HYDROLOGICAL ASSESSMENT OF THE HARMONY KALGOLD EXPANSION PROJECT

EIA REPORT

Project No. EIM-005

Version 1

January, 2022

HYDROLOGIC CONSULTING

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HYDROLOGICAL ASSESSMENT OF THE HARMONY KALGOLD EXPANSION PROJECT

EIA REPORT

Prepared For

EIMS (PTY) LTD

Prepared By

Hydrologic Consulting (Pty) Ltd

Project No. EIM-005

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EXECUTIVE SUMMARY

Hydrologic Consulting has been appointed by Environmental Impact Management Services (EIMS) to undertake a hydrological assessment of the proposed Harmony Kalgold expansion, located approximately 32km north-east of the town of Setlagole, in the North West Province of South Africa.

This hydrological assessment considers the potential hydrological (surface water) impacts related to the proposed expansion and associated works and will form part of the overall EIA Report for the site per NEMA EIA regulations, 2014, Government Notice (GN) R 982 (as amended). Additional regulations in the form of Government Notice 704 (Government Gazette 20118 of June 1999 GN 704) and Section 21 water uses as defined by the National Water Act (Act No 36 of 1998) have also been considered.

PROPOSED EXPANSION

The existing Harmony Kalgold operation wishes to expand its current production from the current production rate of 130,000 tons per month to 300,000 tons per month. A pre-feasibility study has been undertaken. The findings of the pre-feasibility study have concluded that the following new activities and expansions must be provided for:

1. The pit footprint will increase
2. Larger dewatering pipelines
3. Extension to Spanover waste rock dump
4. Road from the pit to new ROM pad.
5. New ROM pad.
6. New plant.
7. Recommission old TSF at low deposition rate.
8. Increase deposition rate at D-zone pit.
9. Install pipeline from Central dam to the new plant.
10. Install a tailings pipeline from the new plant to old TSF and D-Zone pit. (Pipelines for deposition and for return water).
11. Install pipeline from old plant raw water pond to the new plant (D-Zone return water).
12. Install two power lines from Ferndale substation to the new plant.
13. Install a water treatment facility at the new plant.
14. Relocate and expand the explosives magazine.
15. Additional new road from the plant to the N18.
16. New road from pit to ROM pad
17. New road to Spanover waste rock dump extention
18. Increase the size of the water pipe from A-Zone to Central dam.
19. Increase the size of the water pipe from Watertank pit to Central dam

SITE SENSITIVITIES

Figure 3-1 presents the results of the identified site sensitivities as they relate to the surface water environment. This figure illustrates that the proposed expansion infrastructure falling within an identified area of hydrological sensitivity includes:

- Tailings and return water pipeline corridor;

- Powerlines;
- Water pipeline; and
- D-Zone Pit.

Existing infrastructure (e.g. waste rock dumps) and proposed storm water management (necessary to manage dirty water areas) are also within sensitive areas.

GOVERNMENT NOTICE (GN) 704

The Department of Water Affairs and Forestry (now the Department of Water and Sanitation), established GN 704 (as of June 1999) to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. GN 704 includes various conditions which inform the deliverables contained in this report. Of particular relevance is the definition of a dirty area (given the associated implications regarding the management of dirty areas per GN 704), with a dirty area defined as "any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource".

STORM WATER MANAGEMENT PLAN

The operation (both historical mining and proposed expansion) has/will alter the natural environmental state, thereby affecting the generation of storm water. Volumes of storm water generated over disturbed areas will likely increase because of the reduction in natural vegetation, while the quality of the storm water generated is expected to decrease due to the nature of the mining operation. A conceptual level SWMP by which clean and dirty water generating areas are firstly identified and then managed appropriately according to GN 704 requirements has subsequently been developed.

An SWMP that includes both the diversion and storage of runoff generated over dirty water areas has not been implemented for the majority of the site. Areas requiring pollution control (i.e. dirty areas) were consequently delineated based upon the site layout provided (for the expansion) while aerial imagery provided the current status of the site (with regards to areas of works and location of waste rock dumps for example). These dirty areas route to one of six proposed PCDs.

The four pits on the mine (including the future windmill zone pit) have the potential to receive inflows from dirty water areas. The use of pits for the formal storage of dirty storm water (from upslope and not only from rainfall falling over the pit) raises the question of GN 704 compliance – Condition 7(c) in particular. This condition outlines that every person in control of a mine or activity must take reasonable measures to "*minimise the flow of any surface water or floodwater into mine workings, opencast workings…"*. The containment of dirty water in pits has consequently been limited to that generated from rainfall falling over the pit and that generated from peripheral waste rock dumps (where these dumps are immediately adjacent to the pit).

The existing plant and TSF are likewise not considered in this SWMP as the plant may be decommissioned and already has storm water management in place, while the management of the TSF's storm water would require a more detailed investigation that considers the rate of deposition of tailings and overflows to the return water dam (which would need to be adequately sized). Return water from the TSF may also be routed to the D-Zone Pit. It is consequently the recommendation that the TSF's storm water performance be reviewed once the operation of the mine (including the expansion) has been finalised.

The explosives magazine is not included in the management of storm water as this will be a covered area such that containment of dirty storm water is unnecessary.

Overall, this SWMP aims to minimise the final dirty area to limit the unnecessary containment of clean areas. This benefits the operation in reducing the size of the dirty water diversion and the volume of dirty water requiring containment, as well as reducing the impact on the receiving water environment due to the reduction in natural runoff.

WATER BALANCE

A static water balance model has been developed for the mine and considers the proposed expansion's use of water on an average wet and dry monthly basis.

The foundation of the water balance was derived from the September 2021 water balance of the mine. This water balance (provided by the mine) outlines the monthly reticulation of water on the mine from January 2021 to July 2021 (7 months of data). The future water use by the mine has largely been informed by the associated water balance developed by MvB Consulting (2021), which includes an estimated long-term water balance for the years 2021 to 2034.

Various assumptions were necessary for the water balance, with these assumptions largely being due to the uncertainty of the future operation (i.e. projections were made based upon existing and may not be representative of the future). The performance of six proposed PCDs is also uncertain given the level of assessment.

IDENTIFIED IMPACTS

Eroded soils have the potential to cause sedimentation of downstream watercourses. Disturbed areas should consequently be stabilised with erosion control methods used where stabilisation is not possible. A rehabilitation plan for the site should be developed inclusive of topsoil replacement where possible. A re-vegetation strategy including maintenance/aftercare should likewise be developed for disturbed areas.

Operation of earthmoving machinery or maintenance vehicles on-site during construction, operation, decommissioning and rehab/closure (including the possible storage or handling of hydrocarbons) poses a potential source of hydrocarbon contamination with regards to the surface water environment. An emergency response plan for unforeseen hydrocarbon spills should be developed while the existing surface water monitoring should be reviewed to ensure adequate coverage of the proposed expansion. A storm water management plan is a necessary part of the development of the expansion (as per GN 704) and will form an integral mitigation measure concerning the management of dirty areas.

An increase in runoff could be expected due to the proposed construction of infrastructure which will increase impermeable hardstanding and compaction from the movement of machinery and use of laydown areas. The necessary introduction of a storm water management plan will, however, result in the containment of much of the aforementioned area, thereby effectively decreasing runoff from the site. A decrease in runoff is a typical impact associated with the containment of dirty areas on mines and the mitigation of this impact is often not practical or possible with a reduction in mean annual runoff as an expected outcome.

Flood risk is an impact on the proposed Kalgold Expansion Project and not the environment as with the other impacts identified in this report. This risk is expected to be present during the construction, operational and decommissioning and rehab/closure phases due to the existence of infrastructure/works that could be flooded and the presence of personnel who might be caught in floodwaters. Some infrastructure (roads and power lines) are proposed over the Morokwa River and have a certain flood risk (based on intersection with a watercourse). Other infrastructure located near a watercourse (specifically the Morokwa River) may have a flood risk. Previous flood modelling has been undertaken by SRK and referred to in Section 2.6.1. The summary outlined in this section (2.6.1), motivates revision to the flood-lines for the mine, including the consideration of flood events beyond the 1:100 year RI.

ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

The risk/impact assessment undertaken within this study is based on a desktop assessment.

Flooding is potentially the impact with the greatest significance (whether indicated by an impact table or not). This risk needs to be clearly understood, particularly with regards to D-Zone Pit, waste rock dumps and associated storm water management adjacent to the Morokwa River.

SPECIALIST DECLARATION

Mark Bollaert as the appointed surface water (hydrological) specialist hereby declares that:

- Other than fair remuneration for work performed/to be performed in terms of this application, he has no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise their objectivity
- He has expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and guidelines that have relevance to the proposed activity;
- They undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required; and
- He is aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

EXPERTISE OF AUTHOR

Mr Mark Bollaert has over 15 years of experience working as consulting hydrologist in the United Kingdom and South Africa since having completed his Master of Science (MSc) degrees in Hydrology at the University of KwaZulu-Natal. Mark has since supplemented his tertiary education with professional qualifications which represent his on-going effort towards maintaining a professional approach and continuing in their professional development. These include qualifications from the UK (Chartered Scientist, Chartered Environmentalist and Chartered Water and Environmental Manager) and South Africa (Professional Natural Scientist in Water Resources and Earth Science respectively).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

HYDROLOGICAL ASSESSMENT FOR THE HARMONY KALGOLD EXPANSION PROJECT – SCOPING REPORT

1 INTRODUCTION

Hydrologic Consulting has been appointed by Environmental Impact Management Services (EIMS) to undertake a hydrological assessment of the proposed Harmony Kalgold expansion, located approximately 32km north-east of the town of Setlagole, in the North West Province of South Africa.

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Content from a previous Scoping Report for the proposed Harmony Kalgold expansion (completed by WSP[1] in 2019) has been utilised in some instances, although revisions have been extensive due to changes in the proposed site layout.

1.1 SCOPE OF WORK AND TERMS OF REFERENCE

Kalgold mine is an open-pit mining operation located some 60km south-west of Mahikeng in the North West Province. The mine is owned and operated by Harmony Gold, who acquired the mine in 1999. The mine is located in the Kraaipan Greenstone Belt, which is part of the large Amalia-Kraaipan Greenstone terrane. The largest ore body is found in the D-Zone, which was mined out by a single pit operation along a strike length of 1,300m and to a depth of approximately 290m below the surface. Mining at Kalgold Mine continued at the A-Zone, Windmill and Watertank Open Pits, which are all relatively new opencast operations. Figure 1-1 presents the regional setting of the proposed Kalgold Expansion Project (hereafter also referred to as the site), while Figure 1-2 presents the layout of the Project.

[1] WSP. Hydrological Assessment for the Harmony Kalgold Expansion Project. Scoping Report. Project No.: 41101239. April 2019

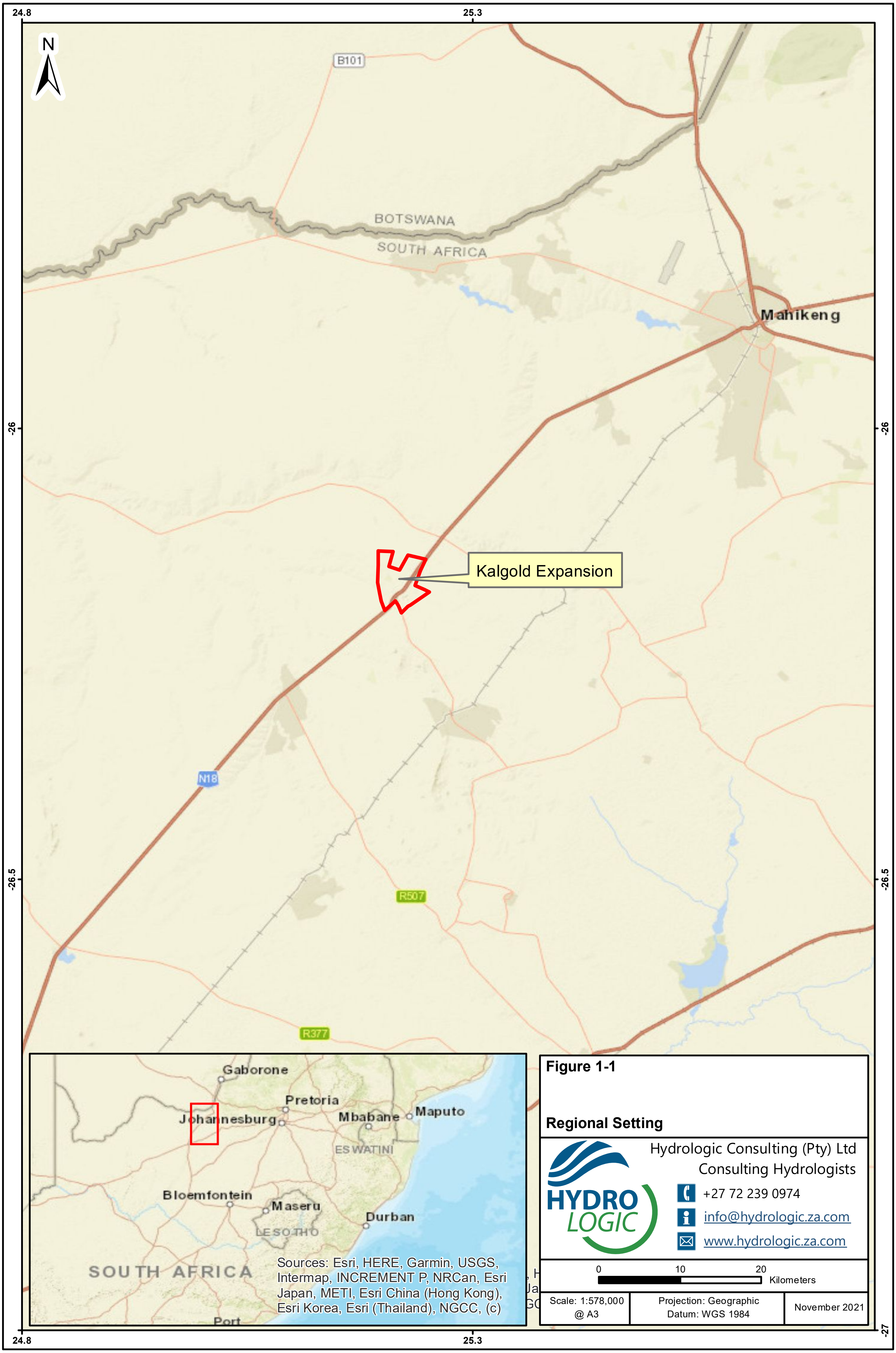

Figure 1-1

Regional Setting

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Scale: 1:578,000 @ A3	Projection: Geographic Datum: WGS 1984	November 2021

Legend

- Expansion Affected Properties
- New Explosives Magazine
- New TMM Workshop
- Existing Central Dam
- Exisiting Local Roads
- A Zone Pit Dewatering
- Emergancy Dam Return Water
- Explosive Magazine Clearance Radius
- Haul Road to new ROM
- New Plant Road
- New Powerline Route
- New Road to Old Plant
- New Road to Windmill Zone Pit
- New Road to WRT Ext
- Tailings to Tailings Dam
- Treated Water Discharge Pipeline
- TSF to D Zone
- Water from D Zone to Return Water Dam
- New ROM Pad
- Water from Return Water Dam to New Processing Plant
- Water Pipeline
- Watertank Pit Dewatering
- New Processing Plant
- Increased Pit Footprint
- Existing TSF
- New Spanover WRD Ext
- Furrow (50K Topo)
- Non-Perennial River Centre line
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Perennial Pan (50K Topo)

Figure 1-2

Layout

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0 1,000 Meters

Scale: 1:28,600 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO27	November 2021

The existing Harmony Kalgold operation wishes to expand its current production from the current production rate of 130,000 tons per month to 300,000 tons per month. A pre-feasibility study has been undertaken. The findings of the pre-feasibility study have concluded that the following new activities and expansions must be provided for:

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1.2 PROJECT OBJECTIVES

The objectives of the study are as follows:

- The objective of the study is to provide the hydrological impact assessment (and associated storm water management plan and water balance) as input into EIA and WULA applications.

To meet stage objectives, the following scope of work has been undertaken:

- Desktop review;
- Hydrological characterisation;
- Sensitivity mapping;
- Conceptual Storm Water Management Plan;
- Water Balance;
- Impact assessment; and
- Reporting.

1.3 LEGISLATIVE AND POLICY FRAMEWORK

The following documents form the legislative and policy framework:

- The National Water Act, Act 36 of 1998 (hereafter referred to as NWA);
- Department of Water and Sanitation (DWS) Government Notice No.704 (GN 704);
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series A: Best Practice Guideline A2: Water Management for Mine Residue Deposits, July 2008.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series A: Best Practice Guideline A4: Pollution Control Dams, August 2007.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series A: Best Practice Guideline A6: Water Management for Underground Mines, July 2008.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G1: Storm Water Management, August 2006.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G2: Water and Salt Balances, August 2006.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G4: Impact Prediction, December 2008.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G5: Water Management Aspects for Mine Closure, December 2008.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series H: Best Practice Guideline H1: Integrated Mine Water Management, December 2008.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series H: Best Practice Guideline H2: Pollution Prevention and Minimization of Impacts, July 2008.
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series H: Best Practice Guideline H3: Water Reuse and Reclamation, June 2006.

2 DESCRIPTION OF THE RECEIVING ENVIRONMENT

Baseline information in this section includes discussions on the rainfall, evaporation, design event rainfall, soils, vegetation, and land cover, as well as site topography and regional and local catchment hydrology.

2.1 RAINFALL

Various weather stations managed by both the South African Weather Services (SAWS) and the Department of Water and Sanitation (DWS) were considered in this project. These, together with their proximity to the site can be seen in Figure 2-1.

Numerous SAWS and DWS stations are located about the site, with the closest station (470516 W) located approximately 2.7km north-east of the site boundary. SAWS data requires purchasing and alternative sources of average monthly site-specific data were instead utilised, sourced from Pegram (2016). Table 2-1 presents the summary of the site-specific Pegram (2016) average monthly rainfall distribution while Figure 2-1 illustrates the rainfall variation in the region about the site.

TABLE 2-1: AVERAGE MONTHLY RAINFALL DISTRIBUTION (PEGRAM, 2016)

Month	Rainfall (mm)
Jan	91
Feb	76
Mar	71
Apr	42
May	16
Jun	7
Jul	4
Aug	6
Sep	13
Oct	18
Nov	55
Dec	71
Total	**470**

*Estimates were sourced for the centre of the site.

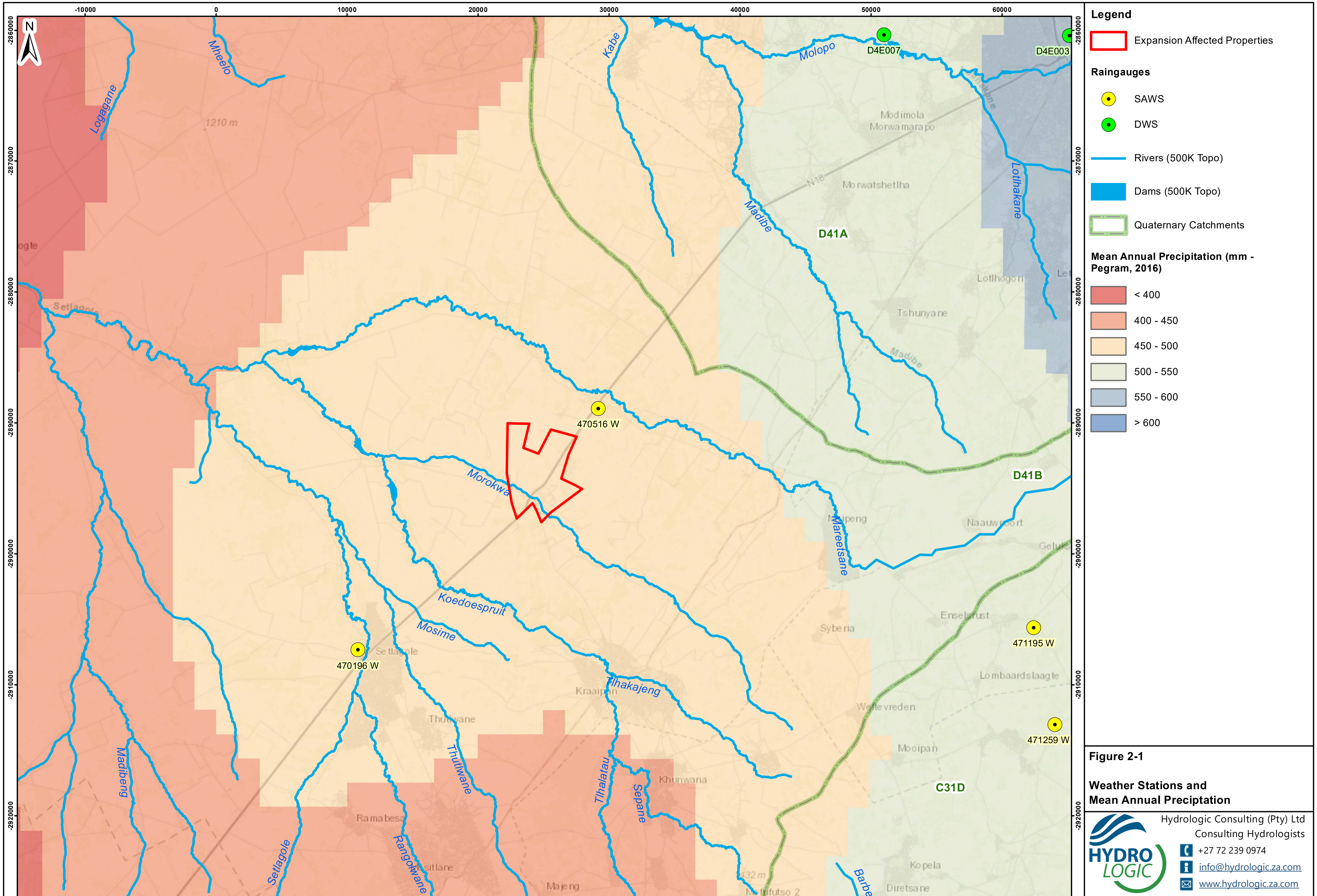

Figure 2-1

Weather Stations and Mean Annual Precipitation

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Scale: 1:250,000 @ A3 | Projection: Transverse Mercator Datum: Hartebeeshoek, LO31 | November 2021

2.2 1-DAY DESIGN RAINFALL DEPTHS

For the development of a storm water management plan, design rainfall is the most important rainfall variable to consider as it is the driver behind peak flows.

Design rainfall estimates for various recurrence intervals (RI) and storm durations were sourced from the Design Rainfall Estimation Software for South Africa (DRESSA), developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm (RLMA) in conjunction with a Scale Invariance approach to provide site-specific estimates of design rainfall (depth, duration and frequency), based on surrounding station records. WRC Report No. K5/1060 (WRC, 2002) provides more detail on the verification and validation of the method. Table 2-2 presents the 24-hour storm depths for various recurrence intervals.

TABLE 2-2: 24-HOUR STORM DEPTH

Recurrence Interval (Years)	Rainfall Depth (24 hour) (mm)
2	57.1
5	77.8
10	91.9
20	105.9
50	124.5
100	138.8
200	153.5

*Estimates were sourced for the centre of the site.

It is important to note, that no allowances for climate change have been made. A risk analysis using the expected life of a structure or process will indicate the relevance of considering climate change (i.e. as the expected life increases the influence of climate change increases).

2.3 EVAPORATION

Evaporation data was sourced from the South African Atlas of Climatology and Agrohydrology (Schulze and Lynch, 2006) in the form of A-Pan equivalent potential evaporation. The average monthly evaporation distribution is presented in Table 2-3 and shows the site has an annual potential evaporation of 2,739mm.

TABLE 2-3: AVERAGE MONTHLY A-PAN EQUIVALENT EVAPORATION

Month	Evaporation(mm)
Jan	319
Feb	248
Mar	223
Apr	172
May	146
Jun	111
Jul	129
Aug	181
Sep	247
Oct	302
Nov	330
Dec	331
Total	**2,739**

*Estimates were sourced for the centre of the site.

2.4 AVERAGE CLIMATE

The average climate for the site is presented in Figure 2-2 using the outcome of the investigation into rainfall and evaporation for the site. The combination of rainfall (Pegram, 2016) and evaporation and temperature (Schulze and Lynch, 2006) result in a hot arid steppe climate according to the Köppen-Geiger climate classification[2].

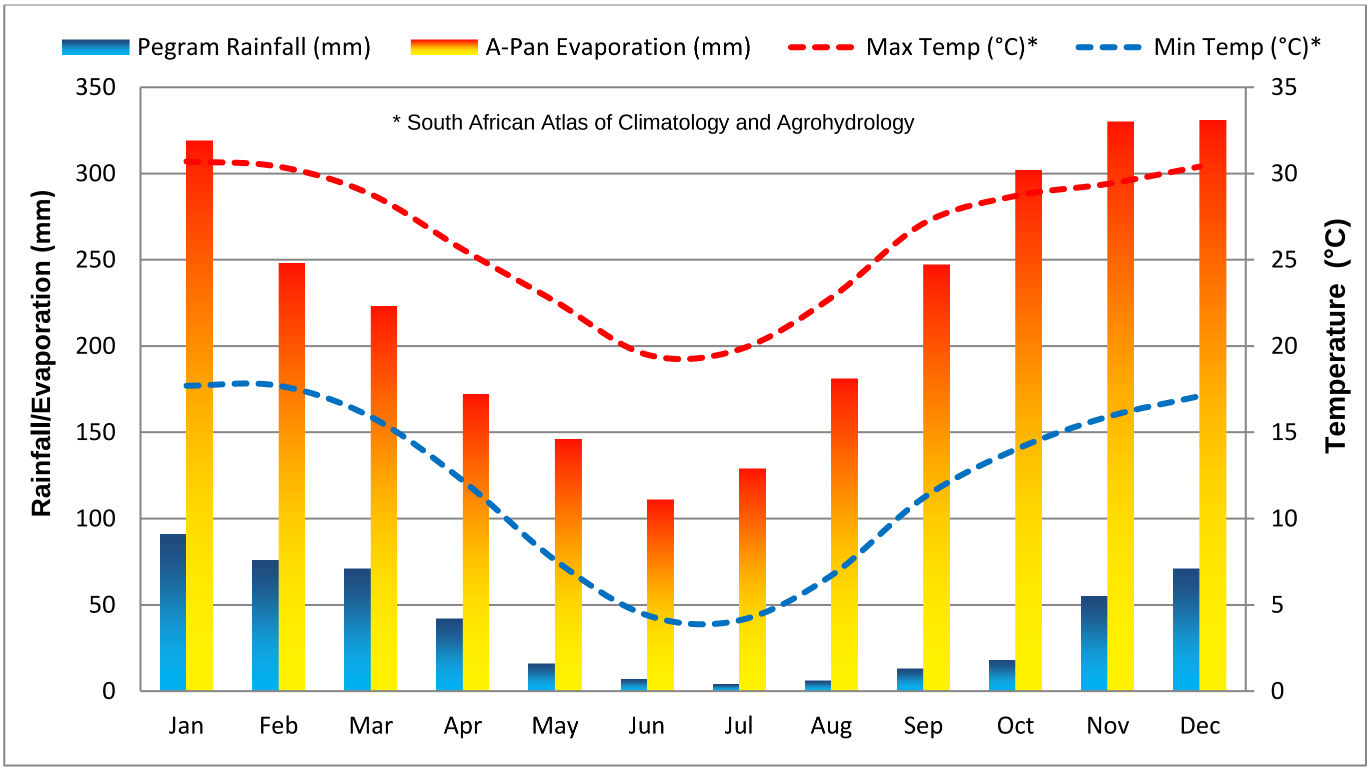


FIGURE 2-2: AVERAGE MONTHLY CLIMATE FOR THE SITE

[2] http://stepsa.org/climate_koppen_geiger.html

2.5 TERRAIN

Three datasets were used to assess the elevation of the site and surrounds, namely:

1. A 2020 point cloud dataset (comprised of three files[3]) was provided by the client which was interpolated to a 1m digital surface model (DSM);
2. A 25m DEM sourced from a National Geo-spatial Information (NGI) dataset; and
3. NGI 1:50,000 topographical map 5m contours.

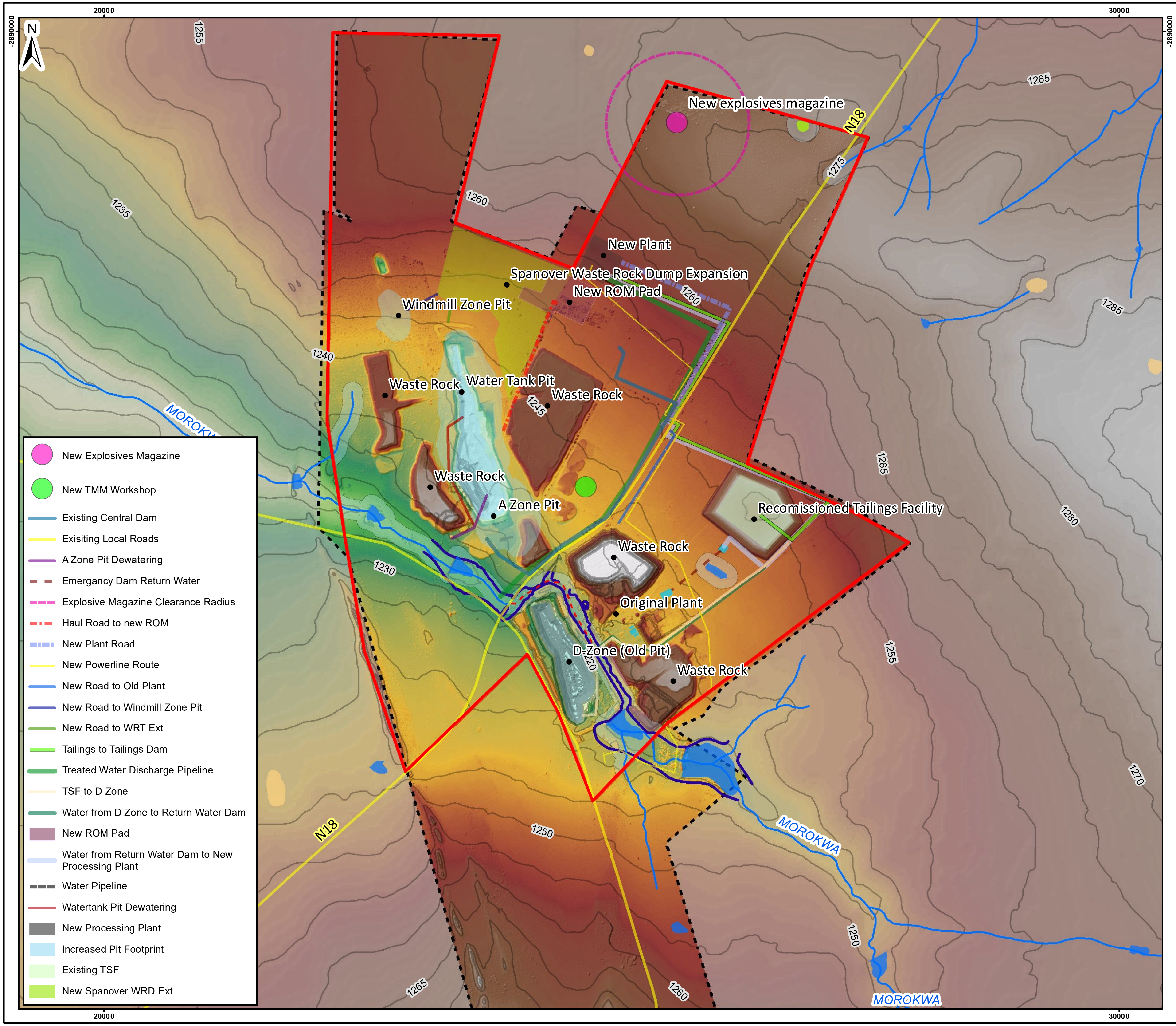
The three elevation datasets utilised are illustrated in Figure 2-3.

The 1m DSM provides an elevation (surface) dataset with a resolution of 1m, with the DSM covering the full area of operation. A review of the DSM did reveal that as a DSM, it contained surface features such as buildings and vegetation. For storm water modelling, flow paths need to be defined according to the bare earth, and surface features have the potential to direct runoff incorrectly (given the use of the DSM to derive flow paths). Some filtering of the DSM was undertaken to remove surface features, however, this is not fully effective as only isolated features can be removed in this manner. The resulting filtered DSM did as such, retain some surface features with areas of trees still being evident (for example). Some inaccuracy in the subsequent analysis of the terrain data for the mine (with regards to the definition of flow paths) is consequently expected.

The 25m NGI DEM was used to supplement areas of missing terrain data and is illustrated using a faded colour palette in Figure 2-3. This data as the name suggests, is presented using a 25m cell size and provides a general understanding of the terrain of the site and surrounds. The capture date of this data is unknown.

The 5m NGI contours were used as a final terrain dataset to illustrate the general 'lie of the land' and illustrates that elevation on the site approximates 1,240mAMSL.

[3] Kalgold 16-10-2020_1m Grid.xyz; Kalgold 16-11-2020_Area 1 - 1m Points Grid.xyz; Kalgold 16-11-2020_Area 2 - 1m Points Grid.xyz



Legend

- Expansion Affected Properties
- 100m Watercourse Buffer
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Perennial Pan (50K Topo)
- 5m Contour (50K Topo)
- Digitised 100 RI Flood-Line (SRK, 2020)
- Furrow (50K Topo)
- Non-Perennial River (50K Topo)
- Point Cloud Survey Extent

Elevation (mAMSL)

High : 1300

Low : 1200

Figure 2-3

Hydrology and Terrain

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0 500 1,000 Meters

Scale: 1:23,000 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO27	January 2022

2.6 HYDROLOGY

Figure 2-3 also illustrates the hydrological setting of the site, while Figure 2-1 presents the river network of the greater region. The site is positioned within quaternary catchment D41B which is drained by the primary Setlagole River.

The site is intersected by the Morokwa River which is the most significant watercourse in the region (about the site). The Morokwa River is classified as a non-perennial river according to the NGI's 1:50,000 topographical map data. Two minor non-perennial tributaries to the Morokwa River intersect the site, while a third minor non-perennial river (which is not a tributary to the Morokwa River), intersects the north-eastern corner of the site.

A few dams are also noted within the site (according to the NGI's 1:50,000 topographical map data) and are generally located along the Morokwa River. One exception to this is the small dam to the south-west of the TSF. Open reservoirs are also noted, although these are understood to be part of the mining operation and thereby not fed by natural upstream/upslope catchments.

A 100m watercourse buffer including both rivers and dams has been presented in Figure 2-3, as it applies to the application of GN 704.

This report does not account for the presence or significance of any wetlands/vleis, which would require consideration by a wetland specialist.

2.6.1 FLOOD-LINES

An SRK Consulting report[4] includes an Appendix with details relating to the development of flood-lines along the Morokwa River. The largest event modelled (the 1:100 RI flood-line) was digitised (traced) from this report and is replicated in Figure 2-3. The digitisation of this flood-line means there could be some inaccuracy in its replication, however, given the scale of the map (1:23,000), this error is likely to be minimal (with regards to visualisation).

The extent of the modelled flooding covers the majority of the Morokwa River intersecting the site, although the lower reach of the river was not included. When reviewing the results, flood-lines are not continuous at the north-eastern end of D-Zone, where the right-hand side of the flood-line (when looking downstream) includes two 'gaps'. This suggest that there could be flood 'pathway' to the N14 underpass.

The SRK report was the only available source of possible flooding at the mine (at the time of this study). While the validity of the SRK flood-lines is not assessed in this report (i.e. no review of the SRK report has been undertaken), there remain aspects of the SRK flood-line modelling that are necessary to consider when applying the resulting flood-lines to this study. As per the SRK report, the following was performed:

- A 1m contour survey was converted into a Digital Terrain Model (DTM).
    - This contour survey (capture date unknown) would allow for a 1m vertical accuracy in the resulting flood-lines (i.e. the flood-lines cannot provide accuracy beyond the parent data). The combination of a potentially outdated contour survey due to changes in the operation and a 1m contour interval, mean that the extent of flooding (as modelled) could be inaccurate.

[4] SRK Consulting, February 2020, Stormwater Management Plan for Harmony Kalgold, Rock Dump and Stockpile, Report Number 552579/1

- The maximum event modelled was the 1:100 year RI event.
    - The position of the river between D-Zone and the Original Plant requires that the river channel is able to accommodate the full flood event, since flooding of D-Zone may otherwise occur. Larger flood events including the Regional Maximum Flood and possibly the Probable Maximum Flood should be considered so as to account for the potential flood risk to D-Zone. A review of the latest terrain data (the 1m DSM developed for this study) suggests a likely spill points into D-Zone that could become active during even moderate flooding (< 1:100 RI event).

The 1:100 RI flood-line as replicated in this report, is consequently considered at a high-level with regards to the expected extent of flooding.

Proposed storm water infrastructure (as per Section 5), is required to be on the downslope end of mining works (such as waste rock dumps alongside the Morokwa River. This proposed storm water infrastructure (necessary to comply with GN 704), may need to account for potential flooding in its position and design (if flood protection berms are required).

The brief summary outlined in this section, motivates revision to the flood-lines for the mine, including the consideration of flood events beyond the 1:100 year RI.

The reader is referred to the SRK report for more detail related to the flood modelling previously undertaken.

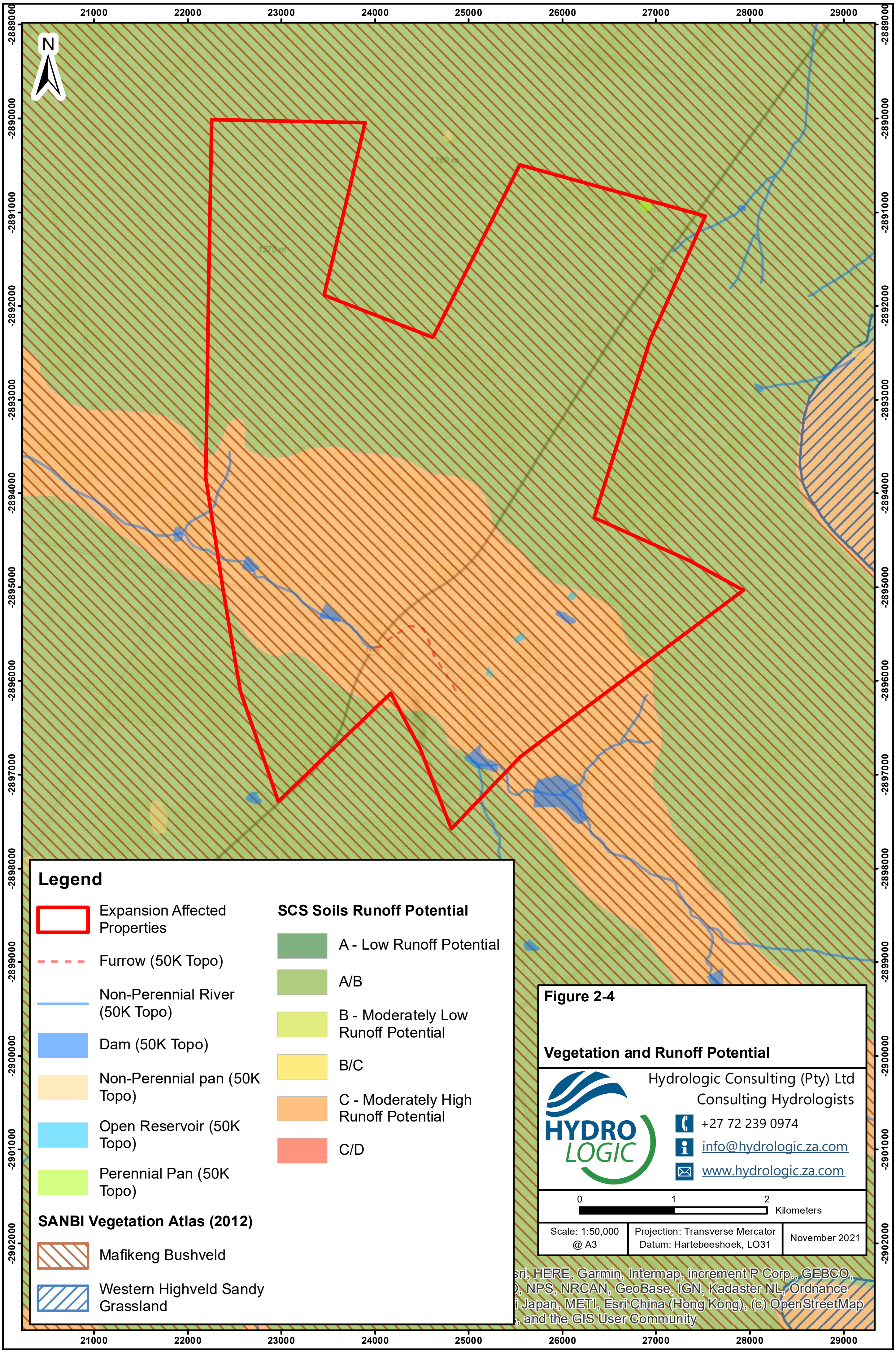
2.7 SOILS, VEGETATION AND LAND-COVER

In considering the Soil Conservation Service for South Africa (SCS-SA) dataset of the site, soils are classified as being either within hydrological soil group A/B (low to moderately low runoff potential) adjacent to the Morokwa River or within C group soils (moderately high runoff potential) present within the remaining areas of the site.

The natural vegetation of the site is classified as Mafikeng Bushveld (according to SANBI, 2012).

Some of the current land-cover of the site is unsurprisingly classified as ‘mines and quarries’ according to the Department of Environmental Affairs (DEA) 2018 dataset and matches up well with the known areas of exposed mining on site. ‘Cultivated’ and ‘Grassland’ also commonly occur over the site, however, cultivated areas are expected to have been historically present with cultivation having since stopped. Scatterings of ‘Forested Land’ also occur within grassland areas, while ‘Waterbodies’ and ‘Built-up’ areas are also identifiable.

The distributions of the SCS soil types and natural vegetation are illustrated in Figure 2-4 while Figure 2-5 presents the land-cover about the site.



Legend
Expansion Affected Properties
Furrow (50K Topo)
Non-Perennial River (50K Topo)
Dam (50K Topo)
Non-Perennial pan (50K Topo)
Open Reservoir (50K Topo)
Perennial Pan (50K Topo)
SANBI Vegetation Atlas (2012)
Mafikeng Bushveld
Western Highveld Sandy Grassland
SCS Soils Runoff Potential
A - Low Runoff Potential
A/B
B - Moderately Low Runoff Potential
B/C
C - Moderately High Runoff Potential
C/D
Figure 2-4
Vegetation and Runoff Potential
Hydrologic Consulting (Pty) Ltd
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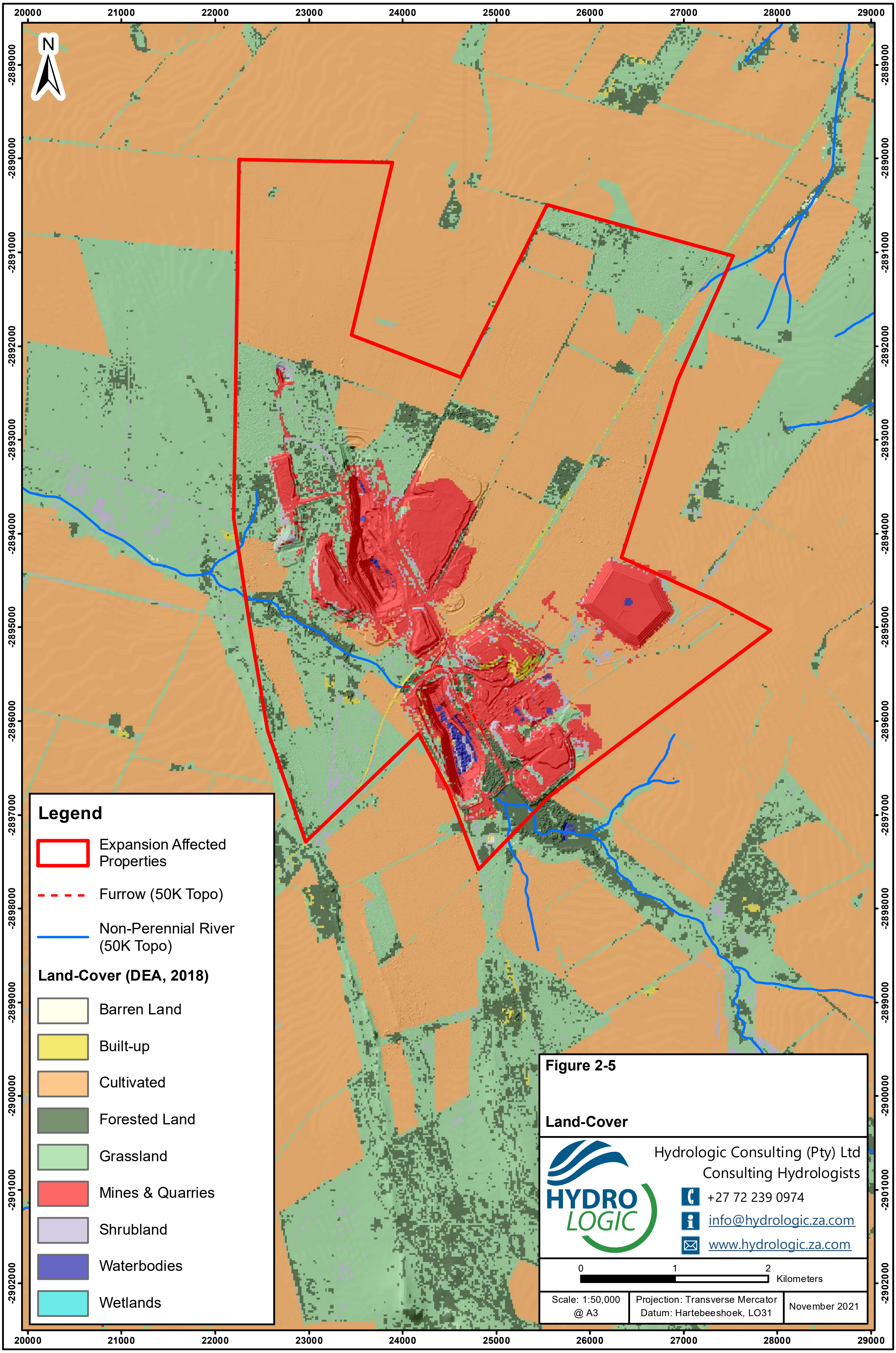
+27 72 239 0974
info@hydrologic.za.com
www.hydrologic.za.com
0 1 2 Kilometers
Scale: 1:50,000 @ A3
Projection: Transverse Mercator Datum: Hartebeeshoek, LO31
November 2021



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-2893000
-2894000
-2895000
-2896000
-2897000
-2898000
-2899000
-2900000
-2901000
-2902000
Legend
Expansion Affected Properties
Furrow (50K Topo)
Non-Perennial River (50K Topo)
Land-Cover (DEA, 2018)
Barren Land
Built-up
Cultivated
Forested Land
Grassland
Mines & Quarries
Shrubland
Waterbodies
Wetlands
Figure 2-5
Land-Cover
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0
1
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Kilometers
Scale: 1:50,000 @ A3
Projection: Transverse Mercator
Datum: Hartebeeshoek, LO31
November 2021

3 IDENTIFIED SITE SENSITIVITIES

Sensitivity mapping was undertaken to identify sensitive features relating to the hydrological (surface water) environment within the site.

The Department of Water Affairs and Forestry (now the Department of Water and Sanitation), established GN 704 to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. This includes the following condition:

Condition 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, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked;

The 100m watercourse buffer is consequently one of the main guiding aspects in the assessment of site sensitivities given its relevance to GN 704, and its applicability to both flooding and the potential for contaminants to enter a watercourse (i.e. a wider river buffer is more likely to keep infrastructure/works outside of areas prone to regular or irregular flooding while enabling more time for containments within runoff, to settle out before entering the watercourse).

Watercourse buffers have been derived from aerial imagery, the 1m DSM and 1:50,000 topographical map watercourse datasets. Watercourse buffers are technically applicable from the edge (top of bank) of the watercourse and not from the centreline (as in the case of rivers). The absence of a river survey means that the river centreline has nevertheless been used to define buffers.

A 100m watercourse buffer distance is, however, limited in its application since site works/infrastructure will either fall within or without this buffer distance, with no grading in site sensitivity possible. An expanded approach to the 100m river buffer was consequently adopted utilising a variation in buffer distances.

Aside from river buffers, the 1:100 year RI flood-line (see Section 2.6.1) was also incorporated into the sensitivity mapping.

The following sensitivity bands were classified:

- Prevent Development
  - A 25m watercourse buffer was used to define the functional area of the watercourse given the potential inaccuracy in datasets considered, and the absence of a channel survey. This distance (25m) is also considered a minor offset from the watercourse (relative to GN 704's 100m distance).
  - All development should be prevented in this area unless water-compatible or otherwise traversing the river (e.g. a power line).
- High
  - A 50m buffer acts as a middle-ground between no buffer and GN 704's 100m buffer and accounts for the increased flood-risk expected.

- The extent of the 1:100 year RI flood-line (discussed in Section 2.6.1) was also classified as having a high sensitivity due to this definition of flooding (versus the broader application of buffers).
- There is a strong disincentive towards development within this area.

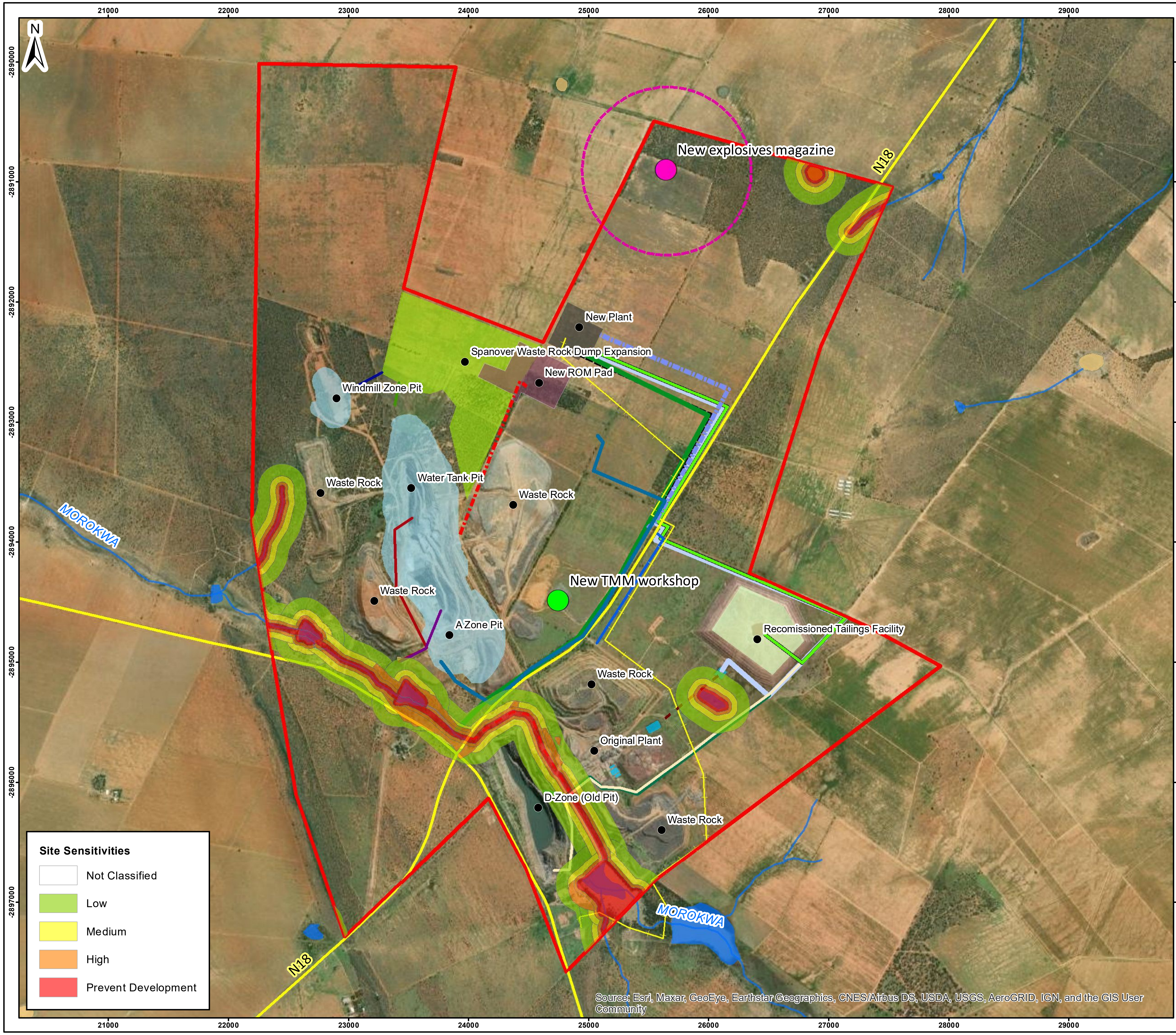
- Medium
  - A 100m buffer distance matches GN 704's prescribed buffer distance and is the minimum distance to a watercourse requiring motivation if works/infrastructure are going to be permitted, including a written exemption from the Minister of the Department of Water and Sanitation.
  - There is a medium disincentive towards development within this area.
- Low
  - A 200m buffer distance is a reasoned maximum distance from a watercourse which in most instances will reflect the largest distance over which flooding would need to be considered. This does not include D-Zone where flooding of the pit would extend beyond 200m (from the watercourse centreline).
  - There is a low disincentive towards development within this area.
- Remainder:
  - There is currently no sensitivity classification for the remainder of the site.

GN 704 restricts development within 100m of a watercourse (i.e. dam or river) and the above outline does not attempt to remove this restriction but is instead a high-level 'scaled' version of this buffer distance.

Figure 3-1 presents the results of the identified site sensitives as they relate to the surface water environment. This figure illustrates that the proposed expansion infrastructure falling within an identified area of sensitivity includes:

- Tailings and return water pipeline corridor;
- Powerlines;
- Water pipeline; and
- D-Zone Pit.

Existing infrastructure (e.g. waste rock dumps) and proposed storm water management (necessary to manage dirty water areas) are also within sensitive areas.



Legend

- Expansion Affected Properties
- New Explosives Magazine
- New TMM Workshop
- Existing Central Dam
- Exisiting Local Roads
- A Zone Pit Dewatering
- Emergancy Dam Return Water
- Explosive Magazine Clearance Radius
- Haul Road to new ROM
- New Plant Road
- New Powerline Route
- New Road to Old Plant
- New Road to Windmill Zone Pit
- New Road to WRT Ext
- Tailings to Tailings Dam
- Treated Water Discharge Pipeline
- TSF to D Zone
- Water from D Zone to Return Water Dam
- New ROM Pad
- Water from Return Water Dam to New Processing Plant
- Water Pipeline
- Watertank Pit Dewatering
- New Processing Plant
- Increased Pit Footprint
- Existing TSF
- New Spanover WRD Ext
- Furrow (50K Topo)
- Non-Perennial River Centre line
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Perennial Pan (50K Topo)

Figure 3-1

Site Sensitivities (Surface Water Environment)

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0 1,000 Meters

Scale: 1:28,600 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO27	January 2022

4 GOVERNMENT NOTICE 704

The aim of the conceptual SWMP as developed in Chapter 4 of this report, is to fulfil the requirements presented in Government Notice 704 (Government Gazette 20118 of June 1999), hereafter referred to as GN 704, and deals with the separation of clean and dirty water.

The Department of Water Affairs and Forestry (now the Department of Water and Sanitation), established GN 704 to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. There are important definitions in the regulation which require understanding.

• IMPORTANT DEFINITIONS IN GN 704

- **Clean water system:** This includes any dam, other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted water.
- **Dirty water system:** This includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste.
- **Dirty area:** This refers to any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource (i.e. polluted water).

• APPLICABLE CONDITIONS IN GN 704

The principle conditions of GN 704 applicable to the development of a SWMP for the site are:

Condition 4 – Restrictions on locality – No person in control of a mine or activity may:

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

(c) except in relation to a matter contemplated in regulation 10 (i.e. Additional regulations relating to winning sand and alluvial minerals from watercourse or estuary), carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest;

(d) place or dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation; or

(e) use any area or locate any sanitary convenience, fuel depots, reservoir or depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year flood-line of any watercourse or estuary.

Condition 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 or any embankment, road or railway, or for any other purpose which is likely to cause pollution of a water resource.

Condition 6 - Capacity requirements of clean and dirty water systems

Every person in control of a mine or activity must:

(a) confine any unpolluted water to a clean water system, away from any dirty area;
(b) design, construct, maintain and operate any clean water system at the mine or activity so that it is not likely to spill into any dirty water system more than once in 50 years;
(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;
(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, 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, unless otherwise specified in terms of Chapter 12 of the Act.
(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.

Condition 7 – Protection of water resources

Every person in control of a mine or activity must take reasonable measures to:

(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 or for purification and disposal in terms of the Act;

(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;

(c) cause effective measures to be taken to minimise the flow of any surface water or floodwater into mine workings, opencast workings, other workings or subterranean caverns, through cracked or fissured formations, subsided ground, sinkholes, outcrop excavations, adits, entrances or any other openings;

(d) design, modify, construct, maintain and use any dam or any residue deposit or stockpile used for the disposal or storage of mineral tailings, slimes, ash or other hydraulic transported substances, so that the water or waste therein, or falling therein, will not result in the failure thereof or impair the stability thereof;

(e) prevent the erosion or leaching of materials from any residue deposit or stockpile from any area and contain material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources;

(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;

(g) at all times keep any water system free from any matter or obstruction which may affect the efficiency thereof; and

(h) cause all domestic waste, including wash-water, which cannot be disposed of in a municipal sewage system, to be disposed of in terms of an authorisation under the Act.

The Minister of the DWS may in writing, authorise an exemption to instances of GN 704 non-compliance.

5 CONCEPTUAL STORM WATER MANAGEMENT PLAN

The operation (both historical mining and proposed expansion) has/will alter the natural environmental state, thereby affecting the generation of storm water. Volumes of storm water generated over disturbed areas will likely increase because of the reduction in natural vegetation, while the quality of the storm water generated is expected to decrease due to the nature of the mining operation. A conceptual level storm water management plan (SWMP) by which clean and dirty water generating areas are firstly identified and then managed appropriately according to GN 704 requirements has subsequently been developed.

The conceptual SWMP will form a necessary part of the Water Use License Application (WULA), to be submitted to the DWS. This storm water management plan is based upon the principles presented in the DWS Best Practice Guideline G1 for Storm Water Management (BPG1).

5.1 MANAGEMENT APPROACH

An SWMP that includes both the diversion and storage of runoff generated over dirty water areas has not been implemented for the majority of the site. Areas requiring pollution control (i.e. dirty areas) were consequently delineated based upon the site layout provided (for the expansion) while aerial imagery provided the current status of the site (with regards to areas of works and location of waste rock dumps for example). The operation is characterised by four opencast pits, various waste rock dumps, a TSF, the existing/new gold plant and the existing/new ROM. A workshop is also proposed for the expansion, as is the relocation of the explosives magazine.

The explosives magazine is not included in the management of storm water as this will be a covered area such that containment of dirty storm water is unnecessary.

The existing plant and TSF are likewise not considered in this SWMP as the plant may be decommissioned and already has storm water management in place, while the management of the TSF's storm water would require a more detailed investigation that considers the rate of deposition of tailings and overflows to the return water dam (which would need to be adequately sized). Return water from the TSF may also be routed to the D-Zone Pit. It is consequently the recommendation that the TSF's storm water performance be reviewed once the operation of the mine (including the expansion) has been finalised.

5.1.1 CONTAINMENT WITHIN PITS

The four pits on the mine (including the future windmill zone pit) have the potential to receive inflows from dirty water areas. The use of pits for the formal storage of dirty storm water (from upslope and not only from rainfall falling over the pit) raises the question of GN 704 compliance – Condition 7(c) in particular. This condition outlines that every person in control of a mine or activity must take reasonable measures to cause effective to "*minimise the flow of any surface water or floodwater into mine workings, opencast workings…*". The containment of dirty water in pits has consequently been limited to that generated from rainfall falling over the pit and that generated from peripheral waste rock dumps (where these dumps are immediately adjacent to the pit).

5.1.2 STORM WATER MANAGEMENT LAYOUT

Figure 5-1 presents the conceptual SWMP for the site inclusive of the dirty areas, identified pit storage and clean areas. Figure 5-2 to 5-4 focus on the overall, northern and southern portions of the SWMP respectively.

Dirty areas are identifiable as 'D1' to 'D17'. Dirty diversions collect dirty water reaching the perimeter of the dirty area directing it towards one of six PCDs. PCDs were kept to a minimum based on drainage under gravity and have been placed and sized according to an approximation of anticipated inflow volumes or available space. PCD sizing is consequently not standardised with the resulting depth for each PCD being variable. Resulting PCD sizes are, however, conceptual and will likely be modified during detailed design.

Clean areas are identifiable as 'C1' to 'C18' and feature diversions on their downslope perimeter. Additional clean areas are also implied where no classification of either dirty or clean exists (within the site boundary). In these cases, no clean area is illustrated since runoff from these areas drains away from dirty areas on the site, thereby not requiring management.

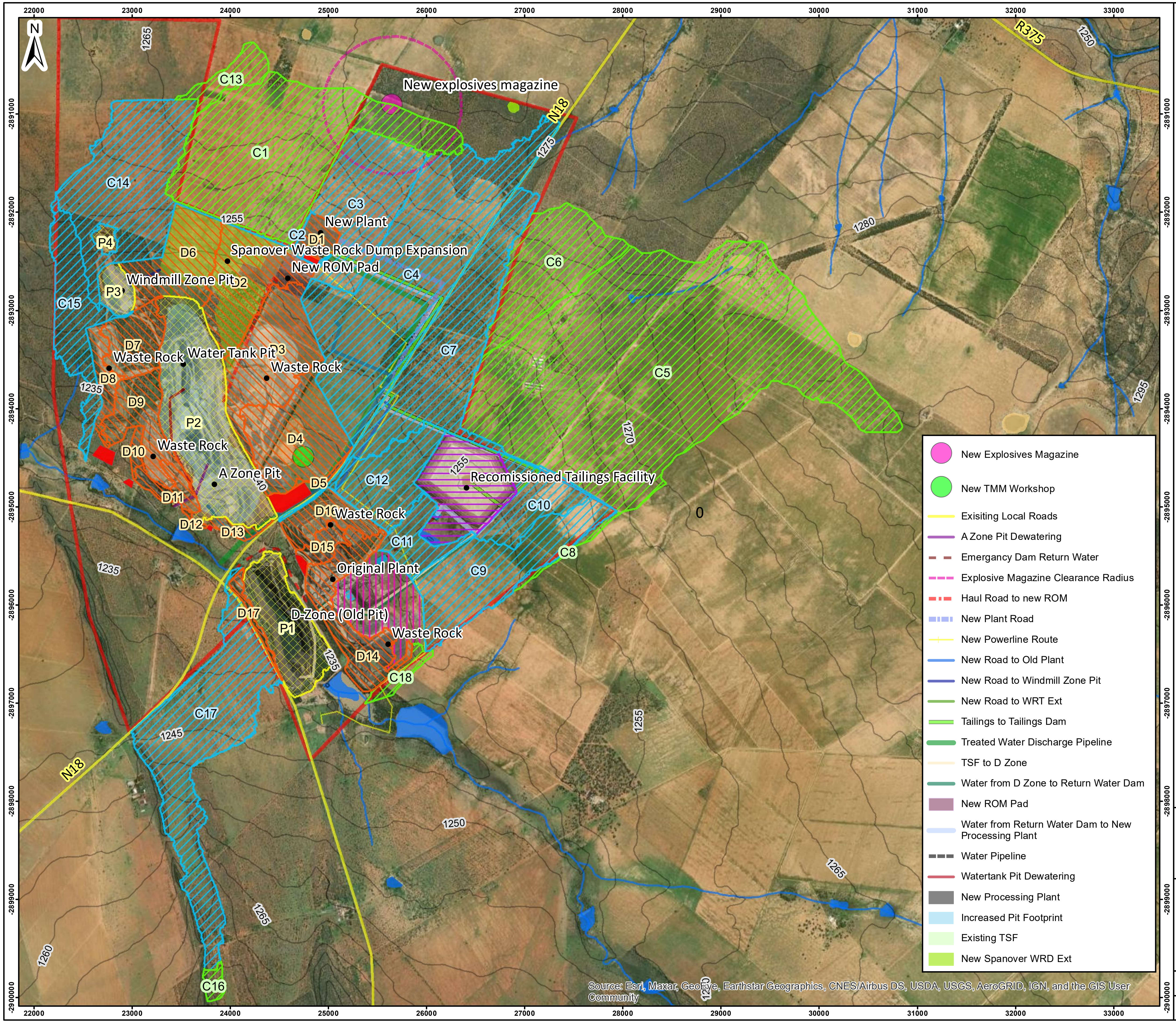
In some instances, a 'dual' purpose diversion is used whereby the position of adjacent clean and dirty areas (relative to terrain), requires both a clean water and a dirty water component to route runoff and keep dirty and clean areas separate. These 'dual' diversions would feature a separating berm between the clean and dirty water diversion.

The TSF and current plant dirty areas have been excluded from the SWMP and are assumed to be managed appropriately.

Overall, this SWMP aims to minimise the final dirty area to limit the unnecessary containment of clean areas. This benefits the operation in reducing the size of the dirty water diversion and the volume of dirty water requiring containment, as well as reducing the impact on the receiving water environment due to the reduction in natural runoff.

5.1.3 FUELS, LUBRICANTS AND CHEMICALS

The storage/handling of fuel, lubricants and chemicals will require special attention due to their hazardous nature. These areas are required to be managed on impermeable floors with appropriate bunding, sumps and roofing. This is regarded as localised management and does not form part of this conceptual SWMP.



Legend

- Expansion Affected Properties
- 5m Contour (50K Topo)
- Furrow (50K Topo)
- Non-Perennial River Centre line
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Perennial Pan (50K Topo)
- Clean Area (SADEM
- Original Plant (Managed Seperately)
- TSF (Managed Seperately)
- Opencast Pit (Self-Contained)
- Clean Area
- Dirty Area
- Pollution Control Dam

Figure 5-1

Dirty and Clean Water Areas

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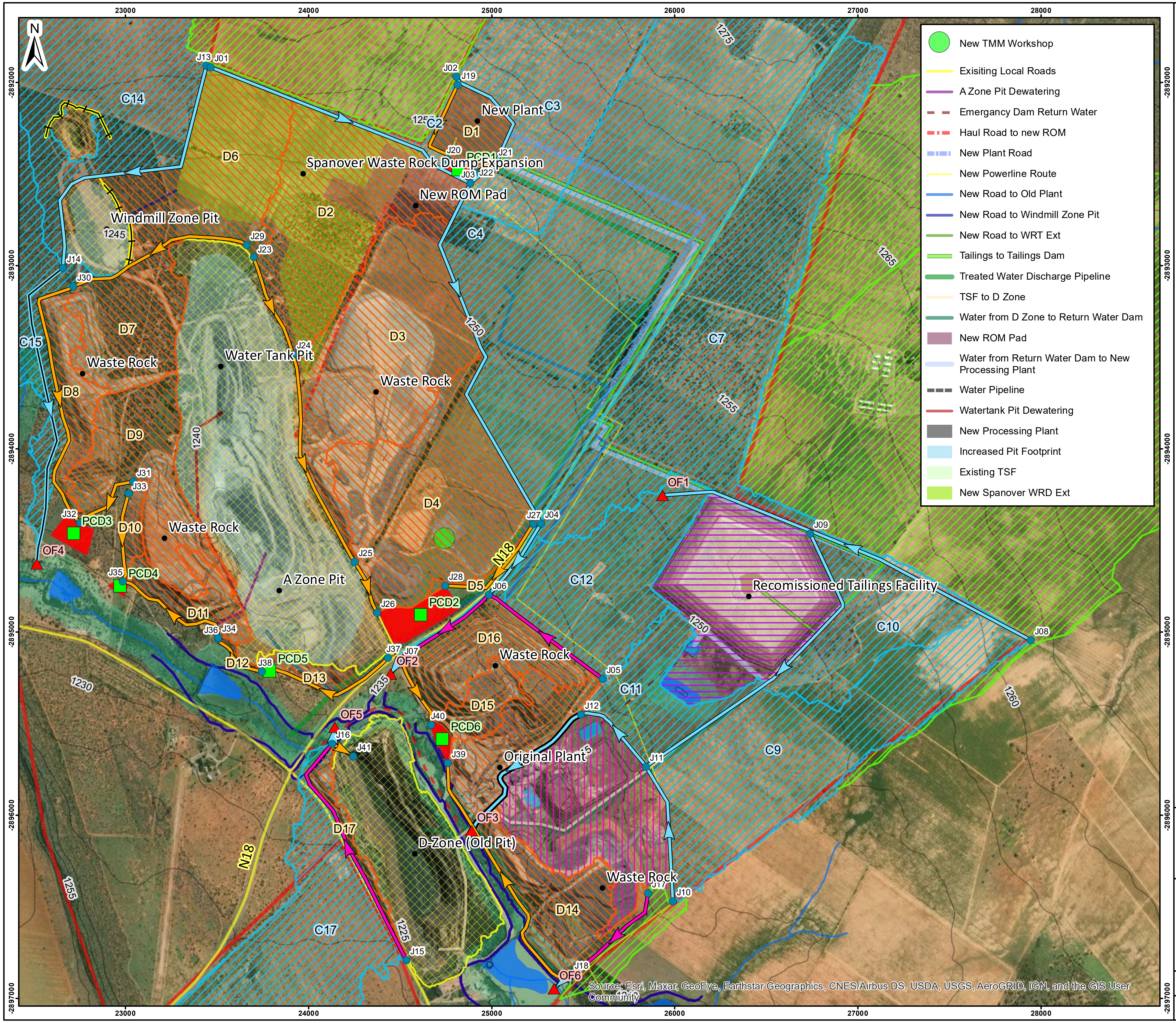
0 1,000 Meters

Scale: 1:36,000 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO25	November 2021



Legend

- Expansion Affected Properties
- 5m Contour (50K Topo)
- Furrow (50K Topo)
- Non-Perennial River Centre line
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Digitised 100 RI Flood-Line (SRK, 2020)
- 100m Watercourse Buffer
- Junction
- Storage
- Outfall
- Berm (Protecting Pit)
- Clean Diversion (Channel & Berm)
- Clean Diversion (Channel and Two-Sided Berm)
- Clean Diversion (Channel Only)
- Dirty Diversion (Channel & Berm)
- Clean and Dirty Diversion (Seperated by Berm)
- Clean Area (SADEM)
- Original Plant (Managed Seperately)
- TSF (Managed Seperately)
- Opencast Pit (Self-Contained)
- Clean Area
- Dirty Area
- Pollution Control Dam

Figure 5-2

Conceptual Storm Water Management Plant (Overall)

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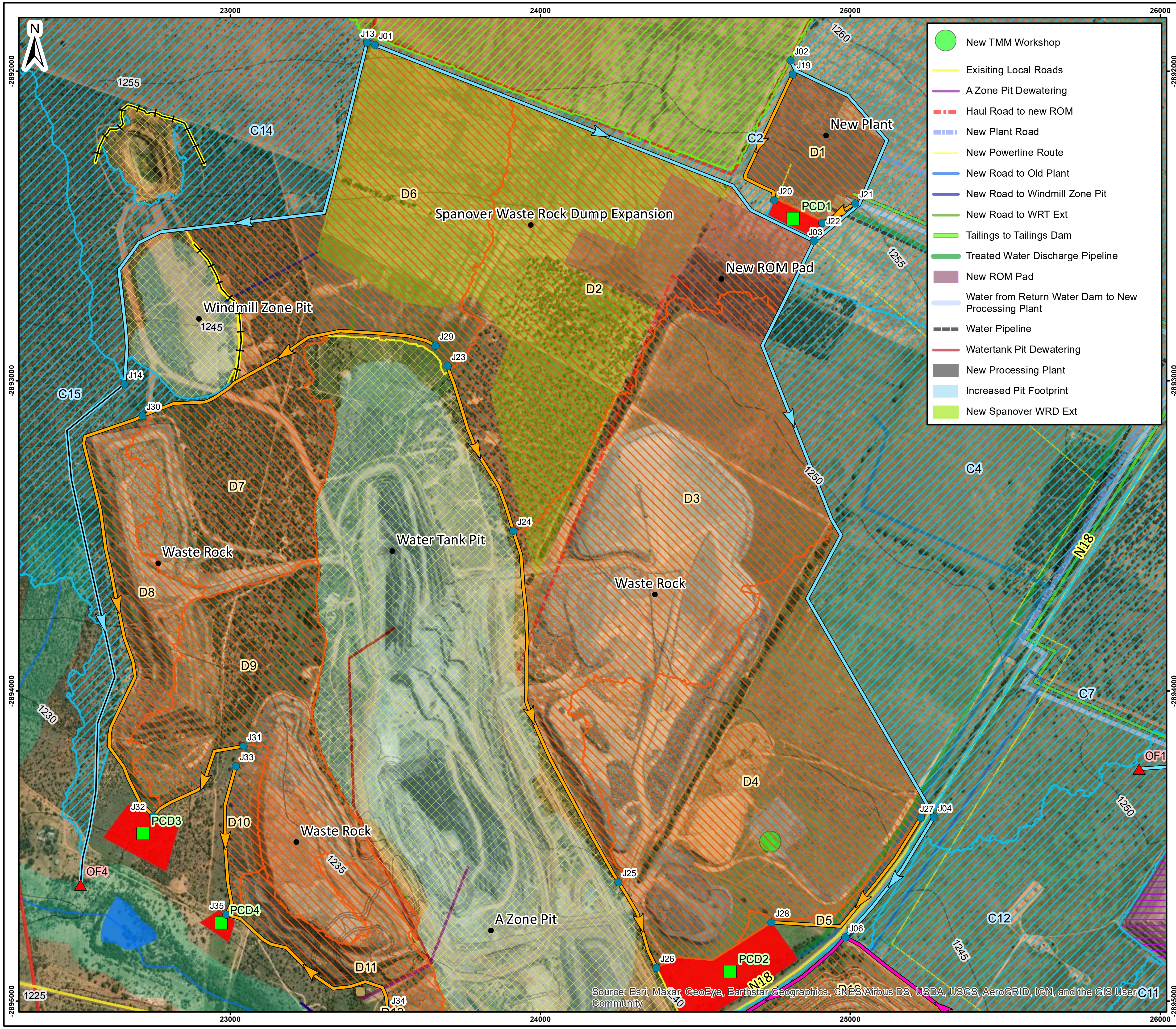
0 1,000 Meters

Scale: 1:19,400 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO25	January 2022



Legend

- Expansion Affected Properties
- 5m Contour (50K Topo)
- Non-Perennial River Centre line
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Digitised 100 RI Flood-Line (SRK, 2020)
- 100m Watercourse Buffer
- Junction
- Storage
- Outfall
- Berm (Protecting Pit)
- Clean Diversion (Channel & Berm)
- Clean Diversion (Channel Only)
- Dirty Diversion (Channel & Berm)
- Clean and Dirty Diversion (Seperated by Berm)
- Clean Area (SADEM
- TSF (Managed Seperately)
- Opencast Pit (Self-Contained)
- Clean Area
- Dirty Area
- Pollution Control Dam

Figure 5-3

Conceptual Storm Water Management Plant (North)

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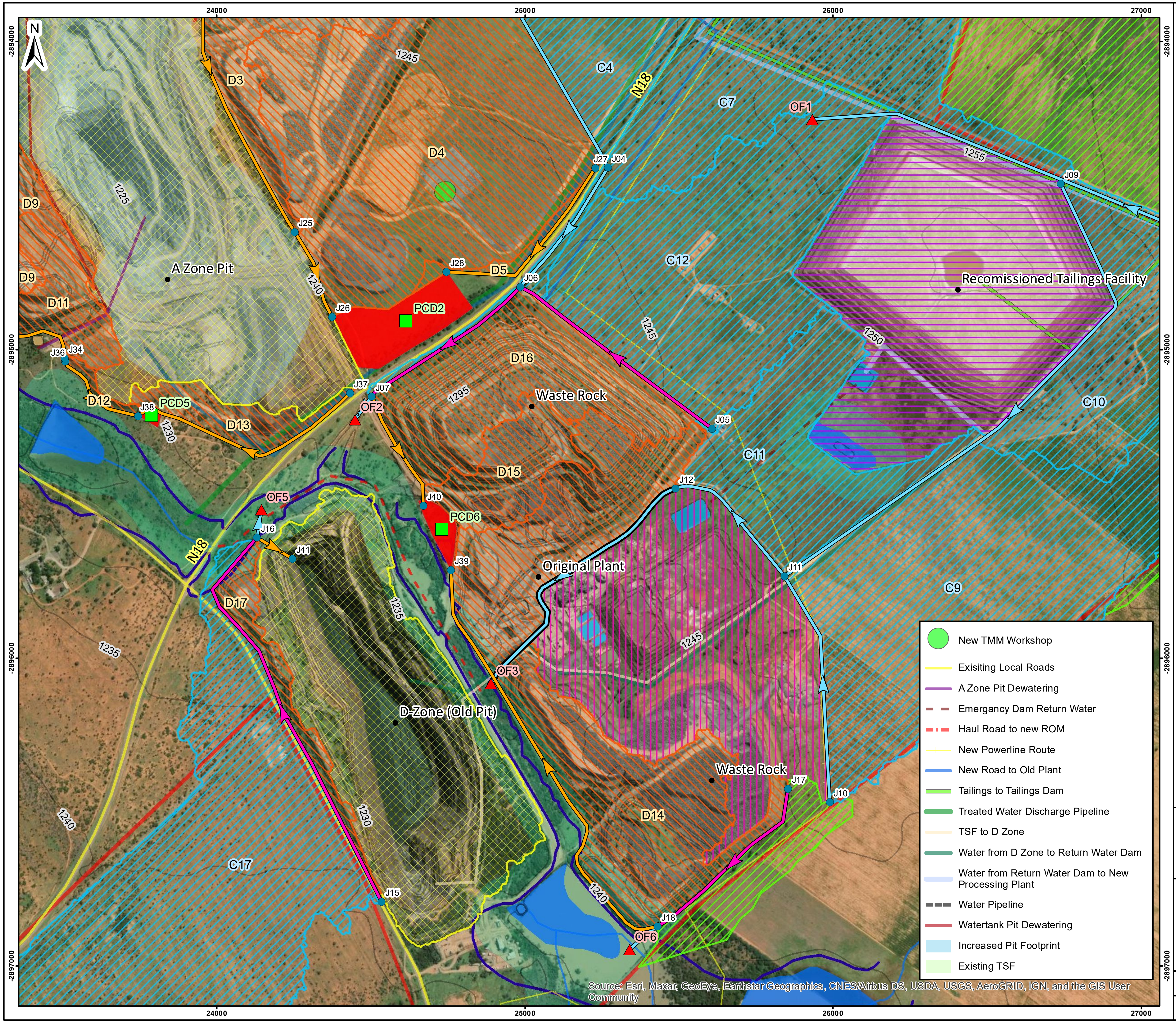
0 500 Meters

Scale: 1:11,500 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO25	January 2022



Legend

- Expansion Affected Properties
- 5m Contour (50K Topo)
- Furrow (50K Topo)
- Non-Perennial River Centre line
- 100m Watercourse Buffer
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Digitised 100 RI Flood-Line (SRK, 2020)
- Junction
- Storage
- Outfall
- Clean Diversion (Channel & Berm)
- Clean Diversion (Channel and Two-Sided Berm)
- Dirty Diversion (Channel & Berm)
- Clean and Dirty Diversion (Seperated by Berm)
- Clean Area (SADEM
- Original Plant (Managed Seperately)
- TSF (Managed Seperately)
- Opencast Pit (Self-Contained)
- Clean Area
- Dirty Area
- Pollution Control Dam

Figure 5-4

Conceptual Storm Water Management Plant (South)

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0 500 Meters

Scale: 1:11,500 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO25	January 2022

5.2 STORM WATER MANAGEMENT INFRASTRUCTURE

Storm water management infrastructure has been conceptually designed in this report as per the requirements of GN 704 and BPG1 using the 1:50 year RI event. No account has been taken of climate change and any potential future increases in rainfall depth or intensity. These will need to be considered depending on the expected life of the relevant structure or operation.

Figures 4-2 to 4-5 illustrate the conceptual SWMP, while Appendix A presents details relating to the development of the SWMP using PCSWMM, which is based on the Storm Water Management Model (Rossman, 2008).

5.2.1 AVAILABLE INFORMATION

The following information was used to develop the (SWMP):

- Climate Data: Particularly design rainfall depths and monthly rainfall and evaporation data;
- Elevation Data: The derived 1m DSM as outlined in Section 2.5 was used to define flow routes and subcatchment divisions;
- Aerial Imagery: This utilised the detailed aerial imagery provided by the mine (flown in October and November 2020); and
- Catchment characteristics: Soil characteristics, land-cover, slopes were some of the parameters used to define catchment characteristics.

It should be noted that the location and size for the diversions/containment included in this conceptual SWMP have primarily been determined using the 1m DSM, while areas requiring management have been based upon the layout presented in Figure 1-2 and aerial imagery. As outlined in Section 2.5, there are limitations to the accuracy of this DSM particular for areas with vegetation and consequently the accuracy of the SWMP.

5.2.2 PERMISSIBLE VELOCITIES

The conceptual SWMP has not expressly taken account of velocities in the diversions since this is expected to be considered during details design. In general, velocities over 2 m/s are high enough to cause erosion of grass-lined channels, while velocities over 2.5 m/s can erode concrete linings with joints or cracks, with an upper limit of 8 m/s in the case of reinforced concrete. The South African National Roads Agency Limited (SANRAL) drainage manual (SANRAL, 2013) guides maximum permissible velocities and should be consulted during the detailed design phase. Deposition of sediment due to velocities that are too low may also need to be accounted for during detailed design.

5.2.3 CLEAN WATER SYSTEM - DIVERSIONS

Figure 5-5 represents a typical clean area diversion consisting of a containing berm and channel component (in most instances). The purpose of the channel section is to divert upstream/upslope clean water that would otherwise flow into the dirty area, while the berm section will ensure containment of dirty water within dirty areas. A single instance of a clean water diversion without a berm has also been included as it was necessary to allow flow into the channel from both sides. At this conceptual stage, it is uncertain as to whether deep, narrow channels or shallow, wide channels are preferred. The side slopes for all berms and channels have consequently been kept constant at 1 vertical: 2 horizontal. A minimum channel dimension of 0.5m channel depth and 1.0m channel base breadth has been used to simplify the design.

The channel component has been sized using PCSWMM storm water modelling software to meet the requirement of accommodating the 1:50 year RI event. A Manning's 'n' roughness coefficient of 0.035 (grass) was used in the sizing of the diversions channels. Figure 5-3 illustrates a typical berm and channel where:

- a = Channel Depth
- b = Channel Base Breadth

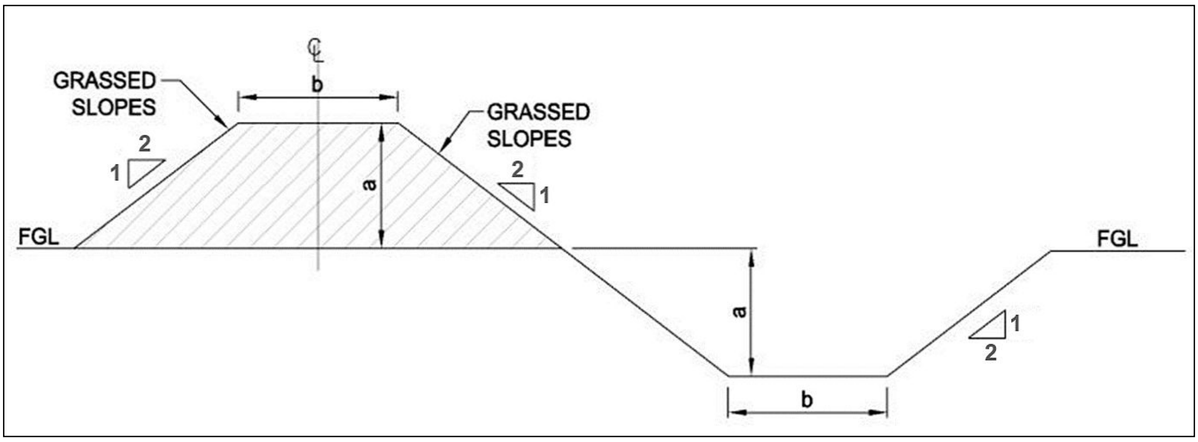

FIGURE 5-5: TYPICAL BERM AND CHANNEL FOR THE STORM WATER DIVERSION SYSTEM

Table 5-1 presents the dimensions of the clean area diversions, including the average longitudinal slope. Average longitudinal slopes were used in modelling each channel segment since additional detail is beyond the scope of this conceptual SWMP. The indicated dimensions and flows may differ from the final design, depending on the construction method, the location of diversions and the additional detail included in the detailed design. The channel dimensions should consequently be reviewed during the detailed design phase.

TABLE 5-1: DIMENSIONS FOR CLEAN AREA DIVERSIONS (1:50 RI EVENT)

Diversion	a (m)	b (m)	Average Longitudinal Slope (%)	Peak Flow (m^3/s)	Comment
J01 to J03	1.5	3.0	0.14	6.5	Passes below new plant's PCD
J02 to J03	1.5	1.0	0.69	5.3	
J03 to J06	1.5	6.0	0.31	19.6	Passes beneath freeway (not modelled)
J05 to J06	1.5	4.0	0.13	11.1	Particularly low fall along diversion length
J06 to J07	1.5	7.0	0.70	34.0	
J07 to OF2	1.5	1.0	7.25	34.0	Requires superstructure due to underpass
J08 to OF1	1.5	3.0	0.70	11.3	Discharges into clean area routing to J05
J09 to J11	1.0	1.0	0.49	1.4	
J10 to J11	1.5	3.0	0.19	5.9	Particularly low fall along diversion length
J11 to J12	1.5	2.0	0.40	8.5	
J12 to OF3	1.0	1.0	0.92	8.5	Concrete channel, berms both sides
J13 to J14	1.0	1.5	0.84	9.0	
J14 to OF4	1.0	1.5	1.02	11.3	No berm to allow inflow from both sides
J15 to J16	1.5	1.0	0.58	8.1	
J16 to OF5	1.5	1.0	3.25	8.1	
J17 to J18	0.75	1.0	1.2	1.9	
J18 to OF6	0.75	1.0	2.7	1.9	

5.2.4 DIRTY WATER SYSTEM - DIVERSIONS

Dirty area diversions have been designed to ensure dirty water generated on the site is contained. These systems will also consist of a berm and channel component routing to a pollution control dam (PCD). The berm and channel component has been designed to accommodate the 1:50 year RI storm event and serves two main purposes:

- Diverting upstream clean water which would otherwise flow into the identified dirty areas.
- Contain dirty water in the identified dirty areas and direct towards the appropriate dirty water containment facility.

Figure 5-8 represents a typical dirty water containment berm and channel. The side slopes for all berms and channels have been kept constant at 1 vertical: 2 horizontal. A minimum channel dimension of 0.5m channel depth and 1.0m channel base breadth has been used to simplify the design. The channel component has been sized using PCSWMM to meet the requirement of accommodating the 1:50 year RI event. A Manning's 'n of 0.015 (concrete) was used in the calculations, associated with a concrete-lined channel.

Table 4-2 presents the dimensions of the clean area diversions, including the average longitudinal. Average longitudinal slopes were used in modelling each channel segment since additional detail is beyond the scope of this conceptual SWMP. The indicated dimensions and flows may differ from the final design, depending on the construction method, the location of diversions and the additional detail included in the detailed design. The channel dimensions should consequently be reviewed during the detailed design phase.

TABLE 5-2: DIMENSIONS FOR DIRTY AREA DIVERSIONS (1:50 RI EVENT)

Diversion	a (m)	b (m)	Average Longitudinal Slope (%)	Peak Flow (m^3/s)	Comment
J19 to J20	0.5	1.0	0.84	-	Terminates at PCD 1, doesn't receive flow per model
J21 to J22	0.5	1.0	1.4	3.1	Terminates at PCD 1
J23 to J24	1.5	4.0	0.21	13.4	
J24 to J25	1.5	4.0	0.30	23.0	
J25 to J26	1.5	4.0	0.16	36.3	Terminates at PCD 2
J27 to J28	0.5	1.0	0.61	0.6	Terminates at PCD 2
J29 to J30	1.0	1.0	0.47	8.6	
J30 to J32	1.0	1.0	0.91	8.8	Terminates at PCD 3
J31 to J32	0.75	1.0	1.62	6.4	Terminates at PCD 3
J33 to J35	0.5	1.0	1.27	1.5	Terminates at PCD 4
J34 to J35	0.75	1.0	0.77	3.8	Terminates at PCD 4
J36 to J38	0.5	1.0	0.87	0.4	Terminates at PCD 5
J37 to J38	0.5	1.0	1.31	1.6	Terminates at PCD 5
J17 to J39	1.25	2.0	0.42	12.2	Terminates at PCD 6
J05 to J40	1.0	1.0	0.46	6.5	Terminates at PCD 6
J15 to J41	0.5	1.0	0.64	1.5	Discharges water from strip of peripheral waste rock to pit

5.2.5 DIRTY WATER SYSTEM – CONTAINMENT

Condition 6 of GN 704 states that clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these clean and dirty water systems do not spill into each other as a result of storm events below and including the 1:50 year RI event. A minimum freeboard of 0.8m above full supply level must also be maintained as per the requirements of GN 704.

Dirty water generated on the site will either flow into one of the pits or one of the six proposed PCDs. No pit dewatering or process water has been factored into the SWMP. Additional sources of water (apart from that generated by rainfall and subsequently runoff) could increase the recommended PCD size.

A simplistic dynamic model of the six PCDs was set up to consider possible storage volumes within the PCD during periods of typical rainfall. From this model, the month with the highest storage volume was used to set an initial depth within the PCSWMM model (for the PCD of relevance). This consideration results in a 'recommended volume' of storage (excluding any process water or other water sources aside from rainfall-runoff).

Table 5-3 presents the volume requirement for the PCDs inclusive of a recommended volume that accounts for the PCD inflow volumes during the wet season. This recommended volume utilised a (simplistic) dynamic analysis of average monthly PCD performance (also referred to in Section 6.3), considering inflows and evaporative losses (with evaporative losses consistently utilising the full PCD area). Table 5-3 should be evaluated and revised as part of the detailed design phase of the project.

TABLE 5-3: CONTAINMENT VOLUMES

Containment	Area (m^2)	1:50 RI Volume (m^3)	Recommended Volume (m^3)	Depth Based on Recommended (m)
PCD1	8,000	15,100	22,100	2.76
PCD2	60,000	174,000	198,800	3.31
PCD3	25,000	85,200	98,800	3.95
PCD4	5,000	13,200	15,100	3.00
PCD5	2,500	5,830	6,500	2.57
PCD6	14,000	69,200	79,400	5.66

The depth of the PCDs varies based upon the extent of the PCD as illustrated in Figures 5-2 to 5-4 and the constant depth/area relationship assumed. Of particular interest is PCD6 which is positioned near the Morokwa River. This PCD captures the dirty water from D14, D15 and D16, however, it is limited in extent by the adjacent waste rock dumps, haul roads and watercourse. The PCD designs presented are, however, indicative and will likely change during detailed design. What is less likely to change (assuming PCD positions are retained) is the 1:50 RI volume which is the minimum volume of storage that is required to be available at all times. Freeboard requirements have also not been factored into this assessment.

Table 5-4 presents the 1:50 RI volumes associated with the pits (P1 to P4). These are (1:50) design storm volumes that may need to be factored into the management of pit water (e.g. sump management) to enable uninterrupted production and to safe guard against loss of equipment or life (due to possible flooding).

TABLE 5-4: PIT 1:50 RI CAPACITIES

Pit	1:50 RI Inflows (m^3)
P1	74,400
P2	161,900
P3	16,200
P4	4,500

5.2.6 REHABILITATION AND RESIDUAL DIRTY AREAS

It is the recommendation that a mine rehabilitation strategy is developed whereby areas of rehabilitation are firstly identified and then completely rehabilitated with the subsequent routing of runoff from these now clean areas, into the downstream clean environment. Prioritising areas of rehabilitation on the perimeter of the site and working inwards would enable more straightforward storm water management including the revised separation of clean and dirty areas. Rehabilitation of previously mined areas and routing of these now clean areas into the downstream environment would also demonstrate an effort by the operation to further minimise the impact of site works on surface water resources and by association, further compliance with GN 704 Condition 7(c).

For the minor dirty areas not managed by the SWMP (residual dirty areas), the mineral deposits should be cleaned up with rehabilitation of soils and vegetation where this process results in significant disturbance to the surface (e.g. where vegetation is stripped away). Excavations should likewise be filled in with the replacement of topsoil and vegetation. Only once this is done, will the proposed SWMP be acceptable from a GN 704 standpoint, since minor residual dirty areas have been intentionally excluded from the SWMP managed dirty area on the premise that this rehabilitation will occur at the same time as the implementation of the SWMP. The reason for this exclusion is to minimise the dirty area requiring management (and therefore reduce necessary PCD volumes) while maximising the clean area on the site (thereby limiting the overall impact of the site on surface water quantities in the surrounding region).

6 WATER BALANCE

A static water balance model has been developed for Kalgold Mine and considers the future (proposed) expansion of the operation.

The foundation of the water balance was derived from the September 2021 water balance of the mine[5]. This water balance (provided by the mine) outlines the monthly reticulation of water on the mine from January 2021 to July 2021 (7 months of data). The future water use by the mine has largely been informed by the associated water balance developed by MvB Consulting (2021), which includes an estimated long-term water balance for the years 2021 to 2034. The MvB report also included additional data that was used to supplement the 7 months of data provided by the mine where possible (such that a full year of monthly recordings from August 2020 to July 2021 could be included in the analysis)

6.1 MODEL DESCRIPTION

The static water balance presented in this report includes average monthly wet and average monthly dry season scenarios. The wet season is averaged for October to March, with the dry season averaged for April to September.

6.2 MODEL SUMMARY

The water balance model schematic for the average monthly wet and dry season flows have been summarised in Figures 6-1 and 6-2. Average conditions have been assumed where possible to present an 'average' water balance. Being an average, interannual increases or decreases in the water balance as presented are likely.

[5] Current Water Balance_Sep2021.xlsx

TABLE 6-1: AVERAGE MONTHLY WATER BALANCE – WET SEASON

Monthly Water Balance for Kalgold Mine (wet season)				
Facility Name		**Water In**		**Water Out**
Kalgold Mine	**Water Circuit/stream**	**Quantity (m³/month)**	**Water Circuit/stream**	**Quantity (m³/month)**
Central Dam				
	From: Water Tank Abstraction (Pit)	64,473	To: Dust Suppression	4,418
	From: A-Zone Abstraction (Pit)	114,871	To: Gold Plant	178,871
	From: Boreholes	4,579	To: Evaporation	195
	From: Rainfall	62	To: Workshop	500
	Total	**183,984**		**183,984**
Gold Plant				
	From: Central Dam	178,871	To: Tailings	340,136
	From: D-Zone (Pit)	238,386	To: Process Losses	90,249
	From: Boreholes	2,504		
	From: Crafford Dam	10,625		
	Total	**430,385**		**430,385**
Potable (e.g. Change House, Ablutions, Kitchens)				
	From: Boreholes	5,969	To: Consumption	1,194
			To: Septic Tanks / Sewage Plant	4,775
	Total	**5,969**		**5,969**
Septic Tanks/Sewage Plant				
	From: Excess Potable	4,775	To: Evaporation or Treatment and Discharge	4,775
	Total	**4,775**		**4,775**
Workshop				
	From: Central Dam	500	To: Reuse or Evaporation	500
	Total	**500**		**500**
PCD 1				
	From: Runoff from Dirty Area	2,580	To: Evaporation	1,518
	From: Direct Rainfall	1,280	To: Dust Suppression	1,000
			To: PCD Storage (wet season surplus)	1,342
	Total	**3,860**		**3,860**
PCD 2				
	From: Runoff from Dirty Area	11,265	To: Evaporation	10,757
	From: Direct Rainfall	4,396	To: PCD Storage (wet season surplus)	4,903
	Total	**15,660**		**15,660**
PCD 3				
	From: Runoff from Dirty Area	5,529	To: Evaporation	4,521
	From: Direct Rainfall	1,819	To: PCD Storage (wet season surplus)	2,826
	Total	**7,347**		**7,347**
PCD 4				
	From: Runoff from Dirty Area	856	To: Evaporation	886
	From: Direct Rainfall	383	To: PCD Storage (wet season surplus)	353
	Total	**1,239**		**1,239**
PCD 5				
	From: Runoff from Dirty Area	363	To: Evaporation	426
	From: Direct Rainfall	167	To: PCD Storage (wet season surplus)	104
	Total	**530**		**530**
PCD 6				
	From: Runoff from Dirty Area	4,549	To: Evaporation	2,600
	From: Direct Rainfall	1,022	To: Dust Suppression	1,000
			To: PCD Storage (wet season surplus)	1,970
	Total	**5,571**		**5,571**
Total Water Balance		**658,580**		**658,580**

TABLE 6-2: AVERAGE MONTHLY WATER BALANCE – DRY SEASON

Monthly Water Balance for Kalgold Mine (dry season)				
Facility Name		**Water In**		**Water Out**
Kalgold Mine	**Water Circuit/stream**	**Quantity (m^3/month)**	**Water Circuit/stream**	**Quantity (m^3/month)**
Central Dam				
	From: Water Tank Abstraction (Pit)	125,317	To: Dust Suppression	7,118
	From: A-Zone Abstraction (Pit)	117,229	To: Gold Plant	241,993
	From: Boreholes	7,157	To: Evaporation	106
	From: Rainfall	14	To: Workshop	500
	Total	**249,717**		**249,717**
Gold Plant				
	From: Central Dam	241,993	To: Tailings	364,864
	From: D-Zone (Pit)	183,956	To: Process Losses	65,521
	From: Boreholes	1,180		
	From: Crafford Dam	3,255		
	Total	**430,385**		**430,385**
Potable (e.g. Change House, Ablutions, Kitchens)				
	From: Boreholes	6,790	To: Consumption	1,358
			To: Septic Tanks / Sewage Plant	5,432
	Total	**6,790**		**6,790**
Septic Tanks/Sewage Plant				
	From: Excess Potable	5,432	To: Evaporation or Treatment and Discharge	5,432
	Total	**5,432**		**5,432**
Workshop				
	From: Central Dam	500	To: Reuse or Evaporation	500
	Total	**500**		**500**
PCD 1				
	From: Runoff from Dirty Area	198	To: Evaporation	418
	From: Direct Rainfall	295	To: Dust Suppression	1,417
	From: Wet Season Surplus	1,342		
	Total	**1,835**		**1,835**
PCD 2				
	From: Runoff from Dirty Area	741	To: Evaporation	1,754
	From: Direct Rainfall	1,013		
	Total	**1,754**		**1,754**
PCD 3				
	From: Runoff from Dirty Area	364	To: Evaporation	783
	From: Direct Rainfall	419		
	Total	**783**		**783**
PCD 4				
	From: Runoff from Dirty Area	56	To: Evaporation	145
	From: Direct Rainfall	88		
	Total	**145**		**145**
PCD 5				
	From: Runoff from Dirty Area	24	To: Evaporation	62
	From: Direct Rainfall	38		
	Total	**62**		**62**
PCD 6				
	From: Runoff from Dirty Area	299	To: Evaporation	535
	From: Direct Rainfall	235	To: Dust Suppression	1,970
	From: Wet Season Surplus	1,970		
	Total	**2,505**		**2,505**
Total Water Balance		**699,763**		**699,763**

6.3 MODEL ASSUMPTIONS

The following assumptions (based upon provided information) were made during model development:

- The MvB (2021) report's estimated long-term water balance for 2022 to 2034 was averaged to derive an annual total.
- This annual total was then split into the wet season and dry season proportions based upon the current mining operation (using water balance data from August 2020 to July 2021).
- The proposed workshop is assumed to use 500m^3 of water a month, with this water either being reused or lost to evaporation.
- A-Zone and Water Tank pit abstractions assumed are necessary and based upon the MvB (2021) report. These abstractions are sent to the central dam. After minor losses (to evaporation, dust suppression and the proposed workshop use). The bulk of the Central dam water (derived from the two pits) is sent to the plant (for use as priority water).
- Existing borehole abstractions are assumed to remain as current (no increase), such that additional water is first prioritised from the Central dam transfer with the makeup of the water requirement then sourced from the D-Zone pit.
- Crafford dam abstraction water use is set to the future estimate as it is less than current.
- The gold plant water use has been considered as a single entity (as per the MvB report) despite the potential that there could be two gold plants in operation.
- Likewise, the abstraction of water for the plant from tailings deposited into either D-Zone or the recommissioned TSF has not been separated from one another (as per the MvB report) and due to the uncertainty of the division of water in this regard. The same is true for the deposition of water (along with tailings material).
- The proportion of rainfall running off from dirty areas into PCDs is for the dry season (2%) and the wet season (7%) is representative of actual.
- The PCD evaporative losses are based upon the full PCD area (as conceptualised in the SWMP in Section 5), regardless of the depth of water.
- The model is based upon static input information and is therefore not dynamic. This for instance influences the simulation of PCD performance as feedbacks of water from one month to the next are not accurately represented.
- A simplistic 'dynamic' assessment of the PCDs was nevertheless developed alongside the static water balance to assess PCD performance over the year. From this assessment, PCD's 1 and 6 are noted as not drying. As such, the expected increase in dust suppression due to the expansion was derived from 1,000m^3 monthly contributions for these two PCDs, resulting in the PCD's drying out (such that they would not slowly build up water during the year). This is a high-level assessment, however, and a more detailed analysis of PCD performance would be required (once PCD locations and designs have been finalised.
- Transmission losses as part of the water circuit are negligible.
- Data supplied by the client is accurate and representative.
- Rainfall and evaporative data sourced for the site as per Section 2 are accurate and representative.

7 HYDROLOGICAL IMPACTS AND MITIGATION MEASURES

An impact is essentially any change (positive or negative) to a resource or receptor brought about by the presence of the project component or by the execution of a project related activity.

The potential impacts of the project have been evaluated using a recognised risk assessment methodology developed to ensure communication of the potential consequences or impacts of activities on the hydrological (surface water) environment as set out in the National Environmental Management Act (NEMA). A quantitative approach was taken in determining environmental significance since this enables a cross-disciplinary assessment of impact whereby the interpretation of impact significance is the same (i.e. a high impact on the surface water environment has the same interpretation as a high impact on ecology).

7.1 METHOD OF ASSESSING IMPACTS

The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

7.1.1 DETERMINATION OF ENVIRONMENTAL RISK

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER).

The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{E + D + M + R}{4} \times N$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 7-1.

TABLE 7-1: CRITERIA FOR DETERMINING IMPACT CONSEQUENCE

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table 7-2.

TABLE 7-2: PROBABILITY SCORING

Probability Score	Description
1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
3	Medium probability (the impact may occur; >50% and <75%),
4	High probability (it is most likely that the impact will occur- > 75% probability), or
5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

$$ER = C \times P$$

TABLE 7-3: DETERMINATION OF ENVIRONMENTAL RISK

Consequence						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 7-4.

TABLE 7-4: SIGNIFICANCE CLASSES

Environmental Risk Score	Description
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9 & <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

7.1.2 IMPACT PRIORITISATION

Further to the assessment criteria presented in the section above, it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

TABLE 7-5: CRITERIA FOR DETERMINING PRIORITISATION

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable Loss of Resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 5-5. The impact priority is therefore determined as follows:

$$Priority = CI + LR$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (Refer to Table 7-6).

TABLE 7-6: DETERMINATION OF PRIORITISATION FACTOR

Priority	Prioritisation Factor
2	**1**
3	**1.125**
4	**1.25**
5	**1.375**
6	**1.5**

In order to determine the final impact significance, the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

TABLE 7-7: FINAL ENVIRONMENTAL SIGNIFICANCE RATING

Rating	Description
≤ -17	High negative (i.e. where the impact must have an influence on the decision process to develop in the area).
> -17 ≤ -9	Medium negative (i.e. where the impact could influence the decision to develop in the area).
> -9 < 0	Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).

0	No impact
>0 <9	Low positive (i.e. where this impact would not have a direct influence on the decision to develop in the area).
≥ 9 < 17	Medium positive (i.e. where the impact could influence the decision to develop in the area).
≥ 17	High positive (i.e. where the impact must have an influence on the decision process to develop in the area).

7.2 PROJECT PHASES

The Kalgold Expansion Project involves the addition and expansion of surface infrastructure. This impact assessment has been developed on the understanding that the project is comprised of the following phases:

- Construction – surface infrastructure will be built on land cleared for that purposes;
- Operation – mining operations will commence;
- Decommissioning – all mining operations will cease with surface infrastructure removed; and
- Rehab/Closure – disturbed surface areas will undergo rehabilitation as part of the mine's closure plan.

Both a preceding 'planning' phase and 'post-closure phase' are intended for the project, however, for this EIA phase report, it is assumed that no changes will have yet occurred to the surface water environment (planning phase) or the rehabilitation would have reinstituted the pre-development hydrological regime (post-closure phase).

No alternatives are relevant to this EIA phase report.

7.3 IDENTIFIED IMPACTS

7.3.1 EROSION OF SOILS

Eroded soils have the potential to cause sedimentation of downstream watercourses. The construction/expansion of infrastructure will lead to new areas being disturbed, resulting in the potential for soil erosion to occur during times of rainfall, while the decommissioning of this infrastructure will result in the same. If not mitigated, erosion could continue during the operational phase, although it is expected soils would settle to a degree, reducing the potential volume of erosion for any given rainfall event. The rehab/closure phase may have an overall positive impact on any existing erosion without formal erosion mitigation in place, although there could also be some increase in erosion due to earthworks. Potential erosion is exacerbated by the moderately high runoff potential (see Section 2.7) of soils in parts of the site, which would cause a higher proportion of rainfall to be converted into runoff, thereby increasing the runoff's potential erosivity, although the limited surface area to be disturbed will limit the overall erosion of soils on-site during all project phases.

Disturbed areas should consequently be stabilised, with erosion control methods used where stabilisation is not possible. A rehabilitation plan for the site should be developed inclusive of topsoil replacement where possible. A re-vegetation strategy including maintenance/aftercare should likewise be developed for disturbed areas.

TABLE 7-8: EROSION OF SOILS (CONSTRUCTION AND DECOMMISSIONING PHASE)

Impact Name	Erosion of Soils				
Phase	Construction and Decommissioning				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature	-1	-1	Nature	2	2
Extent	3	1	Extent	2	2
Duration	4	2	Duration	4	3
Environmental Risk (Pre-mitigation)					-11.0
Mitigation Measures					
• *Suitable erosion control should be utilised where necessary.* • *The disturbed footprint should be minimised as far as practically possible.* • *Clearing of vegetation and associated excavation areas should be kept to a minimum, particularly in areas where soils are unstable.* • *Construction should ideally be scheduled to take place during the dry season when rainfall and associated erosion potential is at its least. For longer construction periods of more than six months, construction should be scheduled such that exposure of soils (before addition of hardstanding or rehabilitation) occurs mostly within the dry season as far as possible.* • *All disturbed areas must be rehabilitated (as soon as possible) to represent the previous undisturbed environment (soil, land-cover, slope) as closely as possible to limit the impact on receiving water resources (by limiting soil erosion).* • *Disturbed areas or areas rehabilitated with soils should be stabilised as soon as possible using plants (e.g. grass) or other mechanical methods (e.g. profiling or erosion control blankets).* • *A practical erosion control handbook should be developed, based on the principles developed in this report and given to the construction contractors to ensure the impact on receiving water resources is limited.* • *Where erosion is nevertheless likely to occur, it is recommended to use settling facilities or silt fences.* • *A rehabilitation plan for the site inclusive of topsoil replacement where possible, a re-vegetation strategy and maintenance/aftercare and should be developed for disturbed areas.* • *Implementation of the SWMP will result in possible erosion largely being contained.*					
Environmental Risk (Post-mitigation)					-5.25
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Cumulative Impacts					2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.					
Degree of potential irreplaceable loss of resources					1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.125
Final Significance					-5.91

TABLE 7-9: EROSION OF SOILS (OPERATIONAL AND REHAB/CLOSURE PHASE)

Impact Name	Erosion of Soils				
Phase	Operational and Rehab/Closure				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature	-1	-1	Magnitude	2	2
Extent	3	1	Reversibility	2	2
Duration	4	1	Probability	3	3
Environmental Risk (Pre-mitigation)					-8.25
Mitigation Measures					
• *Suitable erosion control should be utilised where necessary.* • *The disturbed footprint should be minimised as far as practically possible.* • *Clearing of vegetation and associated excavation areas should be kept to a minimum, particularly in areas where soils are unstable.* • *Construction should ideally be scheduled to take place during the dry season when rainfall and associated erosion potential is at its least. For longer construction periods of more than six months, construction should be scheduled such that exposure of soils (before addition of hardstanding or rehabilitation) occurs mostly within the dry season as far as possible.* • *All disturbed areas must be rehabilitated (as soon as possible) to represent the previous undisturbed environment (soil, land-cover, slope) as closely as possible to limit the impact on receiving water resources (by limiting soil erosion).* • *Disturbed areas or areas rehabilitated with soils should be stabilised as soon as possible using plants (e.g. grass) or other mechanical methods (e.g. profiling or erosion control blankets).*					

• *A practical erosion control handbook should be developed, based on the principles developed in this report and given to the construction contractors to ensure the impact on receiving water resources is limited.* • *Where erosion is nevertheless likely to occur, it is recommended to use settling facilities or silt fences.* • *A rehabilitation plan for the site inclusive of topsoil replacement where possible, a re-vegetation strategy and maintenance/aftercare and should be developed for disturbed areas.* • *Implementation of the SWMP will result in possible erosion largely being contained.*	
Environmental Risk (Post-mitigation)	-5.25
Degree of confidence in impact prediction:	Medium
Impact Prioritisation	
Cumulative Impacts	2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.	
Degree of potential irreplaceable loss of resources	1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.	
Prioritisation Factor	1.125
Final Significance	-5.91

7.3.2 POLLUTANTS ENTERING THE SURFACE WATER ENVIRONMENT

Operation of earthmoving machinery or maintenance of vehicles on-site during construction, operation, decommissioning and rehab/closure (including the possible storage or handling of hydrocarbons) poses a potential source of hydrocarbon contamination with regards to the surface water environment. An emergency response plan for unforeseen hydrocarbon spills should be developed while the existing surface water monitoring should be reviewed to ensure adequate coverage of the proposed expansion.

A storm water management plan is a necessary part of the development of the expansion (as per GN 704) and will form an integral mitigation measure with regard to the management of dirty areas. Uncontrolled release of tailings or contaminated water (e.g. due to a pipeline failure) is possible and would be considered a residual risk (post mitigation).

Important. This section only considers the surface water impact from the proposed surface activities. It is expected that the groundwater specialist assess the potential impact of possible seepage of contaminated groundwater into surface water resources.

TABLE 7-10: POLLUTANTS ENTERING THE SURFACE WATER ENVIRONMENT (CONSTRUCTION AND DECOMMISSIONING)

Impact Name	**Pollutants Entering the Surface Water Environment**				
Phase	Construction and Decommissioning				
Impact Name					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature	-1	-1	Magnitude	4	3
Extent	4	4	Reversibility	2	2
Duration	4	4	Probability	5	2
Environmental Risk (Pre-mitigation)					-17.5
Mitigation Measures					
• *Implement a storm water management plan inclusive of containment of dirty water areas.* • *Ensure the tailings facility and return water dam have adequate capacity to contain both operational water and the relevant design storm (e.g. probable maximum precipitation) and that all are adequately engineered to prevent failure (e.g. of embankments or side slopes).* • *Keep tailings pipelines (and any other pipelines with possible contaminants) within the managed dirty water footprint where possible.* • *Keep tailings pipelines (and any other pipelines with possible contaminants) well maintained to prevent leakage.* • *Store hydrocarbons off site where possible, or otherwise implement hydrocarbon storage.*					

• *Handle hydrocarbons carefully to limit spillage.* • *Ensure vehicles are regularly serviced so that hydrocarbon leaks are limited.* • *Designate a single location for refuelling and maintenance where possible.* • *Keep a spill kit on site to deal with any hydrocarbon leaks.* • *Remove soil from the site which has been contaminated by hydrocarbon spillage.* • *Undertake surface water monitoring to enable change detection related to contaminants originating from the site.*	
Environmental Risk (Post-mitigation)	-6.5
Degree of confidence in impact prediction:	Medium
Impact Prioritisation	
Cumulative Impacts	2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.	
Degree of potential irreplaceable loss of resources	1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.	
Prioritisation Factor	1.125
Final Significance	-7.31

TABLE 7-11: POLLUTANTS ENTERING THE SURFACE WATER ENVIRONMENT (OPERATIONAL PHASE)

Impact Name	**Pollutants Entering the Surface Water Environment**				
Phase	Operational				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature	-1	-1	Magnitude	5	5
Extent	4	4	Reversibility	3	3
Duration	4	4	Probability	5	2
Environmental Risk (Pre-mitigation)					-20
Mitigation Measures					
• *Implement a storm water management plan inclusive of containment of dirty water areas.* • *Ensure the tailings facility and return water dam have adequate capacity to contain both operational water and the relevant design storm (e.g. probable maximum precipitation) and that all are adequately engineered to prevent failure (e.g. of embankments or side slopes).* • *Keep tailings pipelines (and any other pipelines with possible contaminants) within the managed dirty water footprint where possible.* • *Keep tailings pipelines (and any other pipelines with possible contaminants) well maintained to prevent leakage.* • *Store hydrocarbons off site where possible, or otherwise implement hydrocarbon storage.* • *Handle hydrocarbons carefully to limit spillage.* • *Ensure vehicles are regularly serviced so that hydrocarbon leaks are limited.* • *Designate a single location for refuelling and maintenance where possible.* • *Keep a spill kit on site to deal with any hydrocarbon leaks.* • *Remove soil from the site which has been contaminated by hydrocarbon spillage.* • *Undertake surface water monitoring to enable change detection related to contaminants originating from the site.*					
Environmental Risk (Post-mitigation)					-8
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Cumulative Impacts					2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.					
Degree of potential irreplaceable loss of resources					2
Medium: Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.25
Final Significance					-10

TABLE 7-12: POLLUTANTS ENTERING THE SURFACE WATER ENVIRONMENT (REHAB AND CLOSURE PHASE)

Impact Name	Pollutants Entering the Surface Water Environment				
Phase	Rehab and Closure				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature	-1	-1	Magnitude	3	3
Extent	4	4	Reversibility	2	2
Duration	4	4	Probability	4	2
Environmental Risk (Pre-mitigation)					-13
Mitigation Measures					
• *Implement a storm water management plan inclusive of containment of dirty water areas.* • *Ensure the tailings facility and return water dam have adequate capacity to contain both operational water and the relevant design storm (e.g. probable maximum precipitation) and that all are adequately engineered to prevent failure (e.g. of embankments or side slopes).* • *Keep tailings pipelines (and any other pipelines with possible contaminants) within the managed dirty water footprint where possible.* • *Keep tailings pipelines (and any other pipelines with possible contaminants) well maintained to prevent leakage.* • *Store hydrocarbons off site where possible, or otherwise implement hydrocarbon storage.* • *Handle hydrocarbons carefully to limit spillage.* • *Ensure vehicles are regularly serviced so that hydrocarbon leaks are limited.* • *Designate a single location for refuelling and maintenance where possible.* • *Keep a spill kit on site to deal with any hydrocarbon leaks.* • *Remove soil from the site which has been contaminated by hydrocarbon spillage.* • *Undertake surface water monitoring to enable change detection related to contaminants originating from the site.*					
Environmental Risk (Post-mitigation)					-6.5
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Cumulative Impacts					2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.					
Degree of potential irreplaceable loss of resources					1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.125
Final Significance					-7.31

7.3.3 DECREASE IN RUNOFF

An increase in runoff could be expected due to the proposed construction of infrastructure which will increase impermeable hardstanding and compaction from the movement of machinery and use of laydown areas. The necessary introduction of a storm water management plan will, however, result in the containment of much of the aforementioned area, thereby effectively decreasing runoff from the site.

The increased development of the opencast pits will serve to likewise reduce surface water contributions.

A decrease in runoff is a typical impact associated with the containment of dirty areas on mines and the mitigation of this impact is often not practical or possible with a reduction in mean annual runoff as an expected outcome.

Important. This section only considers the surface water impact from the proposed surface activities. It is expected that the groundwater specialist assess the potential impacts of the dewatering of proposed works.

TABLE 7-13: DECREASE IN RUNOFF AND/OR STREAMFLOW (CONSTRUCTION, OPERATIONAL AND DECOMMISSIONING PHASE)

Impact Name	Decrease in Runoff and/or Streamflow				
Phase	Construction, Operational and Decommissioning				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature	-1	-1	Magnitude	2	2
Extent	4	3	Reversibility	4	4
Duration	4	4	Probability	5	5
Environmental Risk (Pre-mitigation)					-17.5
Mitigation Measures					
• *Keeping the contained dirty area to a minimum thereby limiting this impact.* • *Discharge excess water of an acceptable quality back into the surface water environment (river).*					
Environmental Risk (Post-mitigation)					-16.25
Degree of confidence in impact prediction:					Low
Impact Prioritisation					
Cumulative Impacts					2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.					
Degree of potential irreplaceable loss of resources					1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.125
Final Significance					-18.28

TABLE 7-14: DECREASE IN RUNOFF AND/OR STREAMFLOW (REHAB PHASE)

Impact Name	Decrease in Runoff and/or Streamflow				
Phase	Rehab and Closure				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature	-1	-1	Magnitude	1	1
Extent	3	3	Reversibility	4	4
Duration	4	4	Probability	5	5
Environmental Risk (Pre-mitigation)					-15
Mitigation Measures					
• *Keeping the contained dirty area to a minimum thereby limiting this impact.* • *Discharge excess water of an acceptable quality back into the surface water environment (river).*					
Environmental Risk (Post-mitigation)					-15
Degree of confidence in impact prediction:					Low
Impact Prioritisation					
Cumulative Impacts					2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.					
Degree of potential irreplaceable loss of resources					1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.125
Final Significance					-16.88

7.3.4 FLOOD RISK (RIVER)

Flood risk is an impact on the proposed Kalgold Expansion Project and not the environment as with the other impacts identified in this report. This risk is expected to be present during the construction, operational, decommissioning and rehab/closure phases due to the existence of infrastructure/works that could be flooded and the presence of personnel who might be caught in floodwaters.

Some proposed infrastructure (tailings & return water pipeline and power lines) crosses the Morokwa River and have a certain flood risk (based on intersection with a watercourse). This infrastructure, however, likely has a low flood vulnerability thereby limiting the potential impact of flooding. Other infrastructure (e.g. waste rock dumps) located near a watercourse (specifically the Morokwa River) may have a flood risk. Previous flood modelling has been undertaken by SRK and referred to in Section 2.6.1. The summary outlined in this section (2.6.1), motivates revision to the flood-lines for the mine, including the consideration of flood events beyond the 1:100 year RI.

No flood modelling was undertaken as part of this study. The potential impact from flooding cannot be fully defined in this report due to both the uncertainty as to the current accuracy of the SRK flood-lines as well as how infrastructure will be constructed (that intersects the defined flood-zone (e.g. would pipelines be placed above the maximum flood level).

Important. It should, however, be noted that the potentially severe impact of flood risk is not adequately conveyed by the impact table below since the probability of extreme flooding is low, resulting in the impact appearing less significant than may be warranted.

TABLE 7-15: RIVER AND SURFACE WATER FLOOD RISK (ALL PHASES)

Impact Name	**Flood Risk (River and Surface Water)**				
Phase	Construction, Operational, Decommissioning, Rehab and Closure				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature	-1	-1	Magnitude	5	5
Extent	2	2	Reversibility	3	3
Duration	1	1	Probability	2	1
Environmental Risk (Pre-mitigation)					-5.5
Mitigation Measures					
• *Works should ideally not take place, nor infrastructure placed within 100m of the river or within the 1:100 year flood-line so as to limit the applicability of Section 21 water uses and GN 704 Condition 4.* • *The defined 1:100 year flood-line should be defined for infrastructure or works near a watercourse, while the expansion of excavated areas (i.e. pits) should be assessed with regards to the potential that flood waters could enter them.* • *Flood protection in the form of berms or increased flood conveyance (through river engineering) may be necessary where a flood risk exists.* • *If determined to be relevant to the proposed expansion, flood modelling should be undertaken to define the flood risk and consequently the expected impact (previous flood modelling has been undertaken although the accuracy of this flood modelling is not known).* • *D-Zone Pit is adjacent a river diversion and flood protection and adequate conveyance of flood waters should be confirmed given the potential for a breach of flood waters into D-Zone Pit.*					
Environmental Risk (Post-mitigation)					-2.75
Degree of confidence in impact prediction:					Low
Impact Prioritisation					
Cumulative Impacts					2
Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change. The current Kalgold operation means that the proposed expansion will enhance existing impacts.					
Degree of potential irreplaceable loss of resources					1
Low: Where the impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.125
Final Significance					-3.09

7.4 ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

Flooding is potentially the impact with the greatest significance (whether indicated by an impact table or not). This risk needs to be clearly understood, particularly with regards to D-Zone Pit, waste rock dumps and associated storm water management adjacent to the Morokwa River.

The impact assessment undertaken within this study is based on a desktop assessment.

8 SURFACE WATER MONITORING

When considering sampling locations, Figure 8-1 identifies two sampling locations along the Morokwa river. One upstream of the mine and the other downstream of the mine. The Morokwa River is the only watercourse where monitoring may be possible. Other non-perennial rivers intersecting the site are unlikely to yield sufficient streamflow to allow for repeat sampling.

Sampling locations within the site boundary and as close as possible to the area of works are preferential due to the potential for dilution the further away a sample point is located and the possibility of other land uses (e.g. farming) limiting the potential for change detection resulting from the water quality changes at the site alone.

8.1 MONITORING PROGRAMME

The monitoring programme for the site should consequently focus on the two sampling locations identified in Figure 8-1.

Sampling should take place every quarter although the frequency of monitoring should also be agreed with the DWS. Any waters that will be discharged into the natural environment must be tested and comply with the relevant water quality limits. If necessary, the water will be treated before discharge. This is specifically applicable to the PCD's which may fill over time, necessitating the removal of water.

Parameters that need to be monitored should include (but are not limited) to those in Table 6-1. This table can be refined through the focus on contaminants of concern if known or as they become identified over time (i.e. if a potential contaminant is shown to be constantly below effluent limits, then its monitoring can be reduced/excluded in favour of more relevant contaminants).

TABLE 8-1: MONITORING PARAMETERS

Infield measurements		
pH	Electrical conductivity	Total dissolved solids
Laboratory analysis		
pH	Ammonium	Copper
Electrical conductivity	Alkalinity as $CaCO_3$	Mercury
Boron	Sulphate	Chloride
Selenium	Cobalt	Fluoride
Arsenic	Phosphate	Magnesium
Nitrate	Total dissolved solids (TDS)	Zinc
Bicarbonate	Cadmium	Potassium
Sodium	Calcium	Barium
Chrome	Chrome VI	Iron
Aluminum	Lead	Manganese

Bi-annual monitoring reports should, as a minimum, include the following:

- Comparison of water samples to differentiate seasonal variations and general trends due to the historic mining activities;

- Comparison of water samples to standards and guidelines set by the Department of Water and Sanitation (DWS); and
- Analysis of parameters over time so that trends can be established.

Applicable effluent standards are provided in the '*Revision of General Authorisations in Terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998)'* published under Government Notice 665 in Government Gazette 36820, dated 6 September 2013, while the Water Research Commission (WRC) provides gold mine specific guidance[6].

[6] *A Manual to Assess and Manage the Impact of Gold Mining Operations on the Surface Water Environment* by W. Pulles, R. Heath and M. Howard, Water Research Commission Report No. TT 79/96.

Legend

- Expansion Affected Properties
- Proposed Sampling Location
- New Explosives Magazine
- New TMM Workshop
- Existing Central Dam
- Exisiting Local Roads
- A Zone Pit Dewatering
- Emergancy Dam Return Water
- Explosive Magazine Clearance Radius
- Haul Road to new ROM
- New Plant Road
- New Powerline Route
- New Road to Old Plant
- New Road to Windmill Zone Pit
- New Road to WRT Ext
- Tailings to Tailings Dam
- Treated Water Discharge Pipeline
- TSF to D Zone
- Water from D Zone to Return Water Dam
- New ROM Pad
- Water from Return Water Dam to New Processing Plant
- Water Pipeline
- Watertank Pit Dewatering
- New Processing Plant
- Increased Pit Footprint
- Existing TSF
- New Spanover WRD Ext
- Furrow (50K Topo)
- Non-Perennial River Centre line
- Dam (50K Topo)
- Non-Perennial pan (50K Topo)
- Open Reservoir (50K Topo)
- Perennial Pan (50K Topo)

Figure 8-1

Proposed Sampling Location

Hydrologic Consulting (Pty) Ltd
Consulting Hydrologists
HYDRO LOGIC
+27 72 239 0974
info@hydrologic.za.com
www.hydrologic.za.com

0 — 1,000 Meters

Scale: 1:28,600 @ A3	Projection: Transverse Mercator Datum: Hartebeeshoek, LO27	November 2021

9 CONCLUSION AND RECOMMENDATIONS

Baseline information including rainfall, evaporation, design event rainfall, soils, vegetation and land-cover, as well as site terrain, flooding and regional and local catchment hydrology have been considered for the proposed Kalgold Mine expansion.

Site Sensitivities

Figure 3-1 presents the results of the identified site sensitivities as they relate to the surface water environment. This figure illustrates that the proposed expansion infrastructure falling within an identified area of sensitivity includes:

- Tailings and return water pipeline corridor;
- Powerlines;
- Water pipeline; and
- D-Zone Pit.

Existing infrastructure (e.g. waste rock dumps) and proposed storm water management (necessary to manage dirty water areas) are also within sensitive areas.

Government Notice (GN) 704

The Department of Water Affairs and Forestry (now the Department of Water and Sanitation), established GN 704 (as of June 1999) to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. GN 704 includes various conditions which inform the deliverables contained in this report. Of particular relevance is the definition of a dirty area (given the associated implications regarding the management of dirty areas per GN 704), with a dirty area defined as "any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource".

Storm Water Management Plan

The operation (both historical mining and proposed expansion) has/will alter the natural environmental state, thereby affecting the generation of storm water. Volumes of storm water generated over disturbed areas will likely increase because of the reduction in natural vegetation, while the quality of the storm water generated is expected to decrease due to the nature of the operation. A conceptual level SWMP by which clean and dirty water generating areas are firstly identified and then managed appropriately according to GN 704 requirements has subsequently been developed.

An SWMP that includes both the diversion and storage of runoff falling over dirty water areas has not been implemented for the majority of the site. Areas requiring pollution control (i.e. dirty areas) were consequently delineated based upon the site layout provided (for the expansion) while aerial imagery provided the current status of the site (with regards to areas of works and location of waste rock dumps for example). These dirty areas route to one of six proposed PCDs.

The four pits on the mine (including the future windmill zone pit) have the potential to receive inflows from dirty water areas. The use of pits for the formal storage of dirty storm water (from upslope and not only from rainfall falling over the pit) raises the question of GN 704 compliance – Condition 7(c) in particular. This condition outlines that every person in control of a mine or activity must take reasonable measures to cause effective to "*minimise the flow of any surface water or floodwater into mine workings, opencast workings…"*. The containment of dirty water in pits has consequently been limited to that generated from rainfall falling over the pit and that generated from peripheral waste rock dumps (where these dumps are immediately adjacent to the pit).

The existing plant and TSF are likewise not considered in this SWMP as the plant may be decommissioned and already has storm water management in place, while the management of the TSF's storm water would require a more detailed investigation that considers the rate of deposition of tailings and overflows to the return water dam (which would need to be adequately sized). Return water from the TSF may also be routed to the D-Zone Pit. It is consequently the recommendation that the TSF's storm water performance be reviewed once the operation of the mine (including the expansion) has been finalised.

The explosives magazine is not included in the management of storm water as this will be a covered area such that containment of dirty storm water is unnecessary.

Overall, this SWMP aims to minimise the final dirty area to limit the unnecessary containment of clean areas. This benefits the operation in reducing the size of the dirty water diversion and the volume of dirty water requiring containment, as well as reducing the impact on the receiving water environment due to the reduction in natural runoff.

Water Balance

A static water balance model has been developed for the mine and considers the proposed expansion's use of water on an average wet and dry monthly basis.

The foundation of the water balance was derived from the September 2021 water balance of the mine. This water balance (provided by the mine) outlines the monthly reticulation of water on the mine from January 2021 to July 2021 (7 months of data). The future water use by the mine has largely been informed by the associated water balance developed by MvB Consulting (2021), which includes an estimated long-term water balance for the years 2021 to 2034.

Various assumptions were necessary for the water balance, with these assumptions largely being due to the uncertainty of the future operation (i.e. projections were made based upon existing and may not be representative of the future). The performance of six proposed PCDs is also uncertain given the level of assessment.

Identified Impacts

Eroded soils have the potential to cause sedimentation of downstream watercourses. Disturbed areas should consequently be stabilised with erosion control methods used where stabilisation is not possible. A rehabilitation plan for the site should be developed inclusive of topsoil replacement where possible. A re-vegetation strategy including maintenance/aftercare should likewise be developed for disturbed areas.

Operation of earthmoving machinery or maintenance vehicles on-site during construction, operation, decommissioning and rehab/closure (including the possible storage or handling of hydrocarbons) poses a potential source of hydrocarbon contamination with regards to the surface water environment. An emergency response plan for unforeseen hydrocarbon spills should be developed while the existing surface water monitoring should be reviewed to ensure adequate coverage of the proposed expansion. A storm water management plan is a necessary part of the development of the expansion (as per GN 704) and will form an integral mitigation measure concerning the management of dirty areas.

An increase in runoff could be expected due to the proposed construction of infrastructure which will increase impermeable hardstanding and compaction from the movement of machinery and use of laydown areas. The necessary introduction of a storm water management plan will, however, result in the containment of much of the aforementioned area, thereby effectively decreasing runoff from the site. A decrease in runoff is a typical impact associated with the containment of dirty areas on mines and the mitigation of this impact is often not practical or possible with a reduction in mean annual runoff as an expected outcome.

Flood risk is an impact on the proposed Kalgold Expansion Project and not the environment as with the other impacts identified in this report. This risk is expected to be present during the construction, operational and decommissioning and rehab/closure phases due to the existence of infrastructure/works that could be flooded and the presence of personnel who might be caught in floodwaters. Some infrastructure (roads and power lines) are proposed over the Morokwa River and have a certain flood risk (based on intersection with a watercourse). Other infrastructure located near a watercourse (specifically the Morokwa River) may have a flood risk. Previous flood modelling has been undertaken by SRK and referred to in Section 2.6.1. The summary outlined in this section (2.6.1), motivates revision to the flood-lines for the mine, including the consideration of flood events beyond the 1:100 year RI.

Flooding is potentially the impact with the greatest significance (whether indicated by an impact table or not). This risk needs to be clearly understood, particularly with regards to D-Zone Pit, waste rock dumps and associated storm water management adjacent to the Morokwa River.

The impact assessment undertaken within this study is based on a desktop assessment.

Mark Bollaert

(MSc, PrSciNat , CSci, CEnv, C.WEM)

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10 REFERENCES

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APPENDIX A: STORM WATER CALCULATIONS

A.1 MODEL CHOICE

PCSWMM is a model package that makes use of the USEPA Storm Water Management Model (SWMM), which is a computer program that computes dynamic rainfall-runoff from developed urban and undeveloped or rural areas (Rossman, 2008).

The SWMM model suits application to this project since it can account for:

- Time-varying rainfall;
- Rainfall interception in depression storage;
- Infiltration of rainfall into unsaturated soil layers;
- Evaporation of standing surface water;
- Routing of overland flow; and
- Capture and retention of rainfall/runoff.

The development of SWMP's using SWMM have been undertaken for many thousands of studies throughout the world including (Rossman, 2008) South Africa.

A.2 DESIGN HYDROGRAPHS

A.2.1 DESIGN STORM

In assessing the storm water management, it was necessary to define the associated rainfall that would cause this flooding. A hypothetical storm consequently needed to be developed which utilised the depth-duration-frequency (DDF) data provided by DRESSA (see Section 2.2). This hypothetical storm is the design rainfall that will produce the highest peak flow at each location independent of catchment response time (which is the index of the rate at which stormflow moves through a catchment). To calculate the hypothetical storm, the DRESSA 1:50 year RI rainfall depth for various durations (e.g. 5 minutes, 30 minutes and 2 hours) was transformed into a synthetic rainfall distribution or design hyetograph.

A.2.2 MODEL PARAMETERISATION

The 1m DSM was used to separate dirty and clean areas (draining by gravity). Land cover parameters were estimated according to the surface infrastructure layout, 2018 DEA land-cover dataset and soil types (as per Section 2.7).

A.2.2 MODEL RUN

Dynamic wave routing was set for the model run along with a variable time step. The resulting runoff continuity and routing continuity error was 0% which is optimum. The resulting peak flows and characteristics for the dirty and clean areas are presented in Table A-1 which does not include run-on from upstream catchments.

TABLE A-1: CLEAN AND DIRTY AREA CHARACTERISTICS FOR THE 1:50 YEAR EVENT

Name	Area (ha)	Precipitation (mm)	Infiltration (mm)	Runoff Coefficient	Runoff Volume (ML)	Peak Runoff (m³/s)
C1	251.0	124.5	74.7	0.37	116.1	6.4
C2	6.3	124.5	74.7	0.39	3.1	0.9
C3	109.6	124.5	74.4	0.38	52.2	5.0
C4	285.5	124.5	72.6	0.39	139.4	10.3
C5	649.4	124.5	64.8	0.43	344.1	11.3
C6	100.6	124.5	74.7	0.38	47.1	3.3
C7	161.6	124.5	72.7	0.50	124.1	5.9
C8	5.4	124.5	73.6	0.40	2.7	0.9
C9	108.9	124.5	58.4	0.51	70.1	5.9
C10	46.0	124.5	74.2	0.38	21.7	1.5
C11	29.7	124.5	46.3	0.59	21.9	2.6
C12	61.1	124.5	59.1	0.90	378.4	11.1
C13	23.6	124.5	74.7	0.38	11.1	0.8
C14	156.2	124.5	74.4	0.42	85.5	8.9
C15	65.9	124.5	67.1	0.44	35.7	3.6
C16	5.9	124.5	74.2	0.39	2.9	0.4
C17	186.1	124.5	72.2	0.41	95.1	8.4
C18	11.2	124.5	46.4	0.60	8.3	2.1
D1	13.5	124.5	20.9	0.82	13.8	4.8
D2	77.3	124.5	55.6	0.53	51.4	14.0
D3	88.4	124.5	60.8	0.48	53.1	15.2
D4	85.0	124.5	52.3	0.55	58.7	15.8
D5	2.0	124.5	44.9	0.61	1.5	0.7
D6	60.9	124.5	63.9	0.47	35.4	9.3
D7	35.9	124.5	68.9	0.43	19.1	3.7
D8	18.0	124.5	58.5	0.51	11.4	4.1
D9	45.1	124.5	54.7	0.52	29.4	6.5
D10	4.6	124.5	57.5	0.52	3.0	1.6
D11	14.6	124.5	57.7	0.52	9.4	4.2
D12	1.1	124.5	57.0	0.52	0.7	0.4
D13	7.1	124.5	54.0	0.54	4.8	1.8
D14	60.4	124.5	52.2	0.53	40.1	16.5
D15	11.6	124.5	56.4	0.50	7.3	3.3
D16	30.0	124.5	56.1	0.53	19.8	7.8
D17	6.5	124.5	56.5	0.53	4.3	2.0
P1	68.2	124.5	20.3	0.83	74.3	33.4
P2	149.8	124.5	14.5	0.87	161.9	63.2
P3	15.3	124.5	17.2	0.85	16.2	6.9
P4	5.7	124.5	43.3	0.64	4.5	2.2