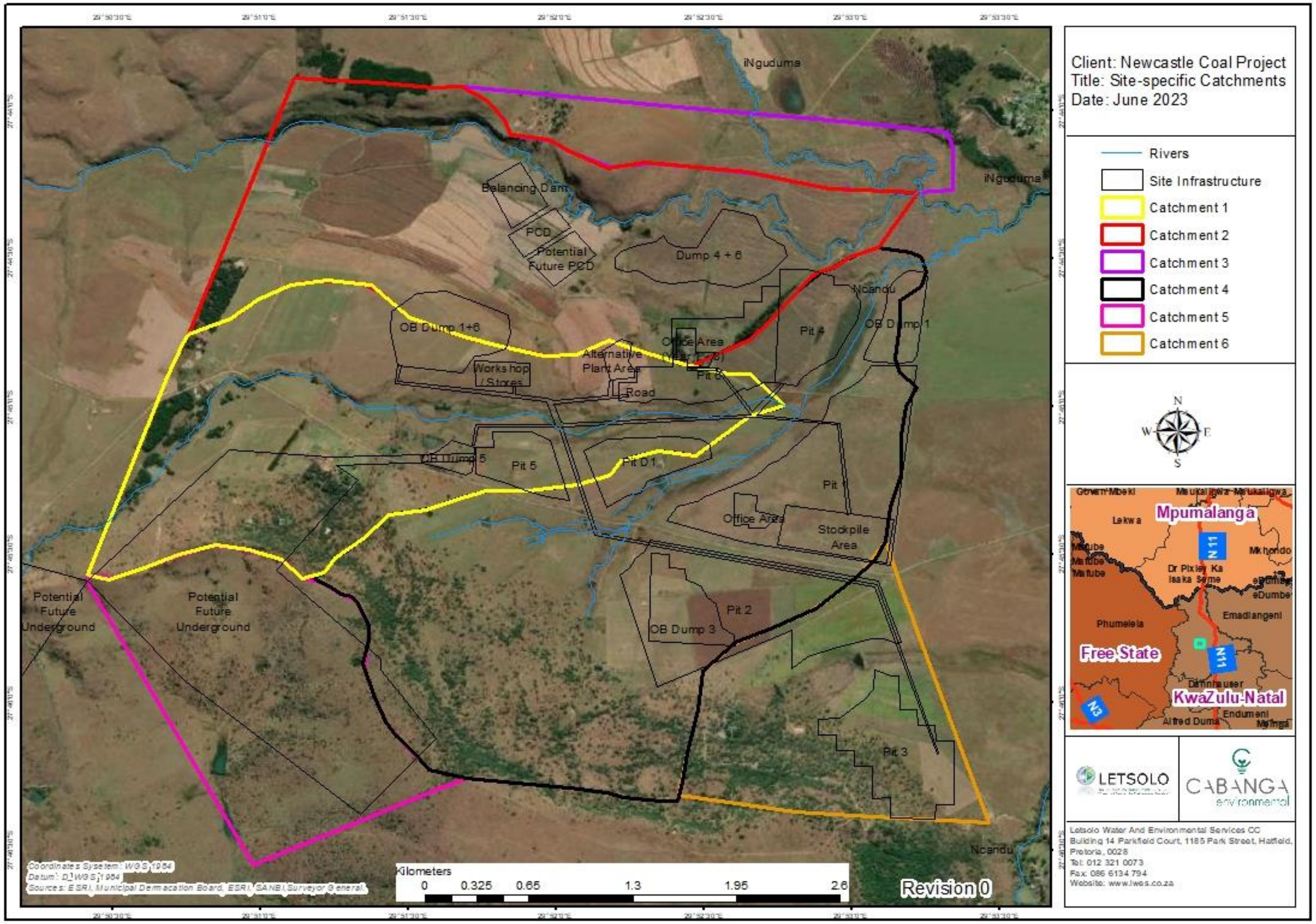


Figure 5-3: Site-specific catchments

6. HYDROLOGICAL CALCULATIONS

After the delineation of catchment areas, flood calculations were conducted based on the hydrological characteristics and flood calculation methods discussed below.

6.1. Peak flow calculations

Peak flow refers to the maximum rate of discharge caused by high runoff during heavy rainfall. Peak flow estimation is very important for the design of infrastructures to be built near a stream. Peak flows for different sites are influenced by the following parameters:

- Area of catchment

This refers to the footprint area for each activity. This area was measured using the proposed infrastructure layout.

- Mean Annual Precipitation (MAP)

The MAP was determined from hydrological data.

- Length of the longest watercourse

Survey data was used to delineate the hydrological path for each proposed area. This path is referred to as the Length of the longest watercourse.

- Average slope

Flat surfaces are associated with low peak flows and steep surfaces are associated with high peak flows. The slope was determined for each area to determine the peak flows.

- Time of concentration

Time of concentration is a concept used in hydrology to measure the response of a watershed to a rain event. It is defined as the time needed for water to flow from the most remote point in a watershed to the watershed outlet. It is a function of the topography, geology, and land use within the watershed.

- Run-off factor

The runoff coefficient (c) represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception; all of which affect the time distribution and peak rate of runoff.

- Combined - C

The total runoff coefficient considers slope, permeability, and land cover.

6.1.1. Catchment-based peak flows

The catchment-based peak flows were calculated for floodlines purpose. Due to larger catchment size, the SDF method was used to calculate these peak flows. The peak flows for the ND system range between 721 and 767 m^3/a for the 1 in 50 years return period, while for the 1 in 100 years return period the range is between 907 and 965 m^3/a (Table 6-1). For the iNguduma system, the upstream catchment (IGM 01) recorded peak flows of 519 and 646 m^3/a for the 1 in 50 and 1 in 100 years return periods respectively. The lower most catchment of the iNguduma system (IGM 03) recorded the highest peak flows in the system with 941 and 1 173 m^3/a for the 1 in 50 and 1 in 100 years return periods respectively. The after confluence (AC) catchment incorporates the iNguduma and Ncandu systems, it recorded 977 and 1 229 m^3/a for the 1 in 50 and 1 in 100 years return periods respectively.

Table 6-1: Catchment-based peak flows

Catchment	Peak floods m^3/s			
	Rational method		SDF	
	1:50-year	1:100-year	1:50-year	1:100-year
IGM 01	519	646	445	560
IGM 02	679	849	564	709
IGM 03	566	715	941	1173
IGMT 01	424	530	362	455
ND 01	969	1227	767	965
ND 02	906	1150	721	907
AC	1244	1574	977	1229

6.1.2. Site-specific peak flows

The rational method was used for the peak flow calculations of site-specific catchments due to their smaller surface area. The site-specific peak flows range between 9.57 and 55.68 m^3/a for the 1:50-year return period and range between 11.91 and 69.29 m^3/a for the 1:100-year return period (Table 6-2). The sub-catchment with the large surface area (C4) recorded the highest peak flows of 55.68 and 69.29 m^3/a for the 1:50 and 1:100-year return periods, respectively.

Table 6-2: Site-specific peak flows

Catchments	Peak Flows (m^3/s)	
	Rational method	
	1:50 year	1:100 year
C1	40.71	48.52
C2	42.24	52.57
C3	9.57	11.91
C4	55.68	69.29
C5	21.88	27.23
C6	18.12	22.55

7. CONCEPTUAL STORMWATER MANAGEMENT

Stormwater management involves the control of surface runoff. The volume and rate of runoff substantially increase as land development occurs. Stormwater runoff occurs when precipitation from rain flows over the land surface. The addition of roads, driveways, parking lots, rooftops, and other surfaces that prevent water from soaking into the ground to our landscape greatly increases the runoff volume created during storms.

A Stormwater Management Plan (SWMP) is based on the principles and guidelines outlined in the GN 704 of the National Water Act of 1998 and the BPG G1: Stormwater Management Plan (DWF, 1999). The primary objectives of the SWMP according to the BPG 1 are:

- To address the impact that mining operations have on water flow and quality during different hydrological cycles;
- To determine the impacts the hydrological cycle has on mining activities;
- To protect life and property from floods; and
- To protect and conserve the environment and water resources.

The objectives of a SWMP are site-specific but some general objectives include:

- Protection of life (prevent loss of life) and property (reduce damage to infrastructure) from flood hazards;
- Planning for drought periods in a mining operation;
- Prevention of land and watercourse erosion (especially during storm events);
- Protection of water resources from pollution;
- Ensuring continuous operation and production through different hydrological cycles;

- Maintaining the downstream water quantity and quality requirements;
- Minimising the impact of mining operations on downstream users; and
- Preservation of the natural environment (water courses and their ecosystems).

7.1. Surface infrastructure influenced by stormwater

The mine proposed the following surface infrastructure:

- Opencast pits – According to BPG 1, opencast pits are considered dirty water catchments that contaminate water bodies by introducing suspended solids (SS) and other contaminants formed during the extraction of coal.
- Overburden stockpiles – These are residues deposited during the mining activity such as fines, carbonaceous shales and waste rock dumps. They are regarded as dirty water catchments by BPG 1.
- PCD - PCDs are designed to collect and store dirty water runoff at the mining area. It also stores water pumped from opencast pits. They are regarded as dirty water facilities as they store dirty water. They are not allowed to overflow more than once in a 50-year return period.
- Offices – SS are the main water contaminants at offices; therefore, they can be considered clean water catchments.
- Conveyor belt – They are designed to convey coal from the pits to the coal stockpiling area. They can cross both clean and dirty water catchments.
- Roads – With regards to tarred roads, the BPG 1 regard them as clean water catchment as they are not expected to be contaminated by waste coal. Haul roads on the other hand are regarded as dirty water catchments because they may contain dissolved and suspended contaminants.
- Plant, stockpile, and workshop area – These are considered dirty facilities due to the coal stockpiling area, chemical handling, and washing of machinery.

7.2. Change in Peak Flows

The previous Chapter presented pre-mining site-specific peak flows (Table 6-2) of the study area. To design stormwater infrastructure, post-mining peak flows were calculated for channels, culverts, and stormwater sump sizing. Pre-mining peak flows refer to peak flows before the proposed project commences. Post-mining refers to the estimated peak flows during and after mining. Table 7-1 presents a change in peak flow in the study area. The table shows that the peak flow of catchments with no surface infrastructure (C3 and C5) did not change for the pre- and post-mining activities. The catchment (C1) that hosts most of the mining infrastructure recorded the most increase in peak flow, with an increase of 20.51 m^3/a for the 1:50-year return period and 23.75 m^3/a for the 1:100-year return period.

Table 7-1: Change in site-specific peak flows due to infrastructure development

	Catchment		TC (hours)		RC		Peak floods m^3/s		Flood volume (m^3)
		1:50-year	1:100-year	1:50-year	1:100-year	1:50-year	1:100-year	1:50-year	1:100-year
Pre-development	C1	0.76	0.76	33.9	35.5	48.67	62.52	55.48	71.27
	C2	1.52	1.52	34.9	36.7	33.18	42.9	75.65	97.81
	C3	0.49	0.49	34.9	36.7	16.43	21.27	12.08	15.63
	C4	0.64	0.64	34.5	36.3	78.53	101.19	75.39	97.14
	C5	0.35	0.35	47.7	50.3	62.02	80.11	32.56	42.06
	C6	0.16	0.16	39.9	77.45	59.99	77.45	14.40	18.59
Post-development	C1	0.76	0.76	48.2	48.9	69.18	86.27	78.87	98.35
	C2	1.52	1.52	46.7	48.3	44.48	56.58	101.41	129.00
	C3	0.49	0.49	34.9	36.7	16.43	21.27	12.08	15.63
	C4	0.64	0.64	42.6	44	96.94	122.64	93.06	117.73
	C5	0.35	0.35	47.7	50.3	62.02	80.11	32.56	42.06
	C6	0.16	0.16	43.7	46.1	65.7	84.82	15.77	20.36

7.3. Clean and dirty water catchment

The purpose of designing stormwater management facilities is to ensure that the surface runoff from clean catchments does not mix with the surface runoff from dirty catchments. Dirty catchments include all the areas where coal will be handled such as opencast pits, overburden dumps, sorting and stockpiling areas. Clean catchments are areas where water has not come into contact with dirty areas. Figure 7-1 below illustrates clean and dirty catchments.

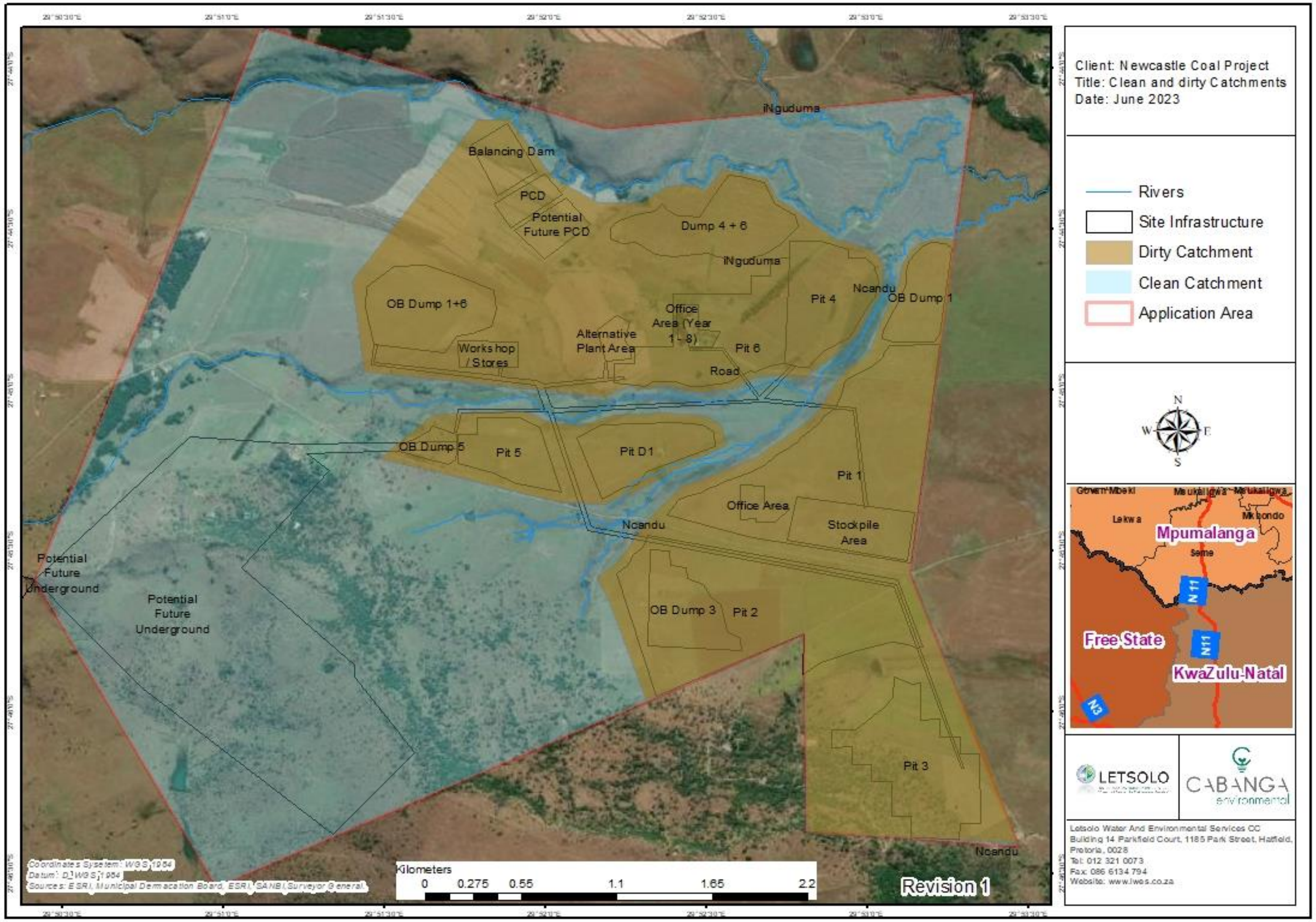


Figure 7-1: Clean and dirty water catchments

7.4. Stormwater Infrastructure

The previous subsection presented the increase in peak flow influenced by the introduction of surface infrastructure in the study area. This subsection presents the proposed stormwater infrastructure that will manage the increase in peak flow and flood volume.

7.4.1. Berms

Berms serve as catchment dividers and separate clean water catchments from dirty water catchments. A system of vegetated and compacted berms (Figure 7-2) should be built around the dirty catchments to contain dirty runoff and divert it into dirty water containment facilities such as PCDs and pits. The berms will also prohibit the clean runoff from entering the dirty water catchment and divert it back to the environment. They should also be built around haul roads to prevent the washing away of contaminants from the roads to a clean environment. The berms should also be constructed around the sorting plant, stockpiling area, and workshop area to prevent external runoff from entering. They should also be constructed outside the 1:100-year flood inundation boundary and the 100m watercourse buffer to ensure compliance with the GN 704 which will be discussed in the next chapter.

7.4.2. Channels

All channels should be placed inside the berms; and they should be trapezoidal with a slope of 0.5% (1V:1.5H). To prevent erosion and seepage of contaminants, all channels should be lined with impervious surface such as concrete or plastic. A HDPE liner plastic that is 1.5 mm in thickness is proposed for all channels. The main purpose of channels is to convey surface runoff into the dirty water containment facilities. The haul roads that go into the sorting plant, stockpiling, and workshop areas should be used to convey dirty runoffs from these areas into the designated water containment facility. At the point where these roads intersect the stormwater channels, a cut-off trench (Figure 7-2) should be opened to convey the runoff from the haul roads into the stormwater channels. A silt trap should be fitted where the channel discharge into the PCD to prevent siltation in the PCD.

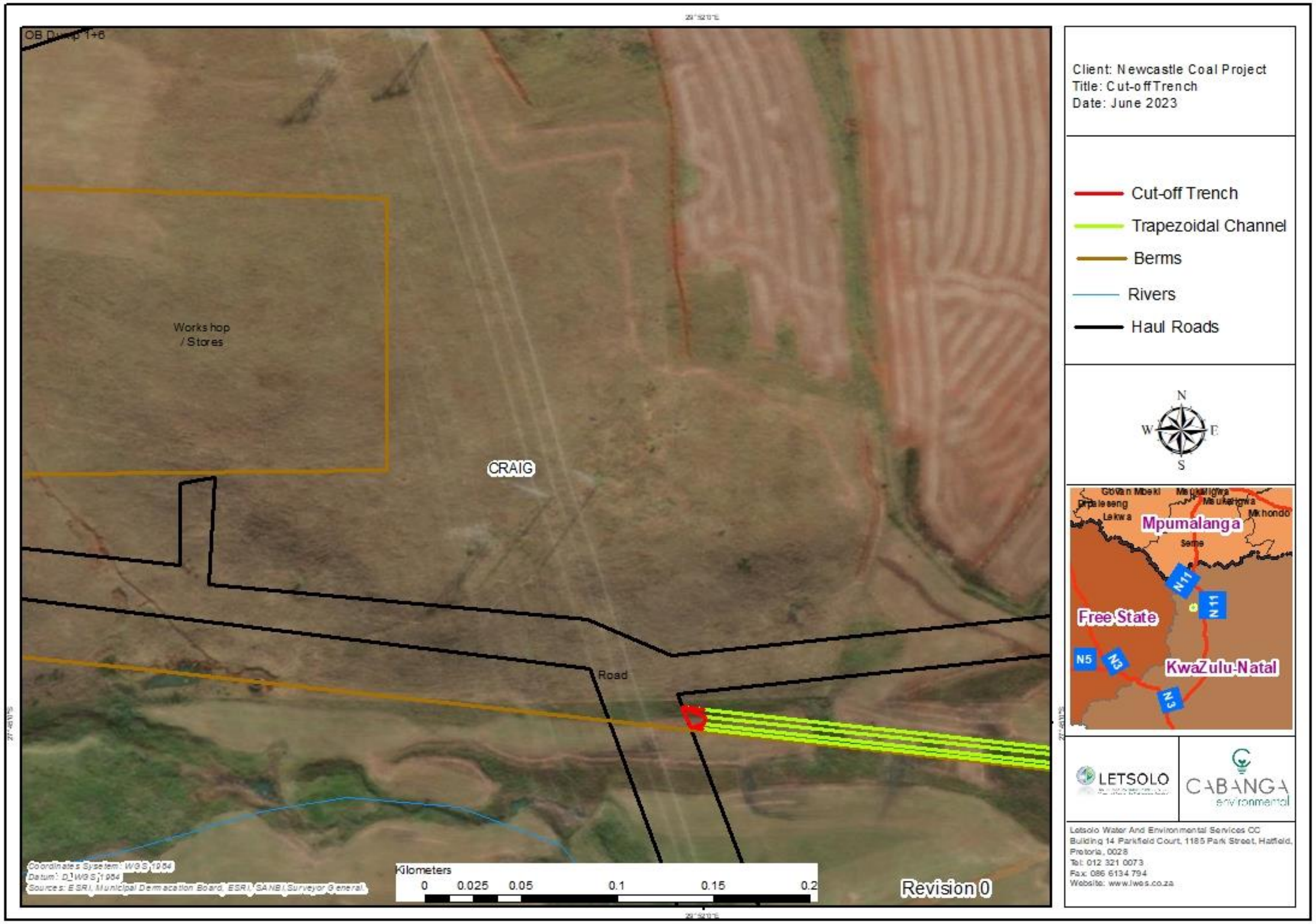


Figure 7-2: Proposed location for cut-off trench

The channels were sized to convey the increased peak flow. Table 7-1 presents sizing specific of the proposed channels. According to the conceptual design of stormwater channels, plastic lined trapezoidal channels with a normal depth of 0.5 m, top width of 2.62, and a bottom width of 1.62 m will be sufficient enough to convey surface runoff during the worst-case scenario of a peak flow of 4.62 m^3/a into a designated dirty water catchment facility.

Table 7-2: Channel sizing summary

	Concrete Trapezoidal
Worst-case peak flow (m^3/a)	4.62
Roughness coefficient ($s/m^{1/3}$)	0.09
Normal depth (m)	0.5
Side slopes (V:H)	1:1.5
Bottom width (m)	1.62
Top width (m)	2.62
Velocity (m/s)	4.35

7.4.3. Dirty water containment facilities

Dirty water containment facilities are facilities designed to capture and store dirty water from dirty catchments such as PCDs and opencast pits (in-pit storage). The proposed PCDs and the sump at the workshop were designed by Human Element. The location of the proposed PCDs was assessed according to surface drainage. It was found that the location of the main PCD is upstream of the drainage and would not be able to collect dirty runoff from the hosting dirty catchment. The location of the PCD named 'Potential Future PCD' (Figure 7-4) is suitable for dirty water collection, therefore, the main PCD should be moved to this location. The oil trap sump will collect runoff mixed with oil and chemicals at the workshop. Should the plant stay on the surface, a stormwater sump will be required to contain dirty runoff. According to the conceptual design of the stormwater sump, a rectangular sump with a depth of 2 m and a capacity of 220 m^3 will be sufficient to contain dirty runoff from the plant.

7.4.4. Culverts

Culverts will be needed where the proposed roads cross the streams onsite. The culvers were sized to convey worst-case peak flow. All the culverts must be assigned an extra 0.5 m depth to accommodate hydraulic jumps during flooding. Table 7-2 presents culvert sizing specifics.

Table 7-3: Culvert sizing specifics

Culvert	Number of small culverts	PF (m^3/s)	Normal Depth (m)	Bottom width (m)
1	2	60.2	2	2
2	3	81.78	2	2
3	3	84.21	2	2
4	3	88.49	2	2
5	4	49.94	1	2
6	2	53.09	2	2

According to the conceptual design of:

- Culvert 1, two rectangular culverts of 2 m in depth and a bottom width of 2 m will be sufficient to convey flood volume during the worst-case scenario of a peak flow of 60.2 m^3/s;
- Culvert 2, three rectangular culverts of 2 m in depth and a bottom width of 2 m will be sufficient to convey flood volume during the worst-case scenario of a peak flow of 81.78 m^3/s;
- Culvert 3, three rectangular culverts of 2 m in depth and a bottom width of 2 m will be sufficient to convey flood volume during the worst-case scenario of a peak flow of 84.21 m^3/s;
- Culvert 4, three rectangular culverts of 2 m in depth and a bottom width of 2 m will be sufficient to convey flood volume during the worst-case scenario of a peak flow of 88.49 m^3/s;
- Culvert 5, four rectangular culverts of 1 m in depth and a bottom width of 2 m will be sufficient to convey flood volume during the worst-case scenario of a peak flow of 49.94 m^3/s; and
- Culvert 6, two rectangular culverts of 2 m in depth and a bottom width of 2 m will be sufficient to convey flood volume during the worst-case scenario of a peak flow of 53.09 m^3/s.

The location of the culverts and other stormwater infrastructures is shown in Figure 7-3.

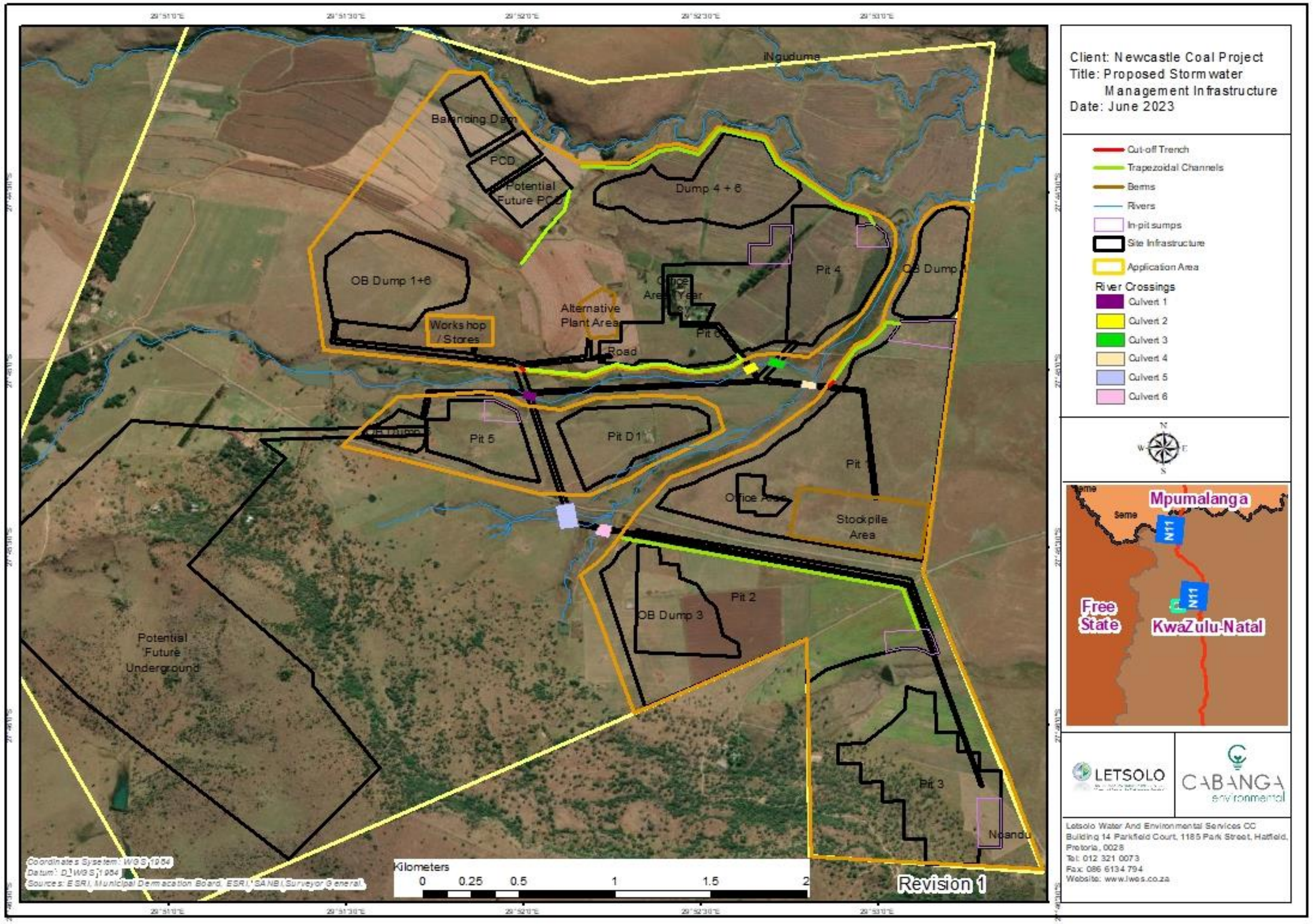


Figure 7-3: Proposed stormwater management infrastructure

8. FLOODLINES

The peak flows obtained from Table 6-1 were used as the input for the delineation of the 100 years flood event. The output tables (Appendix 1) indicate that the difference between 1 in 50 and 1 in 100 floodlines is minimal among the output variables. Therefore, only the 1:100 years flood lines were mapped to indicate the worst-case buffer zone.

The output variables include the following (Appendix A);

- Crit W.S - Critical Water Surface Elevation,
- E.G. Slope - Slope for the energy grade line,
- Flow Area - Total Area of cross-section active flow,
- Froud # Chnl - Froude Number for the main channel,
- Q total - Total flow in cross-section
- Top W Chnl - Top Width of the main channel, and
- Vel Chnl - Average Velocity of flow in the main channel

Floodlines for the 1:100-year return period were determined for the streams passing through the study area. Floodlines delineation is governed by Government Notice (GN) 704 Restriction 4 which states that no person in control of a mine or activity may (DWF, 1999):

- *(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100-year floodline 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 (sand mining), 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.*

Figure 8-1 illustrates the proposed infrastructure against the 1:100-year flood inundation boundary and the 100m watercourse buffer for the streams. The figure shows that multiple proposed infrastructures are within the 1:100-year flood inundation boundary and the 100m watercourse buffer. The affected infrastructure includes

- Balancing PCD;
- PCD;

- Overburden 4+6;
- Overburden 1;
- Pit 1;
- Pit D1;
- Pit 4;
- Pit 5; and
- Pit 6

Therefore, according to Restriction 4 of GN 704, the mine is restricted from mining on the above-mentioned pits unless they get an exemption from the regulatory authority, DWS, in terms of GN704 Regulation 3. An exemption application should be lodged, citing the specific GN 704 condition. Additionally, Section 21c and I water use should be indicated as including the pits in the water use license application. Alternatively, the extent of pits and overburden dumps must be reduced to refrain from establishing an infrastructure area within the floodline boundary.

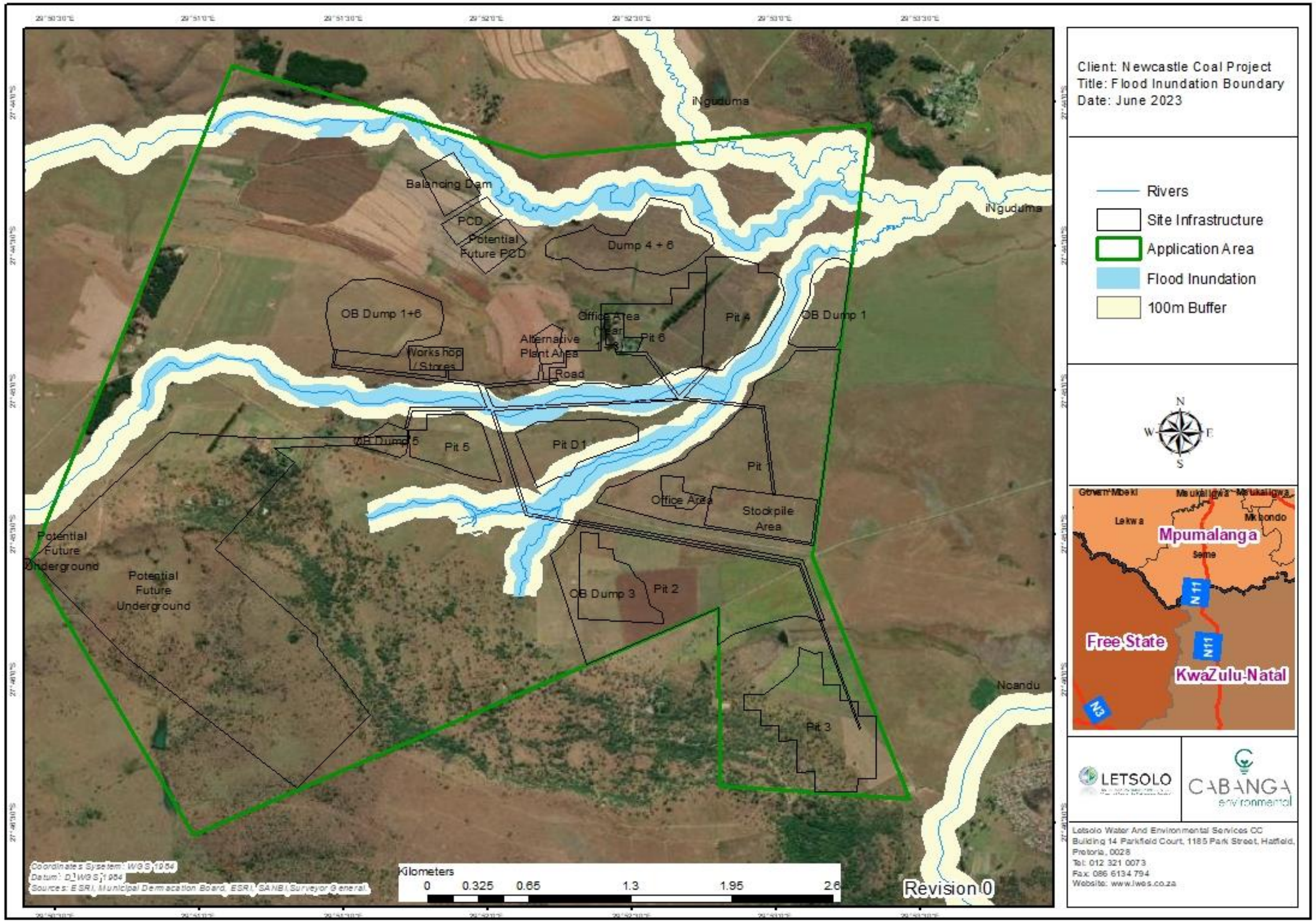


Figure 8-1: Flood inundation for the 1:100-year return period and 100m watercourse buffer zones

9. WATER BALANCE

In hydrology, a water balance equation can be used to describe the flow of water in and out of a system. A system can be one of several hydrological domains, such as a drainage basin. Water Balance equations use the principles of conservation of mass in a closed system, whereby any water entering a system (via precipitation), must be transferred into either evaporation, or surface runoff (eventually reaching the channel and leaving in the form of discharge, or stored in the ground. This equation requires the system to be closed, and where it is not (for example when surface runoff contributes to a different basin), this must be considered. The water balance can be illustrated using a water balance graph which plots levels of precipitation and evapotranspiration often on a monthly scale. Water balance calculations can be used to help manage water supply and predict where there may be water shortages or excesses that may need additional dirty water containment facility. Water balance calculations presented below area estimated, detailed calculations will be conducted after the installation of flow meters and the availability of flow meter readings.

9.1. Water circuits

Each water circuit was assessed individually to indicate all water sources, losses, and storage as summarised in Figure 9-2. To distinguish between clean and dirty water, different colours were used in the sketch (Figure 9-2).

The Water Balance sketch demonstrates the balance between inputs and outputs. The inputs in the system include the following:

- Rainfall
- Runoff from upstream areas
- Water abstracted for usage and top-up

The outputs include the following:

- Catchment losses like capillary and infiltration water
- Evaporation
- Water re-use

9.1.1. Domestic

It is anticipated that the project will use approximately 56 kilolitres of water per day for portable use, ablution and the laundry, washing of vehicles and equipment, and dust suppression at haul roads (Cabanga, 2023).

The source of water to meet the estimated water demand of approximately 20 440 m^3/a is either from the Newcastle Local Municipality or borehole abstraction, or a combination of both (Cabanga, 2023). For dust suppression and wash bay, it is advised that the sources of water should be return water from dirty water containment facilities (to be discussed further below).

It is advised that 20% of this water should be used at the workshop for purposes. The remaining 80% should be used for domestic purposes at offices and administration block areas within the mine site such as the plant area and security and weigh bridge. Based on the distribution of personnel, it is anticipated that the grey water distribution from the offices and administrative block areas will be as follows (Figure 9-1):

- 25% will be collected at the plant septic tank,
- 25% will be collected at the security checkpoint and weigh bridge septic tank,
- The remaining 50% will be allocated to the Offices and admin block septic tank.

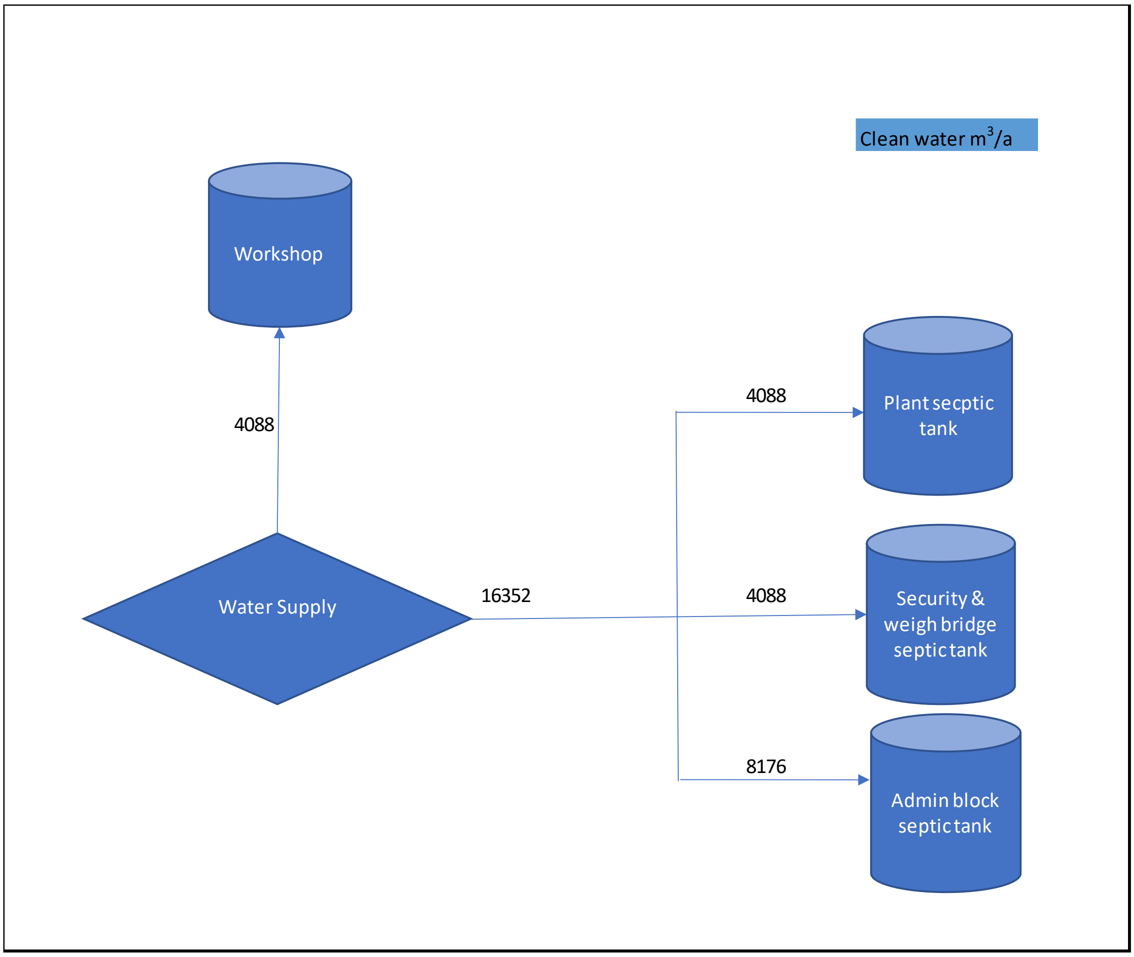


Figure 9-1: Domestic water distribution diagram

9.1.2. Alternative plant area

The plant area will be used for the crushing and screening of coal; therefore, it is regarded as a dirty water facility. The sources of water in this area are direct rainfall and water pumped from the main PCD for spraying during the crushing of coal. Should the mine option for a mobile plant, water for spraying will be obtained from the hosting pit. The area will lose water through evaporation and surface runoff. Table 9-1 presents plant area water balance calculations. According to the Scoping Report by Cabanga (2023), the crushing, screening, and sorting plants will require about 0.3 m^3/hour (2 628 m^3/a) for water spraying during the crushing of coal. The table below shows that the water pumped to the plant will be higher than the required quantity from the Scoping Report, therefore, there will be enough water for spraying during crushing.

Table 9-1: Alternative plant Area water balance

Alternative Plant Area			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	28 725	Evaporation	57 771
Pumped from Main PCD	60 018	Surface runoff	30 972
Total in	88 743	Total out	88 743
		Surplus/deficit	0

9.1.3. Workshop and stores area

Handling of chemicals and washing of machinery at the workshop and storage area characterises it as a dirty water facility. The area will receive water through rainfall and water pumped from the PCD for washing machinery at the wash bay (Table 9-2). The losses of water include evaporation and surface runoff. Table 9-2 presents water balance calculations for the workshop and stores area.

Table 9-2: Workshop and stores water balance

Workshop and Stores			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	40 070.9	Evaporation	80 589.6
Return water from main PCD	57 749.2	Surface runoff	17 230.5
Total in	97 820.1	Total out	97 820.1
		Surplus/deficit	0

9.1.4. Stockpiling area

Coal will be stockpiled in designated stockyard area, this makes it a dirty water facility. The area will receive water through rainfall, water seeping from coal stockpiles, and water used for dust suppression. The area will lose water through surface runoff and evaporation. Table 9-3 presents water balance calculations for the stockpiling area.

Table 9-3: Stockpiling area water balance

Stockpiling area			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	144 057	Evaporation	289 723
	207 610	Surface runoff	61 944
Total in	351 667	Total out	351 667
		Deficit/surplus	0

9.1.5. Main Pollution Control Dam

The main Pollution Control Dam (PCD) is a dirty water containment facility. It will collect surface runoff from the hosting dirty catchment (Figure 7-1), and it will also receive water from rainfall. This facility will also be used to store water pumped from the pits during dewatering process. The PCD will lose water through evaporation, water pumped for reuse at the workshop and alternative plant. When the main PCD gets full, water should pump to the Balancing PCD to avoid overflows. Table 9-4 presents water balance calculations for the main PCD.

Table 9-4: Main PCD water balance

Main PCD			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	44 034	Evaporation	88 560
Surface runoff	1 057 789	Reuse at Workshop	57 749
Pumped from pits	4 246 000	Reuse at Plant	60 018
		Pumped to Balancing PCD	1 542 449
		Retained in PCD	1 028 299
		Dust suppression	2 570 748
Total in	5 347 823	Total out	5 347 823
		Surplus/deficit	0

9.1.6. Balancing Pollution Control Dam

The Balancing PCD is a dirty water containment facility designed to collect overflow from the main PCD. In addition to water pumped from the main PCD, the Balancing PCD will also receive water from rainfall. It will lose water through evaporation and water pumped for dust suppression. Table 9-5 presents water balance calculations for the Balancing PCD.

Table 9-5: Balancing PCD water balance

Balancing PCD			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	66 944	Evaporation	321 879
Pumped From main PCD	1 542 449	Retained in PCD	257 503
		Dust suppression	1 030 011
Total in	1 609 393	Total out	1 609 393
		Surplus/deficit	0

9.1.1. Opencast Pits

Opencast pits are dirty water facilities where coal will be extracted. At other dirty catchments, in-pit sumps will be used as temporary dirty water storage facilities. The in-pit storage facility should be located at the lowest elevation and should be at least 20% of the surface area of the pit. The pits will be receiving water from rainfall, surface runoff channelled from dirty water catchments, and groundwater ingress. An estimate of groundwater ingress was modelled for each proposed pit by Gradient Consulting (GC, 2023) and was incorporated in opencast pits water balance. The pits will lose water through evaporation, pumping to PCD, and direct reuse for dust suppression. A gooseneck will be placed at the pit areas to fill in water bowsers for dust suppression. To avoid the occurrence of acid mine drainage (AMD) and to keep the in-pit sumps dry as possible, pumping of water from the in-pits sumps to the main PCD must take place. Pumping of water from the pits will trigger section 21j of the NWA, therefore, a WUL will be needed. Table 9-6 presents water balance calculations for the opencast pits.

Table 9-6: Opencast pits water balance calculations

Pit 1			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	154057.6	Evaporation	309836.5
Surface runoff	112014.4	Dust suppression	317146.7
Groundwater Ingress	1100920.3	Pumped to PCD	740009.1
		Retained in pit	0
Total in	1366992.3	Total out	1366992.3
		Surplus/deficit	0

Pit D1			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	160993.5	Evaporation	323785.8
Groundwater Ingress	380706.0	Dust suppression	65374.1
		Pumped to PCD	152539.6
		in pit storage	0.00
Total in	541699.4	Total out	541699.4
		Surplus/deficit	0

Pit 2			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	151107.3	Evaporation	303903.0
Surface runoff	65797.4	Dust suppression	551282.0
Groundwater Ingress	1924604.9	Pumped to PCD	1286324.6
		in pit storage	0
Total in	2141509.6	Total out	2141509.6
		Surplus/deficit	0

Pit 3			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	65266	Evaporation	131261
Groundwater Ingress	947485	Dust suppression	264447
		Pumped to PCD	617043
		in pit storage	0
Total in	1012751	Total out	1012751
		Surplus/deficit	0

Pit 4			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	43978	Evaporation	88447
Surface runoff	112477	Dust suppression	124687
Groundwater Ingress	347615	Pumped to PCD	290936
		In pit storage	0
Total in	504070	Total out	504070
		Surplus/deficit	0

Pit 5			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	26377.26	Evaporation	53049.24
Groundwater Ingress	725999.60	Dust suppression	209798.29
		Pumped to PCD	489529.33
		in pit storage	0
Total in	752376.86	Total out	752376.86
		Surplus/deficit	0

Pit 6			
Water in	Volume (m^3/a)	Water out	Volume (m^3/a)
Rainfall	64898	Evaporation	130521
Surface runoff	98460	Dust suppression	286979
Groundwater Ingress	923760	Pumped to PCD	669618
		in pit storage	0
Total in	1087118	Total out	1087118
		Surplus/deficit	0

Figure 9-2 illustrates the water balance schematic diagram for the Newcastle Mining Project. The figure presents the overall water balance for the mine and assumes that all the pits are active although the pits will be periodically operated. Therefore, annual water balance updates will be needed throughout the life of the mine.

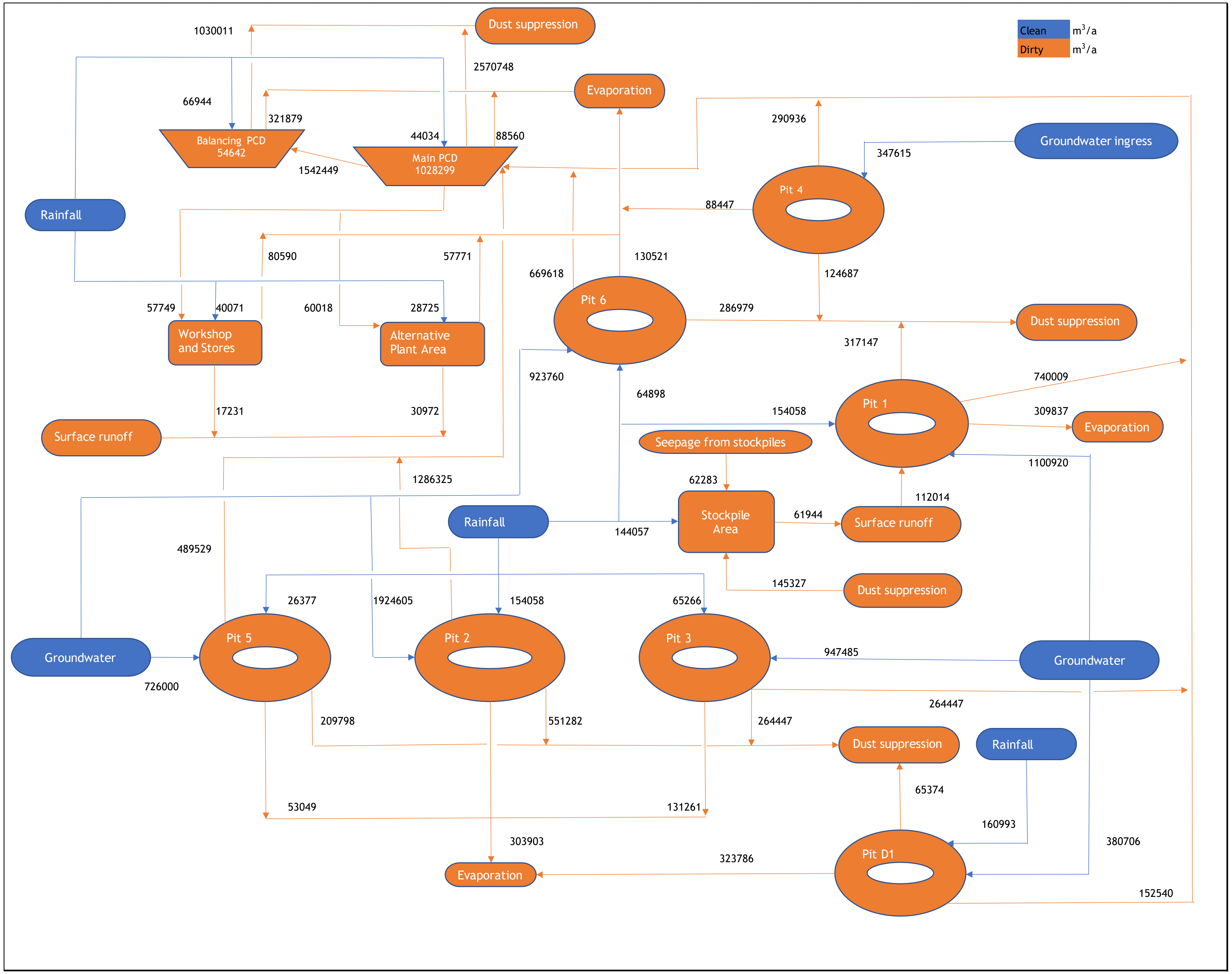


Figure 9-2: Water balance schematic diagram

10. BASELINE WATER QUALITY

Water samples from the monitoring points (Figure 10-1) were collected on the 19th of January 2023 to determine the water quality of the two systems. System 1 (iNguduma) is located in the northern part of the application area. It hosts monitoring points IGM 01 to IGM 02 and IGMT 01 which is located on a tributary of the iNguduma system. The second system (Ncandu) is located in the south-eastern parts of the mining area. It hosts sampling points ND 01 and ND 02. The sampling point AC is located east of the application area; and it is after the confluence of the main system (Ncandu) and its tributary (iNguduma). The other streams that drain the study area are non-perennial and were dry during the day of sampling. Table 10-1 shows the geographic coordinates of all the monitoring points.

Table 10-1: Geographic coordinates of the sampling points

Sampling points	Lat	Long
IGM 01	-27.736372°	29.883683°
IGM 02	-27.738000°	29.893700°
IGM 03	-27.748100°	29.922767°
IGMT 01	-27.735194°	29.850926°
ND 01	-27.785127°	29.898169°
ND 02	-27.759908°	29.911028°
AC	-27.750072°	29.931592°

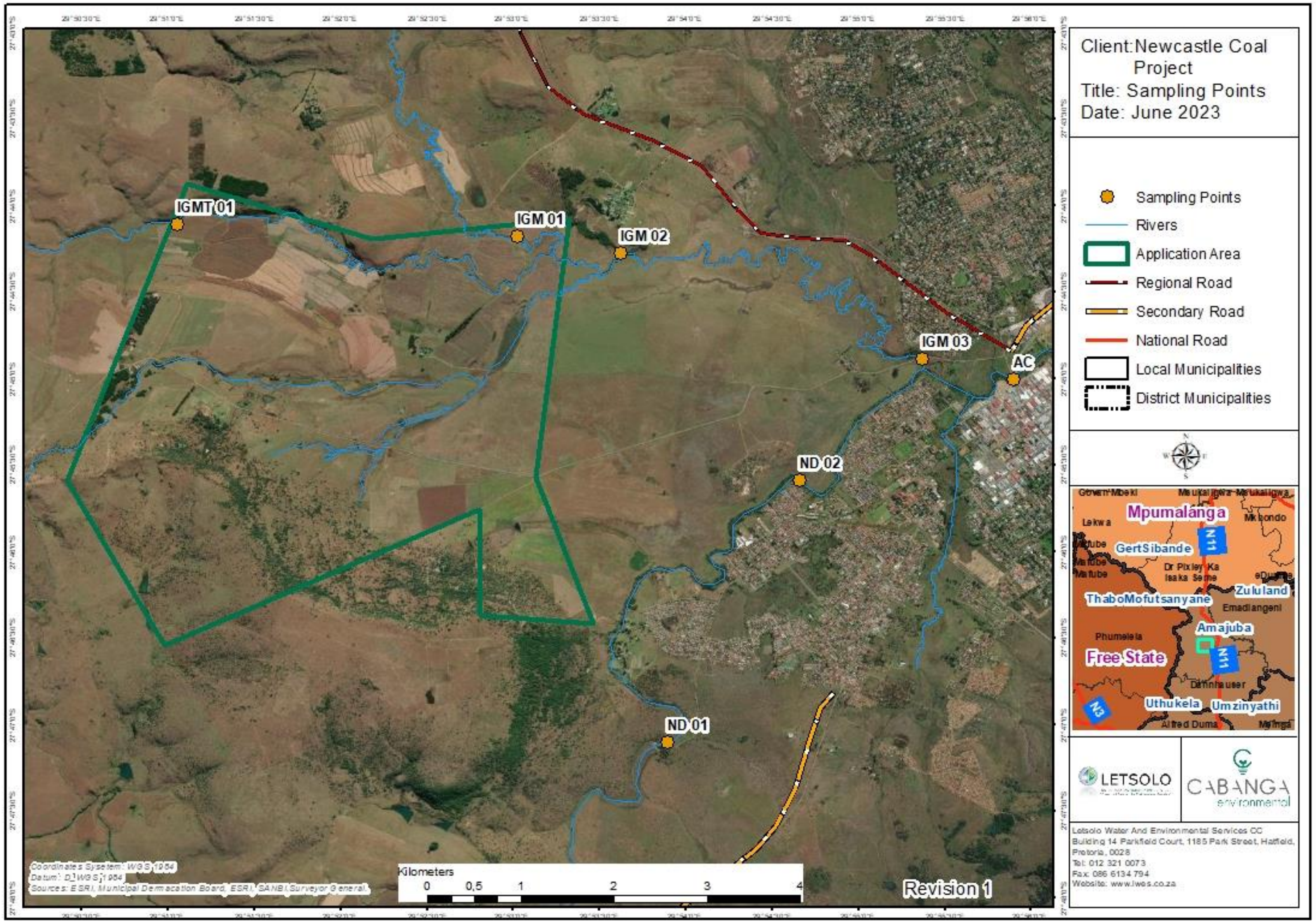


Figure 10-1: Sampling points

The chemical analysis from the sampling points were compared against various water quality guidelines set by the DWS to assess water quality in the study area. The surface water in the study area is mostly used for irrigation, livestock watering, and domestic use. The guidelines used are:

- SANS 241 (2015) for domestic;
- Irrigation and livestock watering (DWAF, 1996).

In terms of water quality guidelines, the surface in the study area is of good quality for all the observed water uses. Most of the chemical parameter were not exceeded by any of the monitoring points, except for EC which exceeded all the guidelines in all the sampled points. The results from chemical analysis (Table 10-2) indicate that the majority of the chemical parameters such as the EC, TDS, SO_4, as well the cations i.e., Ca, Mg, and Na, were higher in the tributary (IGM 01 – IGMT 01) when compared to the main system (ND 01 and ND 02). The farming activity occurring adjacent to the iNguduma River might be the influence of elevated chemical parameters in the system.

Table 10-2: Baseline water quality for surface water bodies around the study area

Chemical Parameters	Water use guidelines				Sampling Points						
	Irrigation	Livestock	SANS241:2015	Exceedance in all guidelines	IGM 01	IGM 02	IGM 03	IGMT 01	ND 01	ND 02	AC
pH	6.5 - 8.4	-	≥ 5 and ≤9.7		7.79	7.63	7.46	7.92	7.41	7.4	7.23
EC	0.4	1.54	≤ 0.17		11.6	11	12.4	11.8	7.71	7.61	11.1
TDS (mg/l)	-	100	≤ 1200		88	80	90	82	54	50	86
Alk - mg CaCO3/l	-	-	-		49.5	52.5	51.7	46	38.5	33.5	53.1
Cl (mg/l)	-	1500	≤ 300		3.76	3.58	4.12	2.36	2.1	2.29	4.21
SO4 (mg/l)	-	1000	≤ 500		6.74	7.03	5.67	5.84	5.71	3.68	5.85
NO3 (mg/l)	5	10	≤ 11		0.297	0.348	0.352	0.283	0.314	0.308	0.321
NO2 (mg/l)	5	10	≤ 0.9		<0.065	<0.065	0.129	<0.065	<0.065	<0.065	0.104
NH4 (mg/l)	-	-	-		0.06	0.057	0.102	0.055	0.049	0.073	0.61
F (mg/l)	2	2	≤ 1.5		<0.263	<0.263	<0.263	<0.263	<0.263	<0.263	<0.263
Ca (mg/l)	-	-	-		8.64	9.92	9.57	9.53	7.54	6.58	9.97
Mg (mg/l)	-	500	< 200		4.79	4.87	5.13	3.87	3.87	2.92	4.71
Na (mg/l)	70	2000	≤ 200		5.93	6.26	6.7	5.82	4.6	4.57	6.71
K (mg/l)	-	-	-		0.704	0.758	0.713	0.677	0.563	0.599	0.817
Al (mg/l)	5	5	0.3 - 0.5		0.535	0.32	0.202	0.184	0.046	0.043	0.017
Fe (mg/l)	-	-	-		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Mn (mg/l)	0.02	10	≤ 0.4		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
TSS mg/l					23	30	26	26	39	10	13
TON mg/l					0.347	0.399	0.481	0.333	0.364	0.36	0.425
Acidity - pH 8.3 CaCO3/l					17.9	9.96	14	12.7	8.16	9.48	14.9

<Below detection level

11. SALT BALANCE

Under normal circumstances, when determining water balances, one tends to only refer to the hydraulic balance, i.e., the accounting of all the in- and output volumes entering and leaving a system. In opposed to this, a water and salt balance uses the hydraulic balance, but then also accounts for the dissolved solids carried in the water streams. In other words, a water and salt balance is a means of accounting for all the products carried in a system where one value can be used to verify the accuracy of the other.

A Water and Salt balance can best be described as a management tool, which assists the user in determining not only the concentration of dissolved solids in a body of water but also, more importantly, to determine the mass of salts carried in a dynamic system.

Once all the water volume data was assessed and confirmed by the mathematical equations, water quality was then introduced to the spreadsheet calculations. Water quality data was sorted for each unit with water quality monitoring data. It is important to note that with Salt load calculations, the monitoring point with the poorest water quality data may not necessarily reflect the worst salt loads. Another determining factor is the volumes concerned. The same basic principles for the water balance apply to the salt balance, i.e., the conservation of mass across a system:

Total salt load in = Total salt load out

Whereby:

Salt load (kg/day) = Flow (m^3/annum) x Salt concentration (mg/l)

The mg/l was converted to kg/m^3.

The amount of salts dissolved in water is normally expressed as a concentration such as in mg/l. This indicates the concentration of the dissolved salt but does not provide any information on the actual amount of salt dissolved in the system. If, however, the volume and the flow rate of the water are brought into the equation, a more meaningful result can be achieved. In this case, not only the concentration of the dissolved substance but also the mass of the substance flowing past a specific point for a specific period can be calculated. Expressions such as Kg/hour or Tons/day will now be the type of units used. When evaluating a dynamic system (i.e., moving as opposed to stagnant water) then the latter method is far more meaningful.

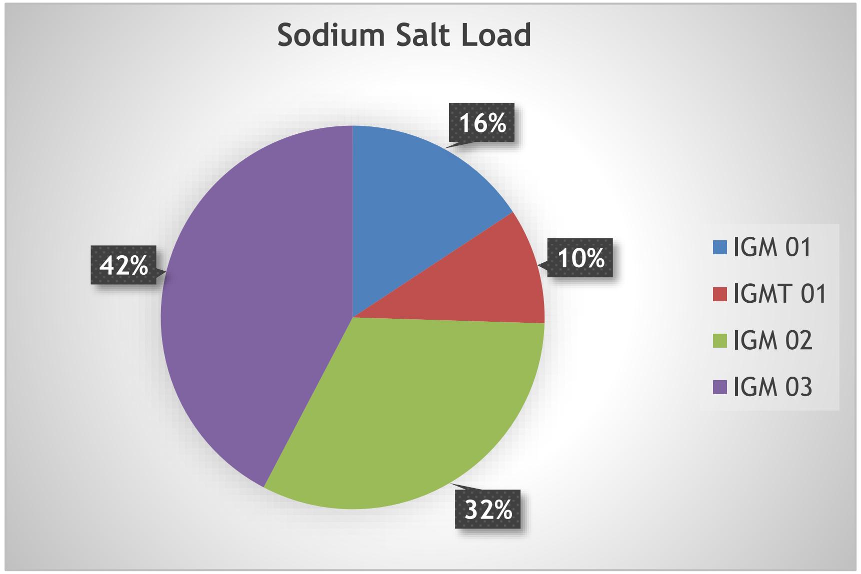
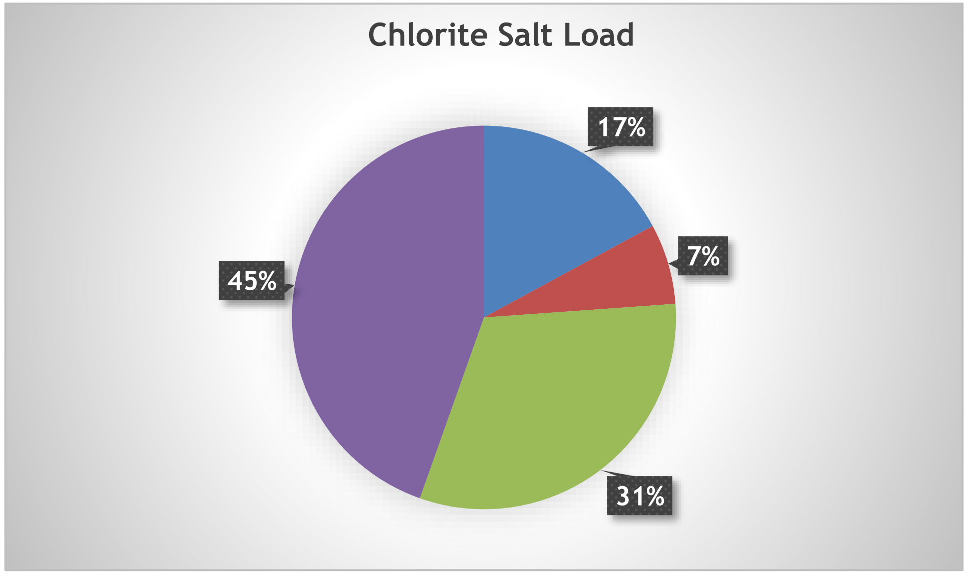
11.1. Salt load calculations

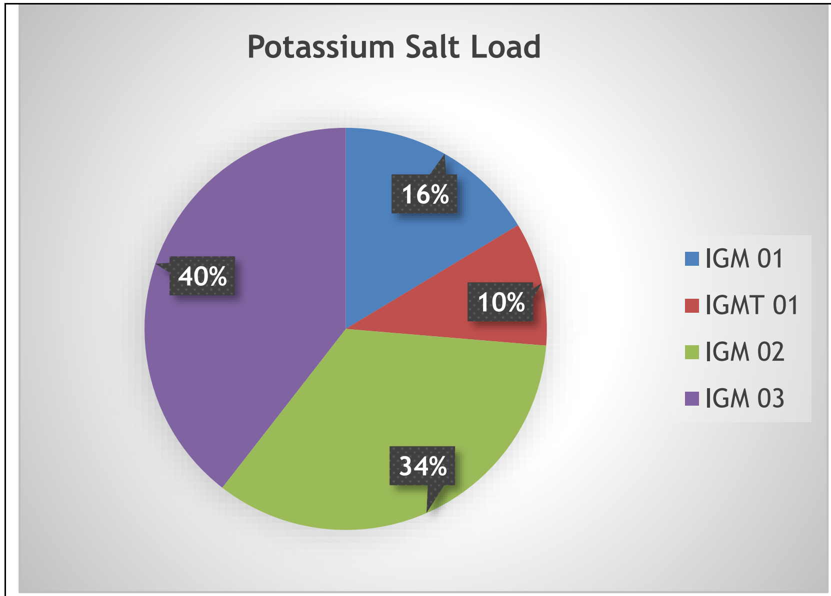
Only selected variables were averaged for analyses and further usage in calculating the salt loads (Table 11-1). The chemical parameters were selected because they can form common salt complexes such as sodium chloride (NaCl), potassium chloride (KCl), and potassium sulphate (K_2SO_4). Only stream-based salt load calculations were done as there are no dirty water containment facilities on site yet.

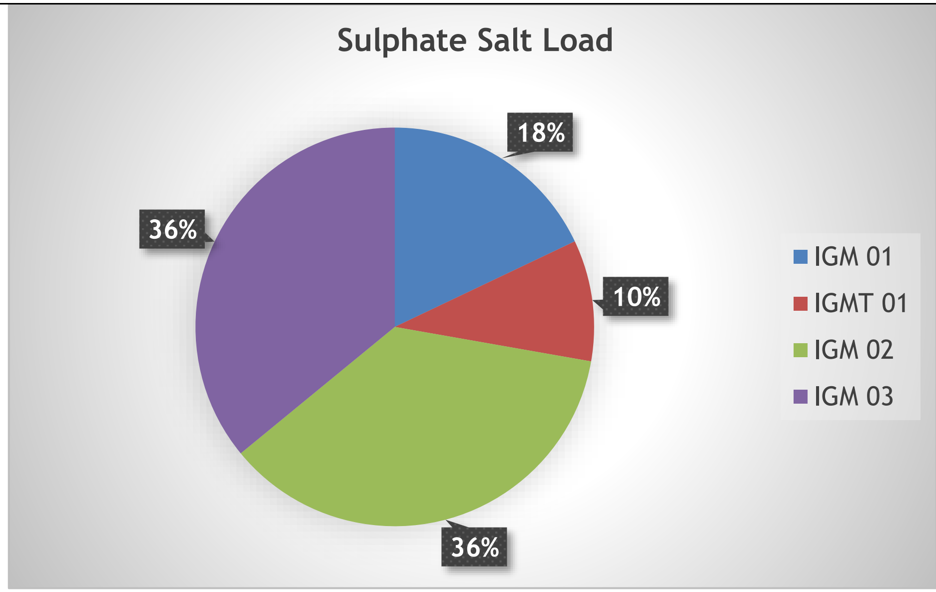
Table 11-1: Catchment-based salt load calculations

M.P	Na (kg/m)	Cl (kg/m)	K (kg/m)	S04 (kg/m)	TDS (kg/m)	Total salts (kg/m)
IGM 01	3256	2065	387	3701	48323	57731
IGMT 01	2022	820	235	2029	28487	33592
IGM 02	6668	3813	807	7488	85208	103984
IGM 03	8762	5388	932	7415	117704	140203
ND 01	14759	6738	1806	18320	173257	214881
ND 02	15014	7524	1968	12090	164272	200869
AC	32238	20227	3925	28106	413179	497674

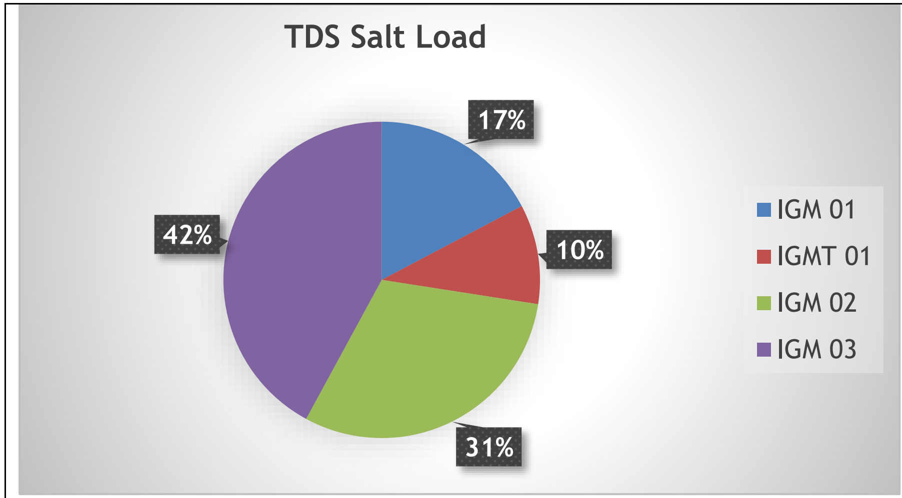
Table 11-2: iNguduma System – Catchment-based salt findings

<table>
<tr>
<td>In the iNguduma system, the upstream point (IGM 01) retained the least Na salts at 16% and the downstream point (IGM 03) retained the most at 42%. The tributary (IGMT 01) contributed 10% of Na salts.

</td>
<td>The downstream point of the iNguduma system retained most of the Cl salts at 45% while the upstream point retained the least at 17%. The tributary contributed 7% of Cl salts into the iNguduma system.

</td>
</tr>
<tr>
<td>The downstream point retained most of the K salts at 40% while the downstream point retained the least at 16%. The tributary contributed 10% of K salts into the main system.</td>
<td>The downstream point and the middle point (IGM 02) retained an equal number of SO_4 salts at 36%. The upstream point retained the least at 18% while the tributary contributed 10%.</td>
</tr>
</table>



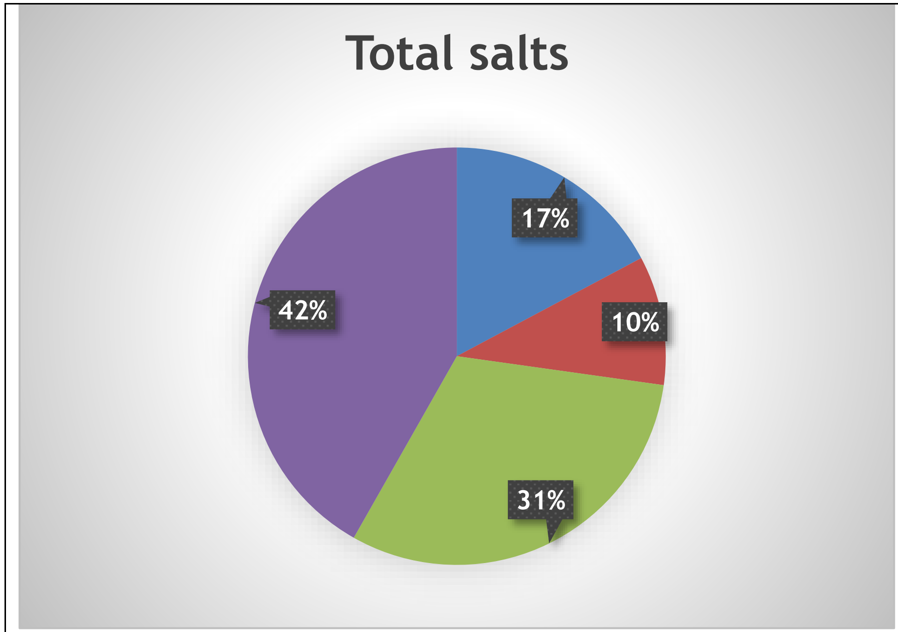


The most TDS salts were retained at the downstream point with 42% and the least were retained at the upstream point with 17%. The tributary contributed 10% to the main system.



Total salts retained

- The IGM 03 point retained most of the total salts at 140 203 kg/m which accounted for 42% of salts at the iNguduma system. This point is the lowermost point in the system and collects salts from upstream. The catchment size (Table 5-1) also contributes to the amount of salts at this point.
- The IGM 02 point retained the second highest salts at 103 984 kg/m which accounted for 31% of salts at the iNguduma System. This point is after the confluence of the iNguduma system and its tributary (IGMT 01), therefore, it also collects salts from the tributary.
- The upstream point retained the least salts at 57 731 kg/m which accounted for 17% of salts at the iNguduma System.


Total salts
17%
10%
31%
42%

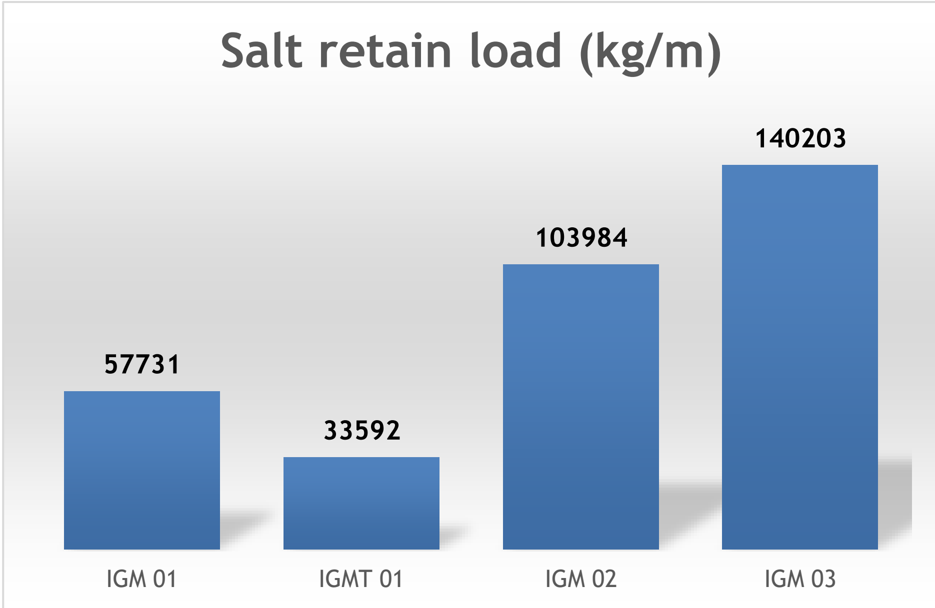
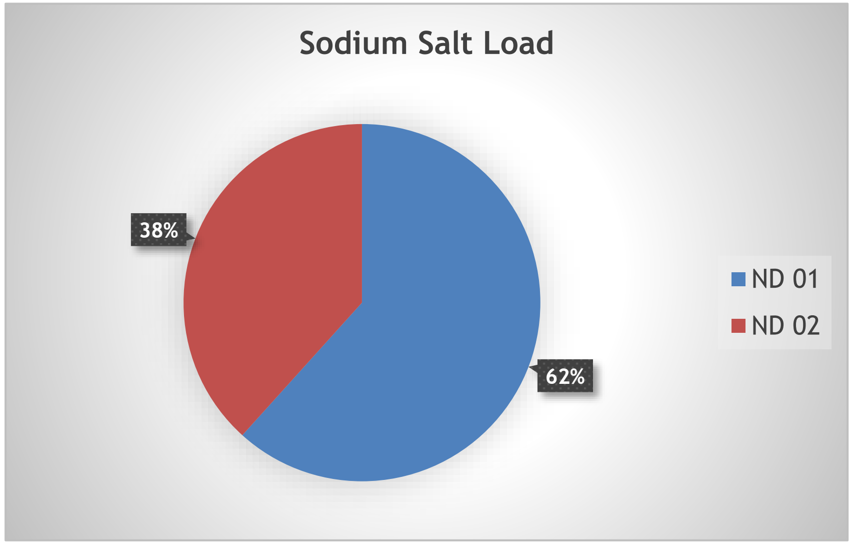
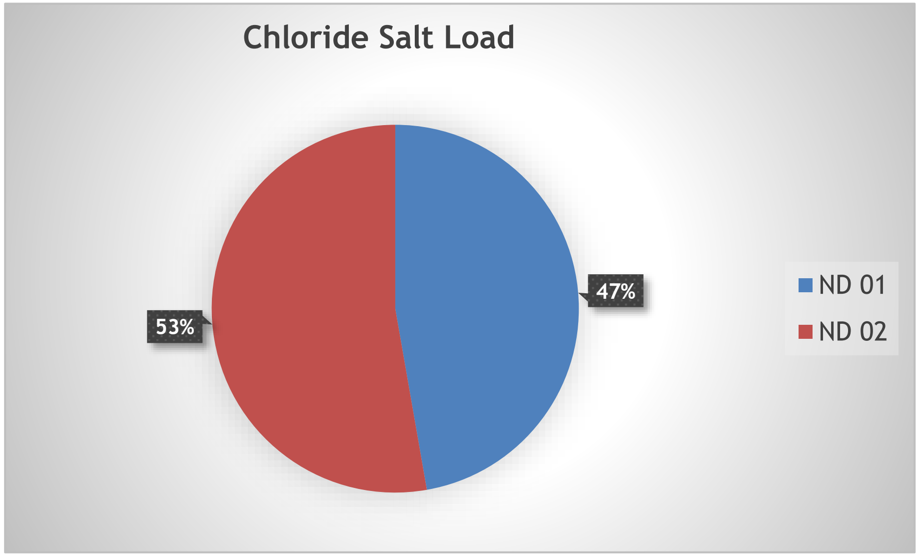
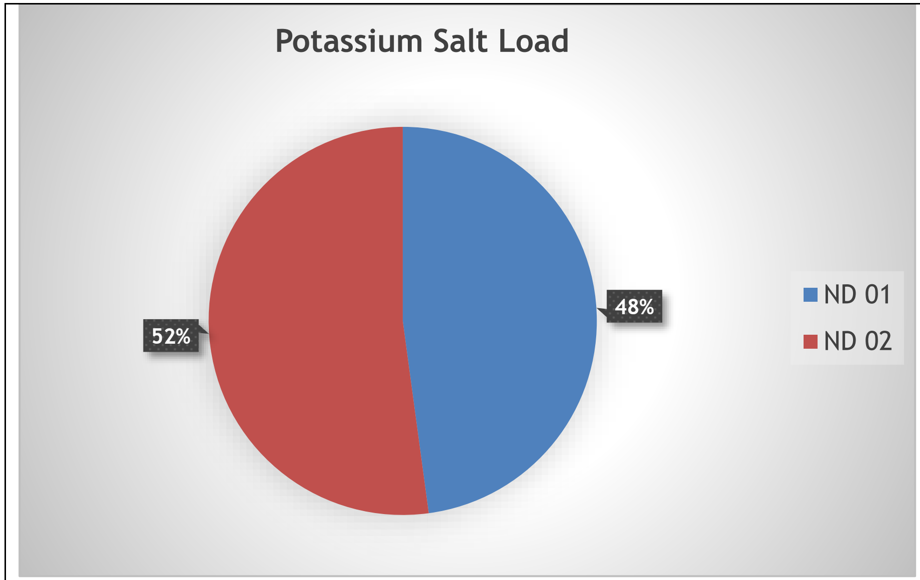
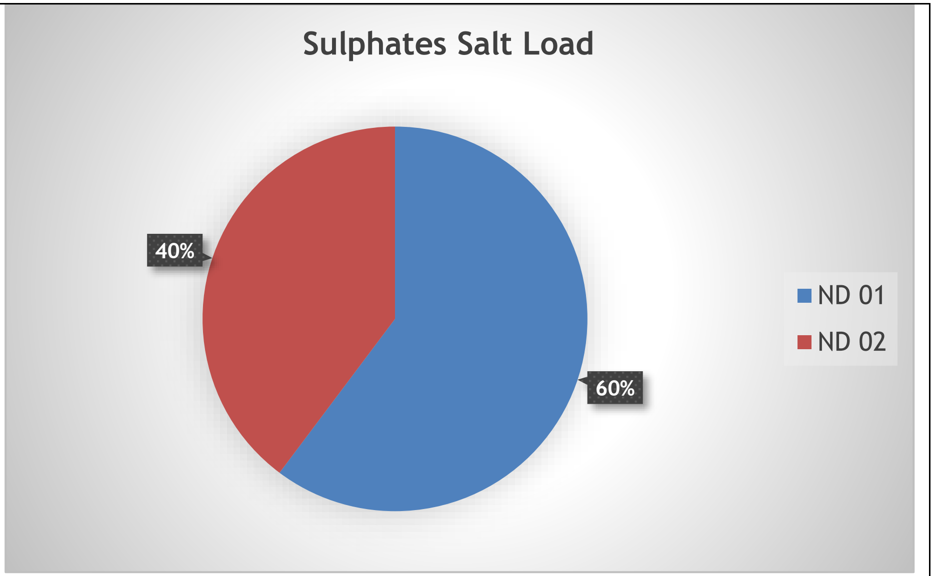
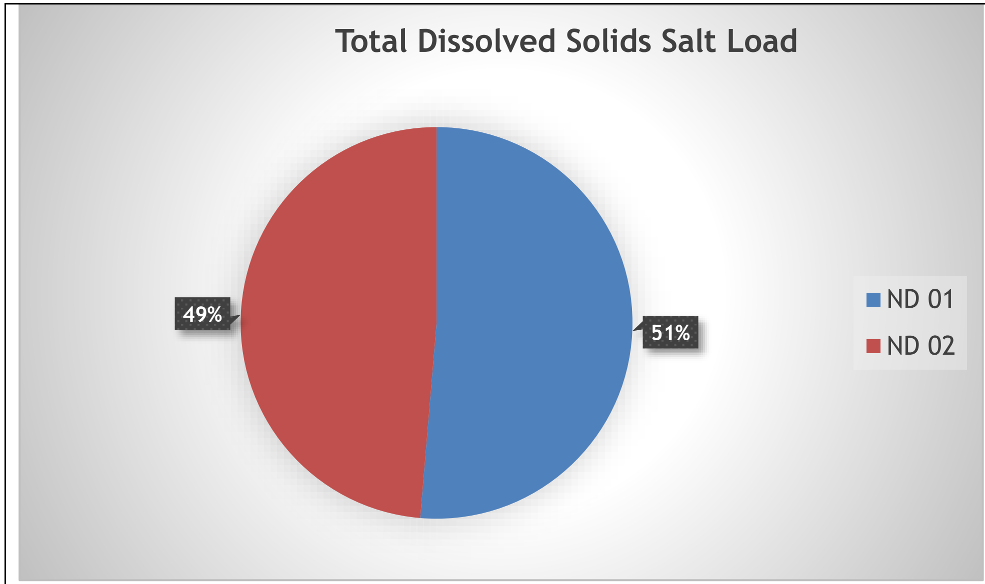

Salt retain load (kg/m)
57731
33592
103984
140203
IGM 01
IGMT 01
IGM 02
IGM 03

Table 11-3: Ncandu system - Catchment-based salt findings

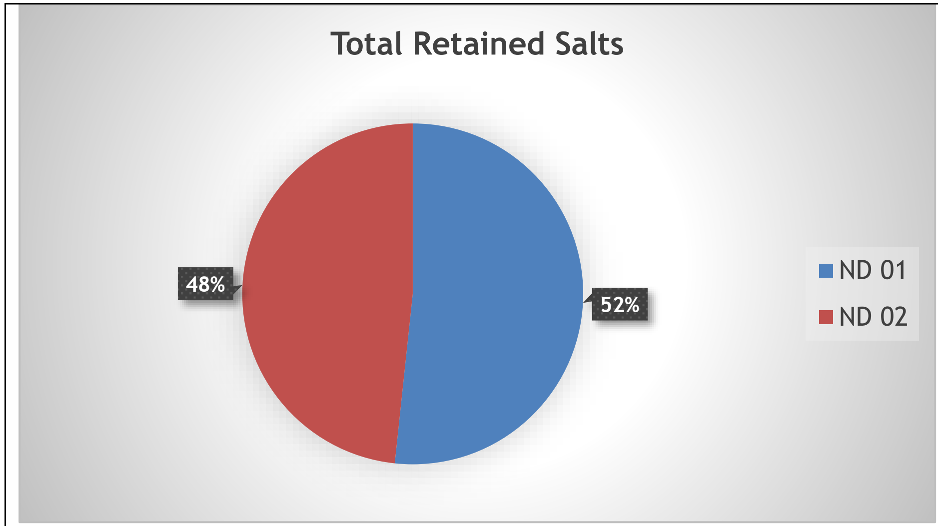
At the Ncandu system, the upstream point (ND 01) retained more Na salts at 62% while the downstream point (ND 02) retained the least at 38%.  	The downstream point retained most of the Cl salts at 53% while the upstream point retained the least at 47%. 
The downstream point retained most of the K salts at 52% while the downstream point retained the least at 48%.	The upstream point retained most of the S04 salts at 60% while the downstream point retained the least at 40%.

	
The most TDS salts were retained at the upstream point with 51% and the least were retained at the downstream point with 49%.	



Total salts retained

- At the Ncandu system, the upstream point retained the most salts at 214 881 kg/m which accounted for 52% of total salts retained in the Ncandu system. This is more than the downstream point that retained 200 869 kg/m, accounting for 48% of total salts.
- The salt calculations results show that salts in the Ncandu system decrease from upstream to downstream, this indicates better quality moving downstream. The occurrence of dense vegetation between the two points serves as a natural rehabilitation system for the water.



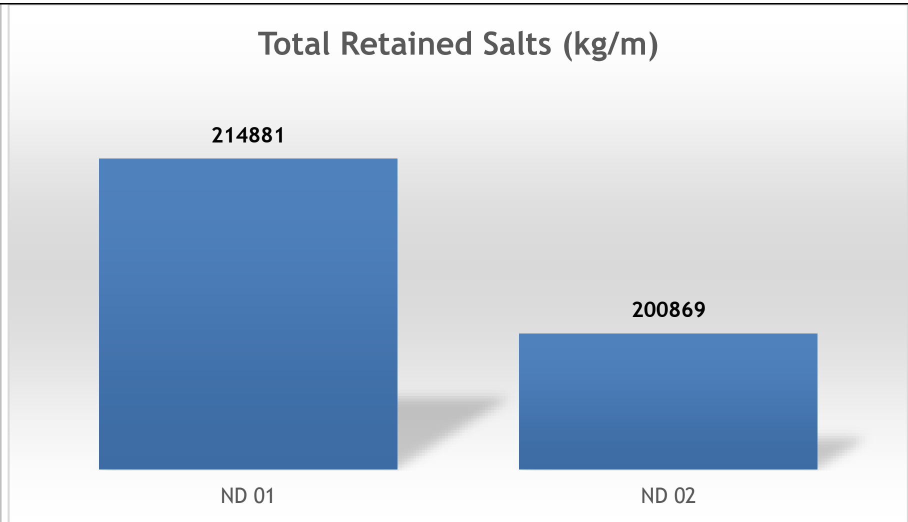
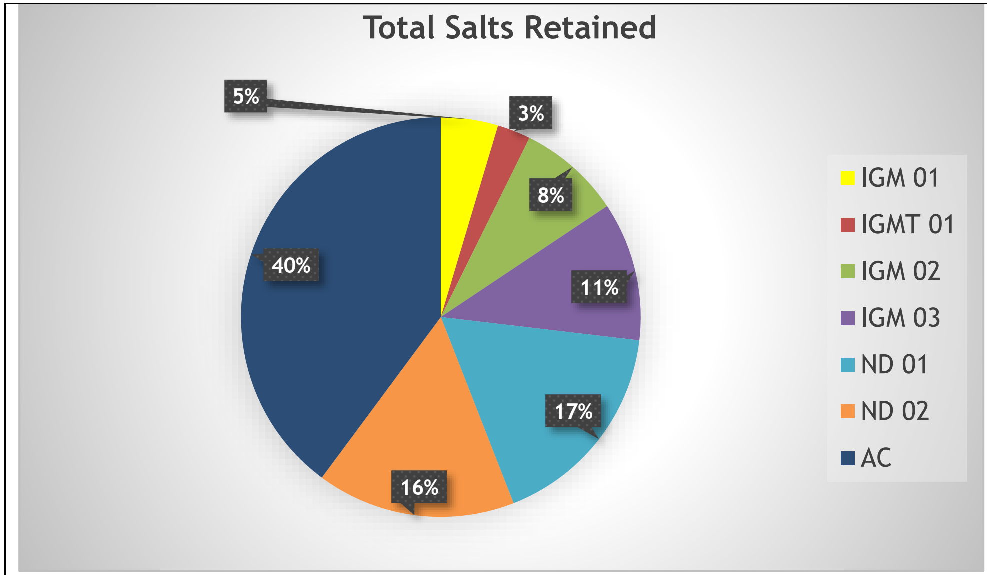
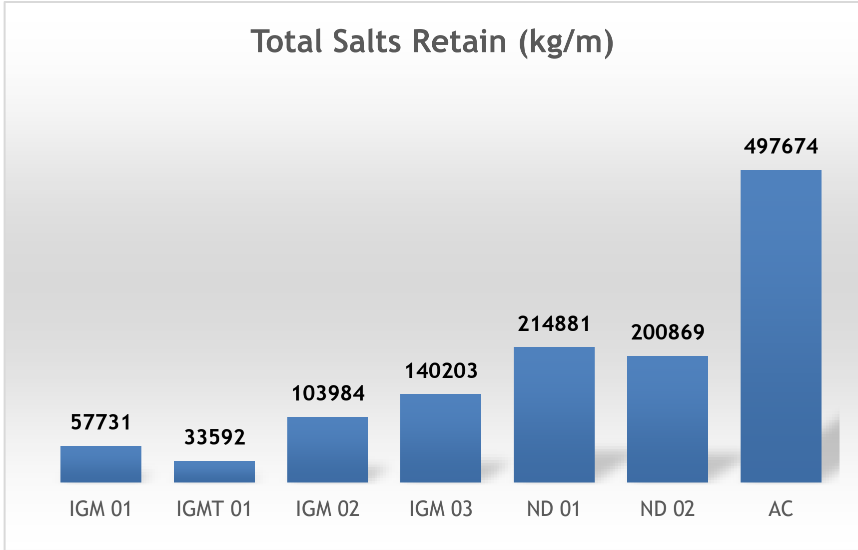


Table 11-4: Total salts retained in the surface water system

Total salts retained

- The salt load calculations for the surface water system around the application area show that the point after the confluence of the Ncandu River and its main tributary iNguduma River retained most of the calculated salts at 497 674 kg/m which accounted for 40% of salts retained in the river system. This is due to the surface area of the contributing catchment and farming activities occurring.
- The tributary system contributed a total of 23% of salts in the Ncandu system. The farming activity adjacent to the iNguduma River is the main contributor of salts in the system. The surface runoff during rainfall and watering of crops constantly introduces pesticides, herbicides, and fertilisers in the tributary. This increases the number of salts in the tributary system.


Total Salts Retained
5%
3%
8%
11%
17%
16%
40%
IGM 01
IGMT 01
IGM 02
IGM 03
ND 01
ND 02
AC


Total Salts Retain (kg/m)
57731
33592
103984
140203
214881
200869
497674
IGM 01
IGMT 01
IGM 02
IGM 03
ND 01
ND 02
AC

12. POTENTIAL IMPACTS

This section looks at the potential impacts of the proposed activity on the surface waterbodies around. The tables below contain a description of the activities which can result in impacts on the hydrological regime specifically related to the activities that are proposed. This is followed by an assessment of the impacts related to these activities.

Table 12-1: Change in flow regime

Impact Component	**Hydrological Yield**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Site establishment and construction of required infrastructure		
Risk/ Impact	• Change in flow regime • Increase in hydrological yield • Change in catchment characteristics		
Project Phase	CO = construction, OP = operational,		
Nature of Impact	Negative		
Type of Impact	Direct: Artificial infrastructure like channels and berms, may have a significant impact on the flow regime due to the change in flow direction and velocity.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Severity	Construction of infrastructure will change the hydrological yield of the hosting catchment by reducing surface runoff through containment of dirty water. The construction of impervious surfaces may also increase the surface runoff.	3	2
Spatial scale	Whole site	2	2
Duration	Life of a mine	4	3
Frequency of activity	Containment of dirty runoff will be daily.	5	3
Frequency of incident/impact	Without mitigation, the activity will definitely impact on the environment.	5	2

Legal issues	Fully covered in legislation	5	5
Detection	An effort is needed to determine the change in the flow regime.	3	3
Consequence	Severity + Spatial scale + Duration	3+2+4 = 9	2+2+3 = 7
Likelihood	Frequency of Activity + Frequency of incident + Legal issues + Detection	5+5+5+3=18	3+2+5+3 = 13
Impact/Risk	Consequence x Likelihood	9x18 = 162	7x13 = 91
Mitigating and Monitoring Requirements			
Required Management Measures	• The location of mining infrastructure must be outside the 1:100 years flood lines and the 100m buffer measured from the center of the stream or lowest elevation drainage lines. • The proposed infrastructure may not impede or divert the flow unless authorised by the DWS. • Efforts should be made to minimise the dirty water catchment. • Berms will be constructed to prevent the mixture of clean and dirty water. Clean water will be allowed to return to environment to prevent further decrease in hydrological yield.		
Required Monitoring (if any)	Water and Salt Balance study must be conducted and amended annually. The quantity component of this report can be used as an early warning for change in flow regime. The outcomes of the study must be used as a management tool as well as a means of investigating the latest technologies for water management.		
Responsibility for implementation	Environmental Officer and Mine Manager		

Table 12-2: Overburden stockpiles

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	Overburden Stockpiling		
Risk/ Impact	Contamination and siltation of water bodies		
Project Phase	CO = construction, OP = operational,		

Nature of Impact	Negative		
Type of Impact	Direct: Surface runoff from overburdened stockpiles will cause contamination and siltation in water bodies.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Severity	Overburden stockpiles contain residue material from the mining of coal. These stockpiles are susceptible to erosion and will easily wash away to nearby streams causing widespread contamination and siltation of water bodies, if not prevented.	5	3
Spatial scale	Area-specific	3	1
Duration	Medium term	3	2
Frequency of activity	Seasonally	3	2
Frequency of incident/impact	Regularly	4	3
Legal issues	Fully covered in legislation	5	5
Detection	Need some effort	3	3
Consequence	Severity + Spatial scale + Duration	5+3+3 = 11	3+1+2 = 6
Likelihood	Frequency of Activity + Frequency of incident + Legal issues + Detection	3+4+5+3 = 15	2+3+5+3 = 13
Impact/Risk	Consequence x Likelihood	11 x 15 = 165	6x13 = 78
Mitigating and Monitoring Requirements			
Required Management Measures	• Ensure that all overburdened stockpiles are outside the 1:100-year floodlines or the 100m watercourse buffer, whichever is the greatest. • Construct suitable berms to separate dirty runoff from stockpiles and clean runoff. • Limit erosion on overburden stockpiles by constructing toe and perimeter berms. • The dirty water separations should be maintained until the area is fully rehabilitated and draining freely.		

	• Direct runoff from the stockpile through channels to dirty water infrastructures. • During the rehabilitation period, erosion control measures should be put in place and maintained.
Required Monitoring (if any)	A maintenance schedule for the repair of eroded berms and stockpiles must be established.
Responsibility for implementation	Environmental Officer and Mine Manager

Table 12-3: Dirty water infrastructures impact assessment

Impact Component	**Dirty Water Infrastructure**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Maintenance and operation of dirty water infrastructure.		
Risk/ Impact	Spillages from dirty water infrastructure Flood events		
Project Phase Nature of Impact	CO = construction, OP = operational, Negative		
Type of Impact	Direct: Dirty water management measures as discussed in this report must be implemented.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Severity	Overflow of PCD may introduce different salts in surface water bodies.	4	1
Spatial scale	In the event of contamination, contaminants will easily travel downstream and affect a neighbouring site.	3	1
Duration	One day to one month	1	1
Frequency of activity	Once off	1	1
Frequency of incident/impact	The activity regularly impacts on the environment	4	2

Legal issues	Fully covered in legislation	5	5
Detection	An effort is needed to determine the change in the flow regime.	3	3
Consequence	Severity + Spatial scale + Duration	4+3+1 = 8	1+1+1 = 3
Likelihood	Frequency of Activity + Frequency of incident + Legal issues + Detection	1+3+5+3 = 12	1+2+5+3 = 11
Impact/Risk	Consequence x Likelihood	8x12 = 96	3x11 = 33
Mitigating and Monitoring Requirements			
Required Management Measures	• The PCDs must be designed, constructed, maintained, and operated in such a way that it is not likely to spill into any clean water system more than once in 50 years. • All PCDs must have a minimum freeboard of 0.8m above the full supply level. • All dirty water infrastructure needs regular maintenance. • Oil separators and dirty water trenches have to be cleaned regularly, and SWMP must be compiled and adhered to throughout the Project. • Discharges from the final effluent must comply with the conditions that will be raised by the DWS when the IWUL is issued.		
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted at the proposed monitoring points in Section 13.		
Responsibility for implementation	Environmental Officer and Mine Manager		

Table 12-4: Open cast pits impact assessment

Impact Component	Opencast Pits	Significance prior to Mitigation	Significance with Mitigation
Activity	Opencast mining and storage of dirty water.		
Risk/ Impact	• Reduction in catchment area • Decrease in hydrological yield • Change in catchment characteristics • Formation of Acid Mine Drainage (AMD)		
Project Phase	CO = construction,		

	OP = operational, CL = Closure and post-closure		
Nature of Impact	Negative		
Type of Impact	Direct: Excavation of open cast pits will reduce contributing catchment, reducing water quantity in watercourses. Water accumulating in pits can react with sulphur reach material causing AMD which can decant into water bodies.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Severity	Reducing stream flow may result in drought. Decanting AMD can cause widespread contamination of water bodies.	5	3
Spatial scale	Regional	3	2
Duration	Medium term	3	2
Frequency of activity	Mining is proposed daily	5	5
Frequency of incident/impact	Often (without mitigation)	4	2
Legal issues	Fully covered in legislation	5	5
Detection	An effort is needed to determine the change in the flow regime, and occurrence of AMD.	3	3
Consequence	Severity + Spatial scale + Duration	5+3+3 = 11	3+2+2 = 7
Likelihood	Frequency of Activity + Frequency of incident + Legal issues + Detection	5+4+5+3 =17	5+2+5+3 = 15
Impact/Risk	Consequence x Likelihood	11x17 = 187	7x15 = 105
Mitigating and Monitoring Requirements			
Required Management Measures	• Ensure that the pits are outside the 1:100-year flood lines or outside of the 100 m watercourse buffer, whichever is greater. • Berms and cut off trenches should be placed around the pits to prevent clean water from entering. • Develop an in-pit sump at the lowest point in the pit so that water diverts away from coal seams and carbonaceous shale.		

	• Correctly rehabilitate the pits (clean material at the top) so that the catchment characteristics return to pre-mining conditions.
Required Monitoring (if any)	Water and Salt Balance study must be conducted and amended annually. The outcomes of the study must be used as a management tool as well as a means of investigating the latest technologies for water management. Water quality monitoring should be conducted monthly.
Responsibility for implementation	Environmental Officer and Mine Manager

Table 12-5: Conveyor belt impact assessment

Impact Component	**Conveyor Belt**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Transporting coal from active pit to plant		
Risk/ Impact	Deterioration of water quality from coal spillages		
Project Phase	CO = construction, OP = operational, CL = Closure and post-closure		
Nature of Impact	Negative		
Type of Impact	Direct: Falling of coal during conveyance will cause water contamination and siltation		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Severity	Siltation and contamination of watercourses	4	1
Spatial scale	In the event of contamination, contaminants will easily travel downstream and affect a neighbouring site.	3	1
Duration	Medium term	3	1
Frequency of activity	Monthly	3	1

Frequency of incident/impact	Infrequent	3	2
Legal issues	Fully covered in legislation	5	5
Detection	An effort is needed to determine the change in the flow regime.	3	3
Consequence	Severity + Spatial scale + Duration	4+3+3 = 10	1+1+1 = 3
Likelihood	Frequency of Activity + Frequency of incident + Legal issues + Detection	4+3+5+3 = 15	1+2+5+3 = 11
Impact/Risk	Consequence x Likelihood	10x15 = 150	3x11 = 33
Mitigating and Monitoring Requirements			
Required Management Measures	• The conveyor belt should be constructed perpendicular to the streams at a point of crossing and spanning across streams is advised. • The conveyor belt should not cross the water bodies at multiple points to avoid widespread siltation and water contamination. • Cover the conveyor belt to prevent spillage of coal in water bodies.		
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted at the proposed monitoring points (Section 13).		
Responsibility for implementation	Environmental Officer and Mine Manager		

13. MONITORING PROGRAMME

A monitoring programme is a crucial tool to identify and manage any risk arising from the potential impacts identified earlier. The proposed monitoring should be practiced throughout the life of the proposed project. The monitoring plans are discussed further below.

13.1. Stormwater infrastructure maintenance

The purpose of the monitoring excise is to identify any malfunctioning of the stormwater infrastructures that are designed to protect water resources. An example of malfunctions includes blockages of culverts and channels by debris and silt, and overflowing of dirty water containment facilities. The proposed stormwater infrastructures should be monitored and maintained regularly to ensure efficiency in dirty water management. A site inspection should be conducted to inspect the conditions of the infrastructure. The site inspection should be conducted by an internal environmental officer on a weekly basis during the rainy season and immediate after every heavy storm. The inspections should be recorded and must indicate the date of inspection, photographs of the conditions of the proposed infrastructures, actions to be taken to fix issues (if found), and the duration taken. The inspections in form of a report should be submitted to the Mine Manger on a weekly basis.

13.2. Water quality

The water quality monitoring programme is a well-structured document indicating the routine monitoring of the selected points which aims to trace changing water quality. Continuous water quality monitoring is necessary to determine the potential impact of the mine and other activities on the nearby water resources. Such impacts would indicate whether the water resources protection measures in place are efficient or not.

Monitoring should be according to South African National Standard (SANS) sampling standards in accordance with methods prescribed by and obtainable from the South African Bureau of Standards (SABS). Table 13-1 presents the geographic coordinates of the proposed monitoring points and Figure 13-1 illustrates the location of the points. The in-pit samples will not be collected at the same time as the pits will not be opened at the same time, therefore, the in-pit samples should be collected as long as the pit is open.

Table 13-1: Geographic coordinates of the proposed water quality monitoring points

Name	Lat	Long
Balancing PCD	-27.739606°	29.863963°
IGM 01	-27.733949°	29.877672°
IGM 02	-27.739951°	29.891877°
IGMT 01_1	-27.734023°	29.852248°
IGMT 01_2	-27.739833°	29.884353°
IGMT 02_1	-27.758749°	29.869287°
IGMT 02_2	-27.741289°	29.888012°
PCD	-27.741387°	29.864794°
Pit 1	-27.748462°	29.884388°
Pit 2	-27.762681°	29.884372°
Pit 3	-27.771971°	29.888505°
Pit 4	-27.744157°	29.883452°
Pit 5	-27.751979°	29.865528°
Pit 6	-27.743996°	29.878828°
Pit D1	-27.752681°	29.874816°
RS 01	-27.748634°	29.849527°
RS 02	-27.750148°	29.880032°

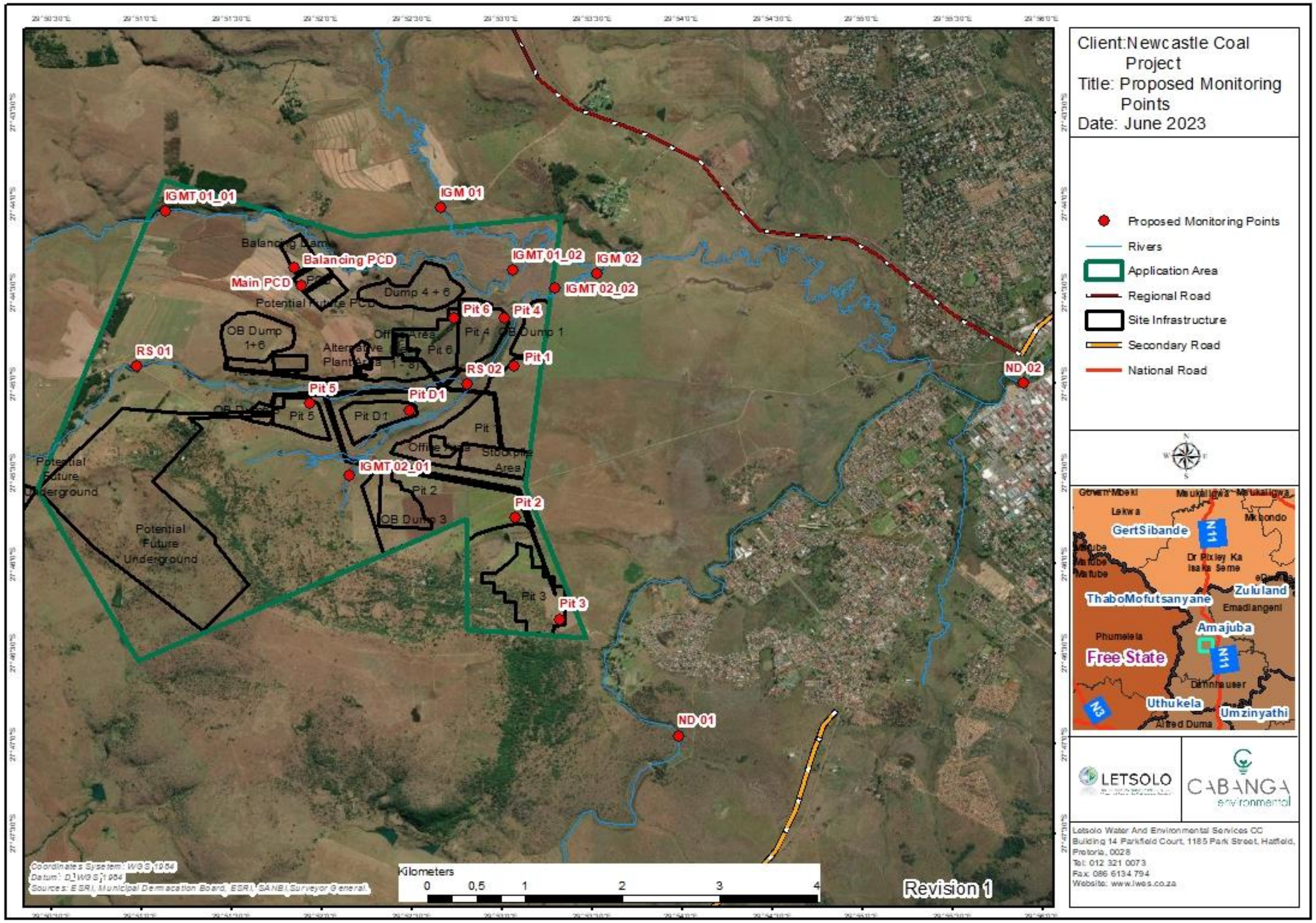


Figure 13-1: Proposed surface water monitoring points

14. CONCLUDING REMARKS

The objectives of this study were to address the potential impact of proposed mining operations on the water flow and water quality processes of the hydrological cycle, and the associated upstream and downstream environmental impacts. The receiving sensitive water resource for this study is the iNguduma River. The INguduma River is a perennial river that that originate in the mountains northwest of study area and flows southeast where it joins the Ncandu River, which is a larger tributary of the iNgagane River within the Pongola-Mtamvuna WMA 4.

Surface water samples were collected on the 19th of January 2023 to determine the baseline water quality in the area of interest. Five selected chemical parameters (TDS, SO_4, Cl, K, and Na) were averaged and used to determine salt distribution in the area of interest. The salt load calculation revealed that salt retention in the Ncandu River decreases from the upstream point to the downstream point, indicating an improvement in water quality. Salt retention in the iNguduma River increase from the upstream to the downstream point, the farming activity adjacent to the river is a likely source of salts in the river.

Stormwater management infrastructures were designed following BPG 1: Stormwater Management. The location of the PCDs was assessed according to surface water drainage and it was found that the main proposed PCD is located upstream of the drainage and would not be able to collect dirty runoff from the hosting dirty catchment. The location of the PCD named 'Potential Future PCD' is suitable for dirty water collection, therefore, the main PCD should be moved to this location.

Floodlines were delineated to check compliance with Condition 4 of the GN 704 and to assess the risk of flooding to the proposed mine infrastructures. The proposed infrastructures that are within the 1 in 100-year inundation boundary and the 100 m watercourse buffer include the PCDs, Overburden 1 and 4+6, Pit 1, Pit D1, Pit 4, Pit 5, and Pit 6. GN 704 Condition 4 restricts mining activity to occur within these boundaries, therefore, it is recommended that the mine applies for an exemption from the DWS. Additionally, Section 21c and I water uses should be indicated as including Pits in the water use license application. Alternatively, the extent of pits and overburden dumps must be reduced to refrain from establishing an infrastructure area within the floodline area. The PCDs should be moved to a location outside the inundation boundary.

15. RECOMMENDATIONS

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

- Surface water quality monitoring should be conducted on a monthly basis to determine any impact on the surface water bodies during operational phase of mining and possibly quarterly after closure. Although a bigger number of monitoring points were proposed, in instances where the infrastructure (like Pit) is not yet established, the findings on compliance should be based on other points where data is collected.
- For surface water bodies, use water quality guidelines state in Table 10-2 to ensure compliance with DWS. For dirty water infrastructures, use water quality limits that will be stated in IWUL to ensure compliance with the issued IWUL.
- Should any of the sampling point exceed any given water quality limit, the source of contamination should be traced and apply suitable mitigation measures.
- The stormwater proposed infrastructure especially berms, stormwater channels, and the main PCD should be constructed before the mining activity commences.
- The stormwater infrastructures should be monitored and maintained on regular basis to remove silts and debris from the stormwater channels and culverts. Records of maintenance can be kept for management purposes.
- A comprehensive water and salt balance should be developed and updated annually as soon the surface infrastructure are placed in order to:
    - Account for salt loads stored in the dirty water containment facilities;
    - Quantify the increase or decrease of salt loads leaving the system into the receiving environment; and
    - Assist the mine to manage its water and wastewater in a responsible manner.
- Install flow meters to record accurate water usage and install rain gauge on site for better water balance calculations.
- Reuse dirty water as far as possible to limit the use of clean water from the municipality/groundwater.
- The main PCD should be moved to the location of the Potential Future PCD so that it can efficiently capture dirty runoff.
- For the pits within the 1:100-year floodline, an GN704 exemption application should be lodged, including the pits in question.
- Rehabilitate the affected area so that the surface drainage can be restored.

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APPENDIX A: Profile output tables.

Table 1: iNguduma tributary 1

Reach	River sta	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S Elev (m)	Crit W.S (m)	E.G Elev (m)	E.G Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude #Chl
MAIN	50	1 in 50	361.71	1232.11	1234.03	1234.03	1234.48	0.007213	3.39	134.52	133.38	0.84
MAIN	50	1 in 100	455.06	1232.11	1234.18	1234.18	1234.71	0.007574	3.68	154.41	133.58	0.88
MAIN	49	1 in 50	361.71	1230.12	1232.79	1232.79	1233.71	0.010337	4.66	100.61	101.81	1.04
MAIN	49	1 in 100	455.06	1230.12	1233.13	1233.41	1233.88	0.007699	4.45	157.9	204.05	0.92
MAIN	48	1 in 50	361.71	1227.02	1230.12	1230.86	1232.21	0.019298	7.57	68.53	58.43	1.47
MAIN	48	1 in 100	455.06	1227.02	1230.38	1231.29	1232.58	0.01905	8	85.45	70.86	1.49
MAIN	47	1 in 50	361.71	1225.76	1228.55	1229.08	1229.95	0.014083	5.52	77.6	72.32	1.22
MAIN	47	1 in 100	455.06	1225.76	1228.77	1229.28	1230.34	0.014359	5.97	100.63	117.35	1.25
MAIN	46	1 in 50	361.71	1224.18	1226.87	1227.5	1228.4	0.018073	5.57	69.13	51.4	1.34
MAIN	46	1in 100	455.06	1224.18	1227.15	1227.71	1228.82	0.016685	5.9	89.75	93.09	1.32
MAIN	45	1 in 50	361.71	1225.08	1226.1	1226.13	1226.5	0.015059	2.87	129.54	182.68	1.06
MAIN	45	1 in 100	455.06	1225.08	1226.12	1226.25	1226.72	0.021263	3.48	134.08	182.72	1.27
MAIN	44	1 in 50	361.71	1223.96	1224.93	1224.93	1225.3	0.011839	2.73	136.64	190.03	0.96
MAIN	44	1 in 100	455.06	1223.96	1225.06	1225.06	1225.48	0.011034	2.91	162.08	191.84	0.95
MAIN	43	1 in 50	361.71	1222.79	1224.27	1224.27	1224.78	0.011668	3.27	114.89	111.3	1
MAIN	43	1 in 100	455.06	1222.79	1224.45	1224.45	1225.04	0.011295	3.49	134.26	113.19	1
MAIN	42	1 in 50	361.71	1220.79	1222.52	1222.8	1223.52	0.017126	4.6	87.7	90.87	1.26

MAIN	42	1 in 100	455.06	1220.79	1222.71	1223.05	1223.81	0.016347	4.9	105.62	99	1.26
MAIN	41	1 in 50	361.71	1221.44	1222.62	1222.62	1223.09	0.011729	3.26	120.69	127.2	1
MAIN	41	1 in 100	455.06	1221.44	1222.77	1222.77	1223.32	0.011313	3.5	140.45	127.71	1.01
MAIN	40	1 in 50	361.71	1218.04	1220.55	1220.81	1221.61	0.011706	5.06	88.76	70.52	1.11
MAIN	40	1 in 100	455.06	1218.04	1220.81	1221.05	1221.91	0.010721	5.24	107.45	71.75	1.09
MAIN	39	1 in 50	361.71	1218.27	1220.37	1220.37	1220.94	0.007138	3.67	118.86	97.63	0.85
MAIN	39	1 in 100	455.06	1218.27	1220.56	1220.56	1221.21	0.007392	3.98	137.16	97.76	0.88
MAIN	38	1 in 50	361.71	1215.36	1216.92	1217.62	1219.21	0.05038	6.7	54.03	50.79	2.06
MAIN	38	1 in 100	455.06	1215.36	1217.16	1217.91	1219.55	0.040426	6.85	66.84	54.4	1.91
MAIN	37	1 in 50	361.71	1216.35	1218.7	1218.7	1219.56	0.008712	4.17	91.28	56.45	0.95
MAIN	37	1 in 100	455.06	1216.35	1218.94	1218.94	1219.98	0.009208	4.62	105.15	68.76	1
MAIN	36	1 in 50	361.71	1214.8	1216.32	1216.89	1218.13	0.036538	6.09	62.74	63.19	1.79
MAIN	36	1 in 100	455.06	1214.8	1216.51	1217.08	1218.53	0.033684	6.47	75.15	66.42	1.76
MAIN	35	1 in 50	361.71	1214.71	1216.66	1216.66	1217.25	0.007629	3.72	115.45	93.35	0.88
MAIN	35	1 in 100	455.06	1214.71	1216.87	1216.87	1217.53	0.00767	4	134.51	94.7	0.9
MAIN	34	1 in 50	361.71	1213.47	1215.63	1215.8	1216.59	0.010927	4.53	88.59	64.41	1.06
MAIN	34	1 in 100	455.06	1213.47	1215.99	1216.07	1216.95	0.008819	4.57	113.08	72.52	0.98
MAIN	33	1 in 50	361.71	1211.91	1214.71	1214.71	1215.66	0.009175	4.88	93.43	65.59	1.01
MAIN	33	1 in 100	455.06	1211.91	1215.02	1215.27	1216.06	0.008944	5.22	116.93	86.12	1.02
MAIN	32	1 in 50	361.71	1210.52	1212.89	1213.53	1214.76	0.018924	6.42	65.7	49.21	1.42
MAIN	32	1 in 100	455.06	1210.52	1213.18	1213.93	1215.19	0.017692	6.77	81.1	56.85	1.4

MAIN	31	1 in 50	361.71	1211.46	1214	1214	1214.6	0.006104	3.87	119.68	94.23	0.82
MAIN	31	1 in 100	455.06	1211.46	1214.22	1214.22	1214.89	0.006252	4.16	140.55	97.93	0.84
MAIN	30	1 in 50	361.71	1212.12	1213.85	1213.85	1214.5	0.010877	3.7	101.91	77.72	1
MAIN	30	1 in 100	455.06	1212.12	1214.07	1214.07	1214.82	0.010628	3.97	118.61	78.83	1.01
MAIN	29	1 in 50	361.71	1212.12	1213.71	1213.71	1214.24	0.009543	3.39	116.44	106.01	0.94
MAIN	29	1 in 100	455.06	1212.12	1213.89	1213.89	1214.51	0.009577	3.68	134.53	106.4	0.96
MAIN	28	1 in 50	361.71	1211.22	1213.12	1213.12	1213.63	0.011068	3.19	116.97	122.16	0.97
MAIN	28	1 in 100	455.06	1211.22	1213.31	1213.31	1213.87	0.010068	3.38	140.63	129.75	0.95
MAIN	27	1 in 50	361.71	1207.7	1210.98	1211.56	1212.56	0.01483	5.82	72.94	60.77	1.25
MAIN	27	1 in 100	455.06	1207.7	1211.28	1211.78	1212.9	0.013528	6.05	92.48	70.49	1.22
MAIN	26	1 in 50	361.71	1207.16	1210.94	1210.94	1211.97	0.00651	4.78	89.07	47.49	0.88
MAIN	26	1 in 100	455.06	1207.16	1211.41	1211.41	1212.44	0.005588	4.87	113.23	53.54	0.83
MAIN	25	1 in 50	361.71	1206.37	1209.73	1210.14	1211.29	0.013065	5.69	69.37	40.97	1.19
MAIN	25	1in 100	455.06	1206.37	1210.06	1210.53	1211.8	0.012512	6.08	83.5	44.92	1.19
MAIN	24	1 in 50	361.71	1208.12	1210.68	1210.68	1211.48	0.007553	4.55	97.07	56.78	0.92
MAIN	24	1 in 100	455.06	1208.12	1210.95	1210.95	1211.88	0.00764	4.9	112.5	57.6	0.94
MAIN	23	1 in 50	361.71	1207.64	1211.12	1211.12	1211.93	0.006187	4.45	103.45	66.63	0.85
MAIN	23	1 in 100	455.06	1207.64	1211.43	1211.43	1212.31	0.006112	4.74	125.1	74.17	0.86
MAIN	22	1 in 50	361.71	1207.35	1210.95	1210.95	1211.83	0.006545	4.55	98.41	61.54	0.87
MAIN	22	1 in 100	455.06	1207.35	1211.32	1211.32	1212.24	0.006119	4.77	122.69	72.39	0.86
MAIN	21	1 in 50	361.71	1208.3	1211.48	1211.48	1212.33	0.007018	4.44	95.98	54.83	0.89

MAIN	21	1 in 100	455.06	1208.3	1211.77	1211.77	1212.74	0.007064	4.79	112.04	56.16	0.91
MAIN	20	1 in 50	361.71	1207.38	1209.37	1209.85	1210.99	0.023595	6.31	69.74	61.3	1.53
MAIN	20	1 in 100	455.06	1207.38	1209.57	1210.1	1211.39	0.02328	6.72	81.66	61.88	1.55
MAIN	19	1 in 50	361.71	1207.57	1209.43	1209.43	1210.1	0.009244	4.04	103.56	74.29	0.97
MAIN	19	1 in 100	455.06	1207.57	1209.65	1209.65	1210.43	0.009079	4.33	120.34	74.29	0.98
MAIN	18	1 in 50	361.71	1206.23	1208.99	1208.99	1209.74	0.007219	4.44	101.64	62.25	0.9
MAIN	18	1 in 100	455.06	1206.23	1209.24	1209.24	1210.11	0.007429	4.8	117.14	62.25	0.93
MAIN	17	1 in 50	361.71	1204.67	1206.97	1207.36	1208.29	0.017433	5.95	79.77	70.45	1.35
MAIN	17	1 in 100	455.06	1204.67	1207.17	1207.59	1208.63	0.017366	6.32	93.87	72.36	1.37
MAIN	16	1 in 50	361.71	1206.28	1208.04	1208.04	1208.6	0.008904	3.74	114.4	94.99	0.93
MAIN	16	1 in 100	455.06	1206.28	1208.23	1208.23	1208.88	0.008923	4.03	132.22	94.99	0.95
MAIN	15	1 in 50	361.71	1202.46	1205.17	1205.82	1207.12	0.020137	6.67	64.26	47.21	1.46
MAIN	15	1 in 100	455.06	1202.46	1205.51	1206.15	1207.48	0.017369	6.83	81.28	54.02	1.39
MAIN	14	1 in 50	361.71	1199.07	1201.79	1202.74	1204.69	0.033072	7.82	51.67	41.43	1.83
MAIN	14	1 in 100	455.06	1199.07	1202.05	1203.07	1205.25	0.031627	8.33	63.16	48.23	1.83
MAIN	13	1 in 50	361.71	1201.28	1204.07	1204.07	1204.67	0.005745	4.09	120.14	87.95	0.81
MAIN	13	1 in 100	455.06	1201.28	1204.21	1204.21	1204.98	0.006885	4.64	132.85	89.24	0.89
MAIN	12	1 in 50	361.71	1199.77	1202.97	1202.97	1204.12	0.009593	5.24	84.1	52.73	1.04
MAIN	12	1 in 100	455.06	1199.77	1203.6	1203.62	1204.45	0.005742	4.69	127.26	73.19	0.84
MAIN	11	1 in 50	361.71	1199.54	1201.78	1202.3	1203.47	0.022303	5.78	63.83	45.87	1.47
MAIN	11	1 in 100	455.06	1199.54	1202.06	1202.63	1203.93	0.020088	6.11	77.18	49.73	1.43

MAIN	10	1 in 50	361.71	1200.29	1202.94	1202.94	1203.85	0.007572	4.42	91.87	54.46	0.92
MAIN	10	1 in 100	455.06	1200.29	1203.3	1203.3	1204.28	0.007033	4.67	112.25	61.22	0.9
MAIN	9	1 in 50	361.71	1201.36	1203.42	1203.42	1204.1	0.008527	3.96	106.15	82.33	0.93
MAIN	9	1 in 100	455.06	1201.36	1203.73	1203.73	1204.42	0.007242	4.05	134.91	95.63	0.88
MAIN	8	1 in 50	361.71	1200.21	1202.33	1202.54	1203.16	0.012348	4.97	99.55	91.26	1.13
MAIN	8	1 in 100	455.06	1200.21	1202.48	1202.8	1203.49	0.014084	5.57	113.3	98.55	1.23
MAIN	7	1 in 50	361.71	1198.74	1201.91	1201.91	1202.63	0.006311	4.62	109.77	72.29	0.86
MAIN	7	1 in 100	455.06	1198.74	1202.24	1202.24	1202.97	0.005784	4.74	134.83	78.49	0.84
MAIN	6	1 in 50	361.71	1198.92	1201.4	1201.4	1202.15	0.007581	4.4	104.12	72.63	0.92
MAIN	6	1 in 100	455.06	1198.92	1201.73	1201.73	1202.5	0.006805	4.55	129.79	82.36	0.89
MAIN	5	1 in 50	361.71	1197.99	1200.52	1200.78	1201.55	0.011657	5.18	90.16	72.14	1.12
MAIN	5	1 in 100	455.06	1197.99	1200.74	1201.08	1201.93	0.012112	5.64	107.21	81.54	1.16
MAIN	4	1 in 50	361.71	1197.89	1199.4	1199.86	1200.82	0.02495	5.66	73.26	72.11	1.53
MAIN	4	1 in 100	455.06	1197.89	1199.59	1200.06	1201.18	0.024205	6.06	87.28	77.43	1.53
MAIN	3	1 in 50	361.71	1197.96	1199.82	1199.82	1200.47	0.010355	4.24	103.02	77.19	1.02
MAIN	3	1 in 100	455.06	1197.96	1200.04	1200.04	1200.8	0.010065	4.52	119.7	77.19	1.03
MAIN	2	1 in 50	361.71	1194.65	1196.52	1197.28	1198.85	0.032259	7.18	58.19	52.36	1.78
MAIN	2	1 in 100	455.06	1194.65	1196.77	1197.61	1199.24	0.029407	7.51	71.8	58.79	1.74
MAIN	1	1 in 50	361.71	1195.97	1197.73	1197.73	1198.3	0.009532	3.98	112.33	93.59	0.97
MAIN	1	1 in 100	455.06	1195.97	1197.92	1197.92	1198.58	0.009387	4.24	130.24	93.59	0.98

Table 2: iNguduma tributary 2

Reach	River sta	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S Elev (m)	Crit W.S (m)	E.G Elev (m)	E.G Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude #Chl
MAIN	21	1 in 50	147	1229.55	1230.38	1230.38	1230.67	0.017783	4.33	35.9	69.33	0.93
MAIN	21	1 in 100	184.85	1229.55	1230.49	1230.49	1230.8	0.016074	4.56	44.17	80.64	0.91
MAIN	20	1 in 50	147	1227.22	1227.76	1227.76	1227.96	0.024436	3.61	40.86	103.82	1
MAIN	20	1 in 100	184.85	1227.22	1227.83	1227.83	1228.06	0.022611	3.84	48.41	106.37	0.99
MAIN	19	1 in 50	147	1223.03	1223.69	1223.63	1223.82	0.012826	3.11	52	125.65	0.76
MAIN	19	1 in 100	184.85	1223.03	1223.75	1223.69	1223.91	0.013518	3.43	59.44	128.9	0.79
MAIN	18	1 in 50	147	1221.91	1222.43	1222.43	1222.61	0.022874	3.5	44.39	127.27	0.97
MAIN	18	1 in 100	184.85	1221.91	1222.49	1222.49	1222.7	0.021586	3.74	52.47	131.28	0.97
MAIN	17	1 in 50	147	1219.21	1219.95	1219.91	1220.12	0.012361	3.58	48.92	111.32	0.78
MAIN	17	1 in 100	184.85	1219.21	1220.02	1219.98	1220.21	0.013022	3.92	56.68	118.18	0.81
MAIN	16	1 in 50	13.15	1218.52	1218.76	1218.76	1218.81	0.031915	1.76	7.49	67.21	0.93
MAIN	16	1 in 100	16.43	1218.52	1218.78	1218.78	1218.84	0.036298	1.95	8.42	70.97	1
MAIN	15	1 in 50	13.15	1215.96	1216.16		1216.19	0.010253	1.19	11.02	75.41	0.55
MAIN	15	1 in 100	16.43	1215.96	1216.18		1216.2	0.012797	1.38	11.93	77.69	0.62
MAIN	14	1 in 50	13.15	1214.83	1215.03		1215.05	0.012117	1.08	12.17	110.25	0.57
MAIN	14	1 in 100	16.43	1214.83	1215.05		1215.07	0.009505	1.09	15.12	114.92	0.52
MAIN	13	1 in 50	13.15	1211	1211.22	1211.19	1211.24	0.016626	1.14	11.49	120.08	0.65

MAIN	13	1 in 100	16.43	1211	1211.22	1211.21	1211.25	0.023143	1.38	11.91	120.7	0.77
MAIN	12	1 in 50	13.15	1209.09	1209.26		1209.27	0.011165	1.01	13.06	124.9	0.55
MAIN	12	1 in 100	16.43	1209.09	1209.28		1209.3	0.008705	1.02	16.28	129.3	0.5
MAIN	11	1 in 50	13.15	1207	1207.35		1207.39	0.011388	1.63	8.11	40.64	0.62
MAIN	11	1 in 100	16.43	1207	1207.36	1207.31	1207.42	0.015032	1.94	8.56	41.59	0.72
MAIN	10	1 in 50	13.15	1206.19	1206.69		1206.7	0.003062	1	13.13	47.19	0.33
MAIN	10	1 in 100	16.43	1206.19	1206.76		1206.78	0.002401	0.98	16.85	52.46	0.3
MAIN	9	1 in 50	63.1	1205.67	1206.43		1206.45	0.00159	1.19	57.72	128.49	0.27
MAIN	9	1 in 100	78.87	1205.67	1206.49		1206.52	0.00168	1.31	66.29	135.55	0.29
MAIN	8	1 in 50	63.1	1205.29	1205.59	1205.59	1205.7	0.028323	2.59	24.69	123.11	0.98
MAIN	8	1 in 100	78.87	1205.29	1205.63	1205.63	1205.75	0.026494	2.77	29.16	130.13	0.97
MAIN	7	1 in 50	63.1	1203.22	1203.65		1203.67	0.003732	1.4	54.21	191.99	0.39
MAIN	7	1 in 100	78.87	1203.22	1203.71		1203.74	0.003096	1.41	66.93	200.59	0.37
MAIN	6	1 in 50	63.1	1202.03	1202.55		1202.59	0.005252	1.86	45.39	165.96	0.48
MAIN	6	1 in 100	78.87	1202.03	1202.57		1202.62	0.007017	2.2	48.01	169.44	0.56
MAIN	5	1 in 50	63.1	1201.37	1201.72		1201.75	0.007146	1.75	46.59	215.77	0.53
MAIN	5	1 in 100	78.87	1201.37	1201.79		1201.82	0.004907	1.64	62.01	246.91	0.45
MAIN	4	1 in 50	63.1	1200.35	1200.92		1200.95	0.005239	2.05	47.9	198.67	0.49
MAIN	4	1 in 100	78.87	1200.35	1200.91		1200.97	0.008847	2.64	46.45	195.69	0.63
MAIN	3	1 in 50	63.1	1198.23	1198.79	1198.79	1199.01	0.027006	4.47	18.83	68.63	1.1
MAIN	3	1 in 100	78.87	1198.23	1198.94	1198.94	1199.06	0.011324	3.46	36.39	139.52	0.74

MAIN	2	1 in 50	63.1	1197	1197.5		1197.52	0.001499	1.03	67.04	159.77	0.26
MAIN	2	1 in 100	78.87	1197	1197.57		1197.58	0.00146	1.1	77.53	159.77	0.26
MAIN	1	1 in 50	63.1	1196.51	1197.14	1197.14	1197.25	0.012523	3.04	28.4	111.68	0.75
MAIN	1	1 in 100	78.87	1196.51	1197.17	1197.17	1197.3	0.015488	3.48	30.94	112.69	0.84

Table 3: iNguduma tributary 2 reach 1

Reach	River sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S Elev (m)	Crit W.S (m)	E.G Elev (m)	E.G Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude #Chl
MAIN	16	1 in 50	13.15	1267.36	1266.38	1266.38	1266.47	0.031551		5.4	29.16	0
MAIN	16	1 in 100	16.43	1267.36	1266.41	1266.41	1266.51	0.030915		6.44	31.91	0
MAIN	15	1 in 50	13.15	1259.45	1259.7	1259.7	1259.77	0.029234	2.1	6.54	52.56	0.94
MAIN	15	1 in 100	16.43	1259.45	1259.73	1259.73	1259.8	0.026263	2.2	7.93	56.06	0.91
MAIN	14	1 in 50	13.15	1252.16	1252.55	1252.55	1252.67	0.028903	2.68	4.97	24.45	0.99
MAIN	14	1 in 100	16.43	1252.16	1252.6	1252.6	1252.72	0.025059	2.79	6.05	26.88	0.95
MAIN	13	1 in 50	13.15	1248	1248.17	1248.17	1248.24	0.034248	2.2	5.99	40.9	1.01
MAIN	13	1 in 100	16.43	1248	1248.2	1248.2	1248.28	0.031965	2.31	7.11	42.76	0.99
MAIN	12	1 in 50	13.15	1239.87	1240.55	1240.51	1240.68	0.019233	2.89	4.54	13.12	0.87
MAIN	12	1in 100	16.43	1239.87	1240.6	1240.57	1240.75	0.020835	3.15	5.21	14.04	0.91
MAIN	11	1 in 50	13.15	1239	1239.35	1239.35	1239.45	0.028125	2.53	5.26	27.59	0.97
MAIN	11	1 in 100	16.43	1239	1239.38	1239.38	1239.49	0.026451	2.71	6.22	29.64	0.96

MAIN	10	1 in 50	13.15	1235.5	1235.73	1235.73	1235.81	0.03196	2.32	5.68	34.11	0.99
MAIN	10	1 in 100	16.43	1235.5	1235.76	1235.76	1235.85	0.030245	2.48	6.65	34.98	0.99
MAIN	9	1 in 50	13.15	1232.3	1232.64	1232.64	1232.74	0.024488	2.57	5.44	28.99	0.92
MAIN	9	1 in 100	16.43	1232.3	1232.68	1232.68	1232.79	0.023239	2.74	6.49	31.28	0.92
MAIN	8	1 in 50	13.15	1229.57	1229.79	1229.79	1229.86	0.033818	2.16	6.08	41.62	1
MAIN	8	1 in 100	16.43	1229.57	1229.82	1229.82	1229.9	0.032375	2.3	7.15	43.31	1
MAIN	7	1 in 50	13.15	1226.7	1227.03	1227.03	1227.12	0.029523	2.43	5.5	32.54	0.98
MAIN	7	1 in 100	16.43	1226.7	1227.06	1227.06	1227.16	0.026573	2.56	6.63	35.63	0.95
MAIN	6	1 in 50	13.15	1224.4	1224.76	1224.72	1224.82	0.016943	2.05	6.64	35.83	0.76
MAIN	6	1 in 100	16.43	1224.4	1224.78	1224.75	1224.86	0.017235	2.24	7.72	38.45	0.78
MAIN	5	1 in 50	13.15	1223.84	1224.06		1224.11	0.017223	1.75	7.57	45.89	0.74
MAIN	5	1 in 100	16.43	1223.84	1224.08	1224.05	1224.14	0.017707	1.93	8.65	47.72	0.76
MAIN	4	1 in 50	13.15	1223.09	1223.29	1223.28	1223.35	0.023797	1.96	6.94	49.48	0.85
MAIN	4	1 in 100	16.43	1223.09	1223.32	1223.31	1223.38	0.02293	2.11	8.17	52.41	0.86
MAIN	3	1 in 50	13.15	1221.45	1221.62	1221.61	1221.68	0.028921	2.06	6.49	47.03	0.93
MAIN	3	1 in 100	16.43	1221.45	1221.63	1221.63	1221.71	0.030271	2.28	7.39	48.75	0.97
MAIN	2	1 in 50	13.15	1219.21	1219.56	1219.56	1219.64	0.020111	2.62	6.32	37.37	0.86
MAIN	2	1 in 100	16.43	1219.21	1219.6	1219.6	1219.68	0.016065	2.59	8.46	59.4	0.79
MAIN	1	1 in 50	13.15	1217.96	1218.17	1218.17	1218.24	0.024553	2.19	7.01	56.45	0.89
MAIN	1	1 in 100	16.43	1217.96	1218.2	1218.2	1218.27	0.022133	2.28	8.65	63.17	0.86

Table 4: iNguduma tributary 2 reach 2

Reach	River sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S Elev (m)	Crit W.S (m)	E.G Elev (m)	E.G Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude #Chl
MAIN	34	1 in 50	63.1	1280.51	1281.41	1281.41	1281.65	0.01078	2.47	32.12	69.91	0.91
MAIN	34	1 in 100	78.87	1280.51	1281.5	1281.5	1281.76	0.010325	2.61	38.88	77.92	0.9
MAIN	33	1 in 50	63.1	1277.22	1278.19	1278.19	1278.48	0.01058	2.5	28.88	54.48	0.9
MAIN	33	1 in 100	78.87	1277.22	1278.3	1278.3	1278.61	0.009925	2.64	35.09	60.93	0.89
MAIN	32	1 in 50	63.1	1274.49	1275.22	1275.22	1275.42	0.011069	2.19	34.29	82.06	0.89
MAIN	32	1 in 100	78.87	1274.49	1275.29	1275.29	1275.52	0.01115	2.36	39.8	83.87	0.91
MAIN	31	1 in 50	63.1	1270.7	1271.93	1271.93	1272.27	0.010187	2.67	26.49	42.85	0.9
MAIN	31	1 in 100	78.87	1270.7	1272.06	1272.06	1272.42	0.009514	2.82	32.12	47.2	0.89
MAIN	30	1 in 50	63.1	1268.09	1268.67	1268.67	1268.87	0.013668	2.05	32.64	84.75	0.94
MAIN	30	1 in 100	78.87	1268.09	1268.74	1268.74	1268.97	0.012623	2.17	39.22	91.66	0.93
MAIN	29	1 in 50	63.1	1264.22	1265.3	1265.29	1265.59	0.012908	2.36	27.05	48.37	0.96
MAIN	29	1 in 100	78.87	1264.22	1265.39	1265.39	1265.72	0.012745	2.56	31.5	51.95	0.97
MAIN	28	1 in 50	63.1	1263.38	1264.03	1264.03	1264.25	0.012886	2.09	32.03	79.74	0.93
MAIN	28	1 in 100	78.87	1263.38	1264.11	1264.11	1264.35	0.011998	2.21	38.37	83.61	0.92
MAIN	27	1 in 50	63.1	1256.41	1258.01	1258.01	1258.44	0.010351	2.95	22.6	28.41	0.93
MAIN	27	1 in 100	78.87	1256.41	1258.17	1258.17	1258.64	0.009524	3.11	27.39	31.43	0.91
MAIN	26	1 in 50	63.1	1256	1256.97		1257.03	0.002091	1.17	61.4	96.79	0.41

MAIN	26	1 in 100	78.87	1256	1257.05		1257.12	0.00227	1.29	69.3	98.68	0.43
MAIN	25	1 in 50	63.1	1256	1256.34	1256.34	1256.48	0.017769	1.69	38.01	135.16	0.99
MAIN	25	1in 100	78.87	1256	1256.38	1256.38	1256.55	0.017117	1.82	44.11	136.46	1
MAIN	24	1 in 50	63.1	1247.71	1248.66	1248.66	1248.94	0.013601	2.33	27.76	54.13	0.97
MAIN	24	1 in 100	78.87	1247.71	1248.76	1248.76	1249.06	0.01242	2.47	33.16	56.92	0.95
MAIN	23	1 in 50	63.1	1244.06	1245.25	1245.25	1245.56	0.014124	2.47	25.59	41.3	1
MAIN	23	1 in 100	78.87	1244.06	1245.36	1245.36	1245.71	0.013418	2.61	30.32	45	0.99
MAIN	22	1 in 50	63.1	1241.13	1241.75	1241.75	1241.97	0.015893	2.1	30.15	69.77	1
MAIN	22	1 in 100	78.87	1241.13	1241.82	1241.82	1242.08	0.01476	2.24	35.46	72.93	0.99
MAIN	21	1 in 50	63.1	1234.27	1235.64	1235.59	1235.94	0.009318	2.48	26.72	39.78	0.86
MAIN	21	1 in 100	78.87	1234.27	1235.72	1235.72	1236.1	0.010465	2.79	30.07	42.31	0.92
MAIN	20	1 in 50	63.1	1234.05	1234.63	1234.63	1234.83	0.016623	1.99	31.77	80.23	1.01
MAIN	20	1 in 100	78.87	1234.05	1234.69	1234.69	1234.92	0.015954	2.11	37.3	83.11	1.01
MAIN	19	1 in 50	63.1	1231.08	1231.68	1231.68	1231.86	0.015876	1.9	33.85	98.43	0.98
MAIN	19	1 in 100	78.87	1231.08	1231.74	1231.74	1231.95	0.014728	2.03	40.17	104.12	0.97
MAIN	18	1 in 50	63.1	1229.31	1229.69	1229.69	1229.8	0.015919	1.79	44.69	191.66	0.97
MAIN	18	1 in 100	78.87	1229.31	1229.73	1229.73	1229.86	0.015848	1.91	51.61	193.98	0.98
MAIN	17	1 in 50	63.1	1226	1226.5	1226.5	1226.66	0.017518	1.79	35.31	110.69	1
MAIN	17	1 in 100	78.87	1226	1226.55	1226.55	1226.74	0.016692	1.93	41.23	112.96	1
MAIN	16	1 in 50	63.1	1223.26	1224.11	1224.11	1224.27	0.008373	2.14	41.85	117.82	0.79
MAIN	16	1 in 100	78.87	1223.26	1224.17	1224.17	1224.35	0.008706	2.29	48.43	119.89	0.82

MAIN	15	1 in 50	63.1	1220.86	1221.54	1221.54	1221.74	0.011952	2.14	35.47	95.01	0.91
MAIN	15	1 in 100	78.87	1220.86	1221.63	1221.63	1221.82	0.010422	2.19	44.06	104.62	0.87
MAIN	14	1 in 50	63.1	1218.79	1219.26	1219.26	1219.4	0.011907	1.68	42.28	156.77	0.85
MAIN	14	1 in 100	78.87	1218.79	1219.31	1219.31	1219.46	0.01214	1.82	49.2	160	0.88
MAIN	13	1 in 50	63.1	1217.24	1217.71	1217.71	1217.87	0.014325	1.84	36.79	115.49	0.93
MAIN	13	1 in 100	78.87	1217.24	1217.77	1217.77	1217.95	0.013695	1.96	43.32	119.1	0.93
MAIN	12	1 in 50	63.1	1215.66	1216.2		1216.31	0.009864	1.48	43.62	127.85	0.77
MAIN	12	1 in 100	78.87	1215.66	1216.25		1216.38	0.009537	1.59	50.88	131.61	0.77
MAIN	11	1 in 50	63.1	1214.86	1215.46		1215.59	0.007684	1.68	43.41	111.11	0.72
MAIN	11	1 in 100	78.87	1214.86	1215.53		1215.67	0.007736	1.81	50.67	117	0.74
MAIN	10	1 in 50	63.1	1214.43	1214.88	1214.83	1215	0.010529	1.56	41.74	134.56	0.8
MAIN	10	1 in 100	78.87	1214.43	1214.93	1214.89	1215.07	0.011019	1.72	48.87	176.92	0.83
MAIN	9	1 in 50	63.1	1213.55	1213.92	1213.92	1214.03	0.015117	1.76	46.62	209.51	0.94
MAIN	9	1 in 100	78.87	1213.55	1213.96	1213.96	1214.08	0.014839	1.86	54.42	214.91	0.95
MAIN	8	1 in 50	63.1	1212	1212.63	1212.59	1212.79	0.010815	1.82	37.31	108.87	0.84
MAIN	8	1 in 100	78.87	1212	1212.67	1212.67	1212.87	0.012059	2.04	42.51	120.79	0.9
MAIN	7	1 in 50	63.1	1211.15	1211.77	1211.77	1211.96	0.012676	2.02	35.15	99.76	0.91
MAIN	7	1 in 100	78.87	1211.15	1211.85	1211.85	1212.04	0.010731	2.06	44.62	130.15	0.86
MAIN	6	1 in 50	63.1	1209.82	1210.59	1210.59	1210.76	0.009919	2.06	39.55	117.45	0.84
MAIN	6	1 in 100	78.87	1209.82	1210.65	1210.65	1210.84	0.009879	2.19	47.06	125.9	0.85
MAIN	5	1 in 50	63.1	1208.5	1209.07	1208.97	1209.15	0.005725	1.4	53.5	137.86	0.62

MAIN	5	1 in 100	78.87	1208.5	1209.13		1209.22	0.005602	1.49	62.02	140.1	0.62
MAIN	4	1 in 50	63.1	1208	1208.39	1208.37	1208.53	0.015047	1.75	37.33	115.21	0.94
MAIN	4	1 in 100	78.87	1208	1208.43	1208.43	1208.61	0.015199	1.91	42.8	117.18	0.97
MAIN	3	1 in 50	63.1	1207.39	1207.51	1207.49	1207.64	0.013086	0.67	40.78	137.88	0.7
MAIN	3	1 in 100	78.87	1207.39	1207.56	1207.54	1207.71	0.013087	0.87	47.2	141.84	0.75
MAIN	2	1 in 50	63.1	1204.63	1205.28	1205.28	1205.46	0.012558	2.22	36.91	105.02	0.93
MAIN	2	1 in 100	78.87	1204.63	1205.35	1205.35	1205.54	0.012396	2.36	43.66	112.41	0.94
MAIN	1	1 in 50	63.1	1203.7	1204.21	1204.21	1204.38	0.014123	2.07	37.55	120.5	0.96
MAIN	1	1 in 100	78.87	1203.7	1204.28	1204.28	1204.45	0.012439	2.12	45.95	130.28	0.92