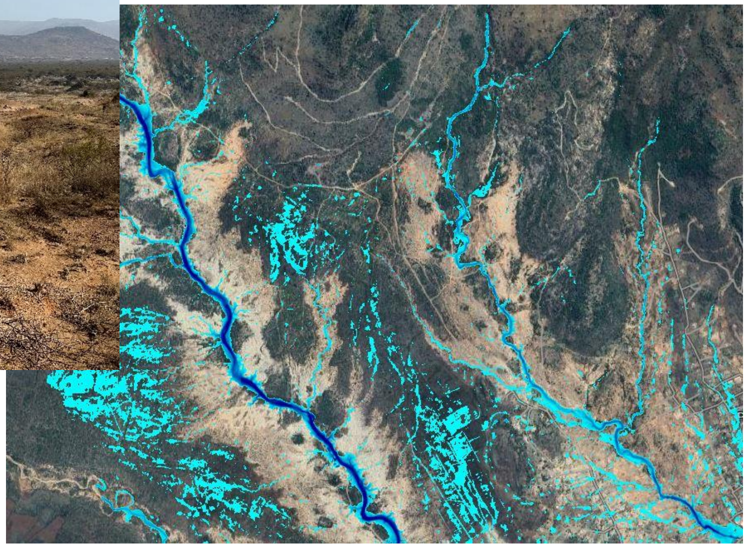
Modikwa Platinum Mine

Modikwa Platinum (Pty) Ltd

Modikwa South3 Opencast Pit Project

SWMP Design Development Report in Support of WUL Application (Including Floodline Study)



DRAFT Report (Rev0)

September 2024

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SYNOPSIS:	This is a design development report for the Modikwa South3 Opencast Pit mining project. This report includes a Surface Water Management Plan (SWMP) and Floodline assessment in support of an Integrated Water Use License Application (IWULA) and Waste Licence Application (WLA). The new DWS requirements for the waste management application are included which covers the standard Waste Checklist and Construction Quality Assurance (CQA) Report.			
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Signed on behalf of Onno Fortuin Consulting (Pty) Ltd (OFC)	

Revision History

Revision	History	Date	Approved
0	DRAFT Report to Segope for comments	2024/09/02	H O Fortuin

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

Onno Fortuin Consulting (Pty) Ltd (OFC) was appointed by Segope Water and Environment Services (Segope) to develop an Integrated Surface-Water Management Plan (SWMP) for the Modikwa South3 Opencast Project. This study is required in support of an EA/ WUL process that is undertaken for Modikwa Platinum (Modikwa).

The Modikwa South3 Opencast Pit evaluation area is located near Steelpoort to the north of the R555 provincial road from Middelburg to Steelpoort, as shown below in **Figure 1-1**.

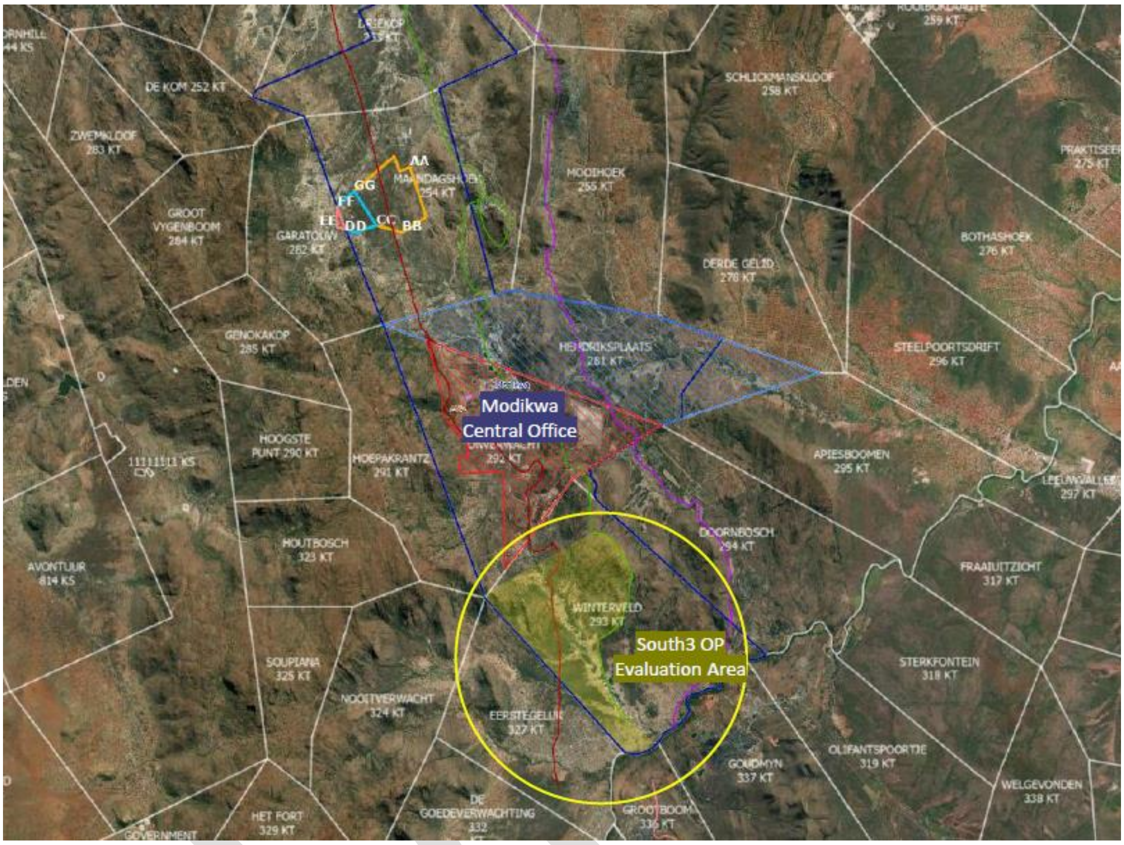

Figure 1-1: Layout Plan – Showing the Modikwa South3 OP Study Area north of the R555 Provincial Road

Modikwa Platinum Mine (MPM) intends to open the Modikwa South3 opencast pit on the farm Winterveld 293 KT located within the Fetakgomo Tubatse Municipality of the Sekhukhune District in the Limpopo Province.

Opencast mining methods will be followed with concurrent backfilling and rehabilitation as the pit extensions progress. Ore from the open pit will be extracted by a combination of excavation, crushing, and washing where the ore will be transported by truck to the Modikwa South2 Shaft, located approximately 6km to the north of the South3 opencast mining activities.

1.2 Background

The Modikwa South3 Opencast Project is located approximately 2km north of the R555 road and approximately 5km west of the town of Steelpoort. The study area is shown below in **Figure 1-2**.

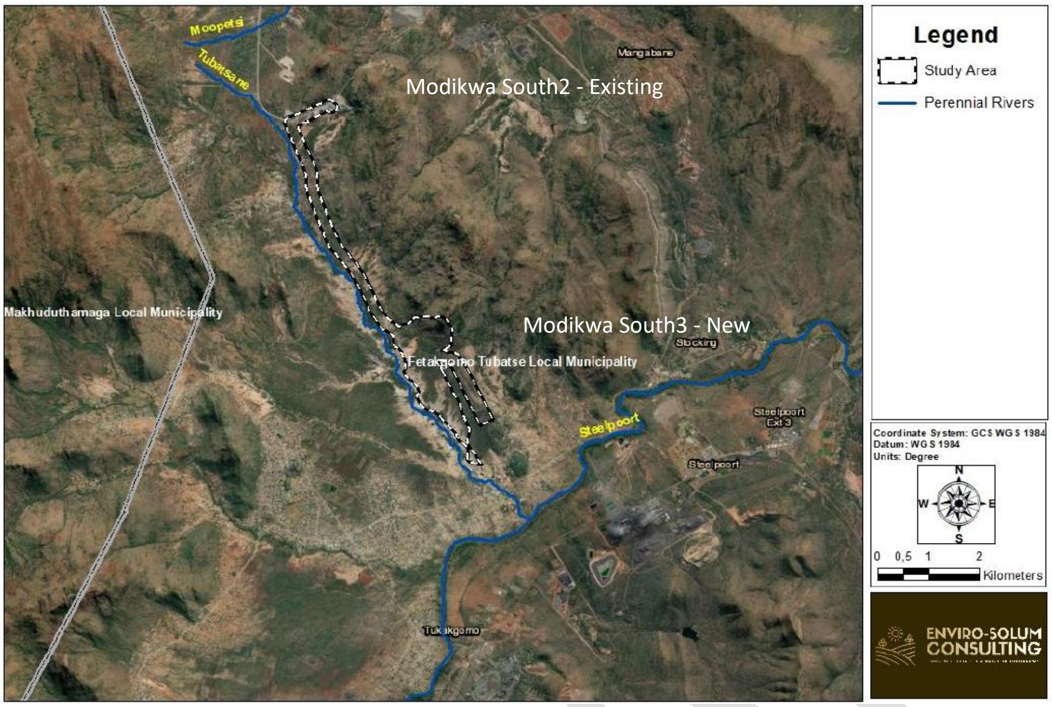

Figure 1-2: Modikwa South3 Opencast Project - Showing the Study Area (Courtesy Enviro-Solum)

The proposed Opencast Shells are shown below in **Figure 1-3**.

Figure 1-3: Modikwa South3 Opencast Project - Showing the Mining Shells (Courtesy Enviro-Solum)

1.3 Definitions & Abbreviations

Organisation

DEA	Department of Environmental Affairs
DWS	Department of Water & Sanitation
DMR	Department of Mineral Resources
Modikwa	Modikwa South3 Opencast Project
NEMBA	National Environmental Management Biodiversity Act
OFC	Onno Fortuin Consulting (Pty) Ltd
Segope	Segope Water and Environment Services
WMA	Water Management Agency
WRC	Water Research Commission

Technical

ABA	Acid Based Accounting
BAS	Best Attainable State
CoP	Code of Practice
DCP	Dynamic Cone Penetration
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EC	Ecological Category
ECL	Environmental Critical Level
ECO	Environmental Control Officer
EI	Ecological Importance
EIS	Ecological Impact & Sensitivity
EMP	Environmental Management Plan
FoS	Factor of Safety
GCL	Geosynthetic Clay Liner
GN	Government Notice
GNR	Government Notice Regulation
HDPE	High-density polyethylene
IWULA	Integrated Water Use Licence Application
LCT	Leachable Concentration Threshold
LoM	Life of Mine
MAP	Mean Annual Precipitation
MAE	Mean Annual Evaporation
MAR	Mean Annual Runoff
MPRDA	Mineral and Petroleum Resources Development Act
MRA	Mining Right Area
MRF	Mine Residue Facility
MTIS	Mineable Tons In-Situ
NPR	Neutralization Potential Rating

OMC	Optimum Moisture Content
PAG	Potential Acid Generation
PCD	Pollution Control Dam
PES	Present Ecological Status
REC	Recommended Ecological Category
RMO	Recommended Management Objective
SWMP	Surface Water Management Plan
SWMM	Surface Water Management Model
TCT	Total Concentration Threshold
WML	Waste Management Licence
WUL	Water Use Licence

Survey

DEM	Digital Elevation Model
Ha	hectares
mbgl	metres below ground level
masl	metres above sea level
LIDAR	Light Detection and Ranging
NGL	Natural Ground Level
SRTM	Shuttle Radar Topography Mission
WGS84	World Geodetic System 1984 – LO29

Symbols

γ_{nat}	Field or natural unit weight, kN/m^3
γ_{sat}	Saturated unit weight, kN/m^3
SG	Specific Gravity
Φ'	Effective stress angle of internal friction, degrees
c'	Cohesion in terms of effective stresses, kPa
cv	Coefficient of consolidation, m^2/day
mv	Coefficient of volume compressibility, 1/MPa
k	Permeability, m/day

2. HYDROLOGICAL LEGISLATION

Various guideline documents and regulatory requirements were studied to ensure that the storm water measures so proposed for the Mine will in fact ensure legal compliance once these remedial actions are implemented by the Mine.

2.1 Regulatory and Guideline Documents

DWS Legislation

- ✓ National Water Act, 1998 (Act 36 of 1998)
- ✓ GN 704 of 4 June 1999
- ✓ GN R991 of 18 May 1984
- ✓ GN R1560 of 25 July 1986
- ✓ DWS Best Practice Guideline Documents – Activity Guidelines
- ✓ Water Quality Management Policies and Strategies in South Africa
- ✓ Minimum Requirements: Handling, Classification, and disposal of Hazardous Waste 2nd Edition 1998

Other Legislation

- ✓ National Environmental Management Waste Act (Act 59 of 2008).
- ✓ Regulations-GNR 634 - Waste Classification and Management Regulations (2013):
- ✓ GNR 635 - National Norms and Standards for the Assessment of Waste for Landfill Disposal (2013)
- ✓ GNR 636 - National Norms and Standards for Disposal of Waste to Landfill (2013)
- ✓ GNR 632 - Regulation Regarding the Planning and Management of Residue Stockpiles and Residue Deposits (2015)
- ✓ Environment Conservation Act, 1989 (Act 73 of 1989)
- ✓ Minerals and Petroleum Resources Development Act (Act 28 of 2002)
- ✓ GN R992 of 26 June 1970
- ✓ National Environmental Management Act, 1998 (Act 107 of 1998)
- ✓ Health Act 2003 (Act 61 of 2003)
- ✓ Municipal By-laws
- ✓ Conservation of Agricultural Resources Act (Act 63 of 1970)
- ✓ Nature Conservation Ordinance (No. 12 of 1983)
- ✓ Constitution of South Africa (Act 108 of 1996)

2.2 Legal Framework

2.2.1 Constitution of RSA, 1996 (Act 108 of 1996)

The Constitution of South Africa specifies the environmental right of the people of South Africa. It then more specifically states that the environment should not be harmful to the health and well-being of its citizens and for the environment to be protected for the benefit of present and future generations.

2.2.2 National Environmental Management Act, 1998 (Act No. 107 of 1998)

The National Environmental Management Act (NEMA) provides the guiding legislation and framework for environmental management in South Africa. The act more specifically describes a set of fundamental guiding principles governing the actions of those organs of state that may significantly affect the environment. The Department of Water Affairs & Sanitation (DWS) is thus guided by these principles in the development and implementation of various policies and strategies.

2.2.3 Minerals and Petroleum Resources Development Act, (Act No 28 of 2002)

The Minerals and Petroleum Resources Development Act (MPRDA) regulates the overall mining process and provides for safety and health in the mining industry. The Act supports the principles of Integrated Water Resource Management (IWRM) by promoting the goal of sustainable development in the process of developing the mineral and petroleum resources of the country.

2.2.4 National Water Act, 1998 (Act No. 36 of 1998)

The National Water Act (NWA) emphasises the effective management of South Africa's water resources through the basic principles of Integrated Water Resources Management (IWRM).

In terms of the Act, various regulations have been developed to regulate, protect, and manage water that is being used from a water resource. Section 26(4) of the Act more specifically has regulations where water users must ensure the following:

- Promoting economic and sustainable use of water
- Conserving and protecting water resources
- Preventing wasteful water use
- Facilitate the management of water use, and
- Facilitate the monitoring of water use and water resources

2.2.5 NWA: Government Notice 704 (GN 704), 1999

In terms of the NWA, specific regulations were promulgated in respect of the use of water for mining aimed at protecting water resources, referred to as **Government Notice No. 704 of 4 June 1999**.

The agreement is that DWS will subscribe to the principles of co-operative governance where DMR should co-ordinate environmental management within the mining industry as part of the EMPr process.

2.2.6 Overall Water Management Context

It is important that the development of a Storm Water Master Plan (SWMP) cannot be done in isolation where this must be guided by the overall water management context that should include the following:

- ✓ National, regional, and site-specific water management context
- ✓ Integrated mine water management in a regional context
- ✓ Mine water management requirements in terms of the life cycle phases of a mine
- ✓ Integrated regulatory and procedural guidance

2.2.7 DWS: Best Practice Guideline G1 - Storm Water Management (2008)

The Best Practice Guidelines (BPG) developed by DWS for Storm Water Management targets the waste management hierarchy as follows:

- ✓ Pollution Prevention
- ✓ Minimization of Impacts (re-use, reclamation & water treatment)
- ✓ Discharge or disposal of waste and/or wastewater (risk based approach)

We have carefully studied the G1 BPG for Storm Water Management and can report the following:

Principle 1: Keep Clean Water Clean

The SWMP model (PCSWMM) developed clearly indicates the clean vs dirty water areas so managed for the Mine.

Principle 2: Collect and Contain Dirty Water

Dirty water areas have been limited to the smallest possible footprint. All dirty water areas are drained to sumps or the in-line silt trap and eventually the PC Dam. The dirty water canals from the ROM stockpile & product stockpile are concrete lined and the dirty canals around the MRF are all HDPE lined. The PC Dam is HDPE lined (Class C barrier design) with a leakage detection system that is linked to a monitoring sump with level control pumps.

Principle 3: Sustainability over Mine Life Cycle

The dirty water facilities have been planned to ensure full compliance for the Mine life cycle. Special extended time simulations (actual rainfall records) were conducted to evaluate the sizing of the PC Dam for the 1:50 year storm event (cumulative impacts, i.e., not only the 1-day event but also cumulative over time).

The extended simulations have shown that the PC Dam has enough storage capacity over the LOM during peak storm events to contain these events with the necessary freeboard (GN704) requirement of 0.8m.

Principle 4: Consideration of Regulations & Stakeholders

This principle strongly supports effective liaison with the Department of Water Affairs & Sanitation (DWS) to ensure that ideas and concepts are confirmed to ensure that the statutory requirements are met. Allowance has been made for a technical presentation to DWS – National to discuss and explain the SWMP for the project. Comments and inputs from DWS will then be incorporated into the final documents that will be handed in for the IWULA.

The guideline document has eight (8) specific steps that are required when a new SWMP is designed and constructed for a Mine:

Step 1: Define the objectives of the storm water management plan

The following objectives have been considered in this SWMP:

- ✓ A comprehensive clean vs dirty water separation system was designed for the Mine.
- ✓ Clean water from on-surface activities is diverted away from the impacted mining activities towards the natural water courses.
- ✓ The dirty water areas have been identified as the Discard Dump, ROM stockpile, Product Stockpile, Workshops and Plant Area.
- ✓ All dirty water areas have been isolated where the runoff from these areas is routed to the Pollution Control Dam (PC Dam) or here referred to as the Return Water Dam (RWD).

- ✓ The infrastructure used to divert the clean and dirty water has been designed according to Regulation GN704 where these facilities must accommodate a 1:50 year peak storm event.

Step 2: Technical Situation Analysis

- ✓ A detailed SWMP model was developed for the Mine where we have used the Canadian software package called PCSWMM.
- ✓ All clean –and dirty water areas have been divided into catchments which are routed as part of the Mine's overall SWMP.
- ✓ The positions of the PC Dam, silt trap, cut-off berms and drains as well as canals have all been indicated on the layout plans.
- ✓ The biggest withdrawal from the PC Dam will be the plant feed followed by dust suppression (0.5 liters/m^2/hour/day assuming a 12hr working day = 6 liters/m^2/day) and evaporation from the dam surface.

Step 3: Conceptual Design and Review

- ✓ Conceptual designs were done for the surface infrastructure and optimized.
- ✓ We are of the opinion that the SWMP proposed is fully optimized and will ensure long-term compliance if implemented.

Step 4: Assess the Suitability of the Existing Infrastructure

There is no existing infrastructure.

Step 5: Define the Infrastructure Changes that are required

There is no existing infrastructure to change.

Step 6: Undertake Detailed Designs of all required Infrastructure

- ✓ The PCSWMM model was used extensively to conduct scenario modelling to optimize the SWMP. The SCS Type 3 design storms have been used in our model, which is applicable for the region.
- ✓ Three (3) rainfall scenarios were investigated to arrive at the recommended PC Dam volume. Full details will be given under the PC Dam designs section of the report.
- ✓ It can be confirmed that the PC Dam has a total storage capacity above the 1:50 year, 1-day peak storm event to ensure that the dam will not spill.
- ✓ To accommodate larger floods the PC Dam has an overflow structure designed for the 1:200-year storm event that will allow for the emergency overflows in the event of such an abnormal peak event.

Step 7: Define Operational, Management & Monitoring Systems & Responsibilities

- ✓ Special long-term extended time simulations were conducted to optimally size the PC Dam with sump and pumps to accommodate peak wet and dry weather periods that is foreseen at the Mine.
- ✓ Reference is also made to the relevant SANS & Liner Industry specifications for the liner installation to ensure that the Construction Quality Procedures (CQP) are adhered to when the liners are installed.
- ✓ Where practically possible, we have limited the impacted dirty water footprint of the Mine to a minimum.

- ✓ Hydropedological buffers identified along the boundaries of this mining area have been clearly demarcated based on the classifications obtained from the specialist. These buffers are incorporated in the General Layout Plans.
- ✓ The environmental specialist has identified a 50m buffer zone from the saturated water courses. Due care has been taken to place the surface infrastructure outside of the these buffer areas. All the SWMP infrastructure falls outside of these buffers, except for some of the clean water cut-off berms.
- ✓ A security fence has been proposed all along the impacted mining infrastructure.

Step 8: Document the SWMP

- ✓ This SWMP is in support of an Integrated WULA that will be submitted for the Mine.
- ✓ This report summarizes the preliminary design concepts that have been incorporated into the SWMP. Due cognizance has been given to operational procedures and maintenance issues that will impact the SWMP.
- ✓ The wetlands have been carefully analysed in our detail designs and we have noted all legislations and recommendations so made in the specialist reports.
- ✓ We have carefully considered the wetland areas and buffers and the SWMP designs have been placed outside of these buffers except for some clean water cut-off berms.
- ✓ We have checked our SWMP and model against the BPG – G1 Storm Water Management guideline and confirm that we do comply.

2.2.8 DWS: Operational Guideline for GN 704, (No M6.1)

In order to come up with more practical operational guidelines, a document was developed by DWS; Guideline Document for the Implementation of Regulations on use of water for mining and related activities aimed at the protection of water resources.

Specific guidelines were developed for these regulations and are practical recommendations to assist with the implementation and operation of these pollution control facilities. The following more specific operational guidelines have a direct impact on this project study area and involve the following:

Regulation 1: Definitions

The definition of ***"activity"*** incorporates the following:

- ✓ "Any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants, and
- ✓ The operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not.
- ✓ In which any substance is stockpiled, stored, accumulated, or transported for use in such process
- ✓ Out of which process any residue is derived, stored, stockpiled, accumulated, dumped, disposed of or transported.

The definition of *"activity"* clearly identifies the Lehlabile Colliery as an affected mining area that needs to be managed by the mine.

The definition of ***"dam"*** incorporates the following:

- *"dam"* includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of polluted water or water containing waste".

Regulation 3: Exemption from requirements and regulations

Exemption from the certain regulations can be granted by the Minister in his/ her own initiative, subject to such conditions as the Minister may determine. The approval of an exemption has been delegated to the Director: Water Quality Management where the applicant should follow the following route:

- ✓ Formal application to be forwarded to the Regional Director, containing at least the following:
  - Motivation and reason for exemption
  - Alternative proposal to the specific requirements of GN704
  - Impact assessment of alternative proposal
  - Management Plan associated with alternative proposal
  - Proposed performance assessment and monitoring techniques

Regulation 4: Restrictions on Locality

No person in control of a mine or activity may-;

- ✓ *"(a) locate or place any residue deposit, dam reservoir, together with any associated structure or any other facility within the 1:100-year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary…."*

This regulation is very clear and therefore prohibits the location of any stockpiles or pollution dam within the 1:100 flood-lines or within a 100m horizontal distance from any watercourse/wetland. The 1:100-year floodlines and the 100m watercourse/ buffer zone are indicated on the layout plans. All infrastructure falls outside of the 1:100-year floodline. All SWMP infrastructure falls outside the scientific wetland buffers.

Regulation 5: Restrictions on use of material

No person in control of a mine or activity may:

- ✓ "*use any residue or substance which causes or is likely to cause pollution of a water resource for the construction of any dam or other impoundment…."*

This regulation prevents the pollution of a water resource by restricting the use of certain materials for the construction of any dam or pollution control features.

Regulation 6: Capacity Requirements of Clean Water and Dirty Water Systems

- ✓ *"(a) confine any unpolluted water to a clean water system, away from any dirty area".*

This is one of the most important best management practice principles to ensure that clean water is diverted away from any contaminated or dirty water area. This goes hand-in-hand with the principle where the dirty water area must be kept as small as possible and even further minimized to ensure the least pollution effect of the water so impacted.

- ✓ *"(c) collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system:"*

Make sure that all dirty water is separated from the clean water system of the Mine by channelling this to a dedicated pollution control dam.

- ✓ *"(d) design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years, and*

- ✓ *(e) design, construct and maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level."*

Regulation 6(d) specifically stipulates that the dirty water dam must **at all-time** be capable to handle a 1:50 year flood event on-top of its **mean operating level** without spilling. A minimum freeboard of 0.8m above the full supply level must always be maintained. Evaporation of surface water has a distinct impact, and an integrated evaporation model was linked to the SWMP models so developed for the Mine.

- ✓ *"(f) design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years".*

Any associated channels so part of the dirty water system must also be able to convey and retain a 1:50 year flood event.

<u>Regulation 7: Protection of water Resource</u>

- ✓ *"(a) prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation of for purification and disposal in terms of the Act".*

The use of HDPE liners as a protective system is commonly used in the industry to prevent seepage of water from these pollution control dams into the natural environment. This condition must be read with the newly imposed waste classification where certain barrier systems are required based on the waste classification.

- ✓ *"(b) design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics".*

Water systems conveying dirty water such as channels must be lined to prevent any pollution entering the natural environment.

- ✓ *"(f) ensure that water used in any process at a mine or activity is recycled as far as practicable, and any facility, sump, pumping installation, catchment dam or other impoundment used for recycling water, is of adequate design and capacity to prevent the spillage, seepage or release of water containing waste at any time".*

Where possible and practicable, water must be re-used and recycled, and every effort must be made to ensure that the dirty water so captured in the pollution control dam is re-used instead of importing clean water into the dirty water cycle of the Mine. An extended time series simulation was run to investigate the impact of the Mine's return water strategy and how best water must be re-cycled for operational usage.

- ✓ *"(g) at all times keep any water systems free from any matter or obstructions which may affect the efficiency thereof".*

The pollution facilities so recommended must ensure that regular maintenance can be performed and effectively operated to ensure that no spillages occur. The silting of pollution control dams is a problem and need to be looked at from a practical point of view.

<u>Regulation 8: Security and Additional Measures</u>

- ✓ "(a) cause any impoundment or dam containing any poisonous, toxic or injurious substance to be effectively fenced-off so as to restrict access thereto and must erect warning notice boards at prominent locations so as to warn persons of the hazardous contents thereof".

The necessary safety measures must be put in place to ensure that the pollution dam is safe.

Regulation 9: Temporary or permanent cessation of mine or activity

- ✓ *"(a) Any person in control of a mine or activity must at either temporary or permanent cessations of operations ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations".*

Any pollution measures so designed must still be operative after mine closure and must still comply with the regulations so mentioned herewith.

Regulation 13: General

The person in control of a mine or activity must:

- ✓ *"provide the manager with the means and afford him or her every facility required to enable the manager to comply with the provisions of these regulations."*

Compliance with the requirements of these regulations ultimately remains the responsibility of the person in control of a mining or related activity.

Regulation 14: Offences and penalties

- ✓ *"(1) Any person who contravenes or, subject to regulation 3, fails to comply with the rest of the regulations is guilty of an offence and liable on conviction to a fine or imprisonment for a period not exceeding five years".*

This regulation clearly outlines the offences and penalties involved should these regulations are not implemented on a mine.

Regulation 16: Commencement

- ✓ *"These regulations will take effect on the date of publication".*

These regulations came into effect on **4 June 1999**. These regulations may not legally be applied retrospectively; however, they lay down certain minimum requirements that be complied with. Should a mining or related activity not comply with these requirements, a reasonable time period shall be granted for the activity to become compliant. The emphasis for existing activities should be placed on progressive improvements within a time frame stipulated by DWA.

2.3 Government Notice 36784 – DEA Waste Classification & Management

Previously, the mining residue management was covered under the MPRDA. This has changed when on 2 June 2014, the National Environmental Management – Waste Amendment Act (NEMWA), - Act No. 26 of 2014 was published which included residue deposits and stockpiles under the environmental waste legislation.

Under schedule 3 of the Act, mine waste is categorised under the Hazardous Waste sector. The understanding being that mine waste is considered hazardous unless proven differently by the mine. This new waste classification act therefore regards residue deposits and residue stockpiles as waste which was promulgated on 23 August 2013 and is regulated as follows:

- ✓ Regulation R635 - National Norms and Standards for the assessment of waste for landfill disposal
- ✓ Regulation R636 – National Norms and Standards for the disposal of waste to landfill

According to SANS 10234, all waste generators must ensure that the waste they generate is classified within 180 days of generation. The norms and standards specify how the waste can be classified and what barrier systems are required for a specific waste stream. The waste is classified according to the National Norms and Standards for Disposal to Landfill according to the following waste classification criteria **(Table 2-1 below).**

Table 2-1: Waste Classification Criteria (SANS 10234)

Waste Type	Total Concentrations (TC)	Leachable Concentrations (LC)	Disposal to Landfill
0	TC > TCT2	LC > LCT3	Not Allowed
1	TCT1 < TC < TCT2	LCT2 < LC < LCT3	Class A (Hh :HH)
2	TC < TCT1	LCT1 < LC < LCT2	Class B (GLB+)
3	TC < TCT1	LCT0 < LC < LCT1	Class C (GLB+)
4	TC < TCT0	LC < LCT0	Class D (GLB-)

TCT = Total Concentration Threshold
LCT = Leachable Concentration Threshold

Table 2-2 below is the landfill classification (Class A to D) for the waste types so identified in **Table 2-1** above.

Table 2-2: Disposal to Landfill Class according to Waste Type

Waste Type	Landfill Disposal Requirements
Type 0 Waste	The disposal of Type 0 waste to landfill is not allowed. The waste must be treated and re-assessed in terms of the *Norms and Standards for Assessment of Waste for Landfill Disposal.*
Type 1 Waste	Type 1 waste may only be disposed of at a Class A landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a Hh/HH landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., Department of Water Affairs and Forestry, 1998).
Type 2 Waste	Type 2 waste may only be disposed of at a Class B landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).
Type 3 Waste	Type 3 waste may only be disposed of at a Class C landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).
Type 4 Waste	Type 4 waste may only be disposed of at a Class D landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB· landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).

2.3.1 Regulation 632 for the Planning and Management of Residue Stockpiles & Residue Deposits

Amended regulations have been published (21 September 2018) to regulate the planning and management of residue stockpiles and residue deposits from a prospecting, mining, exploration, or production operation. This is an amendment to the National Environmental Management – Waste Act 59 of 2008, Regulation R632 of 24 July 2015 deals with the Planning and Management of Residue Stockpiles and Residue Deposits.

This amended regulation stipulates the following:

- ✓ The identification and assessment of **environmental impacts** arising from the establishment of residue stockpiles and residue deposits must be done as part of the Environmental Impact Assessment (EIA), and: -
- ✓ A **risk analysis** must be conducted based on the characteristics and classification of the waste to determine the appropriate mitigation and management measures.

This new regulation sets guidelines how to plan and management new Residue Stockpiles and Residue Deposits, as follows: -

1. <u>Characterisation of Residue Stockpiles and Residue Deposits:</u>

Residue Stockpiles and Residue Deposits must be characterised in terms of the potential risk to; -

- ✓ Health
- ✓ Safety hazard
- ✓ Environmental impact

The Residue Stockpiles and Residue Deposits must be characterised, in terms of; -

- ✓ Physical Characteristics
- ✓ Chemical Characteristics
- ✓ Mineral content that may include the specific gravity of the residue particles and its impact on particle segregation and consolidation

2. <u>Classification of Residue Stockpiles and Residue Deposits</u>

The classification of Residue Stockpiles and Residue Deposits must be undertaken on the following basis: -

- ✓ Characteristics of the residue material
- ✓ Location and dimensions of the deposits (height & surface area)
- ✓ Environmental components that are at risk (importance & vulnerability)
- ✓ Intensity of the potential risks (spatial extent & duration)
- ✓ Pollution impacts confirmed as a result of the Risk Analysis

3. <u>Investigation and Site Selection for Residue Stockpiles and Residue Deposits</u>

The process for the investigation and selection of a site for the Residue Stockpile & Residue Deposit must entail the following:

- ✓ Alternative sites
- ✓ Qualitative evaluation and ranking of sites
- ✓ Feasibility on the highest-ranking sites
- ✓ Geotechnical investigations in support of the alternative sites
- ✓ Geohydrological investigation
- ✓ Preferred Site
- ✓ Preferred site in terms of baseline EIA data
- ✓ Recommended barrier design in support of the preferred site

4. Design of the Residue Stockpile & Residue Deposits

The design process for the Residue Stockpile and Residue Deposits must entail the following:

- ✓ Designs undertaken by a professional civil and/or mining engineer
- ✓ Assessment of the soil profile is critical
- ✓ Account for all phases of the lifecycle
- ✓ Important design considerations to be investigated; -
  - Storm water on-and around the dump
  - Capping design to minimize the mobilization of contaminants
  - Freeboard limit of 0.5m for overtopping
  - Control of decanting of excess water under normal and storm conditions
- ✓ Design Report and Operating Manual

5. Further Actions required

Further impacts that are required involve the following:

- ✓ Impact Management
- ✓ Duties of the Right Holder or Permit
- ✓ Monitoring and Reporting Systems
- ✓ Dust Management and Control
- ✓ Decommissioning, Closure & Post Closure Management

3. WASTE CLASSIFICATION & ACID BASED ACCOUNTING

A detailed ore and waste rock assessment was conducted by SRK, "referred to as; *"Merensky Ore and Waste Rock Assessment – Modikwa Platinum Mines, dated May 2021"*. This report is included in the Environmental Assessment Practitioner (EAP) application conducted by Segope.

3.1 Waste Characterisation

SRK sampled the ore and waste rock where these included nine samples, three each for the roof, ore, and floor materials. A summary of the list of samples tested is shown below in **Table 3-1**.

Table 3-1: Summary of Merensky Ore & Waste Samples Tested

Section	Sample	Composite	Sample Preparation	Analytical Suite
Waste rock - Merensky roof	MR01	MR	Crushed, ground, and composited in equal proportions	Suite 1 and 2
	MR02			
	MR03			
Ore - Merensky ore	MO01	MO	Crushed, ground, and composited in equal proportions	
	MO02			
	MO03			
Waste rock -Merensky floor	MF02	MF	Crushed, ground, and composited in equal proportions	
	MF03			
	Merensky FW			
		3 composites		

1. **Suite 1:** Assessment and classification
2. a.) Total metals/metalloids - Aqua Regia extraction and 34 elements ICP scan to include hexavalent Cr;
3. b.) Inorganic anions - F, TCN, Cl, NH_4 (Free and Saline), NO_3 as N and SO_4; and
4. c.) Reagent water leachates - Australian Standard Leaching Procedure (AS 4439.1, 4439.2, and 4439.3) followed by semi-quantitative 33 element ICP scan for metals and determination of anions - Cl, F, NH_4, NO_3 and SO_4, and physicochemical parameters - EC, pH, Total alkalinity and TDS.

5. **Suite 2:** Characterisation
6. a.) Acid-Base Accounting (ABA) - sulfur speciation (total sulfur, sulfate, and sulfide) and carbon speciation (total and inorganic carbon);
7. b.) Net Acid Generation (NAG) test and analysis of NAG leachate; and
8. c.) XRD mineralogy.

The suite of tests conducted are indicated.

The samples were sent to Waterlab, a SANAS accredited laboratory. a laboratory for analysis. Testing was done based on Regulation 634 & 635 where the following test were performed:

- ✓ Total concentration testing
- ✓ Leach concentration testing

In addition, further Acid-Based-Accounting (ABA) testing was conducted to determine what material is expected to contribute to acid-mine drainage generation.

3.2 Waste Classification

Waste classification testing was conducted based on guidelines provided in Regulation 635. This included testing for the ABA leach testing to confirm the materials that contribute towards acid mine drainage.

Activities and infrastructure impacted by the waste classification include the following: -

- Product Stockpiles
- Waste Rock Dumps
- ROM Stockpile
- Topsoil Stockpile

3.2.1 Total Concentration Test Results

Table 3-2 below presents the total concentration (TC) of elements tested under Section 6 of GNR 635.

According to GNR 635 all the chemicals that could reasonably be expected to occur in the waste should be tested for total concentrations. The TCT0 guideline values are maximum element concentrations allowable that will ensure the protection of a water resource.

Table 3-2: Total Concentration Test Results compared to TCT Guideline Values (Courtesy SRK)

Elements in Waste	Threshold Values for Total Concentrations (mg/kg)			Total concentrations (mg/kg)		
	TCT0	TCT1	TCT2	Merensky roof	Merensky ore	Merensky floor
As, Arsenic	5.80	500	2000	<0.400	<0.400	<0.400
B, Boron	150	15 000	60 000	46	92	151
Ba, Barium	62.5	6 250	25 000	19	19	24
Cd, Cadmium	7.5	260	1040	<0.400	<0.400	<0.400
Co, Cobalt	50	5 000	20 000	104	96	72
Cr_T, Chromium Total	46 000	800 000	N/A	2 553	1 654	3 027
Cu, Copper	16	19 500	78 000	1185	1031	91
CN- (total), Cyanide Total	14	10 500	42 000	4.4	<1.55	22
Cr(VI), Chromium (VI),	6.5	500	2000	<0.010	<0.010	<0.010
F, Fluoride	100	10 000	40 000	<0.5	<0.5	<0.5
Hg, Mercury	0.93	160	640	<0.400	<0.400	<0.400
Mn, Manganese	1 000	25 000	100 000	1 542	1 475	1516
Mo, Molybdenum	40	1 000	4 000	<10	<10	<10
Ni, Nickel	91	10 600	42 400	2 754	3 007	800
Pb, Lead	20	1 900	7 600	8.0	9.2	3.2
Sb, Antimony	10	75	300	<0.400	<0.400	<0.400
Se, Selenium	10	50	200	0.4	<0.400	<0.400
V, Vanadium	150	2 680	10 720	73	52	75
Zn, Zinc	240	160 000	640 000	145	158	145

Total concentrations of boron, cobalt, copper, manganese and nickel exceeded the TCT0 threshold limits.

3.2.2 Leachable Test Results

The leach concentration test results are shown below in **Table 3-3**.

Table 3-3: Leachable Test Results compared to LCT Guidelines (Courtesy SRK)

Elements & Chemical Substances in Waste	Leachable Concentrations Threshold (LCT) Limits (mg/l)				Leachable concentrations (mg/l)		
	LCT0	LCT1	LCT2	LCT3	Merensky roof	Merensky ore	Merensky floor
Metal Ions							
As, Arsenic	0.01	0.5	1	4	<0.001	<0.001	<0.001
B, Boron	0.5	25	50	200	<0.025	<0.025	<0.025
Ba, Barium	0.7	35	70	280	<0.025	<0.025	<0.025
Cd, Cadmium	0.003	0.15	0.3	1.2	<0.001	<0.001	<0.001
Co, Cobalt	0.5	25	50	200	<0.025	<0.025	<0.025
Cr_T, Chromium Total	0.1	5	10	40	<0.025	<0.025	<0.025
Cu, Copper	1	50	100	400	<0.010	<0.010	<0.010
Hg, Mercury	0.006	0.03	0.6	2.4	0.0028	0.0015	<0.001
Mn, Manganese	0.5	25	50	200	<0.025	<0.025	<0.025
Mo, Molybdenum	0.07	3.5	7	28	<0.025	<0.025	<0.025
Ni, Nickel	0.07	3.5	7	28	<0.025	<0.025	<0.025
Pb, Lead	0.01	0.5	1	4	<0.001	<0.001	<0.001
Sb, Antimony	0.02	1	2	8	<0.001	<0.001	<0.001
Se, Selenium	0.01	0.5	1	4	0.001	<0.001	<0.001
V, Vanadium	0.2	10	20	80	<0.025	<0.025	<0.025
Zn, Zinc	5	250	500	2 000	<0.025	<0.025	<0.025
Inorganic Anions							
TDS	1000	12 500	25 000	100 000	28	26	46
Chloride	300	15 000	30 000	120 000	2	<2	<2
Sulfate, SO_4	250	12 500	25 000	100 000	2	2	<2
NO_3 as N, Nitrite-N	11	550	1100	4 400	0.2	<0.1	<0.1
Fluoride	1.5	75	150	600	<0.2	<0.2	<0.2
CN- (total), Cyanide Total	0.07	4	7	28	NA	NA	NA

The leachable concentration test results from distilled water reveal that in general, these constituents are relatively immobile under the neutral pH of the ore and waste rock and are not mobilised into the leachate with their LC all below the LCT0 limit.

The ore and waste rock are assessed to be Type 3 waste, LC < LCT0, irrespective of TC.

The ABA tests results were done to investigate the impact of Acid Mine Drainage (AMD), and more specifically the impact of sulphate on contamination discussed later.

3.2.3 Waste Types

Wastes with any element or chemical leachate concentration above the LCT0 but below or equal to the LCT1 limits, and all total concentrations below or equal to the TCT1 limits (LCT0 < LC ≤ LCT1 and TC ≤ TCT1), are Type 3 Wastes.

Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and LCT0 limits (LC ≤ LCT0 and TC ≤ TCT0), and with all chemical concentration levels also below the following total concentration limits for organics and pesticides, are Type 4 Wastes.

According GNR 636, Type 4 waste should be disposed of at a Class D and Type 3 waste at a Class C landfill design. The waste material should either be placed upon the barrier system prescribed by GNR 636 or a risk assessment should be performed to determine the optimal disposal of the waste material with the minimal impact on water resources.

Based on the testing conducted, the ore and waste rock are assessed to be Type 3 waste, LC < LCT0, irrespective of TC.

The civil infrastructure components therefore classified as a Class C engineered platform, are as follows; -

- ✓ ROM Stockpile
- ✓ Product Stockpile
- ✓ Workshop Areas
- ✓ Waste Rock Dumps
- ✓ PC Dams

The civil infrastructure components classified a Class D engineered platform, are as follows; -

- ✓ Topsoil Stockpile

3.3 Acid Based Accounting (ABA)

The geochemical characteristics of Merensky ore and waste rock is shown below **Table 3-4**.

Table 3-4: Geochemical Characteristics – Merensky Ore & Waste Rock

Facility		Merensky Ore	Merensky waste rock
Geochemical Characteristics	Current pH	Alkaline - paste pH 8.6)	Alkaline - paste pH 8.6 Roof, pH 8.8 Floor
	Future pH	Non-Acid Forming (NAF)	Uncertain Roof, and NAF Floor
	Mineralogy	Silicates - Plagioclase (54%), Enstatite (37%), Diopside (4.7%), Talc (1.5%), Biotite (1.1%),	Silicates - Plagioclase (57-59%), Enstatite (35-36%), Diopside (4.1-4.9%), Biotite (1.0%), Talc (0.7-0.8%)
	Leachate (seepage) quality	Neutral to mildly alkaline (pH 7.8 – 8.4)	Neutral to mildly alkaline (pH 7.0 – 8.5)
		Constituents of Concern - pH, alkalinity, electrical conductivity, iron, and total dissolved solids	Constituents of Concern - pH, alkalinity, electrical conductivity, iron, and total dissolved solids
	Waste type	Type 3 - due to total cobalt, copper, manganese and nickel content	Type 3 - due to total boron, cobalt, copper, manganese and nickel content
	Barrier/liner system	Class C	Class C

The geochemical risks are as follows:

- ✓ Seepage and runoff from the stockpile pose a risk to surface and groundwater quality, especially if groundwater is a source of water supply.
- ✓ Dust from the stockpile pose a risk to the surrounding community.

The following Management Recommendations are made:

- ✓ Collecting percolation and runoff from the stockpile in toe paddocks and channeling to the PCD for management (use in the plant, dust suppression and establishing vegetation).
- ✓ Monitoring the quality of toe seepage collecting in toe paddocks, dirty water dam, surface water, and groundwater for potential constituents of concern to include trends analysis.
- ✓ Diverting clean surface water away from the stockpile using runoff control diversions.
- ✓ Use of dust suppression systems including wind barriers, and irrigation.
- ✓ Continuous monitoring of dust.

4. ENVIRONMENTAL IMPACTS

Various specialist studies have been commissioned in support of this project. The more important environmental impacts are herewith summarised where this will enhance the integrated planning approach that is being followed for this project.

4.1 Geotechnical

A detailed geotechnical investigation was conducted by Andon vd Merwe Consulting Engineering Geologist in association with Dr Tom Verbeek during the month of March 2024. The complete report is attached as **Appendix B**.

Twenty (20) test pits were conducted at various focus areas of the project as shown below in **Figure 4-1**.

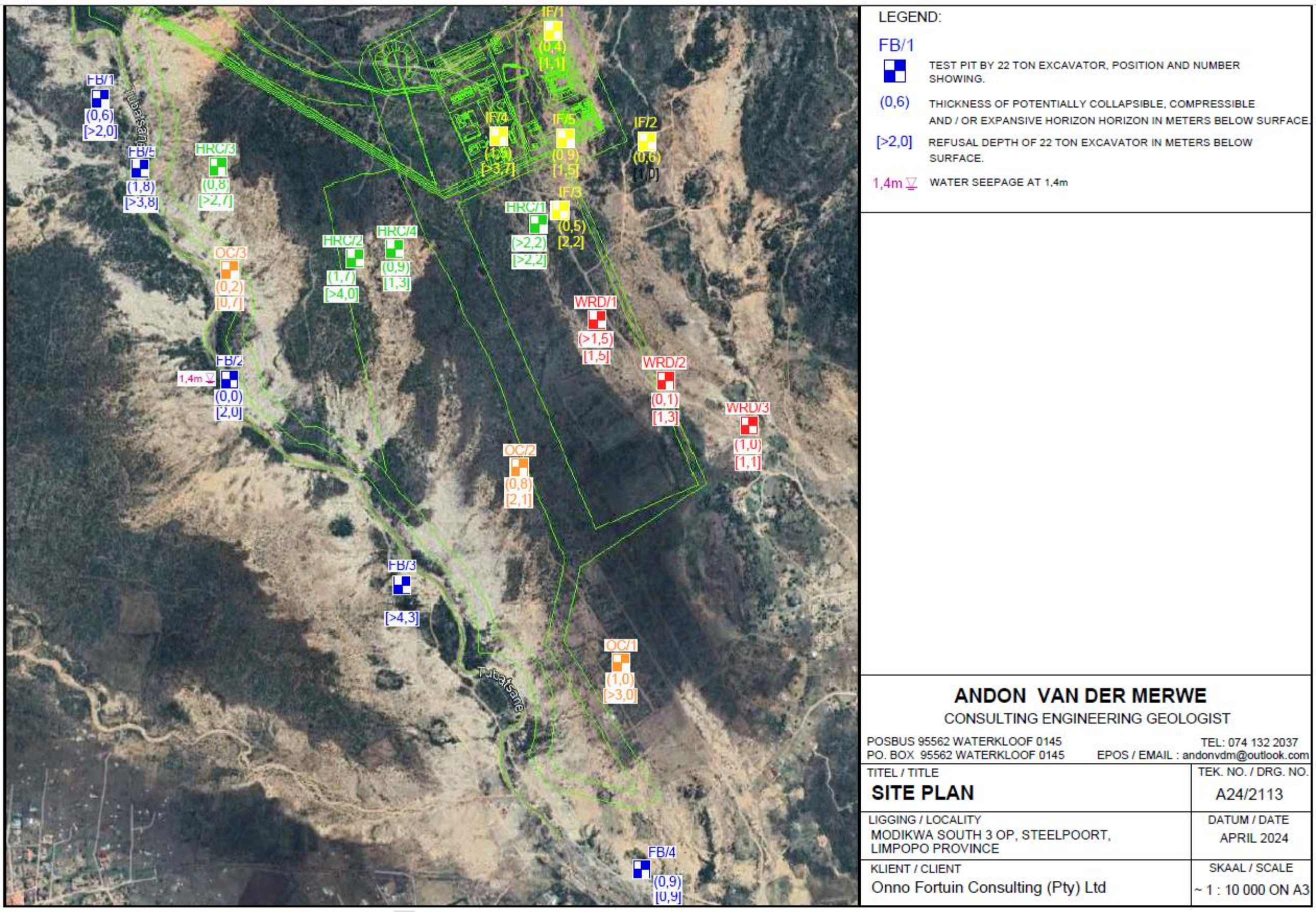

Figure 4-1: Modikwa South3 Project – Showing the 20 x Test Pits Investigated

The focus areas investigated are tagged as follows:

- ✓ IF: Infrastructure Block
- ✓ OC: Opencast Shells
- ✓ HRC: Haul Road/ Conveyor
- ✓ WRD: Waste Rock Dump
- ✓ FB: Flood Berm

4.1.1 Infrastructure Block

This site generally contains very dense cemented alluvium and calcareous alluvium which showed relatively shallow refusal of the 20-ton excavator. The south-western part (and perhaps north-western) of this site contained highly active dark brown clayey colluvium overlying very dense sandy colluvium and a generalized description of the typical soil profile that may be encountered across the Infrastructure Block is as follows:

- ✓ 0,0 – 0,4: **Clayey SAND** containing tree roots; colluvium.
- ✓ 0,4 – 1,5: **Sandy Silty CLAY** containing roots; colluvium.
- ✓ 1,5 – 3,7: **Silty SAND** containing roots; colluvium.

Refusal of the 20-ton excavator was encountered in 80% of the test pits at a depth of between 1,0m and 2,2m on very dense calcareous alluvium/alluvium, elsewhere refusal was not encountered to 3,7m depth

Water seepage was not encountered in any of the test pits to a maximum depth of 3,7m below surface.

4.1.2 Opencast Shells

The test pit results have shown that the eastern - and northern parts of this site are underlain by a thin to moderate horizon of dark brown and black highly active colluvial clay overlying silty and sandy alluvium to considerable depths.

A generalized description of the typical soil profile that may be encountered at the northern part of the Open Cast site is as follows:

- ✓ 0,0 – 0,6: **Sandy CLAY** containing tree roots; colluvium.
- ✓ 0,6 – 1,8: **Silty SAND** containing numerous NODULAR CALCRETE and roots; calcareous alluvium.
- ✓ 1,8 – 2,9: **SAND**; alluvium.
- ✓ 2,9 – 4,0: **Cemented Silty SAND**; alluvium.

Refusal of the 20-ton excavator was encountered in 60% of the test pits at a depth ranging from 0,7m to 2,1m in very dense alluvium, elsewhere refusal was not encountered to a depth of between 3,0m and 4,0m below surface.

No water seepage was encountered to a maximum depth of 4,0m below surface at the Opencast site.

4.1.3 Haul Road/ Conveyor Route

Various geotechnical conditions are present over the Haul Road Conveyor site, which is blanketed by a thin to prominent horizon of dark brown active clayey colluvium overlying sandy alluvium with varying medium dense to very dense soil consistencies.

A generalized description of the typical soil profile that may be encountered across the site is as follows:

- ✓ 0,0 – 0,6: **Sandy CLAY** containing tree roots; colluvium.
- ✓ 0,6 – 1,8: **Silty SAND** containing numerous NODULAR CALCRETE and roots; calcareous alluvium.
- ✓ 1,8 – 2,9: **SAND**; alluvium.
- ✓ 2,9 – 4,0: **Cemented Silty SAND**; alluvium.

Very dense alluvium occurs at shallow depths in some parts of this site and caused excavator refusal. The dark brown highly active colluvium was encountered to a depth exceeding 2,2m below surface in test pit HRC/1.

Refusal was not encountered in any of the test pits to a depth of between 2,2m and 4,0m below surface although slow excavation was encountered.

No water seepage was encountered to a maximum depth of 4,0m below surface at the Haul Road/ Conveyor route.

4.1.4 Waste Rock Dump

The test pit profiles, and visual observations of the site have revealed that the extreme eastern part of the WRD is underlain by sandy and silty alluvial and calcareous alluvial materials to a depth of greater than 1,3m and 2,2m below surface. The largest remaining part is blanketed by dark brown highly active clayey colluvium to a depth of greater than 1,5m or 2,2m below surface.

A generalized description of the typical soil profile that may be encountered at the extreme eastern part of the WRD site is as follows (IF/3):

- ✓ 0,0 – 0,5: **Silty SAND** containing tree roots; alluvium.
- ✓ 0,5 – 2,0: **Sandy Clayey SILT** containing minor NODULAR CALCRETE; calcareous alluvium.
- ✓ 2,0 – 2,2: Silty Clayey SAND; alluvium.

A generalized description of the typical soil profile that may be encountered at the largest remainder of the WRD site is as follows:

- ✓ 0,0 – 0,5: **Sandy CLAY** containing tree roots; colluvium.
- ✓ 0,5 – 2,2: **Sandy Silty CLAY** containing roots; colluvium.

Refusal of the 20-ton excavator was encountered in 75% of the test pits at a depth of between 1,3m and 2,2m below surface on very dense/stiff alluvium or colluvium, elsewhere refusal was not encountered to 2,2m depth although excavation became slow (HRC/1).

No water seepage was encountered to a maximum depth of 2,2m below surface at the WRD site.

4.1.5 Flood Berm

Hard rock norite and anorthosite outcrops were observed within the Tubatsane River along the northern part of the Flood berm area. Thin diabase intrusions were also observed along the Tubatsane Riverbed.

Various geotechnical soil conditions were encountered along the lengthy Flood Berm site which ranged from shallow hardpan calcrete to prominent horizons of alluvial soils. The upper alluvial soils contained areas of well cemented alluvium almost tending to a very soft rock consistency, which was underlain by calcareous alluvium in parts. A generalized description of the prominent horizon of alluvial soils across the Flood Berm site is as follows:

- ✓ 0,0 – 0,4: Well-cemented **Medium SAND**; alluvium.
- ✓ 0,4 – 1,2: Poorly cemented **Medium SAND** containing minor sub-rounded GRAVELS; alluvium.
- ✓ 1,2 – 2,0: **Sandy SILT** containing pockets of powdery CALCRETE and NODULAR CALCRETE; calcareous alluvium.
- ✓ 2,0 – 3,0: Poorly cemented **SAND** containing roots; alluvium.
- ✓ 3,0 – 3,7: **Sandy Clayey SILT** containing scattered NODULAR CALCRETE; calcareous alluvium.
- ✓ 3,7 – 4,3: **Sandy SILT** containing numerous NODULAR CALCRETE; calcareous alluvium.

Refusal of the 20-ton excavator was encountered in 40% of the test pits at a depth ranging from 0,9m to 2,0m below surface on very dense cemented alluvium hardpan calcrete, elsewhere refusal was not encountered to a depth of up to 4,3m below surface.

Slight water seepage was encountered in test pit FB/2 from a depth of below 1,4m. This test pit was excavated adjacent to the Tubatsane River.

4.1.6 Geotechnical Considerations

The following geotechnical considerations are reported:

1) <u>Expansive Soils:</u>
The sandy and gravelly site soils tested "low" in the degree of potential expansiveness. The silty alluvium tested "low borderline medium" or "medium" whilst the dark brown and black, slicken sided clayey colluvium is regarded as "high" in potential expansiveness.

2) <u>Collapsible & Compressible Soils:</u>
From visual observations of the test pit profiles, it is anticipated that the upper 0,1m to 1,0m of sandy and silty soils may be potentially collapsible and compressible upon load.

A Collapse Potential test was conducted on the dense cemented silty sand alluvium in test pit IF/5 at the Infrastructure Block. The material has a low Collapse Potential of 1,9% and a low to moderate Compressibility Ratio of 3,9%. The rating of the material classifies as "Moderate Trouble" in terms of collapse.
.

3) Groundwater & Soil Chemistry:
The water table was only encountered in test pit FB/2, adjacent to the Tubatsane River, at a depth of 1,4m below surface. The rest of the test pits were all dry when profiling was done at the end of the wet season.

4) Shear Strength Parameters:
Disturbed soil samples were collected from various soil horizons at site in order to determine the shear strength parameters of the materials. These samples were re-moulded to 93% Proctor density where after consolidated undrained shear-box tests were performed on the material to determine the shear strength parameters under normal stresses of 20, 50 and 150 kPa.

A summary of the shear box test results is shown below in **Table 4-1**.

Table 4-1: Shear-Box Test Results

HOLE NO.	DEPTH (m)	MATERIAL TYPE	NOR-MAL STRESS (kPa)	INITIAL MOISTURE CONTENT AT 150 kPa (%)	INITIAL DRY DENSITY AT 150 kPa (kg/m³)	VOID RATIO e_0 AT 150 kPa	REL. DENSITY AT 150 kPa	INITIAL SATURA-TION AT 150 kPa (%)	COHE-SION (kPa)	ANGLE OF FRICTION (degrees)
WRD/3	0,0 – 1,0	Sand / Gravel	20, 50, 150	20,0	1 584	0,673	2,65	78,6	29	27
IF/4	0,0 – 3,7	Sand / Silt / Clay	20, 50, 150	24,8	1 496	0,771	2,65	85,2	21	20
HRC/4	0,0 – 0,9	Clay / Sand	20, 50, 150	29,7	1 365	0,941	2,65	83,5	18	34

5) Permeability of Soils:
Disturbed bulk samples were collected of the various soil horizons at site and samples were re-moulded to 93% Proctor density for conducting falling head permeability tests. A summary of the permeability and Standard Proctor compaction test results are shown below in **Table 4.2**.

Table 4-2: Summary of Permeability & Proctor Compaction Test Results

HOLE NO	DEPTH (m)	SOIL TYPE	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)	MAXIMUM DRY DENSITY (Std. Proctor) (kg/m³)	OMC (%)	PERMEABILITY (m/sec)
WRD/3	0,0 – 0,1	Sand / Gravel	21,6	1 562	1 697	20,6	2,987 X 10^{-07}
IF/3	0,0 – 2,2	Silty Sand	24,6	1 465	1 572	23,6	4,123 X 10^{-08}
IF/4	0,0 – 3,7	Sand / Silt / Clay	23,8	1 508	1 613	24,4	2,580 X 10^{-08}
HRC/4	0,0 – 1,1	Clay / Sand	29,6	1 367	1 462	30,4	1,16 X 10^{-06}

From the table above it is evident that the site soils to a depth of 3,7m below surface have a coefficient of permeability in the order of 1,16 X 10^{-06} to 2,580 X 10^{-08} m/s.

Materials which have a coefficient of permeability in the order of 10^{-08} m/s may be considered as a liner in areas required for the proposed new mine development such as the Wast Rock Dump.

6) Excavatibility:
Soft excavation by a 20-ton excavator was possible at the following locations:

- ✓ Infrastructure block: 1,0m to > 3,7m
- ✓ Opencast area: 1,3m to > 4,0m
- ✓ Haul Road/ Conveyor: 1,3m to > 4,0m
- ✓ Waste Rock Dump: 1,3m to > 2,2m
- ✓ Flood Berm: 0,9m to > 4,3m

Very hard excavation by a large excavator combined with hydraulic pecking and ripping is foreseen in the areas underlain by **very dense cemented alluvium** or **very stiff clayey colluvium** or **hardpan ferricrete**.

Blasting is foreseen in the areas underlain by **hard rock norite, anorthosite** or perhaps **hardpan calcrete** which is very well cemented and contain a very soft to hard rock consistency.

The sidewalls of all test pit excavations were stable during the investigation. Excavations for Flood Berm construction in close proximity of the Tubatsane River may have unstable sidewall conditions due to the possible presence of ground water seepage.

7) Earthworks:
The site soils to a depth of 4,0m below surface were tested to determine their Mod AASHTO compaction characteristics for use in construction and a summary of the test results are shown below in **Table 4-3**.

Table 4-3: Summary Table - Showing the MOD AASHTO Compaction Tests

HOLE NO	DEPTH (m)	SOIL TYPE	PI	GM	CBR @95%	COLTO CLASSIFI-CATION	SWELL (%)
OC/1	1,0 – 2,7	Sandy SILT	16	1,40	7	<G9	0,3
FB/2	0,0 – 2,0	SAND	7	1,84	9	G9	0,0
FB/3	1,2 – 4,3	Sand / Silt	18	1,66	4	<G9	0,4
WRD/3	0,0 – 1,0	Sand / Gravel	16	1,74	6	<G9	0,4
IF/3	0,0 – 2,2	Silt / Sand	20	1,59	7	<G9	0,0
IF/4	0,0 – 3,7	Sand / Clay	22	1,29	9	<G9	0,4
HRC/2	0,0- 4,0	Sand / Clay	20	1,47	10	<G9	0,3
HRC/4	0,0 – 0,9	Sand / Clay	20	1,47	5	<G9	1,0

Note : PI = Plasticity Index
GM = Grading Modulus
CBR = California Bearing Ration at 95% Mod AASHTO compaction

Based on the results of the compaction tests, the site soils exhibit very poor compaction characteristics and tested as poorer than G9 according to the COLTO Classification whilst only the sample from FB/2 (sandy material) tested as G9 material.

According to the TRH14 Classification system, the materials tested as G10 mostly and may therefore only be used as bulk fill or subgrade layers for roads construction.

Cognizance should be taken in the design of roads and paved areas of the potentially collapsible, compressible and expansive nature of the upper sandy site soils.

4.1.7 Generalised Conclusions

The following generalised conclusions are made:

a) The sandy and gravelly site soils tested "low" in the degree of potential expansiveness. The silty alluvium tested "low borderline medium" or "medium" whilst the dark brown and black, slicken sided clayey colluvium is regarded as "high" in potential expansiveness.

b) From visual observations of the test pit profiles, it is anticipated that the upper 0,1m to 1,0m of sandy and silty soils may be potentially collapsible and compressible upon load.

c) The site soils tested poorer than G9 quality materials whilst only one sample tested as G9 (according to COLTO) and therefore the site soils showed poor compaction characteristics. The materials (G10 according to TRH14) may be used as subgrade and bulk fill in road construction.

d) Soft excavation by a 20-ton excavator was possible to depths of between 0,7m and > 4,3m below surface. Very difficult excavation by a large excavator combined with heavy dozer ripping, hydraulic pecking and blasting (soft to hard rock conditions) will be required below the refusal depths of the excavator.

e) The test pits over the entire investigated area showed stable sidewalls although slight instabilities of sidewalls may occur along the Flood Berm site where possible water seepage may be excepted within the foundation trenches.

f) Proper drainage should be implemented at the entire site and ponding near foundations must not be permitted.

4.1.8 Infrastructure Block - Recommendations

The following general recommendations are made for the infrastructure block:

1) Very dense/dense or very stiff soil conditions are present from near surface locations to a surficial depth of 0,5m below surface along the Infrastructure Block.

2) The dark brown/black potentially highly active clayey colluvium covers large parts of this site to a depth of > 1,5m or > 2,2m below surface. Most or all of the dark brown/black colluvial clay will have to be removed from below foundations as well as slightly beyond the footprint area of the new Infrastructure Block.

3) Soil Raft construction with Pad footings or conventional foundations are proposed for the Infrastructure Block as a preliminary solution. The soil raft should be constructed with imported G5 material well compacted in layers of say 150mm.

4) The allowable bearing capacity of the very dense/dense or very stiff foundation soils at depths discussed above should be limited to say 150kPa (dense) to 200 kPa (very dense/very stiff).

4.1.9 Haul Road/ Conveyor – Recommendations

The following general recommendations are made for the haul road/ conveyor route:

1) Very dense/dense or very stiff soil conditions are present from surficial depths of between 0,5m and 0,9m below surface along the Haul Road / Conveyor Site.
2) The dark brown/black potentially highly active clayey colluvium covers the entire site to a depth of 0,5m to 2,2m (or deeper) below surface. Most or all of the dark brown/black colluvial clay will have to be removed from below the foundations as well as slightly beyond the footprint area of the foundations.
3) The very dense/dense or very stiff soils in the upper horizon may support light traffic, although better quality wearing course layer is recommended.
4) If a haul road is planned as the primary transport of ROM to Modikwa South2 to the north, more substantial layerworks will have to be designed to support haulage vehicles.
5) The allowable bearing capacity of the dense to very dense/stiff foundation soils at depths discussed above should be limited to say 100kPa (dense) to 150 kPa (very dense/very stiff).

4.1.10 Waste Rock Dumps – Recommendations

The following general recommendations are made for the waste rock dumps:

1) From visual observations of the test pit profiles, it is anticipated that the upper 0,1m to 0,5m of in-situ soils may be potentially collapsible and compressible upon load.
2) Therefore, these materials as well as all organic materials should be removed from the footprint of the WRD, and the base of the excavation should be in-situ densified according to the engineer's specification.
3) The materials at site tested to have a coefficient of permeability (k-value) of 10^{-8} m/s and may be considered as part of the Class C barrier design underneath the WRD.

4.2 Soil & Land Capability Assessment

A detailed soil, land-use and land capability assessment was conducted by Enviro-Solum Consulting (Enviro-Solum) during the month of May 2024. This report is included in the Environmental Assessment Practitioner (EAP) application conducted by Segope.

4.2.1 Dominant Soils within the Study Area

The soil forms in hectares (ha) occurring within the study area are shown below in **Table 4-4**.

Table 4-4: Soil Forms located within the Study Area (ha) (Courtesy Enviro-Solum)

Study Area					
Soil Forms	Area (Ha)	Percentage (%)	Land Capability Class – According to (Smith, 2006)	Agricultural Potential	DAFF (2016) Classification
Bonheim/Abbotspoort	111,19	35,9	Arable (Class IV)	Moderate	8. Moderate
Coega	5,18	1,7	Grazing (Class VI)	Low	4. Very Low to Low
Inhoek/Dundee	55,45	17,9	Watercourse (Class V)	Very Low	2. Very Low
Mispah/Glenrosa	70,13	22,6	Grazing (Class VI)	Low	5. Low
Rocky Outcrop	52,81	17,0	Grazing (Class VII)	Very Low	3. Very Low to Low
Witbank	15,29	4,9	Wilderness (VIII)	Very Low	1. Very Low
Total Enclosed	**310,06**	**100**			

The dominant soils of the northern portion of the Study Area is shown below in **Figure 4-2**.

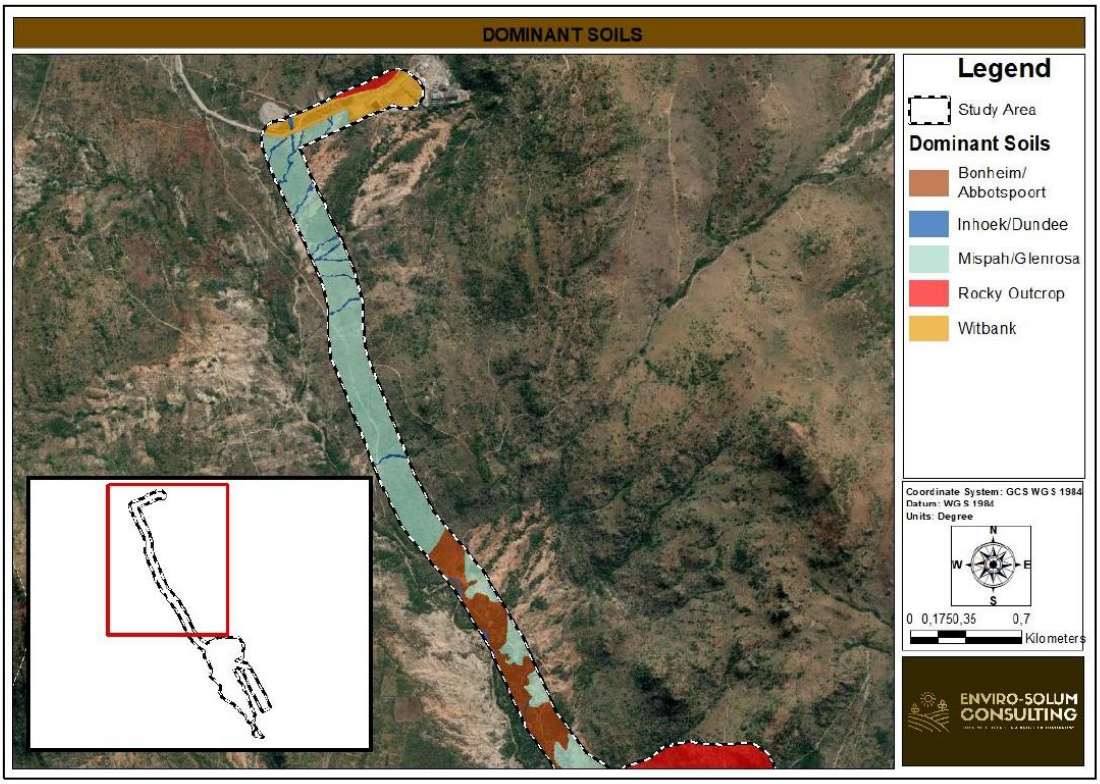

Figure 4-2: Dominant Soils - Northern Portion of Study Area (Courtesy Enviro-Solum)

Similarly, the dominant soils of the southern mining area is shown below in **Figure 4-3**.

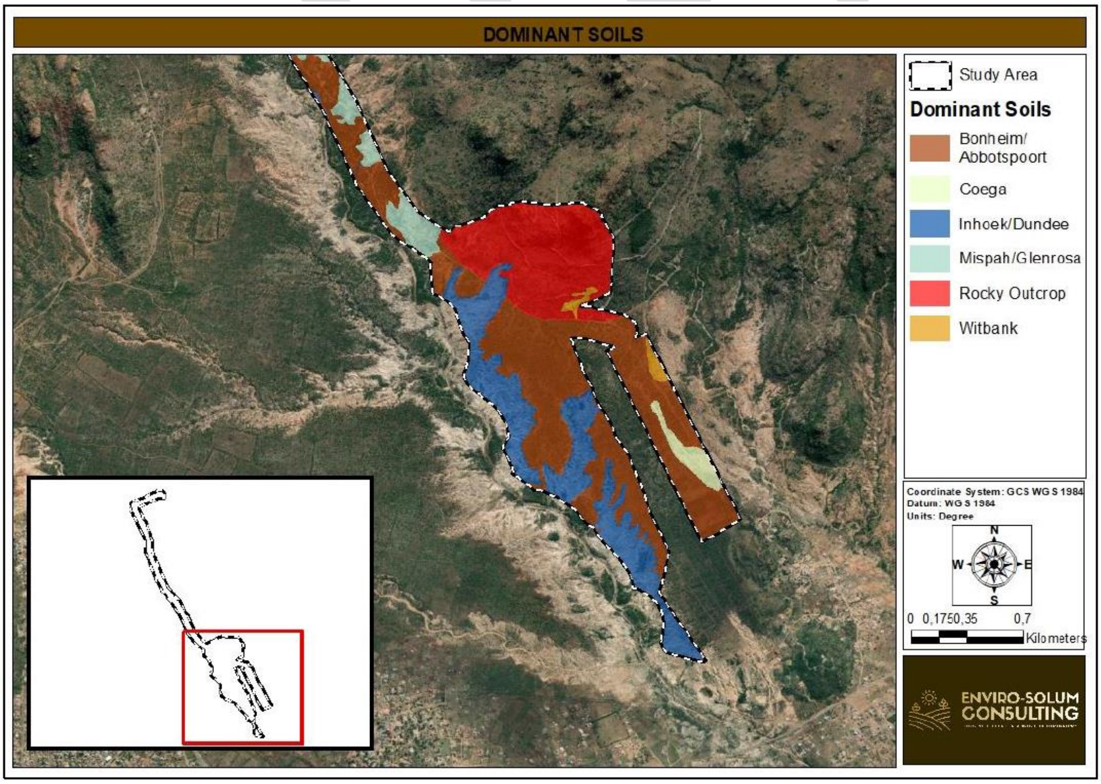

Figure 4-3: Dominant Soils – Southern Mining Area (Courtesy Enviro-Solum)

4.2.2 Land Capability

The land capability of the northern portion is shown below in **Figure 4-4**.

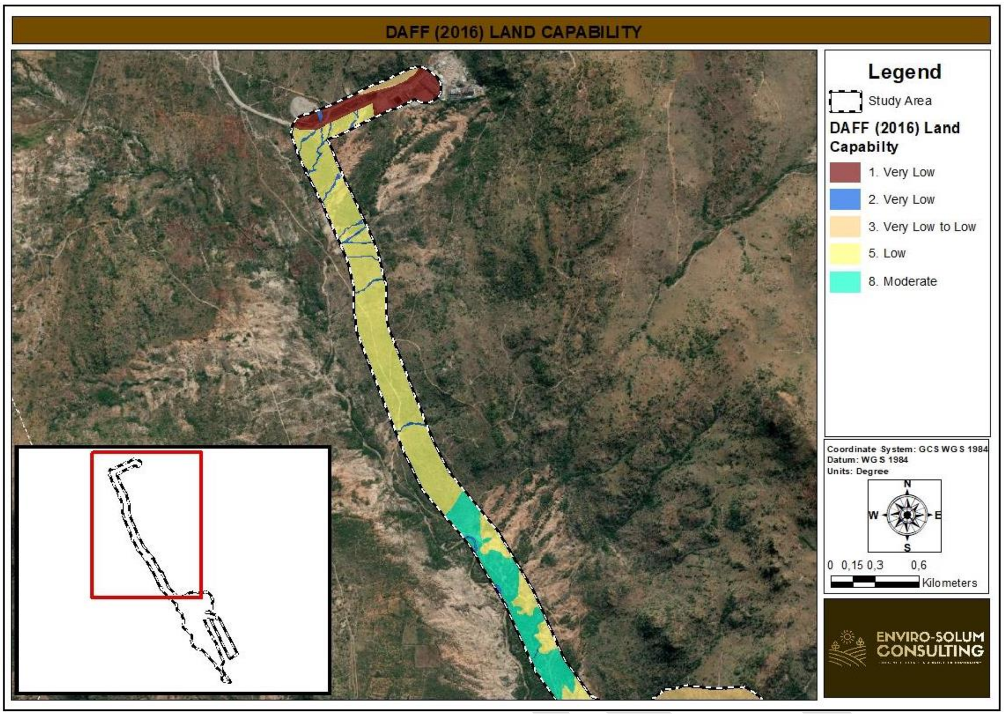

Figure 4-4: Land Capability of the Northern Portion (Courtesy Enviro-Solum)

Similarly, the land capability of the southern mining area is shown below in **Figure 4-5**.

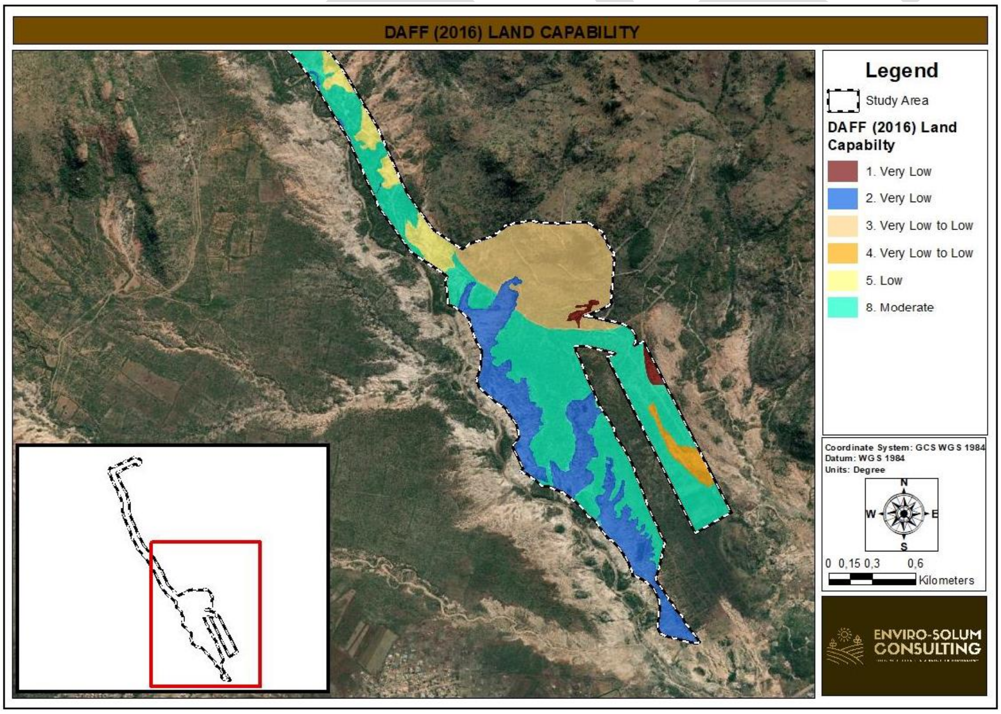

Figure 4-5: Land Capability of the Southern Mining Area (Courtesy Enviro-Solum)

In general, the land capability is classified as very low to moderate.

4.3 Hydropedology

A hydropedological assessment was conducted by Enviro-Solum Consulting during April 2024.

We assume that the report is attached as part of the Environmental Application (EA) submitted by the Segope, the appointed EAP for the project.

4.3.1 Hydropedological Zones

The three (3) hydropedological zones involved are as follows:

- ✓ **Recharge zone** characterised by vertical infiltration through the soil profile and weathered subsoil strata and lateral flow at the bedrock interface during the rainy season.
- ✓ **Interflow zone** characterised by lateral flow in higher permeable layer(s) in the soil profile underlain by lower permeable soil/subsoil material; and
- ✓ **Responsive zone** characterised by saturated and near saturated conditions of the soil profile for most of the year and exfiltration (return flow) of upslope interflow flow during the rainy season.

The hydropedological behaviour of soils are grouped into three (3) hydropedological zones as illustrated in **Figure 4-6** below.

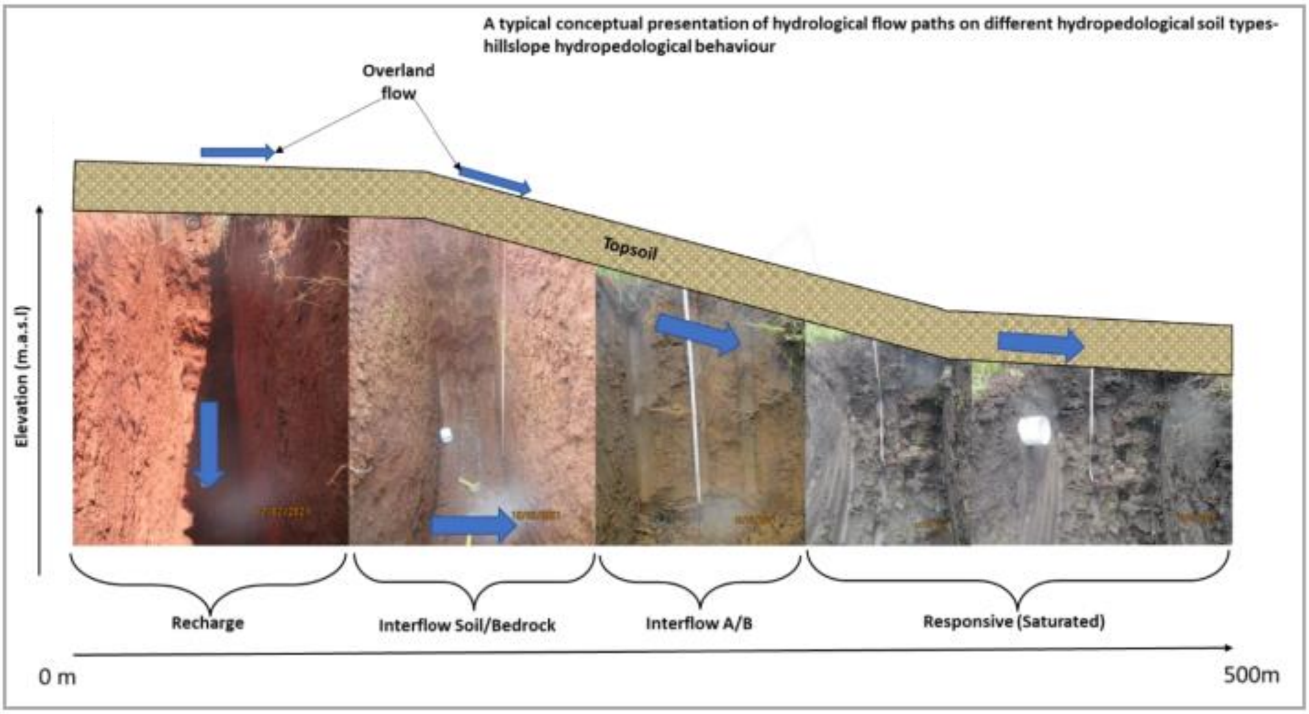

Figure 4-6: Hydropedological Zones based on Soil Hydropedological Behaviour (Courtesy ZRC)

4.3.2 Hydrological Soil Types

By interpreting the soil forms and how they contribute to a watercourse recharge, the following hydrological soil types are shown for the northern portion of the study area, as shown below in **Figure 4-7**.

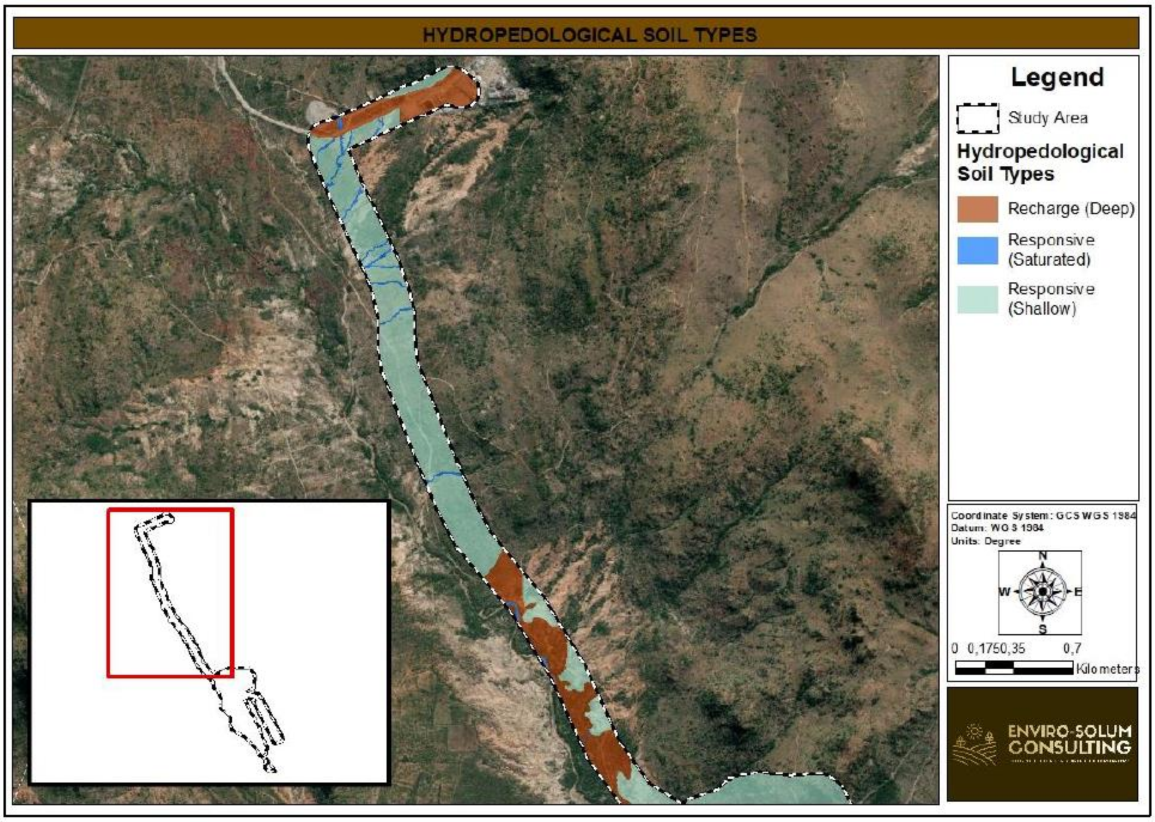

Figure 4-7: Hydropedological Soil Types - Showing the Northern Portion (Courtesy Enviro-Solum)

Similarly, the hydrological soil types for the southern mining area is shown below in **Figure 4-8**.

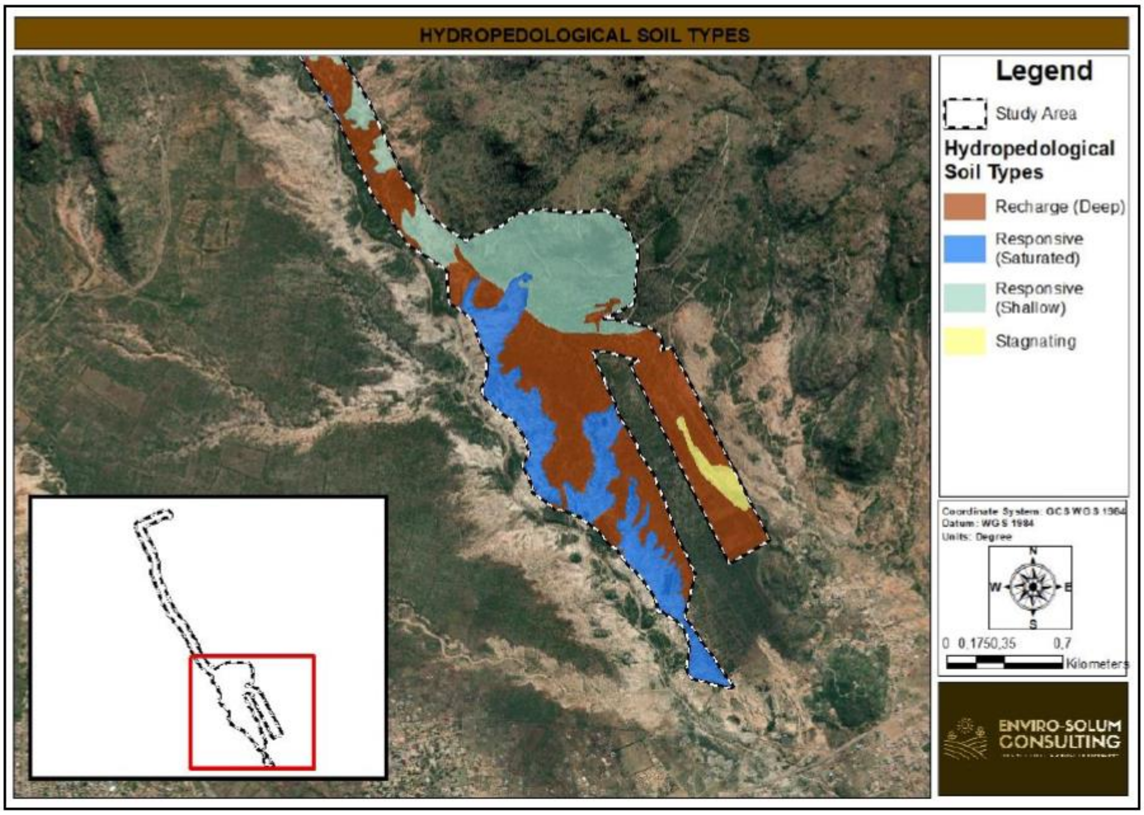

Figure 4-8: Hydropedological Soil Types - Showing the Southern Mining Area (Courtesy Enviro-Solum)

The saturated responsive soils are indicative of the various smaller tributaries that flow into the Tubatsane River. The shallow responsive soils are closely linked to the watercourses of the area.

4.3.3 Hydropedology Buffer Zone

A functional buffer zone or hydropedologically defined as a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another. As a result, the bigger the buffer the greater the results thereof. This is to allow a large enough area to allow for subsurface flow of water to provide a steady but slow recharge to the groundwater or the downslope watercourse.

Due to the absence of subsurface lateral flows or interflow soils which are considered to be soils of high hydropedological importance, the risk of impact on the receiving environment from impact on hydropedological processes is anticipated to be low. The mining footprint is suitably positioned in the shallow responsive soils which only contribute to surface overland flow during rainfall events and recharge deep soils which are unlikely to be linked to the streamflow.

The post mining scenario will likely alter the catchment yield and surface runoff in the greater landscape. The buffer determination for the protection of hydropedological important soils is deemed irrelevant, however the development should be cognisant of the edge effects as well as the loss of catchment yield and the surface runoff component reporting to and recharging the watercourse system.

A 50 meter edge effect buffer can be considered at this stage. This will ensure that, as far as possible the functionality of the system as well as its Present Ecological State does not deteriorate to an unacceptable future state due to loss of recharge. This is well within the 100m GN704 minimum offset buffer from the watercourse of the Tubatsane River or the 1:100 floodline demarcation.

4.3.4 Recommendations

The following more important recommendations are made by the hydropedology specialist:

1) The study area is largely dominated by Responsive (shallow) soils and recharge deep soils highly likely prone to erosion and thus indicating a further increase in runoff volumes in the post development scenario.
2) Therefore, adequate stormwater mitigation measures should be adhered to at all phases of development, to manage the stormwater and channelized water effectively to prevent large pulses in storm water.
3) As further increase in impervious surfaces may lead to changes in the hydrological flow regimes associated with the study area and may result in accelerated erosion and sedimentation of the lower lying areas if not properly attenuated and managed through proper landscaping in order to maintain functionality for downstream users.
4) The proposed development does not pose a development constraint from an hydropedological perspective.

5. HYDROLOGICAL BACKGROUND INFORMATION

5.1 Location

The Modikwa project is located within quaternary catchment B41J where the Tubatsane River passes through the evaluation area to the west before it joins the Steelpoort River, as shown below in **Figure 5-1**.

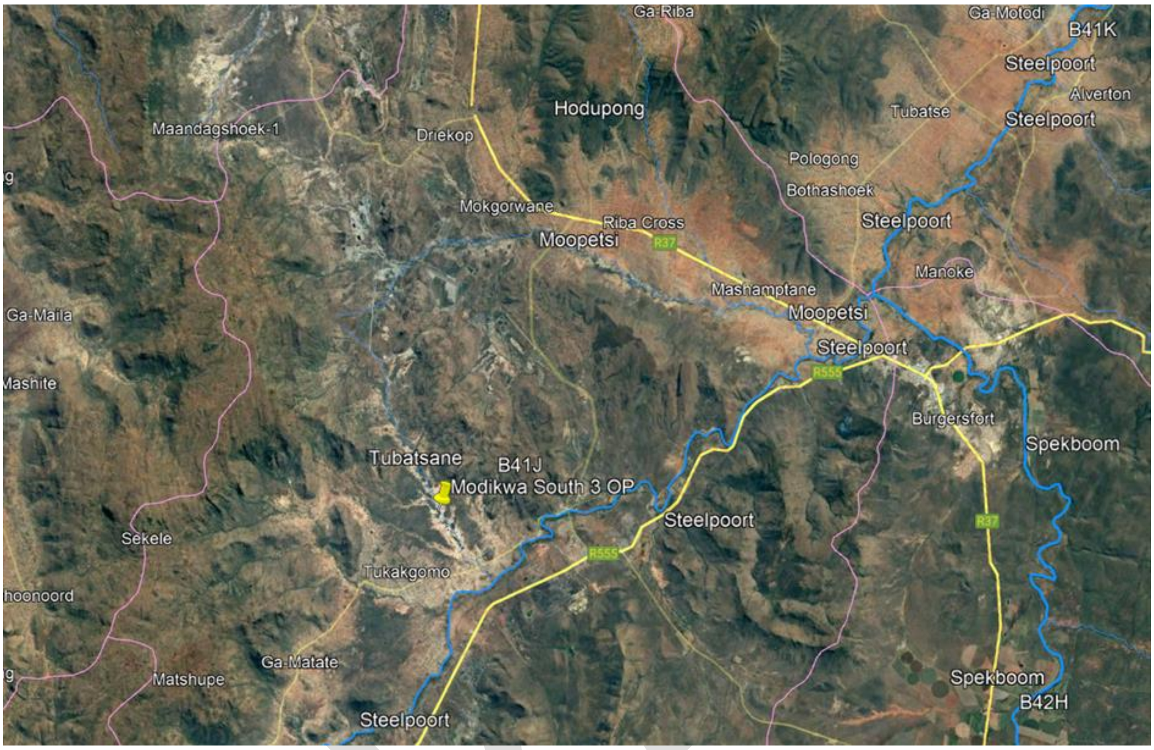

Figure 5-1: Modikwa South3 OP – Located within Quaternary Catchment B41J

A second unnamed tributary of the Steelpoort River borders the eastern edge of the proposed South3 opencast pit evaluation area, as shown below in **Figure 5-2**.

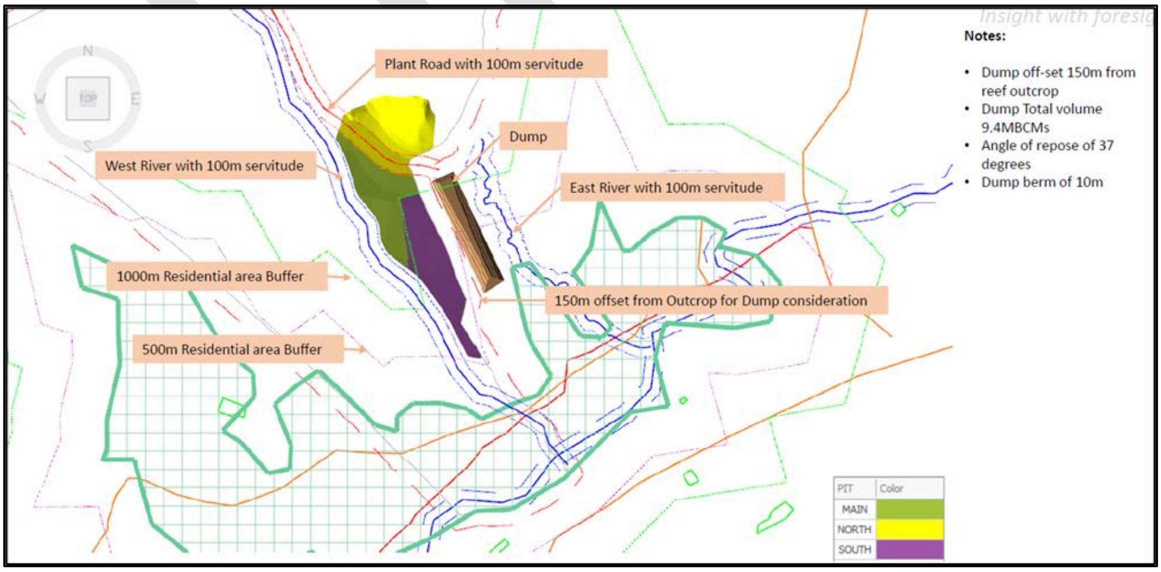

Figure 5-2: Provisional Mining Layout – Modikwa South3 OP showing 100m Stream Buffers

5.2 On-Site Investigation

The on-site investigation of the streams and river on site was conducted on the 17th of July 2024 accompanied by Ms Lorato Rakuba (Segope) and Mr Msimelelo Silomntu from Modikwa. Their inputs and assistance are herewith acknowledged and thanked for.

The investigation included the study of vegetation impacting the flow of water, soil type and compaction thereof. The investigation also focused on the general layout of the area including the proposed mining area and where the infrastructure is being planned.

5.3 LIDAR Survey Data

A detailed survey of the mining area was provided by the Client. The survey data was from a Light Detection and Ranging (LiDAR) survey obtained from the Mine that was flown during June 2024.

The LIDAR survey area is shown below in **Figure 5-3**.

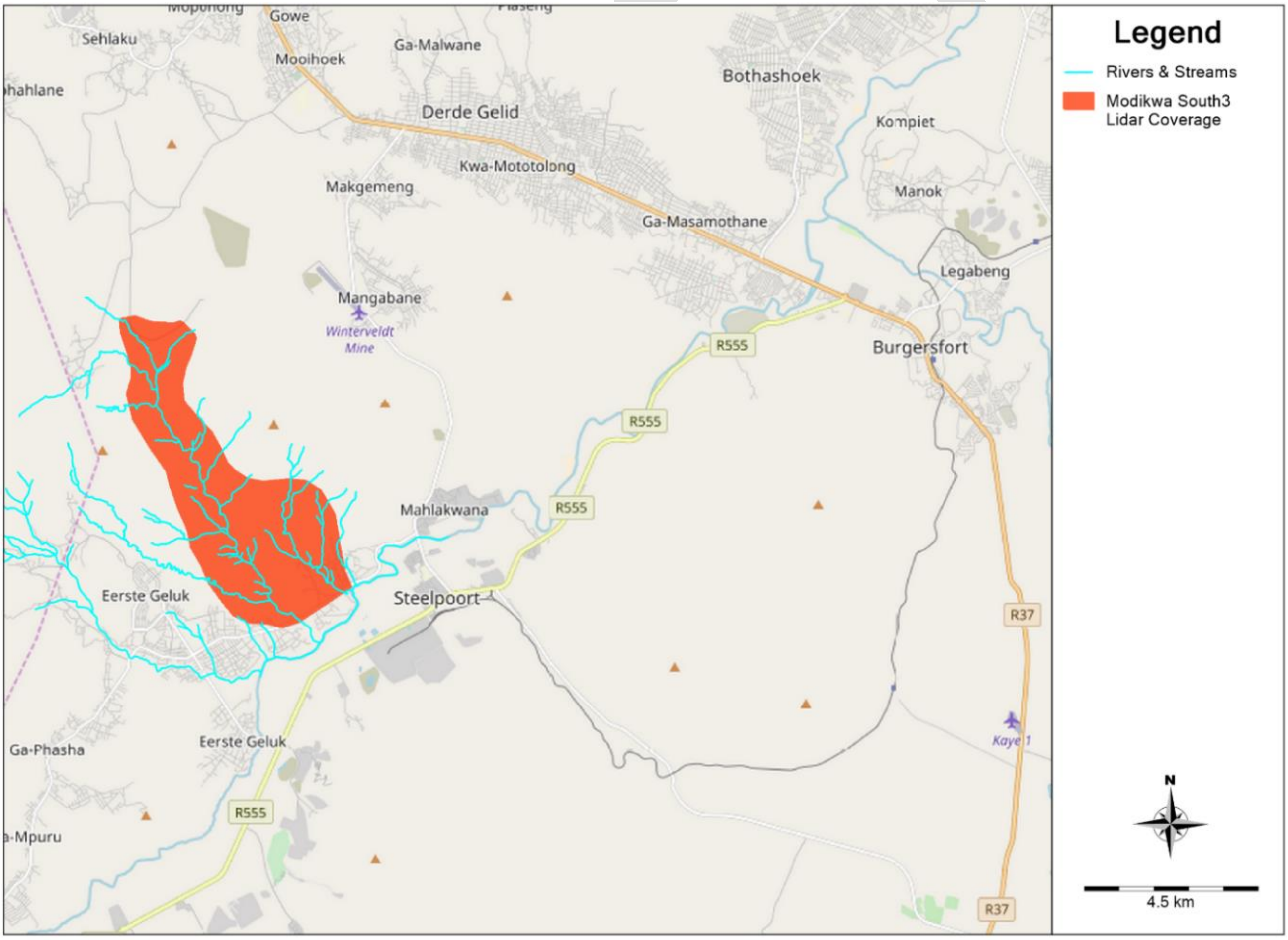

Figure 5-3: Modikwa South3 Project - Showing LIDAR Survey & nearby Towns

The detailed survey, however, did not cover the entire catchment area under consideration.

The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data and the LiDAR data was used to delineate the various subcatchments contributing towards the various streams. The LiDAR survey data, did however, cover the critical impacted areas and was used for the hydraulic modelling. A special combined 1D and 2D flood model was used to simulate the 1:100 event and determine the floodlines.

The catchment areas affecting the Modikwa South3 mining area is approximately 55 km². The catchments for the Tubatsane - and smaller Mofafa rivers are shown below in **Figure 5-4** with the major drainage routes shown as the light blue lines.

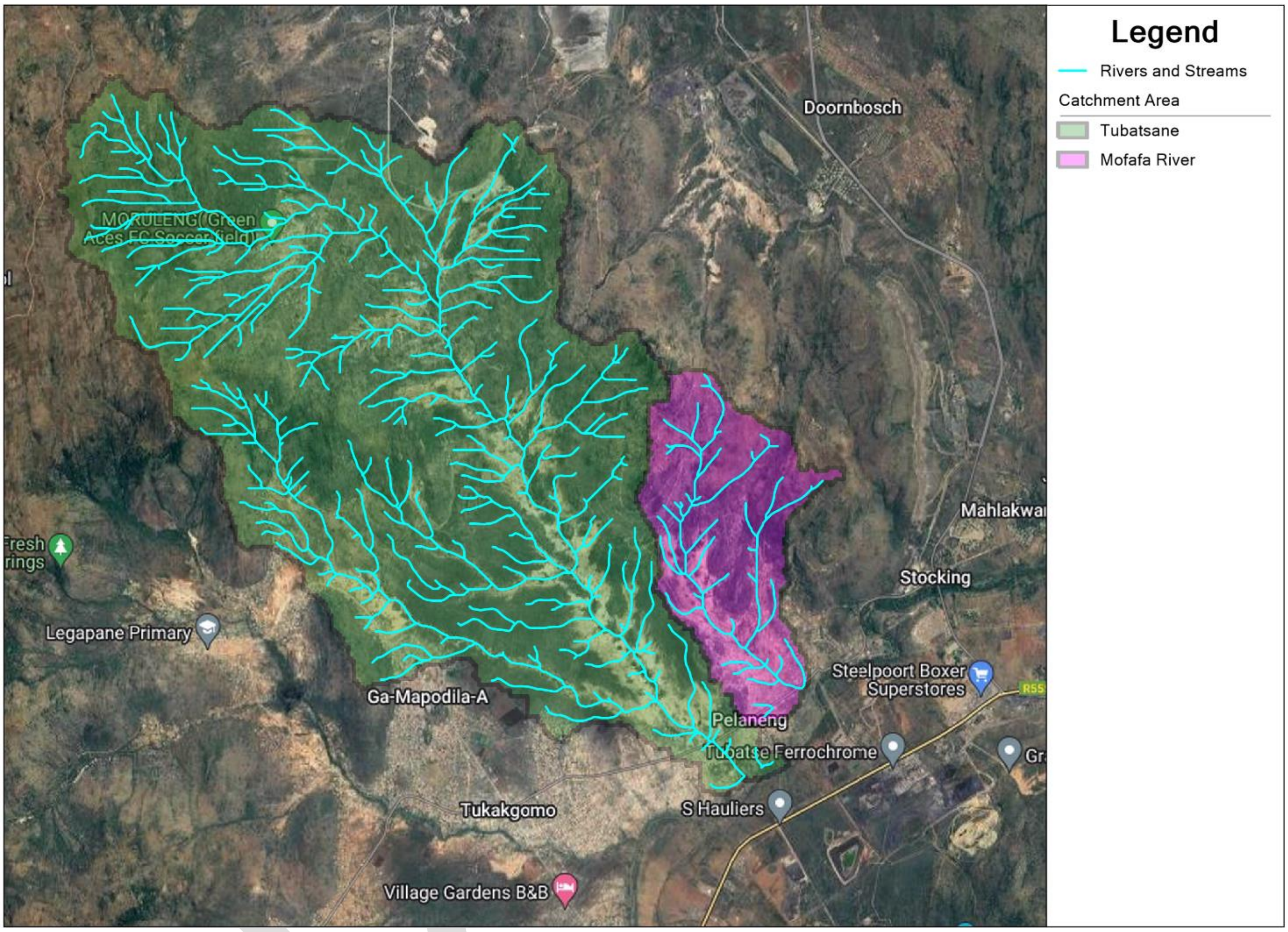

Figure 5-4: Modikwa South3 Catchment Areas – Showing the Tubatsane & Mofafa Rivers

The Tubatsane River is shown below in **Figure 5-5**, where a 3D image of the Digital Terrain Model (DTM) is rendered.

Figure 5-5: Tubatsane River – Showing a 3D Rendering View of the Terrain

In addition to the Tubatsane river and Mofafa river, various smaller streams flow into the Tubatsane river from all directions upstream of the proposed mining area as the area is located in a valley surrounded by high hills. These streams impact the mining activities and the planned mining infrastructure.

5.4 Climate

According to the Water Research Commission (WRC) study of the Water Resources of South Africa (WR 2012), Modikwa South3 falls under the Lower-Olifants Water Management Area (WMA4), and more specifically Quaternary Catchment B41J, with the following characteristics:

- Mean Annual Precipitation (MAP): 598 mm
- Mean Annual Evaporation (MAE): 1 552 mm
- Rain Zone: B4D
- Evaporation Zone: 4A
- Mean Annual Run-Off (MAR): 13.12 x 10^6 m^3 (18.99 mm)

The locality of Modikwa South3 within the Quaternary Catchment B41J is shown below in **Figure 5-6**.

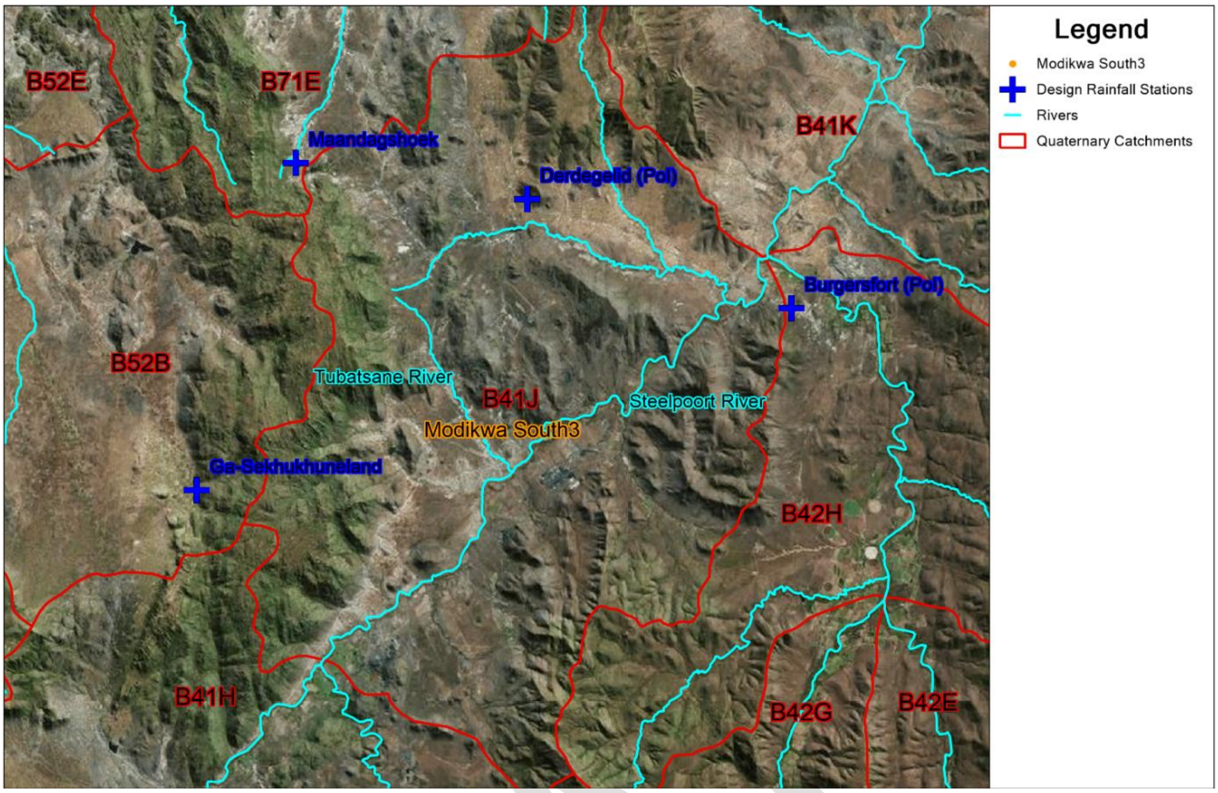

Figure 5-6: Locality Plan - Showing Modikwa South3 within Quaternary Catchment B41J

Modikwa South3 is located at the following coordinates:

- Latitude: 24°43'20.18"S
- Longitude: 30°10'14.52"E

5.4.1 Design Rainfall

Design storm data was obtained from the Design Rainfall Estimation Software for SA, as developed by Smithers & Schulze, University of Natal 2002.

According to the Design Rainfall Estimator, the four (4) closest rainfall stations with the longest records show the following results summarised in **Table 5-1** below.

Table 5-1: Modikwa South3 Project - Design Rainfall Stations with Data

Station	SAWS NR	Record (Years)	Latitude		Longitude		MAP (mm)	Altitude (m)		Return Period						
			(°)	(')	(°)	(')			Duration	2	5	10	20	50	100	200
Derdegelid (POL)	0593306_W	44	24	37	30	11	582	845	1 Day	50.40	68.70	80.80	96.00	115.90	132.10	149.40
									24 Hr	55.44	75.57	88.88	105.60	127.49	145.31	164.34
Burgersfort	0593581_W	28	24	40	30	19	550	774	1 Day	56.50	77.60	93.30	110.10	133.80	153.80	175.20
									24 Hr	62.15	85.36	102.63	121.11	147.18	169.18	192.72
Maandagshoek	**0593126_W**	**70**	**24**	**36**	**30**	**4**	**624**	**1025**	**1 Day**	**52.20**	**71.70**	**86.20**	**101.80**	**123.60**	**142.10**	**161.90**
									24 Hr	**57.42**	**78.87**	**94.82**	**111.98**	**135.96**	**156.31**	**178.09**
Ga-Sekhukhuneland	0593015_W	78	24	45	30	1	552	1260	1 Day	49.90	68.40	82.30	97.10	118.00	135.60	154.60
									24 Hr	54.89	75.24	90.53	111.21	129.8	149.16	170.06

5.4.2 Extended Rainfall Series

The Maandagshoek rainfall station (0593126_W) was chosen due to the longer rainfall record available from this station (70-years). The daily rainfall from the Maandagshoek rainfall station is shown below in **Figure 5-7**.

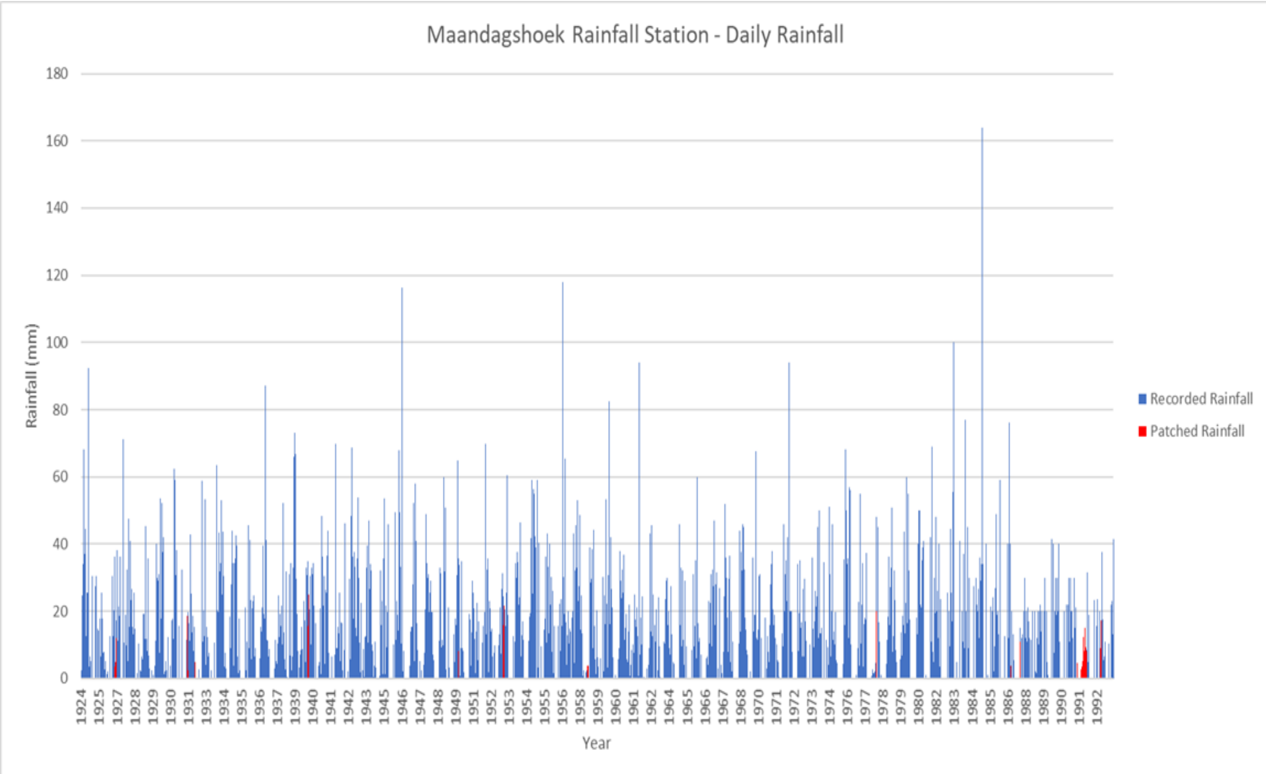

Figure 5-7: Extended 70-Year Daily Rainfall Data for Maandagshoek Rainfall Station

The daily rainfall for the Maandagshoek rainfall station from 1924 to 1994 is shown where the patched rainfall data is shown in red. It should be noted that there are four (4) events in the series where a rainfall higher than 100mm was recorded, with the highest rainfall in a day being 164mm.

The rainfall data was extracted using the Daily Rainfall Data Extraction Utility developed by Richard Kunz (2004). The rainfall database used by the Extraction Utility was developed by Steve Lynch (2003) for the WRC project titled “The development of a raster database of annual, monthly and daily rainfall for southern Africa”.

The mass plots of the Maandagshoek rainfall station were done to identify inhomogeneities in the time series for example originating from change in observer, rain-gauge type, etc. The Mass plots for the Maandagshoek rainfall station is shown below in **Figure 5-8**.

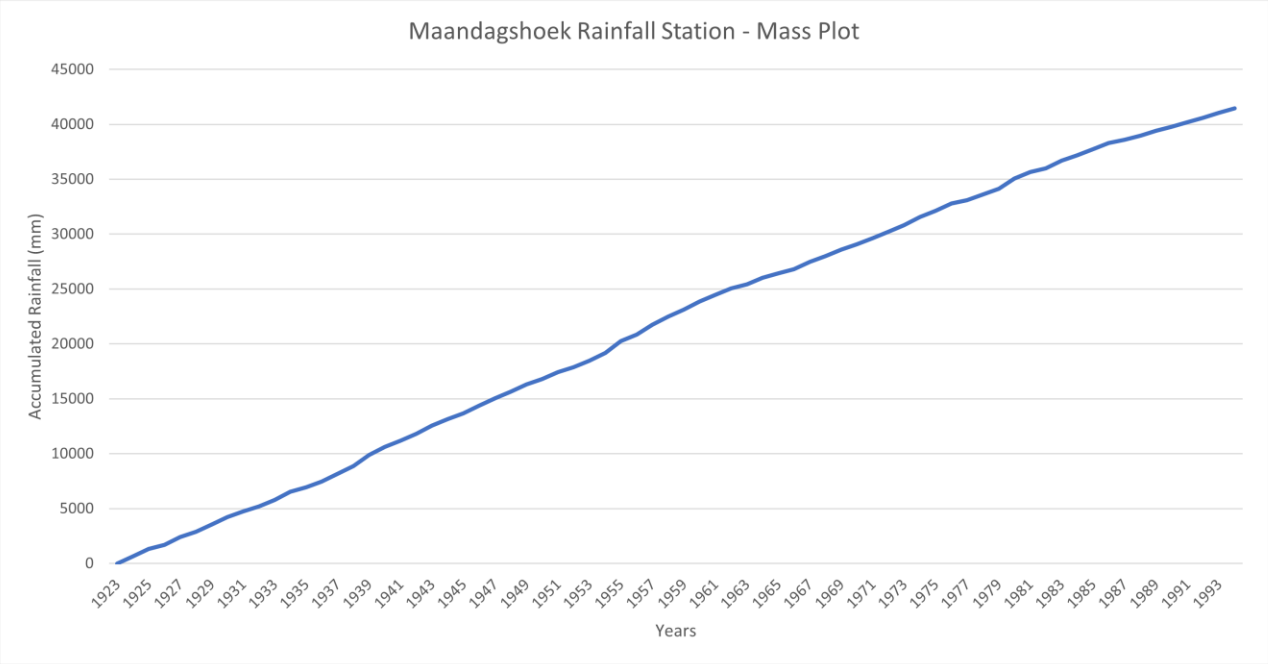

Figure 5-8: Maandagshoek Rainfall Station - Mass Plot Curve

The inhomogeneities are shown by an inflection point around a straight line. The Maandagshoek rainfall station shows some oscillation around the straight line which can be attributed to wet and dry periods in the rainfall record. The total accumulated rainfall volume for the Maandagshoek rainfall station is 4 1452 mm.

The dry and wet periods are best illustrated through annual residual mass curves shown in **Figure 5-9** below.

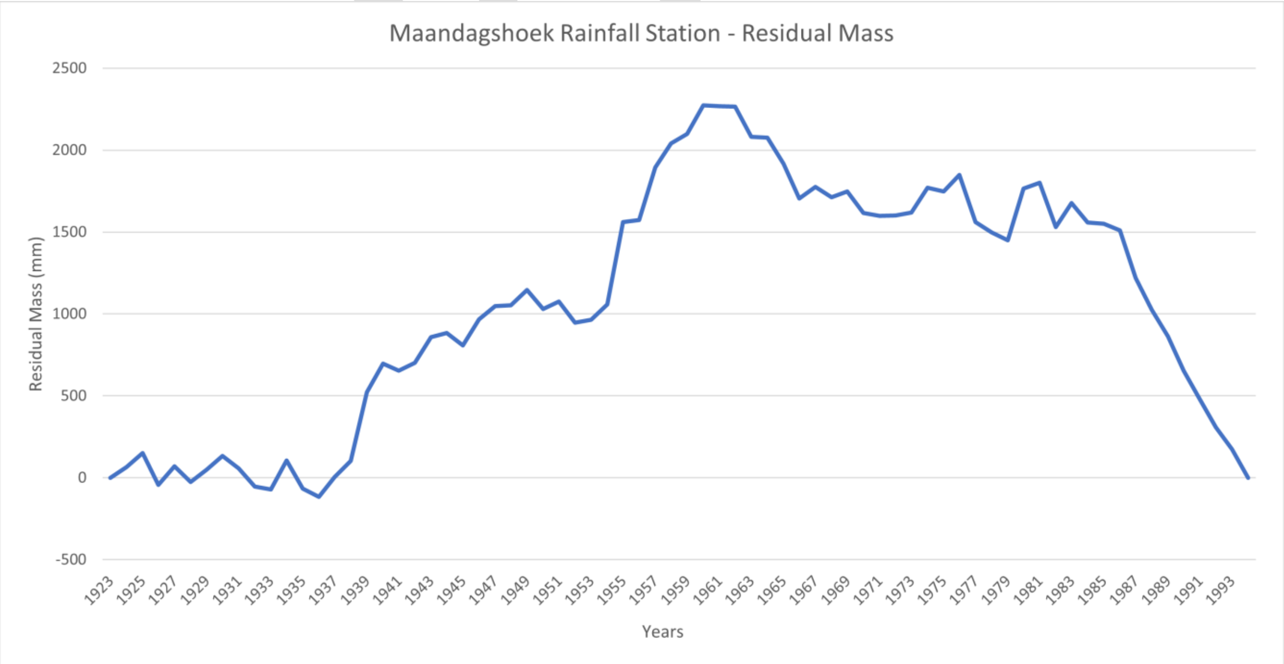

Figure 5-9: Maandagshoek Rainfall Station - Residual Mass Curve

The residual mass curve gives insights into the dry and wet periods with the following details:

- an upward curve indicates an above average sequence
- a horizontal curve indicates an average sequence
- a downward curve indicates a below average sequence

Wet periods can be visualized as an upward curve and dry periods can be visualized as a downward curve. The Maandagshoek rainfall station starts with short alternating wet and dry periods followed by an extended wet period from ±1938 to ±1960 with a few short dry spells in between and finishes with a dry spell from ±1986 to 1994 which coincides with the last batch of patched data.

5.4.3 Monthly Rainfall

The monthly distribution of the Maandagshoek rainfall station is shown below in **Figure 5-10** with a box & whisker plot**,** where the dry season from May to September and the wet season from October to April is clearly visible.

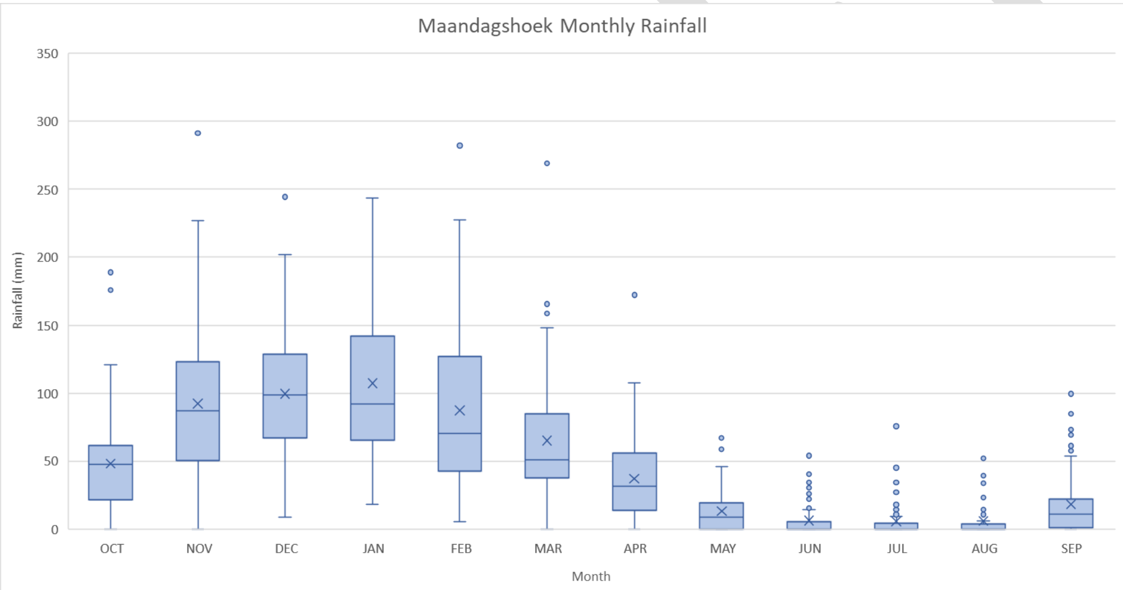

Figure 5-10: Carolina (MUN) Rainfall Station - Monthly Rainfall Distribution

The highest rainfall usually occurs between November to February. The period May to August is dry with only 31.8 mm falling during these months. Most of the annual rainfall (±85%) occurs during the six months from October to March. Based on these statistics, the peak rainfall month is January (107.3mm).

The rain occurs almost exclusively as showers (mild to heavy) and thunderstorms, mainly in summer (October to March). Maximum rainfall occurs from November to February. The winter months are dry. Heavy falls (100 mm plus) in a single 24-hour period are rare but do occur.

The box & whisker plot details:

- ✓ Median – Line in the Box
- ✓ Mean – X in the Box
- ✓ 1st Quartile – Bottom line of the Box

- ✓ 3rd Quartile – Top line of the Box
- ✓ Interquartile Range (IQR) – Distance between 1st quartile & 3rd quartile
- ✓ Outlier – 1.5 x IQR below or above the 1st quartile & 3rd quartile

The average monthly rainfall distribution is shown below in **Table 5-2**.

Table 5-2: Maandagshoek Rainfall Station - Monthly Rainfall Distribution

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average	48.19	92.44	99.69	107.30	87.40	65.09	37.20	13.30	6.43	5.97	6.11	18.29
Std Dev	34.60	55.58	45.13	54.67	60.75	48.29	31.59	15.39	12.88	13.29	12.41	22.11

5.4.4 Monthly Evaporation

Modikwa South3 falls in Quaternary Catchment B41J, which falls within Evaporation Zone 4A. The Mean Annual Evaporation (MAE) for this catchment is 1 552 mm per year.

The monthly distribution of the MAE for Evaporation Zone 4A is shown below in **Table 5-3**.

Table 5-3: Catchment B41J Zone 4A - Monthly Evaporation Distribution

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average	167	158	174	171	142	140	108	91	74	81	107	139

5.5 Frequency Analysis

A frequency analysis of the daily rainfall was done to determine the Depth-Duration-Frequency (DDF) & Intensity-Duration-Frequency (IDF) curves for the Maandagshoek Rainfall Station are shown below in **Figure 5-11** and **Figure 5-12**.

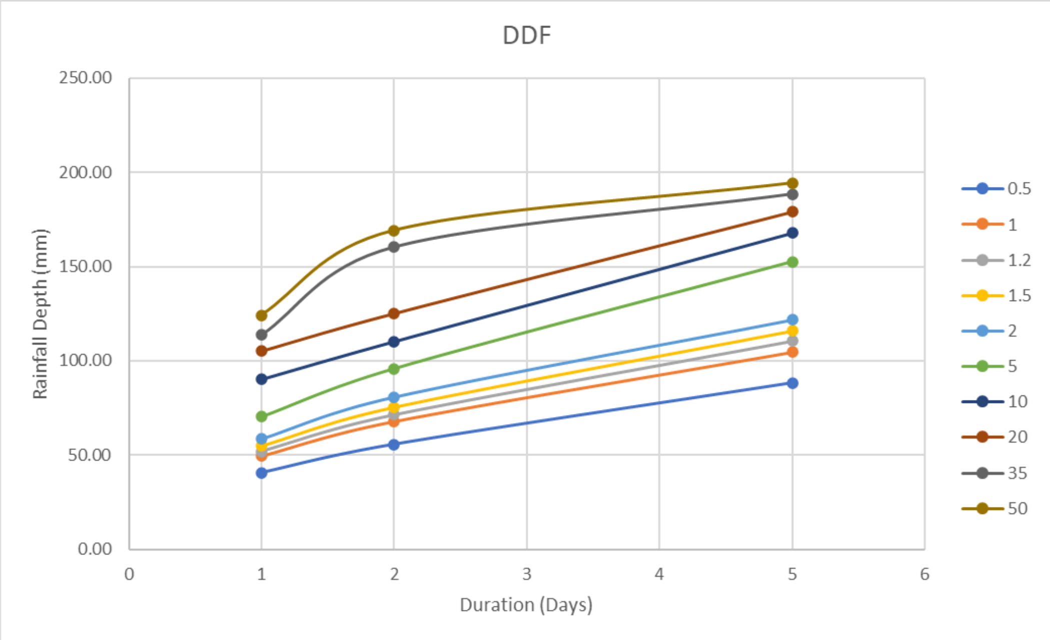

Figure 5-11: Maandagshoek Rainfall Station - Depth-Duration-Frequency

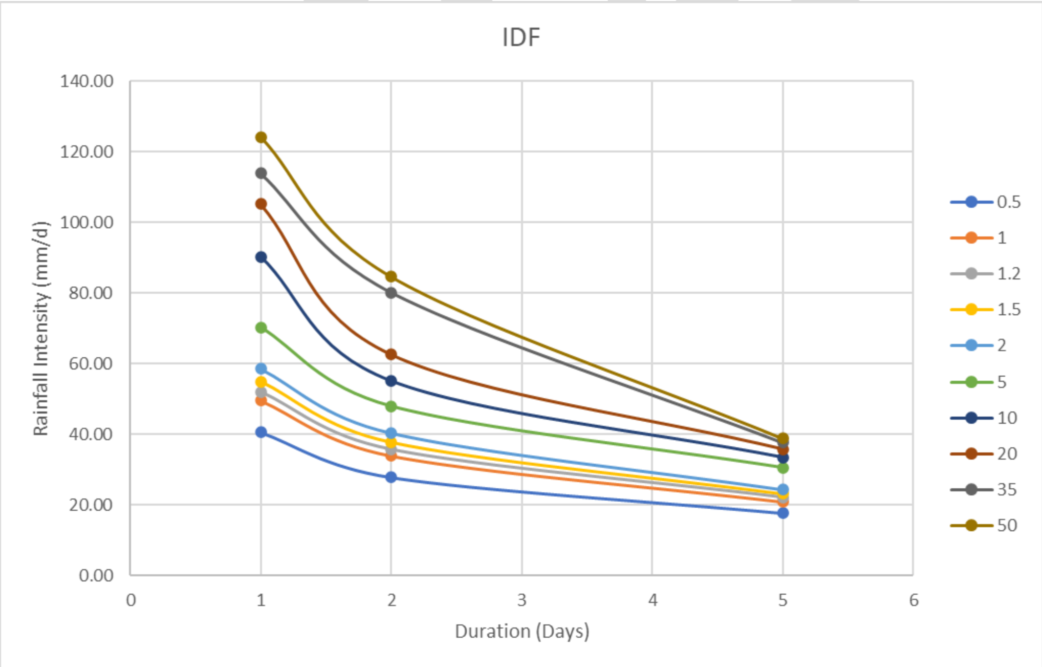

Figure 5-12: Maandagshoek Rainfall Station - Intensity-Duration-Frequency

The daily rainfall data was also used to do an Extreme Value Analysis (EVA). The results from the EVA are shown below in **Table 5-4** and **Figure 5-13.**

Table 5-4: Extreme Value Analysis

Return period T (year)	Full series (mm/day)	Gumbel estimate (mm/day)	Log Pearson (III) Estimate (mm/d)	GEV estimate (mm/day)	MEV estimate (mm/day)
0.5	40.64	32.22	17.00	35.48	32.07
1	49.62	46.17	24.88	46.17	42.10
1.2	51.98	49.84	28.67	49.11	45.02
1.5	54.88	54.34	35.87	52.80	48.74
2	58.61	60.13	52.11	57.69	53.70
5	70.33	78.58	72.23	74.35	69.99
10	90.26	92.53	86.82	88.10	82.49
20	105.14	106.49	99.62	102.95	95.17
35	113.82	117.75	112.82	115.79	105.55
50	124.14	124.93	122.64	124.40	112.22
100		138.89	139.52	142.12	125.33
200		152.84	157.52	161.24	138.60
500		171.29	173.75	188.86	156.37
1000		185.24	204.59	211.68	169.98

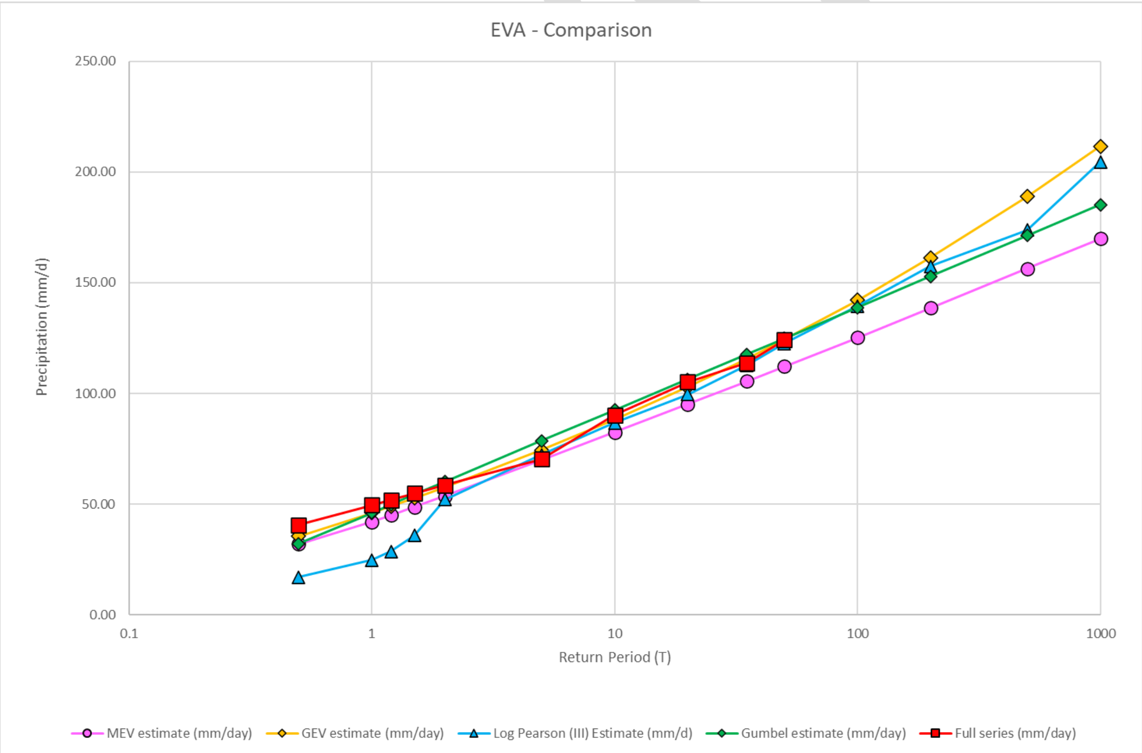

Figure 5-13: Extreme Value Comparison

The Gumbel, Log-Pearson Type III & Generalized Extreme Value (GEV) distributions give very similar results as they are based on annual block maxima, whereas the Meta-statistical Extreme Value (MEV) considers all the daily rainfall data in the time series. The MEV analysis is a new method in EVA and is described in Zorzetto et al (2016). The study by Zorzetto et al found that the MEV outperforms the traditional GEV methods when the return period of interest is longer than the observed rainfall time series.

A conceptual representation of the MEV approach applied to daily rainfall Extreme Value analysis is shown below in **Figure 5-14.**

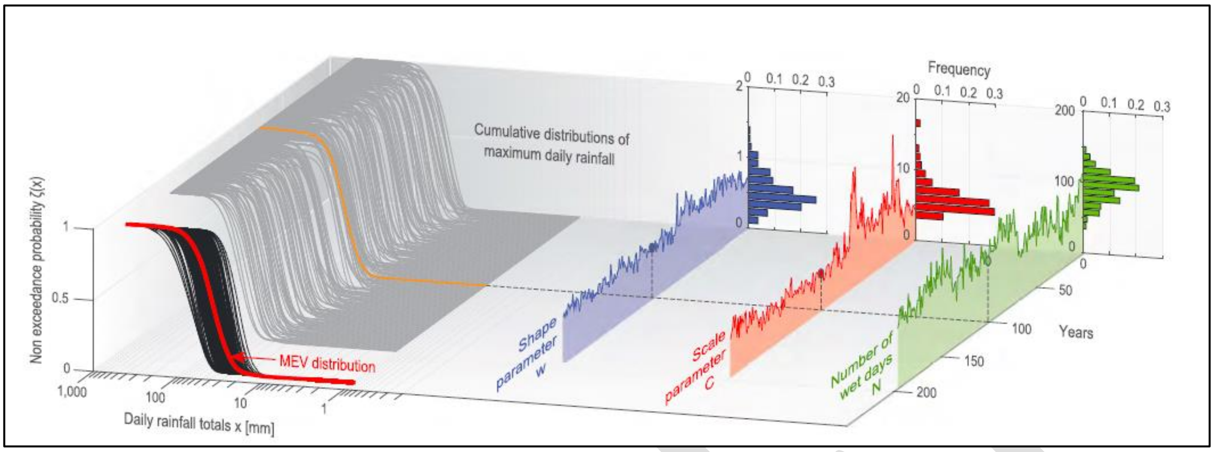

Figure 5-14: Conceptual Representation of MEV (Zorzetto et al – 2016)

The yearly values of the Weibull parameters (in blue and orange) and of the number of wet days (in green) define the cumulative distribution of maximum yearly rainfall (grey distributions are on the left and their projections in black on the vertical x-y plane in foreground). The MEV distribution (in red in the vertical x-y plane in the foreground), accounting for the stochastic variability in C, w, and n, is obtained by averaging over the empirical frequency distribution of the parameters.

6. FLOOD HYDROLOGY

An integrated 1D2D flood modelling approach was used for the Modikwa South3 Project. Various catchments impact the flood water within the mining area.

6.1 Sub-Catchments impacting the Flood Model

The catchment areas that drain through the Modikwa South3 mining area, shown as the red polygon is representative of the LiDAR survey. The sub-catchments of the streams and river flowing into the mining area are the green polygons, as shown below in **Figure 6-1.**

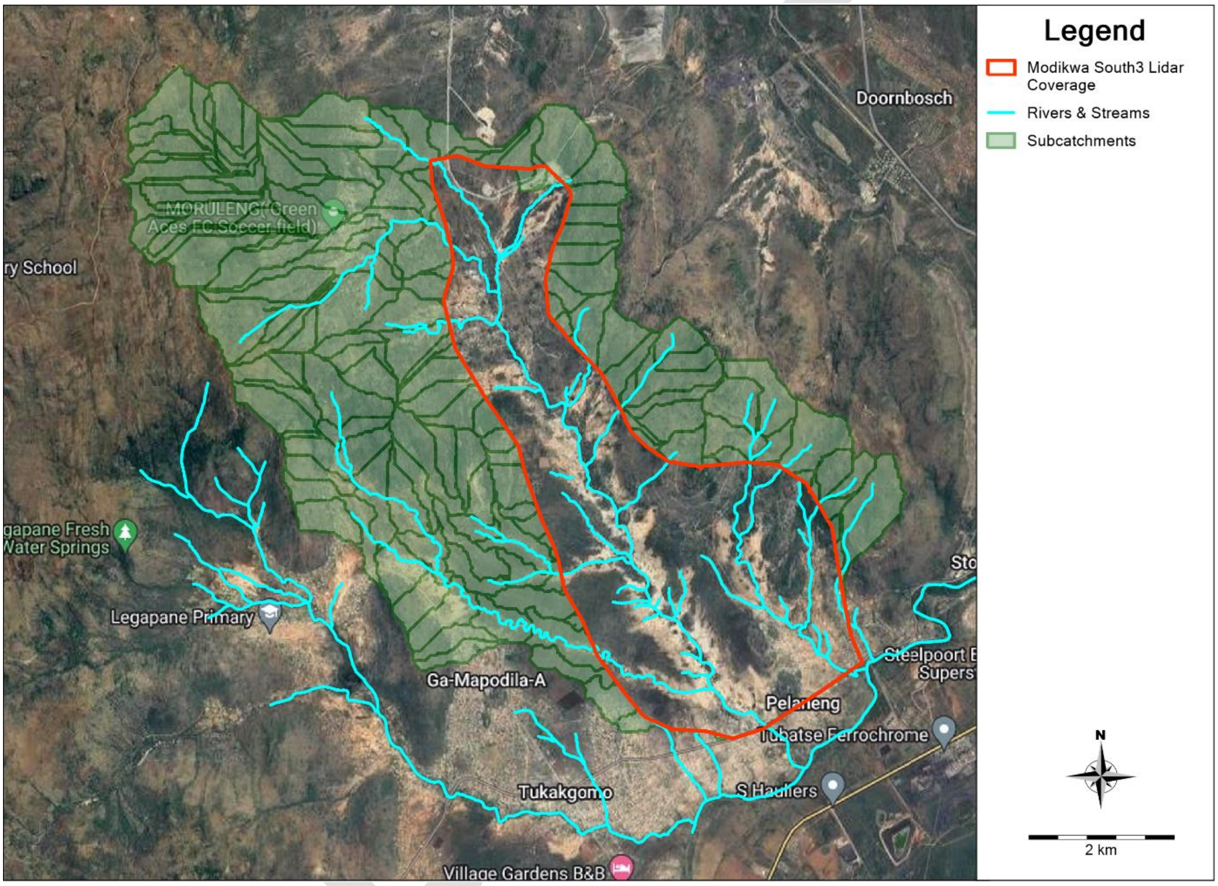

Figure 6-1: Modikwa South3 Project – Showing Streams and Sub-Catchment Areas

The mining area was considered to be a catchment on its own. An integrated 1D-2D modelling approach was used to do the flood modelling for Modikwa South3 Project. The project area is covered by a LiDAR survey enabling detailed rain-on-grid 2D modelling for the hydrology.

The areas outside of the project area are however not covered by a detailed survey and subsequently the flood hydrology for these areas was determined with the SANRAL drainage manual methods which are based on 1D hydrology catchments. The subcatchments outside of the project were determined with the SRTM terrain data that has a spatial resolution of ±30m grids.

6.2 Catchment Hydrology

The SANRAL drainage manual includes a number of programs for the calculation of flood peaks by means of statistical, deterministic, and empirical methods. No flow gauge data is available for either of the streams and therefore a statistical analysis could not be done.

The Rational and Alternative Rational methods are applicable for catchments smaller than 15 km². The empirical method from Midgley & Pitman is applicable for medium to large catchments and in particular rural catchments larger than 100 km². The unit hydrograph method is applicable to catchments between 15 km² and 5 000 km².

The SDF method is a simple and robust method that was developed as a check method and can be seen as an empirical regionally calibrated version of the rational method. The Soil Conservation Service (SCS) method is applicable for catchments smaller than 30 km².

6.2.1 1D Flood Hydrographs

Flood Hydrographs at each stream entering the mining area for the 1:20, 1:50, 1:100 and 1:200-year flood events were determined by using PCSWMM, 1D modelling capabilities. Ground cover influencing the roughness of the surface (Manning's n coefficient) and infiltration parameters were taken into account, as well as subcatchments size and slope when determining these hydrographs.

These parameters were determined from the site inspection, aerial images and WRSM2012 data. Each of the sixty-eight (68) hydrographs were used as upstream boundary conditions, representing the inflow into the mining area that is modelled as a 2D flood area.

The location of each boundary condition as inflow hydrograph is depicted in **Figure 6-1**.

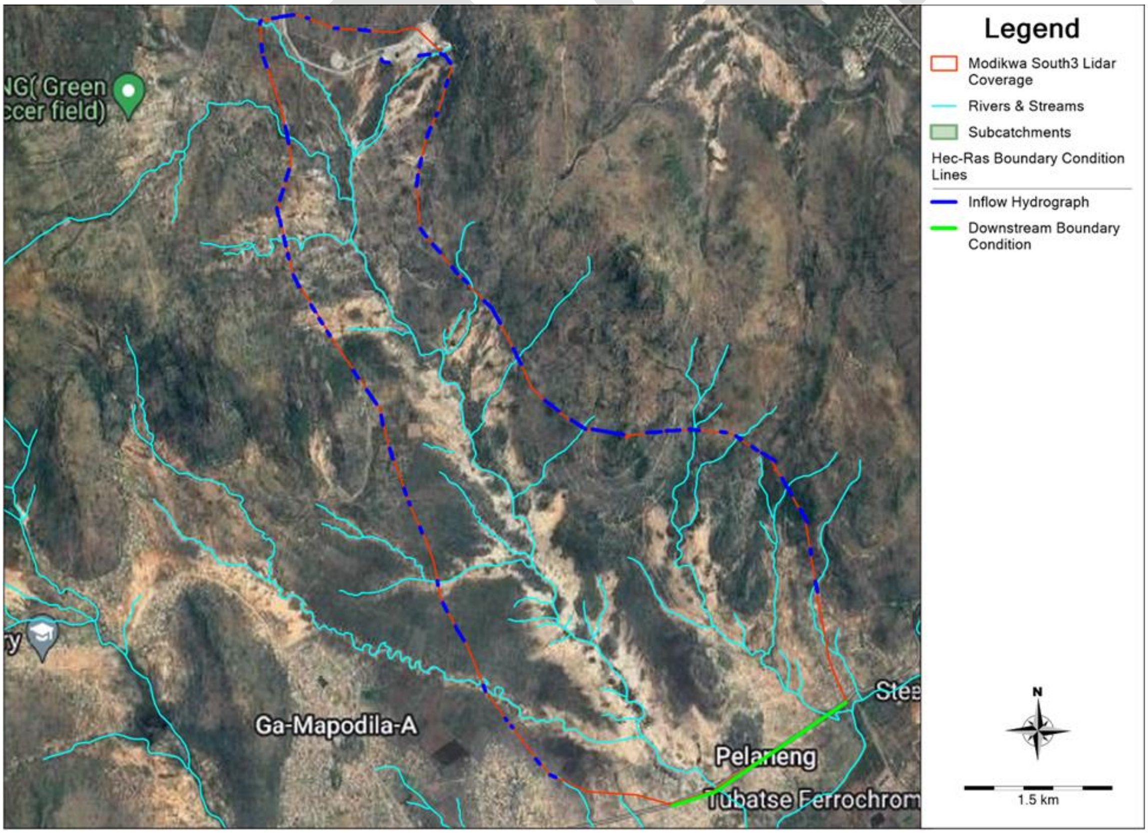

Figure 6-2: 1D Flood Hydrographs – Showing the Hydrograph locations into the Project Area

6.3 2D Flood Modelling

Flood hydraulic studies can be done either in 1D or 2D, each with its own advantages and disadvantages. Historically flood hydraulic studies were done predominantly in 1D due to the lack of computational power.

The significant increase in computational power over the past decade has made 2D flood modelling for small and medium sized areas more commonplace. The 2D flood modelling is particularly advantageous in flat floodplain areas where the flow paths are not immediately obvious. It was decided to model the Modikwa South3 mining area flood hydraulics in 2D due to the relatively flat overbanks in the project area.

The Lidar survey of the project area was converted to a Digital Elevation Model (DEM) through triangulation and is shown below in **Figure 6-3**.

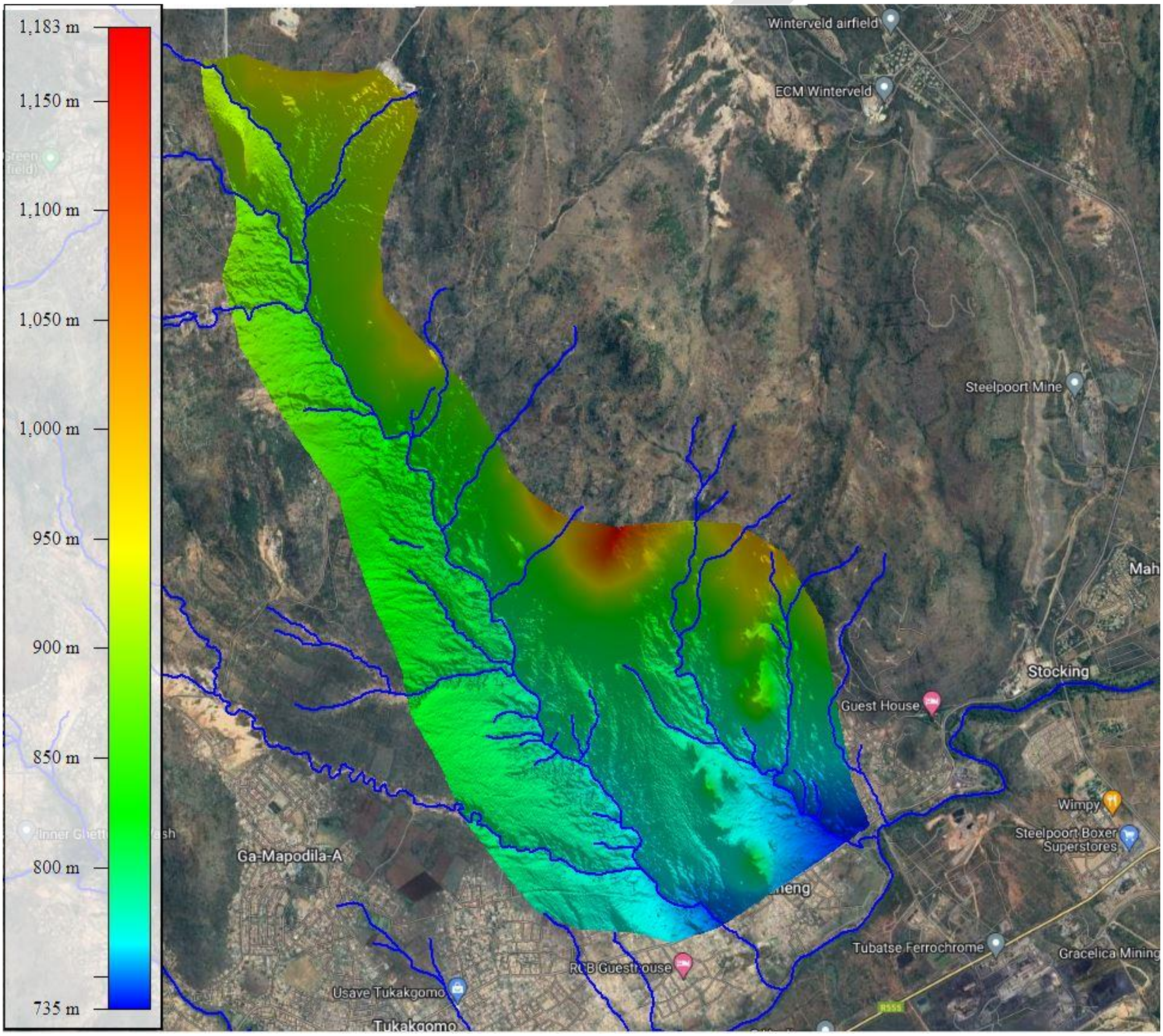

Figure 6-3: Modikwa South3 Project Area – Using the DEM for the 2D Flood Modelling

The flood modelling was done with a 2D HEC-RAS model where a spatially varied manning n was applied. Strictly speaking the Manning n roughness varies with depth. This is however a deficiency in HEC-RAS and was mitigated by choosing conservative Manning n values on the higher side.

Inflow hydrographs as described in Section 6.2.1 were used as the upstream boundary conditions for both streams and normal depth downstream boundary conditions were used where it was assumed that the topography slope is equal to the water surface slope. In addition to the inflow hydrographs the rainfall was modelled on top of the 2D grid as a precipitation boundary condition. The peaks of the inflow hydrographs were modelled to match the peak of the precipitation hyetograph in order to model a worst-case scenario.

6.3.1 Maximum Depths

The maximum depth simulated for each 2D cell during the 1:100-year flood event is shown below in **Figure 6-4** for the entire study area.

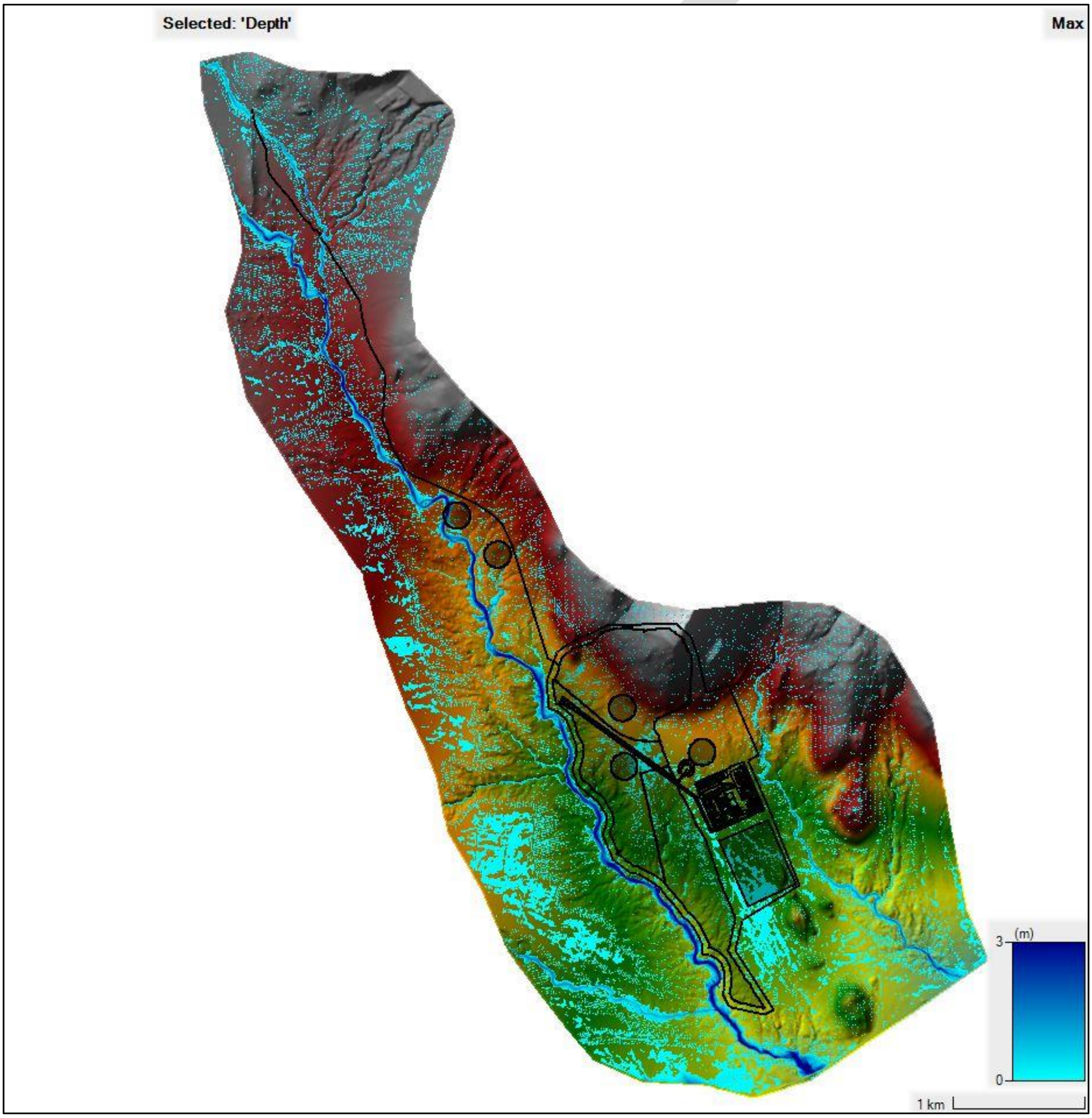

Figure 6-4: Max Depths Simulated during the 1:100 Flood Event - Total Study Area

The flood depths focused around the southern mining area are shown below in **Figure 6-5**.

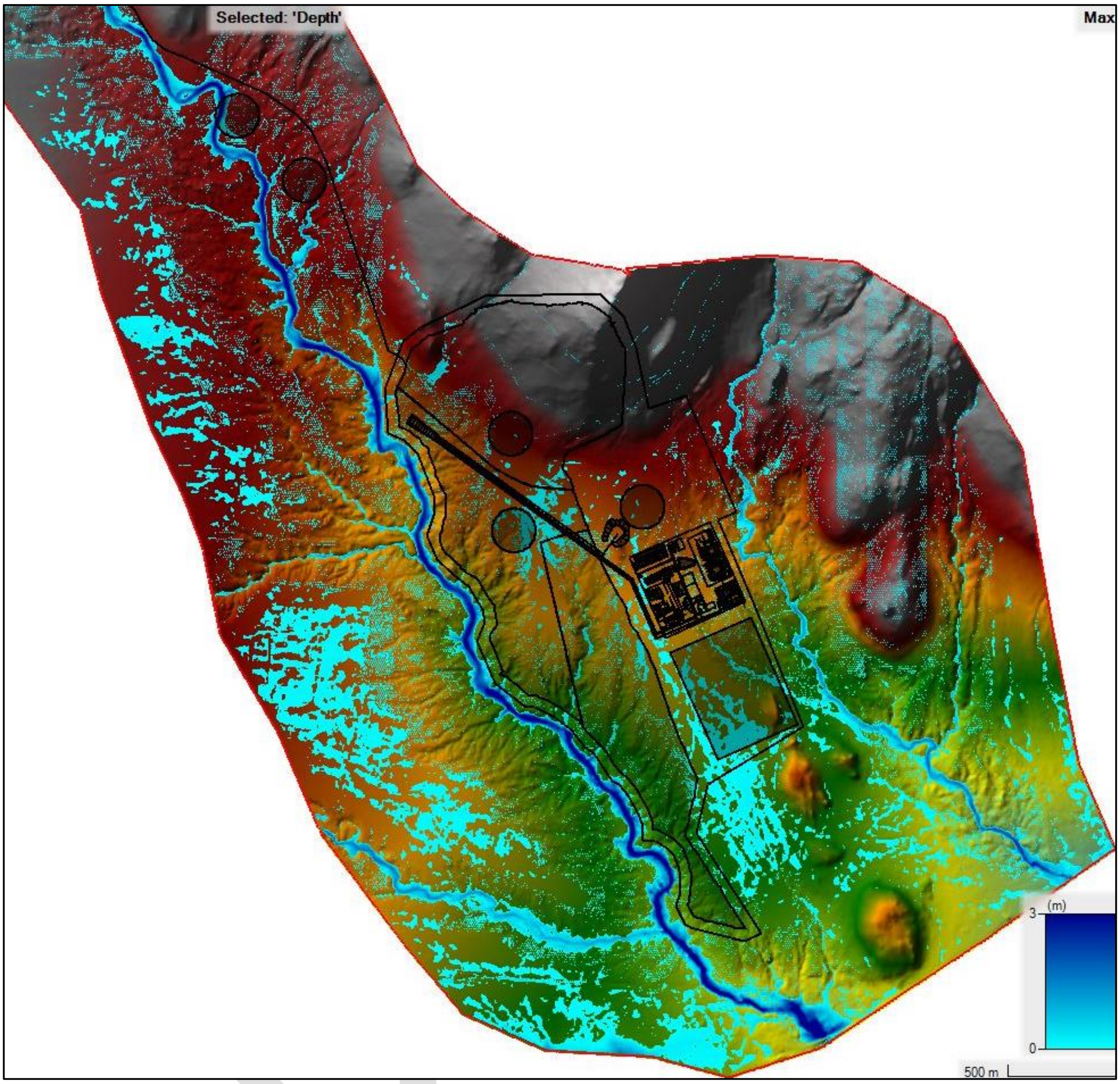

Figure 6-5: Max Depths Simulated during the 1:100 Flood Event – Focused on the Southern Mining Area

The maximum flood depths in the Tubatsane River to the west are mostly just above 3m, with the maximum recorded depth being in the order of 4.7m. The smaller Mofafa River to the east of the proposed infrastructure is at lower depths and only reaches 3m depth in a few locations.

These 1:100 flood images also indicate a small degree of inundation of the proposed infrastructure areas but also small secondary streams that are impacted by the proposed development. Where possible, these secondary streams that are impacted must be diverted away from the impacted mining areas and released as clean water to the natural streams of the area.

The impact of the secondary streams are also clearly visible for the proposed new haul road to Modikwa South2 mine located to the north of the area.

6.3.2 Maximum Velocities

The maximum velocity simulated for each 2D cell during the 1:100 flood event is shown below in **Figure 6-6,** where this covers the entire study area.

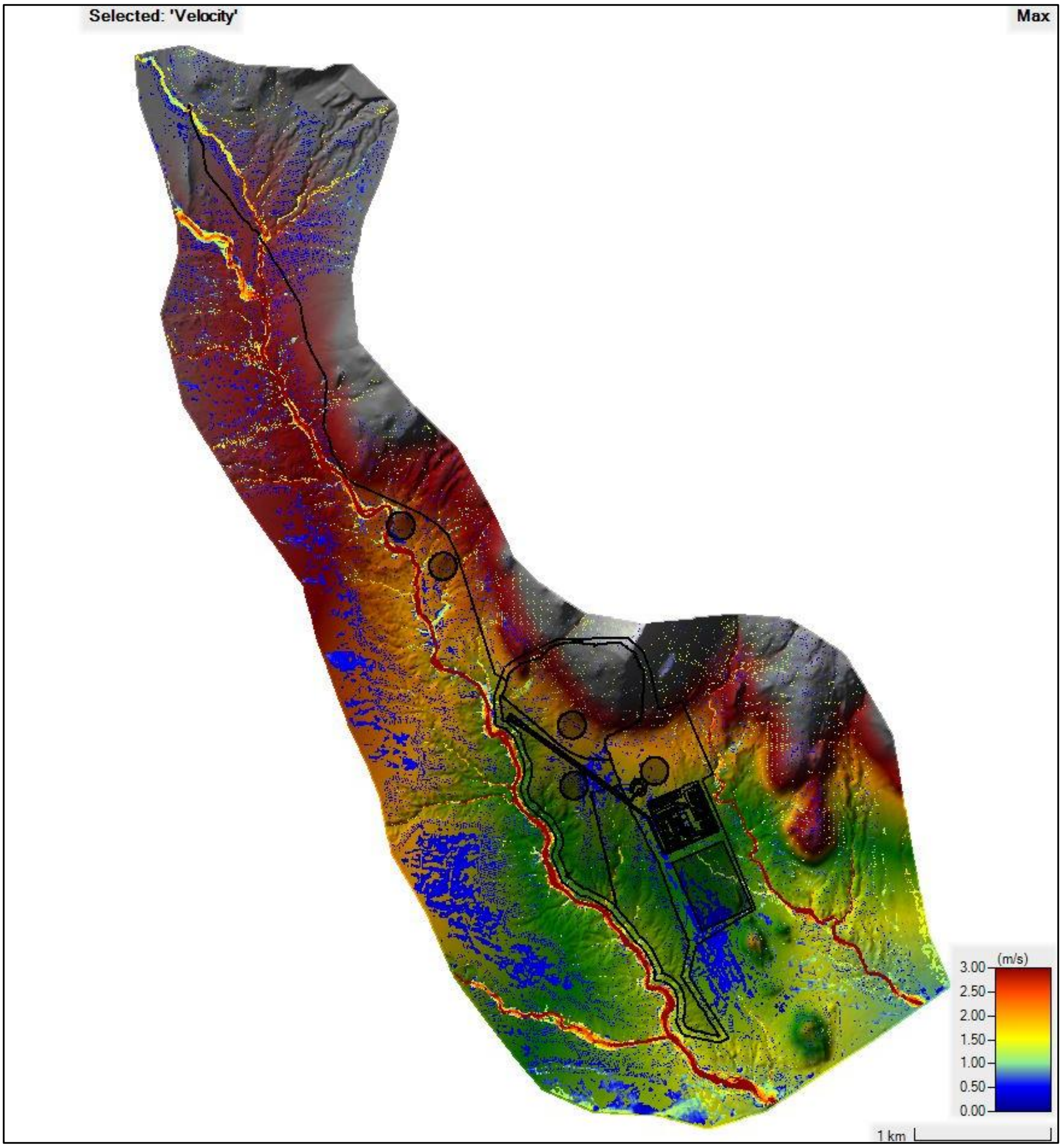

Figure 6-6: Max Velocities Simulated during the 1:100 Flood Event – Total Study Area

The flood velocities in the Tubatsane River are mostly above 3m/s, and the maximum recorded velocity reaches 62m/s in one location. These are significant flood velocities and the impact of this should be taken into account where mining of the opencast shells will occur at depths just adjacent to the Tubatsane River.

The flood water does also show in close proximity to the proposed haul road where it is recommended to change some of the horizontal alignment of this road to stay clear from these hazards.

The more focused flood velocities within the southern mining area are shown below in **Figure 6-7**.

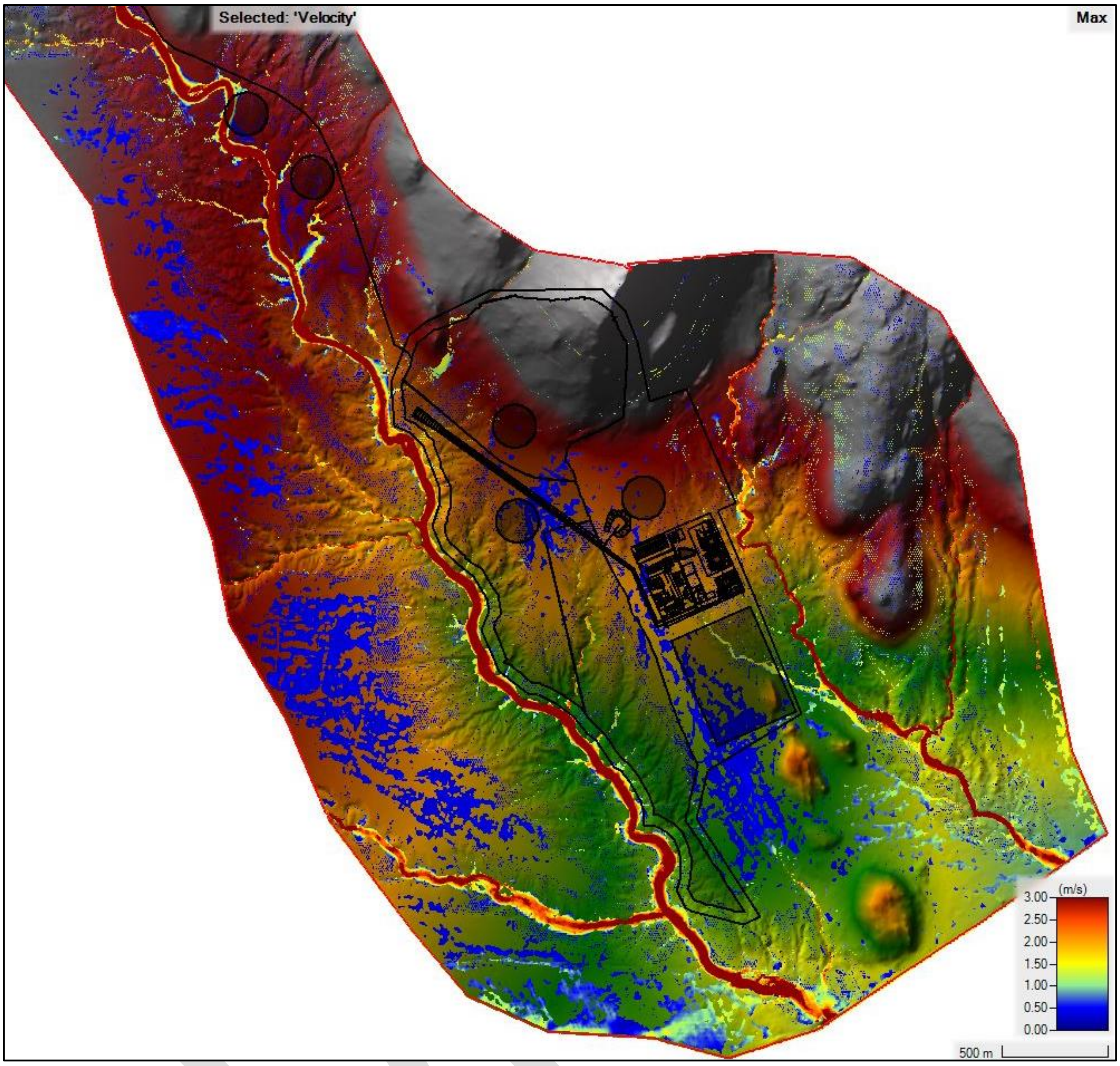

Figure 6-7: Max Velocities Simulated during the 1:100 Flood - Focused on the Southern Mining Area

It can be concluded from the flood maps that the mining activities are not impacted by the 1:100 flood event where the flood waters are still within the 50m and 100m buffers along the Tubatsane River as shown in the above figure. The impact of flood water within the infrastructure areas of the Mine is also protected and only minor stream diversions will be required to divert flood water around the impacted mining areas.

6.3.3 Flood Hazard Maps

Special Flood Hazard Maps were developed where these give a visual representation of the flood hazards where critical areas are identified that are deemed a significant risk for the Mine. The flood hazards are generated where the flood depths are multiplied by the flood velocities (D x V) for each 2D cells during the 1:100 flood event.

The Flood Hazard Map for the entire study area is shown below in **Figure 6-8**.

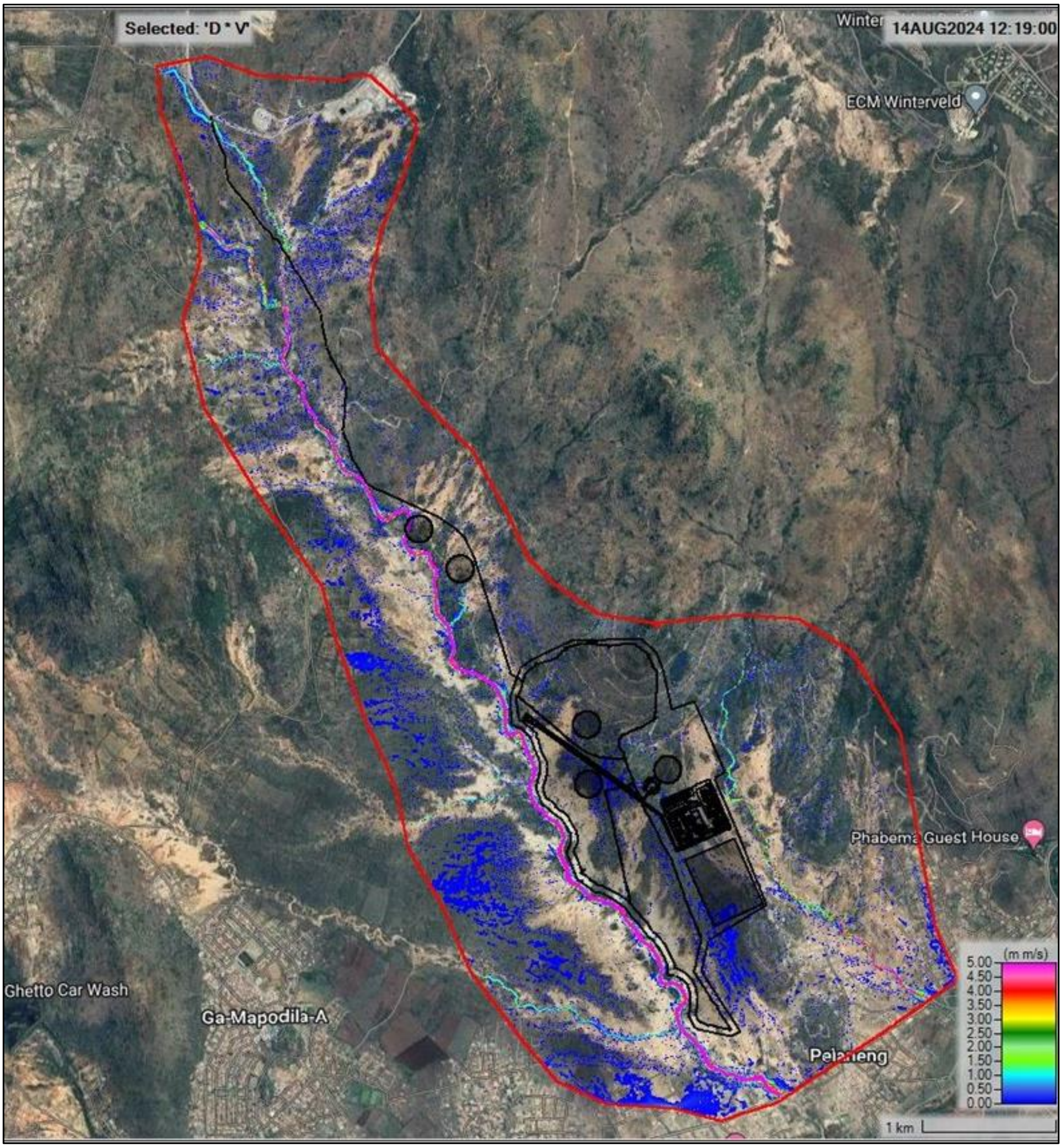

Figure 6-8: Flood Hazard Map (D x V) Simulated during the 1:100 Flood Event – Total Study Area

The flood hazard map gives a good indication of hazard areas posed to humans and structures during a flooding event. It is clear that the entire Tubatsane River is at flood hazards of above $5m^2/s$.

The Flood Hazard Map for the southern mining area is shown below in **Figure 6-9**.

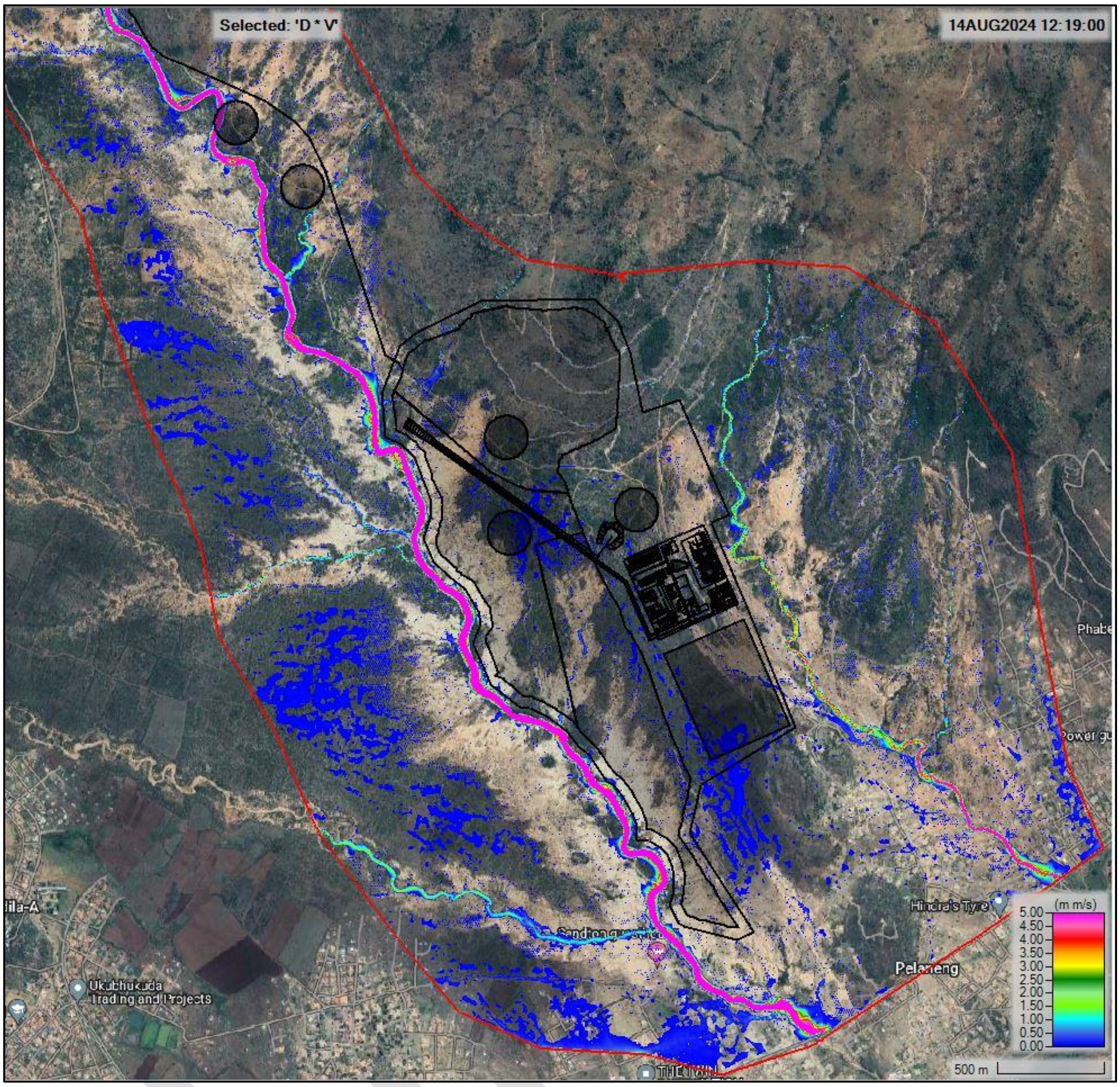

Figure 6-9: Flood Hazard Map (D x V) Simulated during the 1:100 Flood - Southern Mining Area

The maximum hazard in the Tubatsane River is in the order of 4m²/s to 7m²/s, with a maximum value of 24m²/s in one location. The hazards are, however, still within the 100m buffer zone and are therefore contained within the floodplains of the existing river.

The flood hazards of the Mofafa River to the east are at much lower levels.

7. STREAM CROSSINGS

There will be thirty-six (36) stream crossings for the haul road between the proposed new opencast project at Modikwa South3 and the existing Modikwa South2 Shaft Mine. The general locations of these crossings are shown as the green markers in the below **Figure 7-1**.

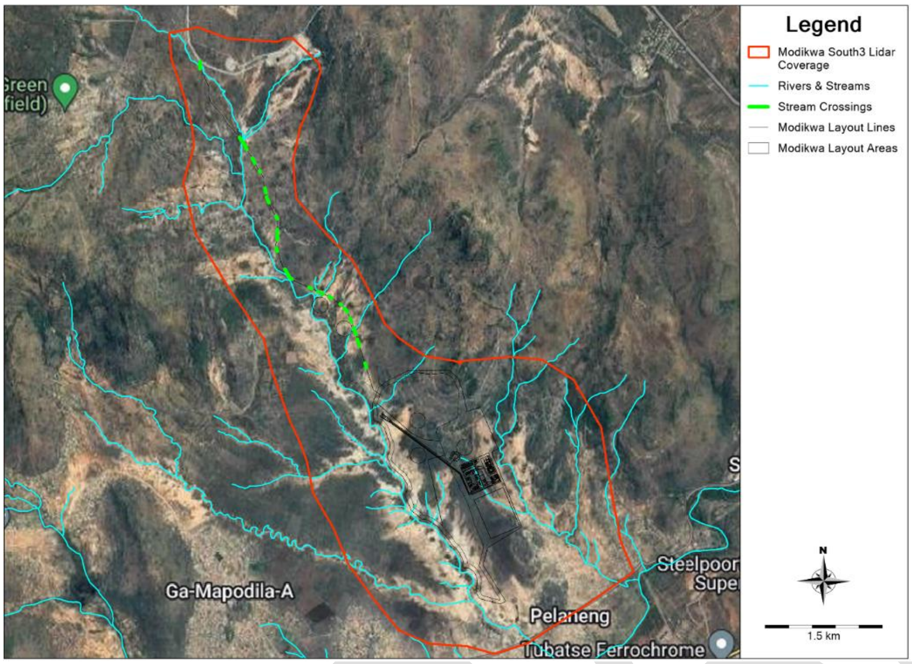

Figure 7-1: Modikwa South3 Project - Showing the General Locations of the Haul Road Stream Crossings

These crossings are at the various primary bigger and smaller secondary streams that join the Tubatsane River, but also the much smaller tertiary crossings as shown below in **Figure 7-2.**

Figure 7-2: Detailed Locations of the 36 x Stream Crossings

The flood hydrograph peaks for the 20- and 100-year flood events for each of the 36 stream crossings are summarised in **Table 7-1**, along with recommended culvert sizes and number of barrels for these crossings.

Table 7-1: Stream Crossings – Showing Floods and Recommended Culvert Sizes

Crossing No.	Flood event (m^3/s)		Culverts Based on 20-Year Flood	
	20-Year	100-Year	Culvert Size (W x H) (mm)	No. of Barrels
Crossing1	19.829	33.855	1800 x 1500	3
Crossing2	59.014	102.227	2400 x 1800	5
Crossing3	1.73	2.591	1800 x 600	1
Crossing4	0.176	0.277	600 x 450	1
Crossing5	1.95	3.412	1200 x 600	2
Crossing6	0.534	0.884	900 x 450	1
Crossing7	0.615	0.978	900 x 450	1
Crossing8	0.758	1.268	900 x 600	1
Crossing9	0.802	1.23	1200 x 450	1
Crossing10	1.192	1.716	1200 x 600	1
Crossing11	3.169	5.168	1200 x 450	4
Crossing12	0.408	0.617	600 x 450	1
Crossing13	0.782	1.418	600 x 450	2
Crossing14	0.117	1.687	600 x 450	1
Crossing15	1.779	2.795	1500 x 450	2
Crossing16	0.192	0.473	600 x 450	1
Crossing17	4.006	6.14	1500 x 1200	1
Crossing18	7.187	12.9	2100 x 1500	1
Crossing19	0.067	0.095	600 x 450	1
Crossing20	0.554	0.783	600 x 600	1
Crossing21	4.047	6.342	1500 x 1200	1
Crossing22	1.979	2.963	1200 x 900	1
Crossing23	0.043	0.062	600 x 450	1
Crossing24	1.258	1.907	1500 x 600	1
Crossing25	0.473	0.649	900 x 450	1
Crossing26	0.039	0.054	600 x 450	1
Crossing27	0.215	0.548	600 x 450	1
Crossing28	10.072	18.663	2100 x 1800	1
Crossing29	0.095	0.209	600 x 450	1
Crossing30	0.121	0.173	600 x 450	1
Crossing31	1.267	1.939	1500 x 600	1
Crossing32	0.195	0.317	600 x 450	1
Crossing33	0.325	0.6	600 x 450	1
Crossing34	0.246	0.407	600 x 450	1
Crossing35	3.646	5.796	1200 x 600	3
Crossing36	0.326	0.514	600 x 450	1

We have evaluated the stream crossings against the SANRAL Drainage Manual standards for typical crossings.

7.1 Road Classification

Roads in South Africa are classified into six (6) general classes. These definitions correspond to the document TRH 26: "South African Road Classification and Access Management". R classes are rural and U classes are urban roads.

According to the SANRAL Drainage Manual (Chapter 8.2), the haul road from Modikwa South3 to Modikwa South2 Shaft is clearly a Class R4 Rural collector roads, with the following description:

- **Class 4 (R4 Rural collector road, U4 Urban collector street)**

  Strategic function: Lower mobility roads with high levels of access for lower traffic volumes in urban and rural areas of local importance.

  Typical descriptions:
  Class R4 Rural collector roads form the link to local destinations. Typically they give access to smaller rural settlements, tourist areas, mines, game and nature parks and heritage sites and large farms. The length of these roads would be shorter than 10km and the AADT should not exceed 1 000 vehicles per day.

  Class U4 Urban collector streets penetrate local neighbourhoods or commercial developments with very little or no through traffic.

7.2 Design Flood Frequency

The design flood frequency is given in Figure 8.2 of the SANRAL Manual, as shown below.

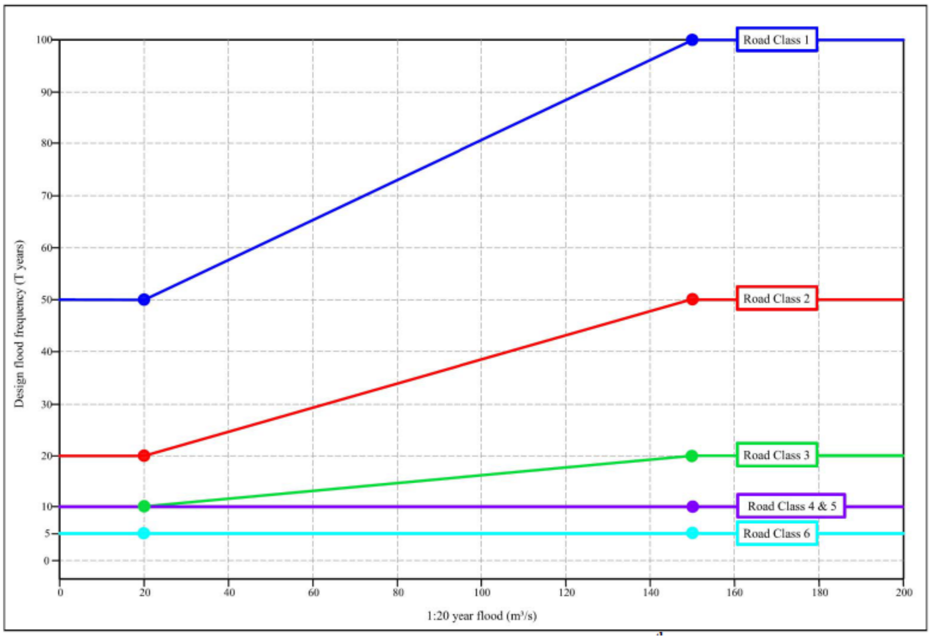

Figure 7-3: SANRAL Design Flood Frequency for Rural Roads

It is clear that a Road Class 4 is designed for a 10 year return period.

The 1:20 year flood event reflects, in essence, the hydrological risk classification of the road-river crossing at the crossing site. The level of the afflux for the Q_{20} event must be below the Shoulder Break Point (SBP) or 2D as shown below in the **Figure 7-4**.

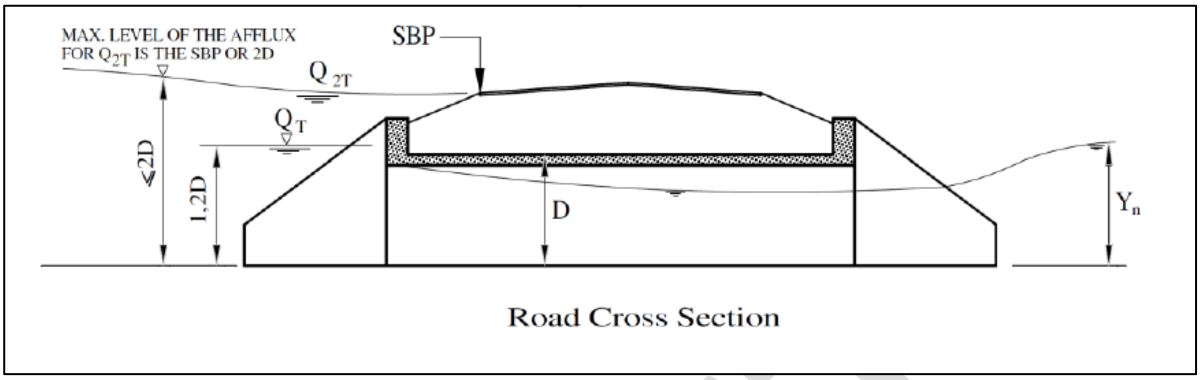

Figure 7-4: Typical Cross Section for a Rural Type 4 Mine Road

The 20-year flood event was thus used to determine the recommended sizes of the culverts at each of the thirty-six (36) stream crossings, as listed in the **Error! Reference source not found.**above Table 7-1. Stream crossings 1, 2 and 11 are the bigger crossings that must be managed for the haul road project.

8. DETAILED SWMP MODEL

8.1 Design Rainstorm

The Maandagshoek rainfall station records were used to define the 1:50 rainfall event where the 1-day 1:50 rainfall depth is 123.6mm. The South African SCS Type 3 Design Rainstorm is shown below in **Figure 8-1** and was used for the 1:50 simulations.

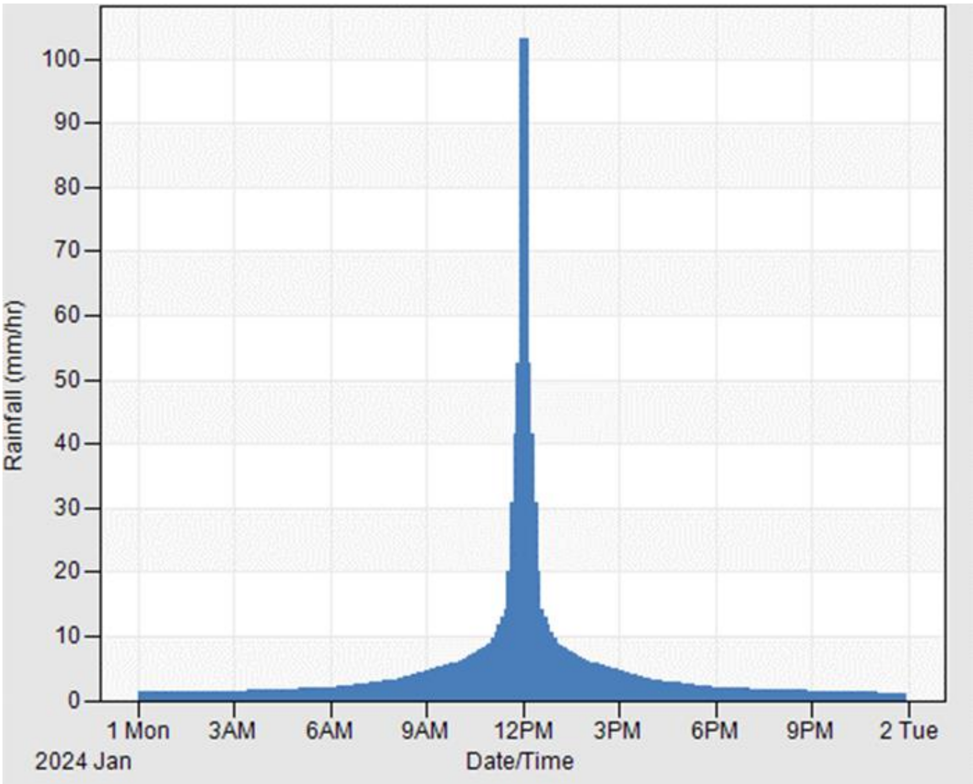

Figure 8-1: Karina Rainfall Station - SA SCS Type 3 Design Rainstorm of 122.9mm

The PCSWMM model was used to simulate the 1:50 design storm on the proposed infrastructure to determine the sizing of the canals. The 1:50 design storm and long-term simulations were used to determine the appropriate sizing for the PCD.

Special design developments were conducted covering the overall scope for the SWMP that will be submitted in support of the Water Use Licence (WUL) application. All the signed design development drawings for the SWMP are included in **Appendix A**.

9. SWMP INFRASTRUCTURE - DESIGN DEVELOPMENTS

The following is a brief summary of the SWMP infrastructure proposed for the Modikwa South3 project.

Special design developments were conducted covering the overall scope for the SWMP that will be submitted in support of the Water Use Licence (WUL) application.

9.1 General Layout Plan

The General Layout Plans is shown on **Dwg: MS-G-01**, included in **Appendix A.**

The following can be reported:

- The drawing is done to a scale of 1: 25 000 showing the terrain contours (major 5m intervals & minor contours 1m interval).
- The clean vs dirty water canals are clearly shown within the three (3) mining areas.

- The Dirty Water System comprise the following:
    - Infrastructure Area: The infrastructure area comprises of a ROM stockpile from where the ore is loaded and transported to Modikwa South2 via the new haul road. The Plant area also comprises of two (2) workshops, offices and change houses.
    - Waste Rock Dump: The Waste Rock Dump (WRD) is regarded as a dirty water footprint and a special site selection process was used to confirm the best location as this is shown in the G-01 plan. Special seepage drains will be installed as part of the Class C barrier design where this impacted water will gravitate to the PCD.
    - Groundwater Inflows: The groundwater inflows in the various opencast pits will be diverted to in-pit sumps from where it will be pumped to the PCD to ensure that mining can continue.
    - New dirty water canals: New lined dirty water canals (red) will be utilized to route the water to the relevant dirty water structures. The canals will either be HDPE or concrete lined.
- The Clean Water System is the remainder of the mining area where the clean-water areas in-between are diverted with grass covered canals and berms away from the impacted mining areas. The following is of importance for the clean water system:
    - Clean water diversion canals/ berms have been placed strategically throughout the mining area (light blue) where the clean water is diverted away from the impacted areas to the natural environment.
- Scientific Buffers: The hydropedology buffers have been provided by the specialist and these have been delineated at maximum 50m from the center of the on the impacted streams. These scientific buffers all fall within the 100m stream offset as per GN704 and are therefore not a limiting factor.
- Stream Crossings: There are thirty six (36 stream crossings that impact the haul road to the existing Modikwa South2 shaft. These crossings have been identified and the associated culvert crossings were confirmed for the 1:20 year flood event.
- Floodline Study: A detailed floodline study was undertaken for the project. The 1:100 flood event is shown on the General Layout Plan. All infrastructure and mining developments have been shifted outside these floodlines and limiting buffers.
- Clean Water Storm Water Discharge from the bigger mining areas have been allowed for in a series of clean water diversion canals and berms. No flood attenuation will be required for the clean water

systems. However, silt fences and special erosion outlet chutes have been designed at these outlets to limit erosion damage and high flows into the surrounding environment. The velocities in the diversion berms are designed to be below 1.5m/s (maximum for grass lined canals) but above the minimum of 0.3m/s (minimum to prevent siltation of the grass canal).

9.2 Dirty Water Canals

Various dirty water canals are designed in support of the Modikwa South3 Project as indicated on the General Layout Plan.

9.2.1 Type of Dirty Canals

These dirty water canals will be either concrete or HDPE lined canals as shown below in **Figure 9-1.**

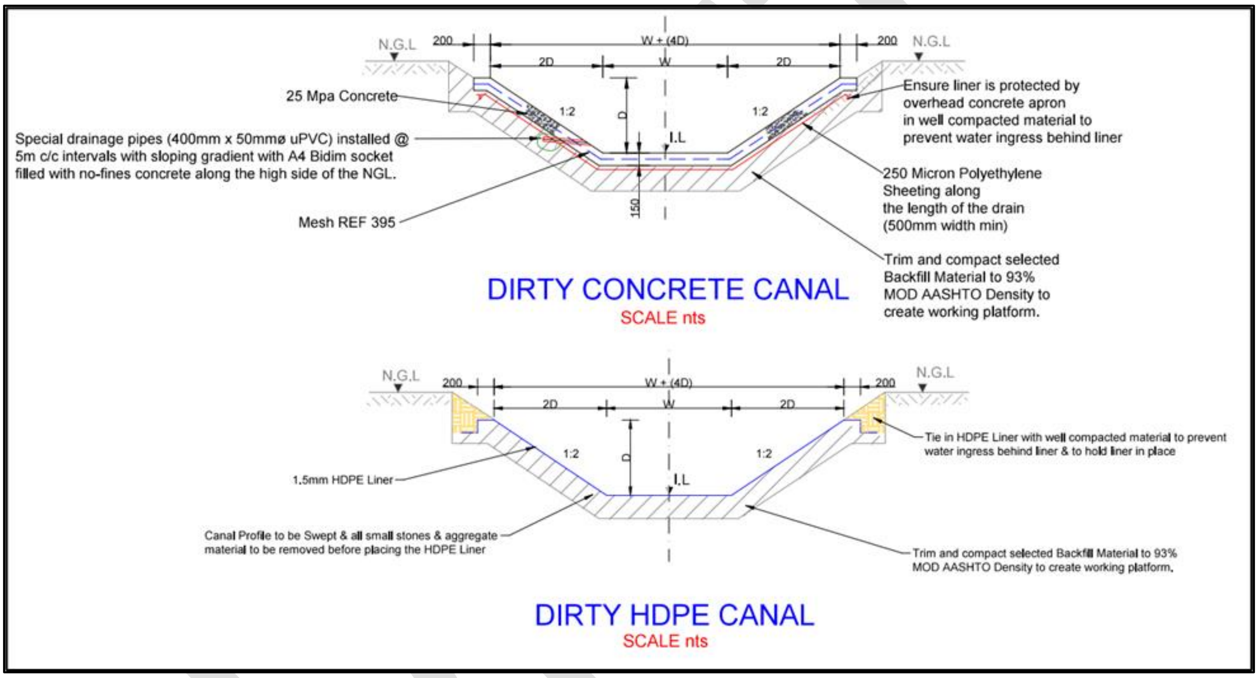

Figure 9-1: Dirty Water Canal Sections – Showing Concrete vs. HDPE Lined

The dirty water canals are either triangular or trapezoidal where these will be either concrete or HDPE lined. based on the impacted operations and maintenance that will be required to keep these canals functional. High canal velocities greater than 2.5m/s will require special energy dissipating structures.

9.3 Clean Water Canals

The clean water canals within the Modikwa South3 Opencast mining areas are shown as the light blue lines in the above Figures 9-2 to 9-4.

The clean water canals will be grass-lined canals. A typical clean water canal section is shown below in **Figure 9-2.**

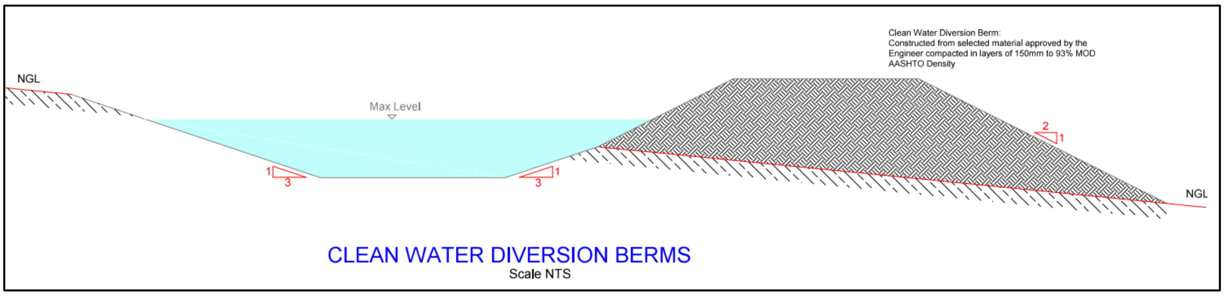

Figure 9-2: Typical Clean Water Canal/Diversion Berm

These clean water canals will be a cut-to-fill operation where the excavated material will be used to construct the side berms along the downstream side of the canal catchment. The clean water canals are trapezoidal canals. The clean water diverted along these clean canals will be released to the natural environment with an outlet structure that will prevent erosion.

The details for this Erosion Structure are shown below in **Figure 9-3.**

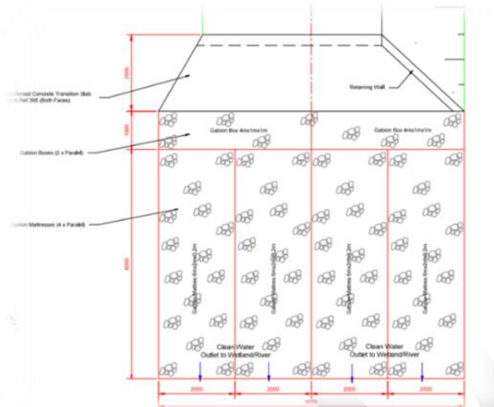

Figure 9-3: Typical Erosion Protection at Clean Water Outlets

9.4 New Pollution Control Dam

A new PC Dam will manage all the impacted water collected from the Plant area, the ROM Stockpile area, the WRD and any dewatering from the opencast pits. The position of the new PCD is shown below in **Figure 9-4**.

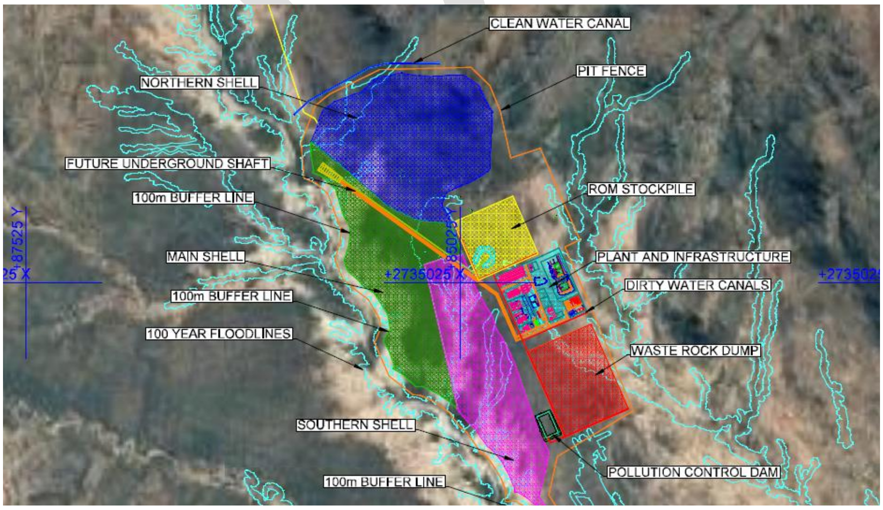

Figure 9-4: New PC Dam Position

9.5 Transfer Sumps

In-pit sumps (HDPE lined) will be built within the opencast pits to accumulate the impacted water from direct rainfall as well as groundwater seepage from where it will then be pumped to the PCD. The sumps have been sized based on the design simulations that were modelled for the 1:50 year storm event.

9.6 In-Line Silt Trap

A Silt trap will be provided at the inflow into the PCD. All dirty water collected from the Mine is discharged via canals or pumps into the silt trap from where the silt is then deposited and captured before it overflows to the PC Dam.

The silt trap is a concrete lined structure with a double chamber system. The basic design principles are the following:

- Design flow through the sedimentation/ silt trap must cater for the 1:10-year – 24-hour recurrence interval.
- The silt trap must allow for easy access to allow for the regular cleaning of the silt trap.
- A rectangular silt trap is proposed with one or two parallel chambers which will increase the retention period through the silt trap to allow for settlement.
- A splitter canal is located upstream of the double chamber silt trap where the option is allowed for to either close-off one silt trap for drying and cleaning whilst the second silt trap can be operational.
- When the operational silt trap is full, it overflows into the second chamber before it then overflows into the PCD's.
- The first operational chamber of the silt trap accumulates the coarsest silt whilst the second parallel chamber allows for the finer silt deposition as the speed through the silt trap decreases significantly.
- The retention time for the 1:10 year – 24-hour storm event through the silt trap should not be less than 20 hours.
- Small weeping holes (20mm diameter) are provided to ensure that the water in the silt traps can be drained over time during dry periods. This will help with the regular cleaning of the silt trap once the water levels in the silt trap have subsided.
- A special sloping drying slab is provided adjacent to the silt trap where the seepage water is then drained back into the silt trap.
- Special rails are proposed in the floor –and wall section of the silt trap which will allow for the protection of the concrete when loaders and heavy equipment are used to remove the silt from the silt trap.

9.7 Emergency Overflow Structures

A concrete emergency overflow structure has been designed at the outlet of the PC Dam. This is required to protect the safety of the dam for extreme storm events bigger than the 1:50 year event.

The following details can be observed for the emergency overflow structures:

- The structure is built in concrete to ensure the integrity of the structure during extreme storm events.
- The overflow structure makes provision for the mandatory 800mm freeboard to be maintained for the PC Dam.
- The overflow structure is sized to accommodate flows for the 1:200-year storm event.

- A special sump section is provided in the overflow structure for the Mine to install a return pump that can draw-down the volume of water in the PC Dam after an extreme storm event.
- The overflow structure makes provision for special protection with gabion boxes and mattresses at the outlet to the natural environment to limit the damage when the dam is overflowing.
- This overflow concrete structure is included in the overall sealing and waterproofing of the Main PC Dam when the HDPE liner is installed.
- The overflow structure is diverted to the natural drainage outlets of the Mine to prevent flooding of the Mine during extreme (abnormal) storm events. This is an industry standard.

10. WASTE LICENCE APPLICATION & CHECKLIST

10.1 Conclusion from Waste Classification

Recommendations and comments on an appropriate barrier design have been made by SRK based on the waste classification conducted for the project, and involves the following:

- PC Dam Class C
- ROM Stockpile: Class C
- Waste Rock Dump: Class C
- Softs & Topsoil Stockpile: Class D

10.2 Barrier Design – New LoM Pollution Control Dams already Installed

The geotechnical investigation conducted confirmed that clay is not readily available from the infrastructure area. It was therefore decided to use an alternative design where the clay layers are replaced with a double HDPE liner where a cuspated leakage detection system is provided in-between.

The design for this Equivalent Class C barrier design is shown below in **Figure 10-1**.

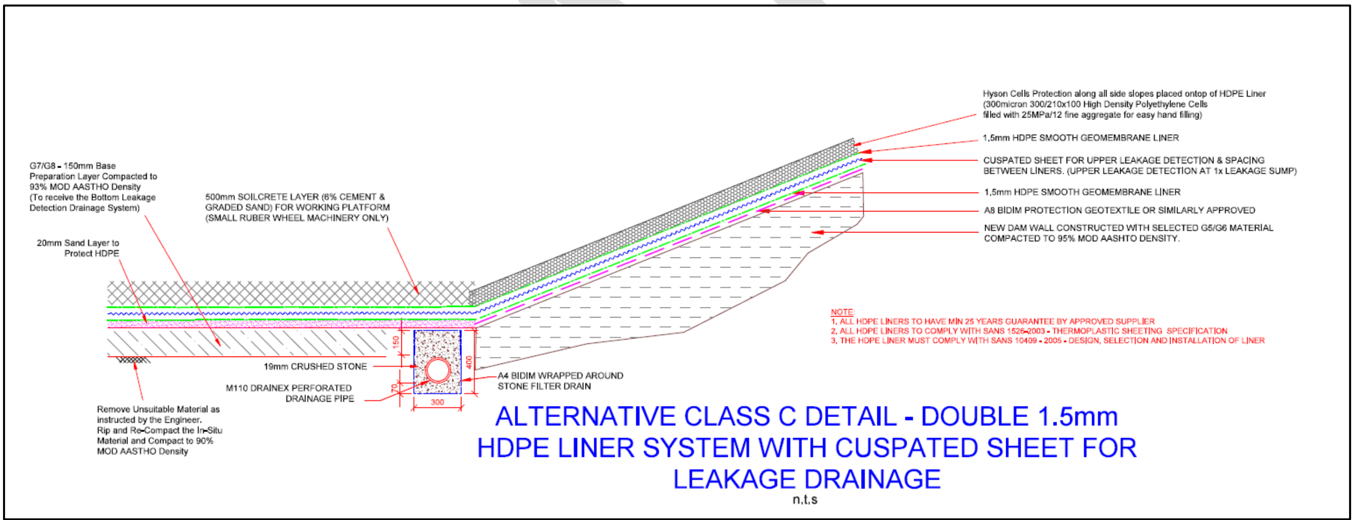

Figure 10-1: Alternative Class C Landfill Barrier (Double HDPE Liner with Cuspated Leakage Detection)

10.2.1 HDPE Geomembrane for PCD's

The recommendation for the HDPE liner design is as follows:

- The client will use a 1.5mm HDPE liner (A 1.5mm HDPE Liner is required for the Class C Barrier Design)
- The liner company will issue a warranty for the HDPE liner to match the life expectancy of the Mine.
- Cleaning operations of the PC Dam will be limited to small rubber wheel machinery such as bobcats. No track machinery is allowed.

10.2.2 Geometric Design of the Plant PC Dam

The PCD dam wall has been restricted below the 5m maximum safety risk impoundment limitation. The dam is built mostly into cut, but where possible and excavation material allowed for this, a cut-to-fill balance was achieved.

The following important design developments have been identified in support of the PC Dam designs:

1) Regarding the proposed dam embankments, it is recommended that the slopes for the embankments are constructed in 1 vertical to 4 horizontal and that the material be compacted in layers of 150mm thickness to at least 93% Mod AASHTO density at -1% to +2% of optimum moisture content.
2) Silty clayey sand and clayey sand (SC-SM and SC USCS) hillwash and residual sandstone soils grade as semi-pervious materials, suitable for use in the semi-pervious zones of earth fill embankments.
3) Regarding the stability of the dam embankments, the embankments will be stable under drained conditions at the proposed slope of 1:4, as confirmed by the geotechnical specialist.

10.2.3 Leakage Detection System

A special under drainage and monitoring system is proposed underneath the Class C barrier design where special detection drains will be built. The drains will be built along the sloped bottom floor of the PC Dam where 19mm crushed stone will be wrapped in A4 Bidim. Special drainage pipes M110 (Drainex or equivalent approved) will be placed in the 19mm crushed stone.

The leakage detection system will be taken to a monitoring manhole outside the PC Dam footprint. Any leakage water will then collect in this manhole. The manhole will be equipped with a submersible pump which operates with floating switch valves. Dirty seepage water collected will be pumped back to the PC Dam. The water from the seepage pipes can then be tested as part of the monitoring programme to establish if there are any leaks in the liner.

10.3 Barrier Design for ROM Stockpiles

Based on the findings from the geotechnical investigation it is recommended that the ROM stockpiles will be constructed based on a Standard Class C design using a GCL, as shown below in **Figure 10-2**.

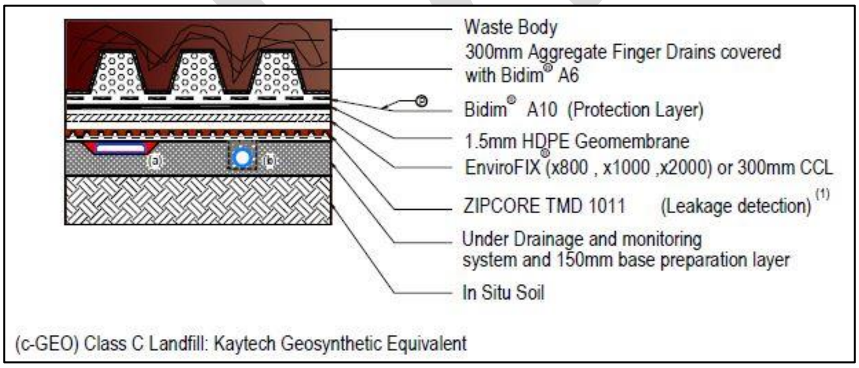

Figure 10-2: Class C Landfill Barrier using a GCL– For the ROM & Product Stockpiles

A special risk-based approach is currently being conducted to investigate the viability of an equivalent Class C barrier design. Various specialists are involved to investigate this alternative design. The results from this investigation will be included in the final design report that will be submitted to DWS for approval.

10.4 Barrier Design for the Waste Rock Dumps

Based on the findings from the geotechnical investigation it is recommended that the Waste Rock Dump (WRD) be constructed based on a standard Class C design, as shown below in **Figure 10-3**.

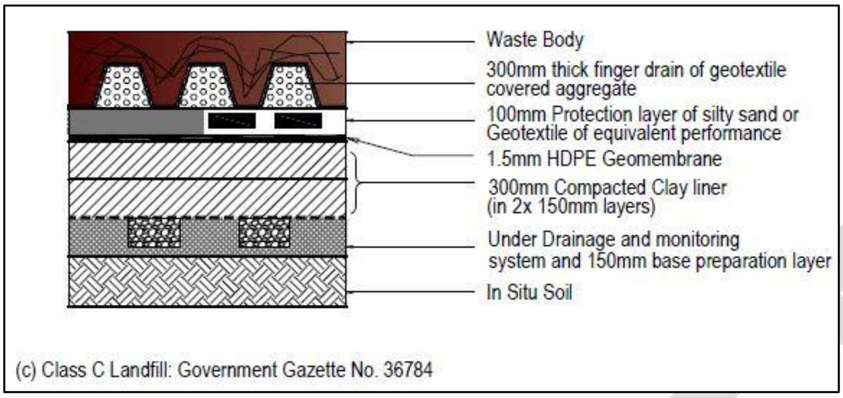

Figure 10-3: Standard Class C Landfill Barrier – For the ROM & Hards Stockpiles

10.5 Barrier Design – Topsoil Stockpiles

From the waste classification, the topsoil stockpiles are classified as a Type 4 waste with a Class D platform.

A typical Class D barrier design is shown below in **Figure 10-4**.

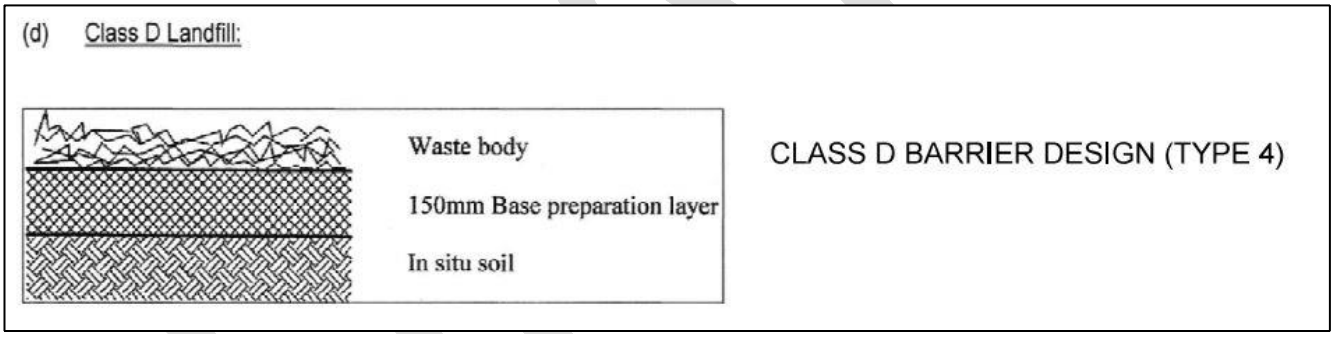

Figure 10-4: Topsoil Stockpiles - Class D Platform

The construction of the topsoil stockpiles will comprise of the following:

- The topsoil will be removed and stockpiled for later re-use as part of the overall rehabilitation.
- The in-situ material will be compacted to 90% MOD AASHTO Density.
- Placing of one-layer of 150mm thickness (G7/G8) material as Base Preparation Layer to construct the platform.
- This platform is shaped to ensure that the clean water from this platform is routed and managed as part of the Mine's clean water system.
- The surface –and seepage water can drain into the natural clean water drainage system of the Mine.

10.6 NEMWA Regulations 2013 – R636 Regulation 3

This section of the report deals specifically with the waste licence application in terms of Regulation 2013 - R636.

The Department of Water Affairs & Sanitation (DWS) has issued an advisory document (revised August 2020 - "Checklist for the Lead Authority, National or Provincial in advance of document submission to commenting Authority". This document is used as a checklist when considering a waste license application in terms of the specific requirements for a pollution control barrier technical report.

The following containment barrier requirements must be included in an application for a waste management licence:

a) Design reports and drawings that must be certified by a registered, professional civil engineer.
b) Service life considerations that must be quantified considering temperature effects on containment barriers.
c) Total solute seepage (inorganic and organic) must be calculated in determining acceptable leakage rates and action leakage rates.
d) Alternative elements of proven equivalent performance which has been considered, such as the replacement of filters or drains with geosynthetic filters or drains, protective soil layers with geotextiles, or clay components with geomembranes or geosynthetic clay liners.
e) All drainage layers must contain drainage pipes of adequate size, spacing and strength to ensure atmospheric pressure within the drainage application for the service life of the landfill.
f) Alternative design layouts for slopes exceeding 1:4 (vertical: horizontal) may be considered provided equivalent performance is demonstrated.
g) Construction Quality Assurance (CQA) during construction.
h) Geosynthetic materials must comply with relevant South African National Standard specifications, or any prescribed management practice or standards which ensure equivalent performance.
i) Consideration of the compatibility of liner material with the waste stream, in particular noting the compatibility of natural and modified clay soils exposed to waste containing salts.

These items will be addressed individually as part of the Construction Quality Assurance (CQA) in support of this waste application.

10.7 DESIGN REPORT & DRAWINGS

The overall designs in support of this project are stipulated in the following documents:

- Design Report: *"Modikwa South3 Opencast Pit Project - SWMP Design Development Report in support of a WUL Application (Including Floodline Study)"*, dated August 2024.
- Complete set of signed-off design development drawings will be included in the Final report that will be issued to DWS.

10.7.1 Professional Indemnity Cover

It is important to note that the design developments have been done to a detailed level based on the specialist studies that were conducted in support of this project. However, as a registered professional engineer with Professional Indemnity (PI) insurance, it is a requirement that additional tests and studies will be required prior to project implementation. This will be critical to ensure that the design developments provided herewith does in fact comply with the approved WUL that will be issued for the project.

We, therefore, take full liability for our designs so proposed and will ensure that the designs so developed for this project are implemented under our direct supervision and control to ensure compliance to the WUL & Waste licences issued by the Authorities. If OFC is not involved with the implementation phase, our PI insurance is automatically cancelled and DWS will be informed accordingly.

OFC will issue As-Built drawings confirming that the final designs so implemented was done under our supervision and in accordance with the design specifications and special conditions of the WUL.

10.8 Service Life Considerations

Regulation 3(2) specifically requires that the service life considerations must be quantified considering temperature effects on containment barriers.

10.8.1 Mining Schedule

The Modikwa South3 Opencast Project has a forecast Life of Mine (LoM) schedule spanning maximum ±10 years.

It can, therefore, be realistically assumed that the majority of the on-surface pollution impact of the Modikwa South3 Opencast Project should be partially mitigated by year twelve (12) after the mining reserve has been mined out and the site will be fully rehabilitated as part of the Mine’s commitment to concurrent rehabilitation and roll-over strategy that is being implemented.

The Plant, Stream Crossings and PCD will be operational for ±10 years and it can therefore be assumed that their design life is ±12 years.

10.8.2 Pollution Plumes & LoM Decant

The impact of operational and long-term pollution plumes are currently being assessed by Segope. The impacts of possible decant points and pollution plumes will be reported.

10.8.3 Service Life Period of Materials used in Barrier Design

The Modikwa South3 Opencast Project will have a service life period of ±10 years. The Plant, Stream Crossings and PCD will have a service life period of ±12 years, which includes 2-years for the final demolition and rehabilitation of the facilities after closure.

The following is therefore confirmed:

- LoM of Plant, Stream Crossings & PCD’s ±12 years.
- Operating period of waste disposal (maximum 10 years).
- The anticipated leachate temperatures for the PC Dams are estimated at 10°C - 25°C, depending on the seasonal temperatures.
- Total tensile strain in the geomembrane (percentage): This is estimated at ±1.8% of the allowable tensile yield elongation (12% for 1.5mm HDPE) which is made up of installation strain, a settlement

component, and some point load effects. Technical data for the HDPE liner will be included in the Construction Quality Assurance Report (CQA).

- The service life of the drainage system is estimated to be at maximum 12 years.
- Service life of other materials: The standard Class C barrier design is proposed. The service life of the HDPE and clay layers is ±12 years.

10.9 Leakage Rates Anticipated

The total solute transport/ seepage through the barrier system is calculated, using the Rowe formula (adapted from 1998), as shown below in the Schematic Diagram in **Figure 10-5**.

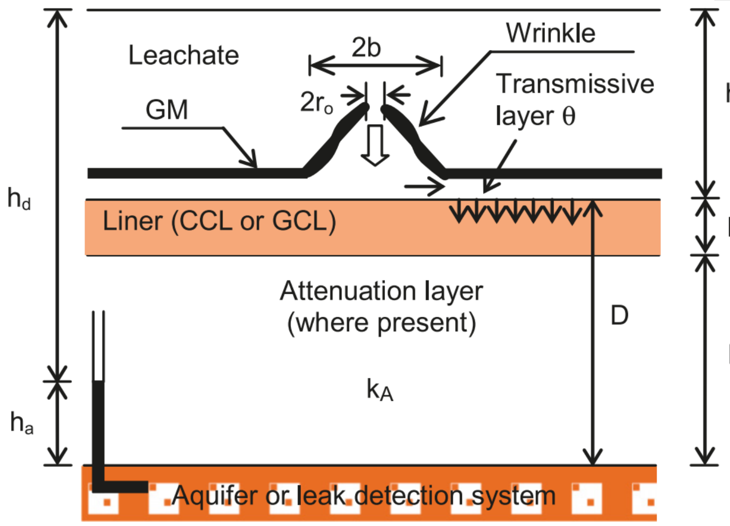

Figure 10-5: Rowe 2012 Leakage Formula - Through a wrinkle of Length (L), Width (2b) and Hole of radius (r_0)

The formula is as follows:

$$Q = 2L[kb + (kD\theta)^{0.5}]h_d/D$$

10.9.1 ROM Stockpiles

The leakage calculated through the ROM stockpiles is as follows:

- Standard Class C Barrier – ROM1: L/day

10.9.2 Pollution Control Dam

The leakage calculated through the PC Dam is as follows:

- Standard Class C Barrier – ROM 1: L/day

The leakage calculations for the various barrier designs will be included in the final report.

10.10 Alternative Elements of proven Equivalent Performance

Regulation 3(2) requires alternative elements to be proven where this has been considered as part of the design, such as the replacement of:

10.10.1 Granular Filters or Drains replaced with Geosynthetic Filters or Drains.

Our designs do not incorporate geosynthetic filters. Our designs allow for granular filter material used in the seepage drains where 19mm crushed stone is wrapped within an A4 bidim geotextile. An M110 drainex perforated drainage pipe is installed to allow for the drainage to the following:

ROM Stockpiles: Seepage drains used as leakage detection underneath the HDPE barrier design reports to the transfer sumps.

10.10.2 Protective Soil Layers with Geotextile

ROM Stockpiles: A 100mm protective soil layer (selected and screened) will be used to protect the HDPE liner complete with finger drains before waste deposition starts.

10.10.3 Clay Components with Geomembranes or Geosynthetic Clay Liners

The following barrier designs are proposed for the various waste management activities:

Waste Rock Dump: The clay material available from the mining area will be used as part of the standard Class C barrier design.

10.11 Atmospheric Pressures within Drainage System

The draining seepage pipes are linked to daylight exits where the seepage water is discharged into the dirty water toe canal system (for the stockpile platforms).

Special bidim material is used to prevent the clogging of the drainage system that comprise of the graded stone wrapped in the A4 bidim geotextile with the perforated draining pipe inside.

10.12 Alternative barrier design on slopes steeper than 1:4

Not applicable.

10.13 Construction Quality Assurance (CQA) Report

The Construction Quality Assurance (CQA) Report covers the following aspects of this Modikwa South3 Opencast Project:

- Parties involved with CQA
- Site Actions during Construction
- Quality Records during Construction
- Construction Quality Assurance i.t.o:
    - Earthworks
    - Drainage Aggregate

  - Geotextile (Bidim)
  - Geomembrane (HDPE Liners)
  - Geosynthetic Clay Liners (GCL)
  - Cuspated Leakage Detection
- Construction Quality Control (CQC) Plan

The detailed Construction Quality Assurance (CQA) Report will be included in the final report.

10.14 Checklist for Waste Management Licence

DWS has issued a checklist during August 2020 to confirm the readiness when a waste licence application is being made in terms of the pollution control barrier design. This waste checklist will be completed in the final report.

10.15 SA National Standards

The project will be implemented using the South African National Standards (SANS 1200) series for typical civil projects. These specifications apply to typical civil construction activities and will be implemented using specific project specifications.

The HDPE liner is a critical component of the project, and the following specifications are included to manage the quality -and installation of the liner:

- SANS 1526-2015 – Thermoplastic sheeting for use as geomembranes. This standard covers the requirements for thermoplastics sheeting for use as Geomembranes. This relates to the Manufacturing Quality Control (MQC) and Manufacturing Quality Assurance (MQA) to ensure that the materials were constructed as specified. This includes amendments to the GRI – GM13 document.
- SANS 10409-2005 – Design, selection and installation of geomembranes. This standard addresses the minimum measures that shall be incorporated by the installation contractor in his Construction Quality Control (CQC) plan to ensure the quality of workmanship and the integrity of the geomembrane liners during the installation phase. It also provides measures for the Engineer to assess if the installation and civils contractors follow the drawings and specifications in terms of the Construction Quality Assurance (CQA). This relates to inspections, verifications, audits and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility.
- Geosynthetic Research Institute (GRI) – Test Method GM13 for Test methods, test properties and testing frequencies for HDPE smooth and textured geomembranes.
- Geosynthetic Research Institute (GRI) – GM19b Standard Specifications for the "Seam Strength and related properties of Thermal Bonded Reinforced Polyolefin Geomembranes/ Barriers".
- Geosynthetic Research Institute (GRI) – GCL3 Specification for Geosynthetic Clay Liners (GCL's). This specification gives standards for Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs).
- Geosynthetic Research Institute (GRI) – Test Methods GT12(b) ISO Version. This specification gives standards for Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.
- Geosynthetic Research Institute (GRI) – GN2 standard for the Joining and Attaching Geonets and Drainage Composites.

11. DECLARATION OF INDEPENDENCE

Onno Fortuin Consulting (Pty) Ltd (OFC) was appointed to develop an integrated Surface Water Management Plan (SWMP) in support of a Water Use Licence (WUL) application for the Modikwa South3 Opencast Project. OFC performed the work relating to this application in an objective manner, even if this resulted in views and findings that are not favourable to the Applicant.

The design developments in support of this SWMP for the Mine are covered by our Professional Indemnity (PI) Insurance, being a direct requirement from DWS. OFC must therefore be involved with the implementation of the SWMP measures so recommended in support of this WUL application to ensure that our PI Insurance covers the parties impacted. The parties directly covered by this PI Insurance are the Mine, the Environmental Assessment Practitioner (EAP), OFC and the Authorities (DWS) who act in a legal capacity.

However, should OFC not be involved with the implementation phase of the SWMP design developments undertaken in this report, the OFC PI Insurance is automatically cancelled. The design developments, and drawings in support of this WUL application are therefore automatically cancelled. As a registered Professional Engineering company, OFC must then advise the DWS in writing of this impact where OFC can be held liable if it, knowingly, did not warn the DWS that the PI Insurance for the WUL application has been suspended.

We hereby declare that OFC has the expertise to conduct this specialist investigation relevant to this application and did not engage in conflicting interests in the undertaking of this study.

Report Compiled By:

If any additional information is required, please feel free to contact the undersigned.

H O Fortuin (Pr Eng)
Reg. No: #900166
DIRECTOR

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DESIGN DIRECTOR

DOCUMENT LIMITATION

This document has been prepared by Onno Fortuin Consulting (Pty) Ltd ("OFC") with all reasonable skill, care, and diligence, subject to the following limitations:

i. The scope of work and deliverables are based on our project proposal that was submitted to the Client and are subject to restrictions and limitations.

ii. The order to proceed are based on the acceptance of our proposal, incorporating all contractual agreements, and taking account of the resources devoted to it by agreement with the Client.

iii. We disclaim any responsibility to the Client and others in respect of any matters outside the scope of the above.

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vi. This document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this document will be accepted to any person other than the Client.

vii. We declare that this report is the original work by OFC. Where other people's work has been used (either from a printed source, internet, or any other source), this has been properly acknowledged and referenced in accordance with normal standard procedures.

viii. It is acknowledged that specialist information by the project team linked to this project are incorporated and integrated into this document and that this has been done with their consent and approval.

ONNO FORTUIN CONSULTING (Pty) Ltd

APPENDIX A – GENERAL LAYOUT PLAN

APPENDIX B – GEOTECHNICAL INVESTIGATION