CONCEPT STORMWATER MANAGEMENT PLAN

UMK Mine

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
BPG	Best Practice Guidelines
CN	Curve Number
DDF	Depth Duration Frequency
DWS	Department of Water and Sanitation
DRU	Daily Rainfall Utility Program
GN634	Government Notice 634
GN 704	Government Notice 704
PCD	Pollution Control Dam
SANRAL	South African National Road Agency
SAWS	South African Weather Service
SCS	Soil Conservation Service
SWD	Stormwater Dam
WRC	Water Research Commission
WRD	Waste Rock Dump

Concept Stormwater Management Plan

1. INTRODUCTION

1.1 BACKGROUND

SLR Consulting (Africa) (Pty) Ltd (SLR), an independent firm of environmental consultants, has been appointed by United Manganese of Kalahari (Pty) Ltd (UMK) to update the Stormwater Management Plan (SWMP) for the UMK Closure Amendment Project.

This study is based on Phase 1 of the project: to develop a conceptual stormwater management plan scheduled to be implemented concurrently with expansion works and when complete will ensure compliance with GN704. Subsequent phases of the project will involve development of detailed engineering designs and construction / implementation.

The project area is located at United Manganese of Kalahari, which is situated approximately 13 km south of the town of Hotazel in the Northern Cape, South Africa. The site locality map is shown in Figure 1-1.

1.2 SCOPE OF WORK

The primary objective of the study is to develop a concept SWMP, and the following studies have been completed to support the scope of work:

- A review of the baseline hydrology of the site and surroundings.
- Delineation of clean water and dirty water catchments based on site operations to ensure compliance with the applicable regulations.
- Recommendations on infrastructure and practices that will further aid to achieve compliance with the applicable regulations.

Costing for the conceptual stormwater management is not covered under this scope of work. The high-level concepts proposed in this report will require refinement under the preliminary and detailed design phases.

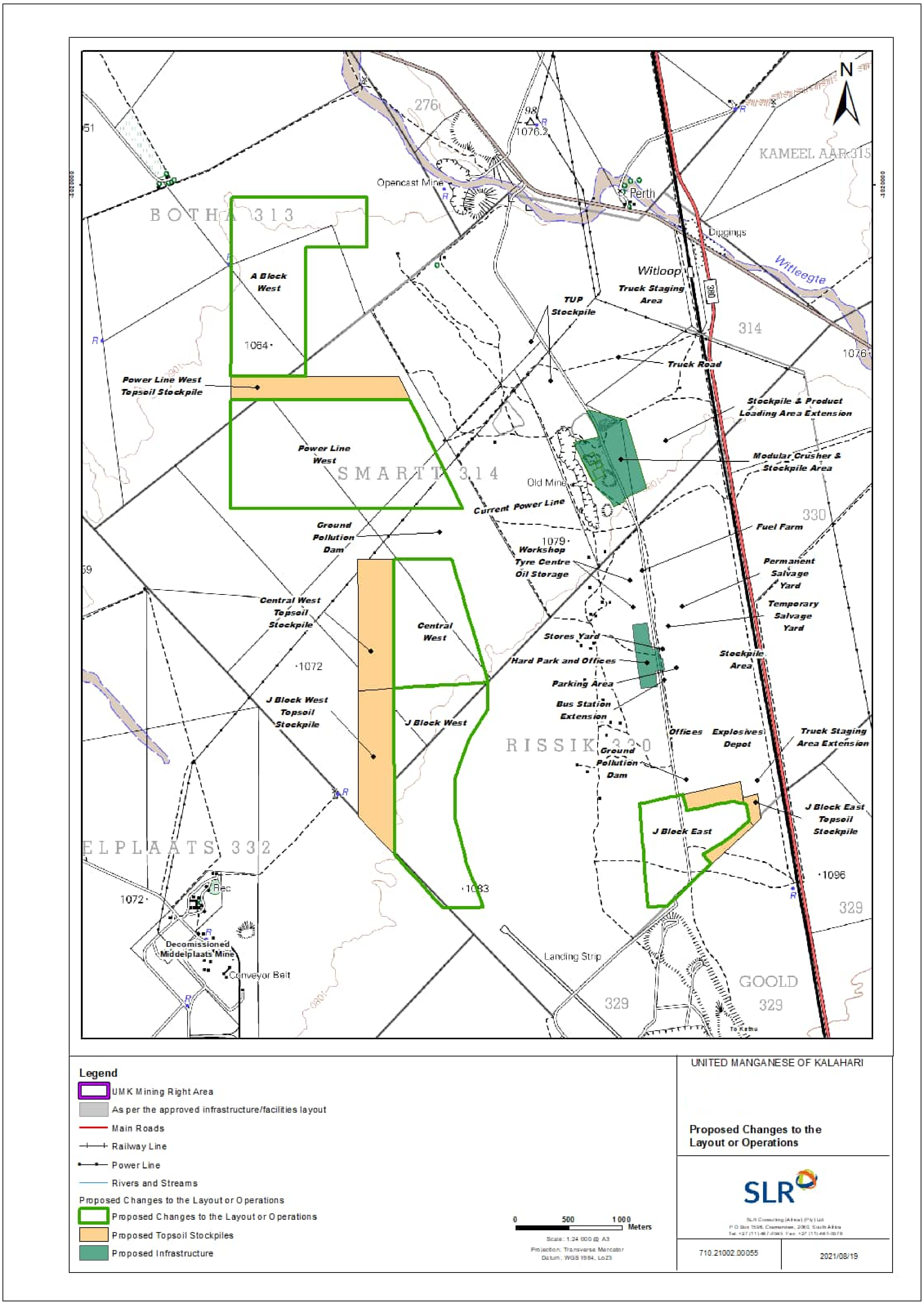

Figure 1-1: Site Layout Map

2. APPLICABLE REGULATIONS AND GUIDELINES

National Water Act (Act No. 36 of 1998), Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN 704), was established to provide regulations for the use of water for mining and related activities aimed at the protection of water resources. Regulations 5, 6, and 7 of the GN 704 are applicable in this study and are summarised below:

- Regulation 5 which restricts the use of residue or substance which causes or is likely to cause pollution of a water resource from use in the construction of any dams, impoundments or embankments or any other infrastructure.
- Regulation 6 which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained, and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water dams should have a minimum freeboard of 0.8m above full supply level; and
- Regulation 7 which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion etc.) and ensure that water used in any process is recycled as far as practicable.

Further requirements are outlined in the Department of Water and Sanitation (DWS) 'Best Practice Guidelines (BPGs) for Water Resource protection in the South African Mining Industry' as highlighted below:

- BPG A4 Pollution Control Dams, Section 6.4.3. In this document it defines the allowable RWD (Return Water Dam) or PCD (Pollution Control Dam) spillage frequency as being a spill every 50 years on average. This is equivalent to stating that a RWD or PCD should be designed with an annual spillage probability of 1:50 (2%) or less. In addition to this, BPG A4 recommends the design is informed by application of a continuous water balance model run at an appropriate time step (preferably daily), where:
  - "The definition of an event is defined as a sequence of spill days occurring during a 30-day window."
  - "The spillage frequency depends on the size of the dam (capacity) and the abstraction and re-use rate."
  - "Confirmation of the dam sizing (based on spillage frequency), by means of continuous modelling."
  - "It is important to consider the loss of storage due to sediment build up in the PCD when sizing the dam."
  - "The PCD water balance will be used to specify a minimum storage level. This ensures that adequate freeboard is maintained so that the stormwater inflow can be accommodated, and the spillage frequency met. The management of the PCD should be according to this minimum level. The dam volume should be reduced to this minimum level as soon as possible after storm events."

  - "It is important to consider that, in general, it is not the single events that result in spillage, rather prolonged wet conditions."

- BPG G1 Stormwater Management, Section 4.2 which defines a methodology of planning, designing and implementing stormwater management measures to ensure separation of clean and dirty water and guidelines to ensure sustainability over the mine's life cycle. It also offers guidelines for the following:
  - Classification of clean and dirty areas.
  - Conceptual designs and review where at this stage, "The designer has to balance the need to obtain preliminary sizes so that water conveyance systems and retention structures can be provisionally sized, without undertaking a detailed design that may have to be discarded due to inadequacies in the stormwater management plan, or changes in the conceptual design."
  - Assess the Suitability of the Existing Infrastructure and define infrastructures changes required.
  - Design of required infrastructure informed by all prior steps.

3. PROJECT SITE AND EXISTING INFRASTRUCTURE

3.1 EXISTING INFRASTRUCTURE

The existing infrastructure is shown in Figure 3-1 and includes the following:

- Plant Area and Crusher Area with associated stormwater infrastructure including several existing PCDs
- Open Pit Area
- ROM Stockpiles
- WRDs around the mining complex
- Topsoil Stockpiles around the mining complex
- Railway Loop

This SWMP study is, however, limited to the following (refer to Figure 3-2):

- Expansion of the mining pit
- Waste rock dumps and topsoil stockpiles
- Offices and parking area
- Temporary and permanent salvage yards
- Explosive's depot
- Workshop

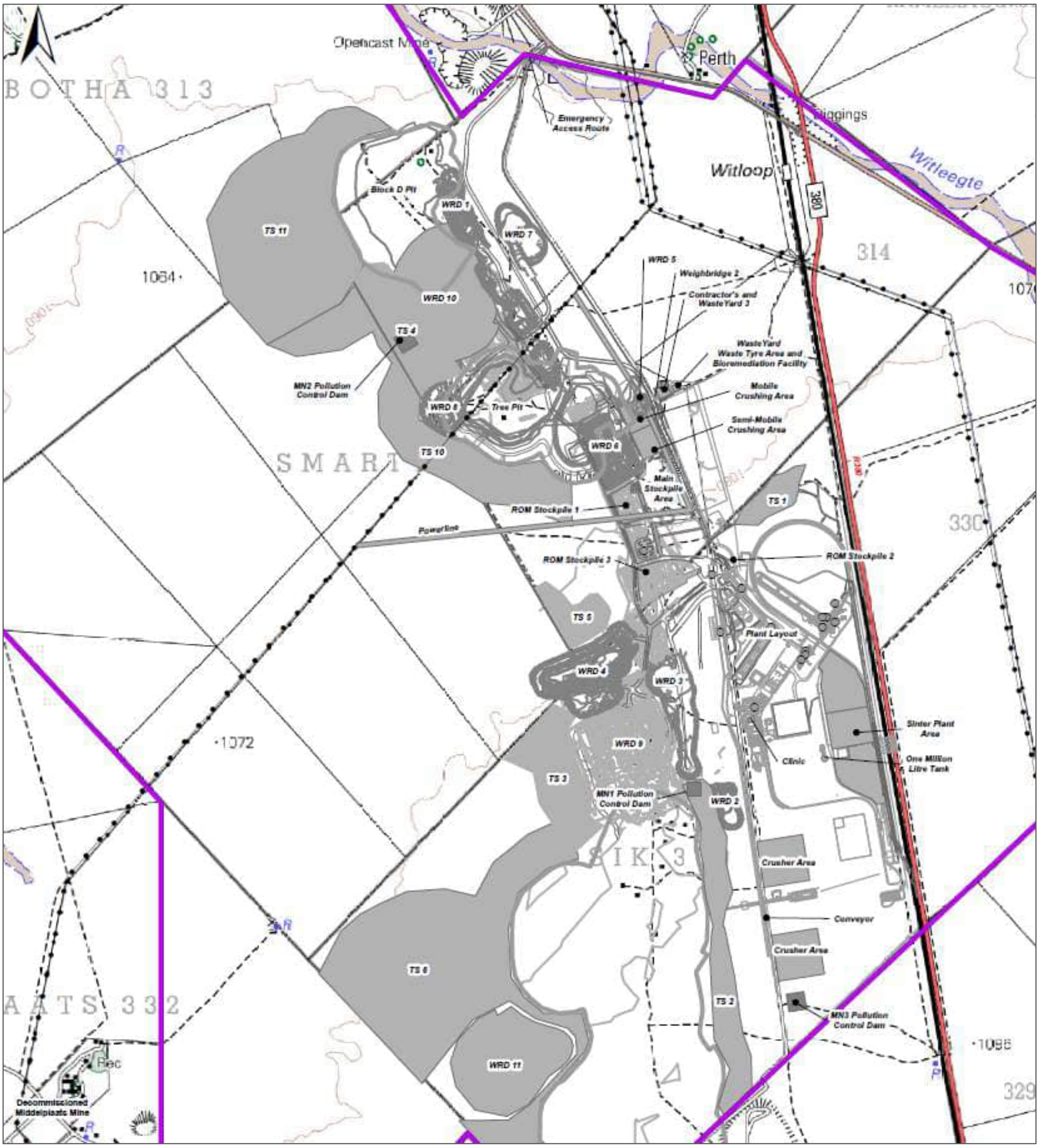

Figure 3-1: Existing Infrastructure at the UMK Mining Operation

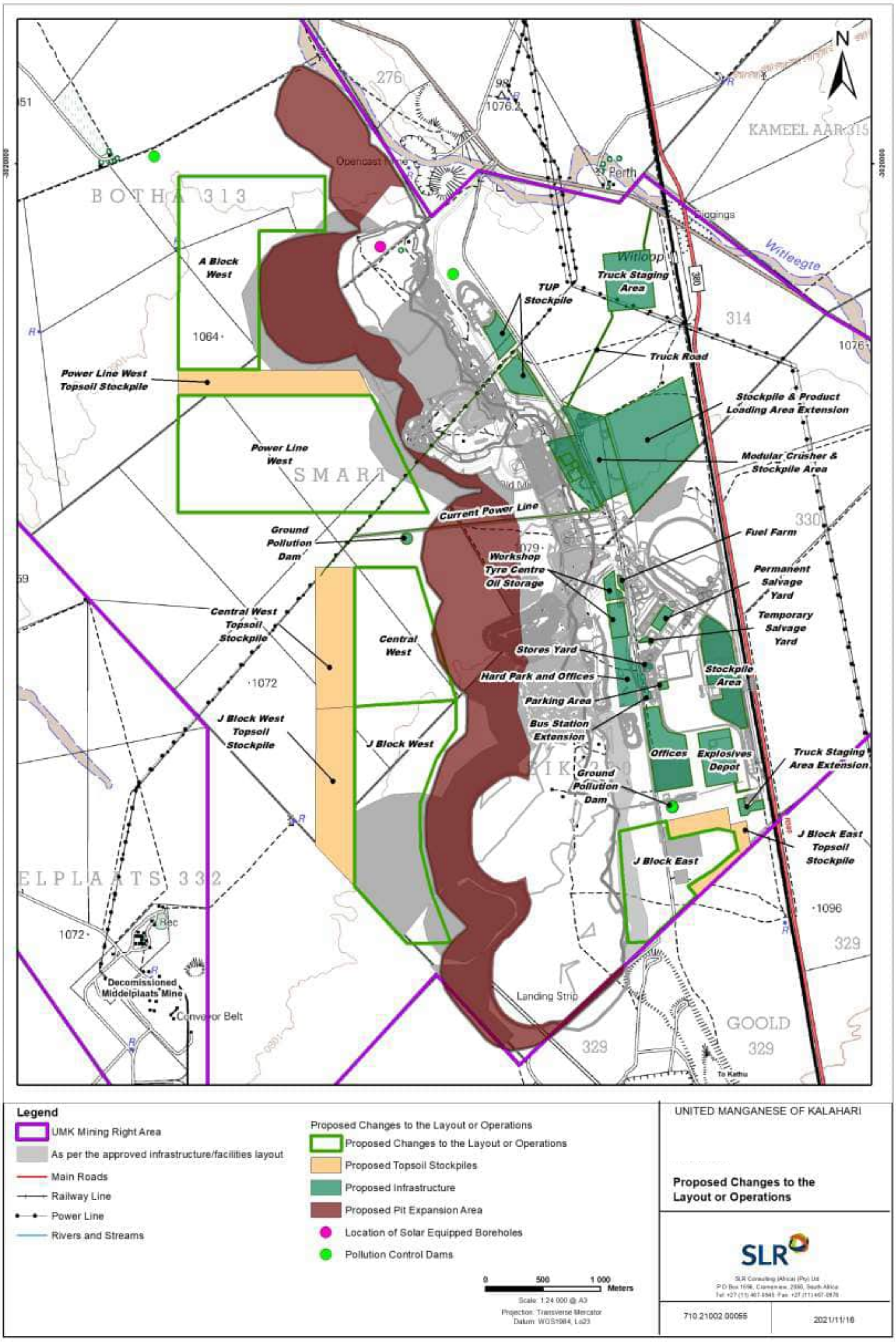

Figure 3-2: Proposed Infrastructure at the UMK Mining Operation

4. GENERAL CONCEPT FOR THE STORMWATER MANAGEMENT

A waste classification and risk assessment review were conducted in January 2022 (UMS 2022). The concept of the proposed SWMP is based primarily on the findings of the study, which are summarised as follows:

- 14 samples (representative of potential waste rock lithology) were assessed and classified as **Non-Potentially Acid Generating.**
- The Kalahari sand and WRD samples were assessed and classified as **non-hazardous**.
- The Kalahari sand and WRD samples were assessed to be Type 3 wastes because barium (Ba), fluoride (F) and manganese (Mn) exceed total concentration threshold 0 (TCT0) with regards to their total concentration ("TC") and Type 4 wastes based on their leachable concentration ("LC").
- The LC results indicate that none of the leachable concentrations in the Kalahari sand and WRD samples exceeded the LCT0 limit. These samples thus do not satisfy the complete criteria for a Type 3 waste (LCT0<LC≤LCT1 and TC≤TCT1) or the complete criteria for Type 4 waste (LC≤LCT0 and TC≤TCT0).
- The Kalahari sand does not require classification or assessment and the inclusion of this material in the classification and assessment procedure was for comparison purposes (SLR 2017).

Based on these finding a Class D Barrier was recommended, which requires 150mm base preparation. This recommendation was also made in 2017 (SLR 2017).

Based on the findings and the current accepted practices on site, a legal opinion (WW 2022) was obtained to determine if storage of dirty water from the WRDs was necessary. A summary of the findings follows:

- The runoff from the existing WRD's at the Mine is currently managed in accordance with GN 704 using berms constructed along the outer edge of the WRDs to catch rolling material and contain overflow of water from WRDs.
- The existing PCDs at the Mine are located close to the product stockpile areas and are used to capture stormwater overflowing from these areas only.
- UMK has confirmed that DWS has not raised any concerns in respect of the Mine's current water management strategy.
- The findings of the Waste Assessment Report conclude that the material samples from the WRDs at the Mine are classified as non-hazardous and do not consist of acid forming material. Therefore, based on these findings, the runoff from the WRDs (and the New WRD – which consists of similar material) constitutes 'clean water', which does not require containment and management in a PCD.

Based on these findings, the concept for the management of stormwater from the WRDs is to collect dirty water runoff through the use of lined berms/paddocks as is the current approved practise at the Mine.

Clean water has been modelled as surface flow across the clean catchments. The recommendation is for the clean water to be collected and stored in paddocks/channels and allowed to evaporate or depending on the topography, diverted using berms into the natural environment. Earthen cut off channels or berms are proposed for construction around the perimeter of the mine site to direct clean runoff away from the site.

Conveyance infrastructure and berms will be positioned adjacent to roads, where possible, to minimise runoff across roads and to maximise the runoff contained from the adjacent catchments.

Surface conveyance infrastructure (i.e., open channels, paddocks), rather than below surface components (i.e., culverts and catchpits) have been incorporated into the concept SWMP as these are often preferred for ease of maintenance as well as minimising depth of excavation and the related cost implications.

5. SITE CHARACTERISTICS

In order to inform the design of stormwater management measures, an understanding of site-specific climatic conditions and topography is required. This section presents a comprehensive review of relevant sources of information sources, as discussed below.

5.1 RAINFALL

Modelling of the stormwater inflows has been undertaken using daily rainfall from the South African Weather Service gauge, station 0393083_W (Milner), and a summary of the data is presented in Table 5-1. Rainfall data for the gauge was extracted using the Daily Rainfall Utility Program (DRU) - Institute for Commercial Forestry Research (ICFR). The programme uses a database of observed and patched daily rainfall data developed under the Water Resources Commission (WRC) project (K5/1156). The monthly averages for the record are presented in Table 5-2. The Milner rainfall record was chosen due to the long rainfall record (shown in the below Table), has a reliable rainfall record (55.9 %), low ratio of patched (32.3 %) and missing data (11.7 %) as well as the proximal location to the site (shown in the below Table). The station also has a higher rainfall amount, within the record, than the 1:50 year return period rainfall amount (143.4 mm).

The mean annual precipitation (MAP) from the observed records (unpatched) is 369 mm and was checked against the average MAP (334 mm) derived for the project site (27°23´S;22°59´E) as per Design Rainfall Estimation of South Africa database. The MAP defined by WR 2012 is shown to be 344 mm.

Table 5-1: Rain gauge 0393083_W (Milner) – Summary of Daily Rainfall Record

Parameter	Value
Latitude	-27.22
Longitude	23.02
Record start (year)	1887
Record end date (DRU record limit) (year)	2000
Years of usable rainfall record	March 1932 to June 2019 (~88 years)
Additional rainfall data sourced	Sept 2000 – June 2019
Distance to site and direction (km)	7 km S
MAP (mm)	369
Max recorded daily rainfall (mm)	161.5
Altitude metres above mean sea level (mamsl)	1118

The rainfall record runs from March 1931 to June 2019. The data before March 1931 was discarded as it was mostly incomplete. The rainfall record from March 1931 to 2000 was lengthened to June 2019 by sourcing additional daily rainfall data from the South African Weather Service (SAWS). The daily rainfall record is shown in Figure 5-1.

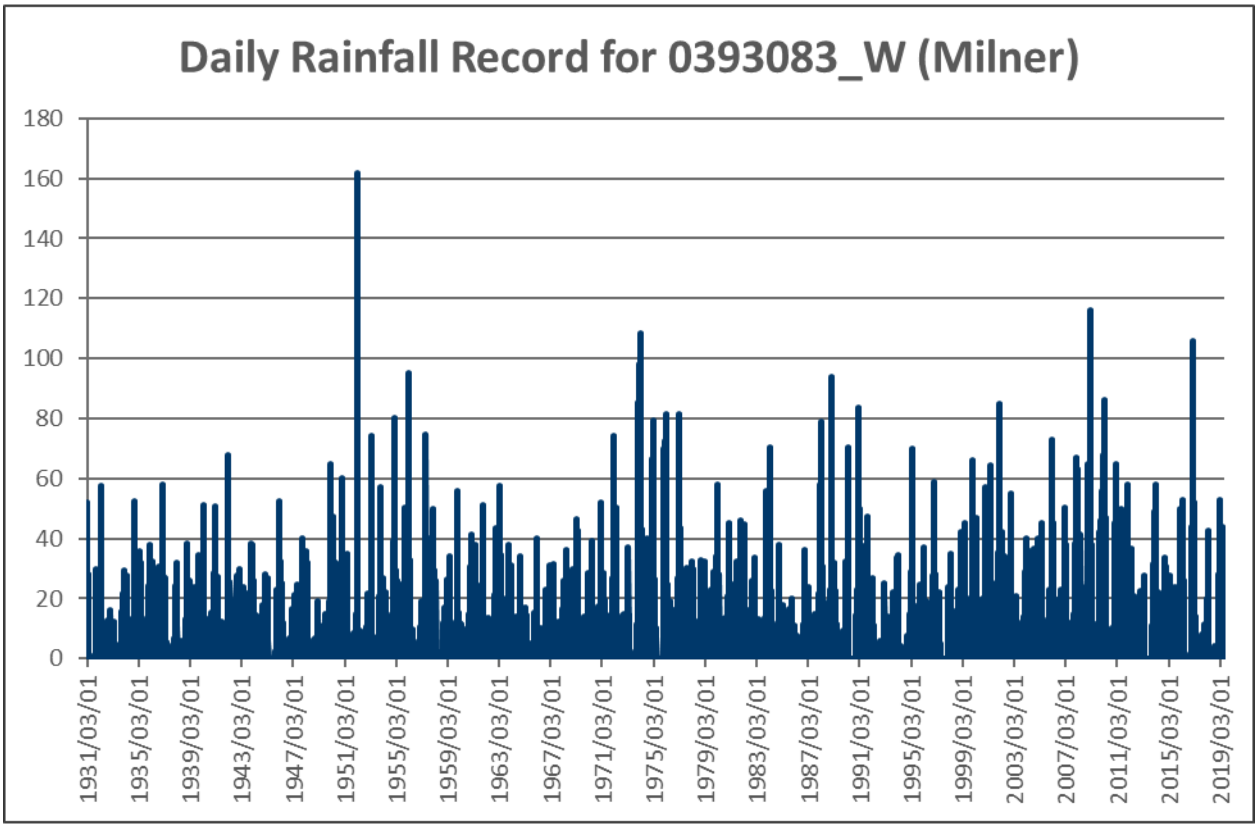

Figure 5-1: Daily Rainfall Record for 0393083_W (Milner)

The monthly averages for the rainfall record are presented in Table 5-2.

Table 5-2: Rain Gauge 0393083_W (Milner) – Monthly Average Rainfall Data

Month	Average	Min	Max
Jan	71.3	0.00	311.7
Feb	63.2	0.00	241
Mar	65.5	0.00	276
Apr	37.5	0.00	197.9
May	15.2	0.00	108.5
Jun	6.7	0.00	86.5
Jul	1.8	0.00	47.2
Aug	3.6	0.00	44.5
Sep	6.1	0.00	77.8
Oct	18.6	0.00	108.8
Nov	32.2	0.00	137
Dec	47.1	0.00	261
Annual Total	**369**	-	-

5.2 EVAPORATION

Evaporation data is based on Symonds Pan (S-Pan) data taken from the WR2012 Database (WR, 2012) for the quaternary catchment D41K (where the project site is located). S-Pan evaporation was converted to open water evaporation using evaporation coefficients from WR90 (WR, 1990), as presented in Table 5-3 below. The evaporation zone is 8A and the Mean Annual Evaporation (MAE) is 2351 mm (WRC, 2012).

Table 5-3: Monthly Average Evaporation Data (WRC, 2012)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
S Pan Evaporation (mm)	269.5	283.9	294.5	276.8	209.9	193.2	144.1	114.7	90.9	106.0	153.7	212.9
Pan Coefficient WR90	0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.83	0.85	0.81	0.81
Lake Evaporation (mm)	218.3	232.8	244.4	232.5	184.7	170.0	126.8	99.8	77.3	88.0	124.5	172.5

5.3 DESIGN STORM DEPTHS

Design storm depth estimates for various return periods and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Kwazulu-Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze 2002).

Table 5-4 presents Depth Duration Frequency (DDF) rainfall estimates for the site that were derived from the Smithers and Schulze method based on analysis of the six nearest rainfall stations.

Table 5-4: Depth Duration Frequency (DDF) Estimates for the Site

Storm Duration (m/h/d)	Return Period (years)						
	2	5	10	20	50	100	200
15 min	15.0	21.3	25.7	30.2	36.3	41.2	46.2
30 min	19.8	28.1	34.0	40.0	48.0	54.4	61.1
45 min	23.3	33.1	40.1	47.1	56.6	64.1	71.9
1 hr	26.1	37.2	45.0	52.8	63.5	72.0	80.7
1.5 hr	30.8	43.8	53.0	62.2	74.8	84.7	95.1
2 hr	34.6	49.2	59.5	69.9	84.0	95.2	106.8
4 hr	40.0	56.9	68.8	80.7	97.0	110.0	123.4
6 hr	43.5	61.9	74.9	87.9	105.6	119.7	134.3

Storm Duration (m/h/d)	Return Period (years)						
	2	5	10	20	50	100	200
8 hr	46.2	65.7	79.5	93.3	112.1	127.1	142.6
10 hr	48.4	68.8	83.3	97.8	117.5	133.1	149.4
12 hr	50.3	71.5	86.5	101.5	122.0	138.3	155.2
16 hr	53.4	75.9	91.9	107.8	129.6	146.9	164.8
20 hr	55.9	79.6	96.2	113.0	135.8	153.9	172.6
24 hr	58.1	82.6	100.0	117.3	141.0	159.8	179.3
1 day	46.7	66.5	80.5	94.5	113.5	128.6	144.3
2 day	56.8	80.8	97.7	114.7	137.9	156.2	175.3
3 day	63.6	90.5	109.5	128.5	154.4	175.0	196.3
4 day	68.2	97.1	117.4	137.8	165.7	187.7	210.6
5 day	72.0	102.5	124.0	145.5	174.9	198.2	222.4
6 day	75.3	107.2	129.6	152.1	182.9	207.2	232.5
7 day	78.2	111.3	134.6	158.0	189.9	215.1	241.4

5.4 ADDITIONAL CONSIDERATIONS

The rainfall record that is available ranges from 1931 to 2019, providing an 87-year long record of daily rainfall (Figure 5-1). In the 87-year long record, the storm depth of 141mm was exceeded only once. We therefore postulate that this one occurrence (in March 1952 of 161mm) is representative of a storm depth equivalent to a 1 in 100 recurrence interval (RI).

Removing this outlier and replotting the rainfall record (refer to Figure 5-2) results in a more consistent rainfall pattern. Three noticeable storm events in the 87-year long record are observed, and all in the last 50 years and are summarised in Table 5-5.

Table 5-5: Highest recorded rain depths in the rainfall record

Date	Rainfall mm
1974/03/01	108.5
2009/02/17	116.0
2017/01/04	106.0

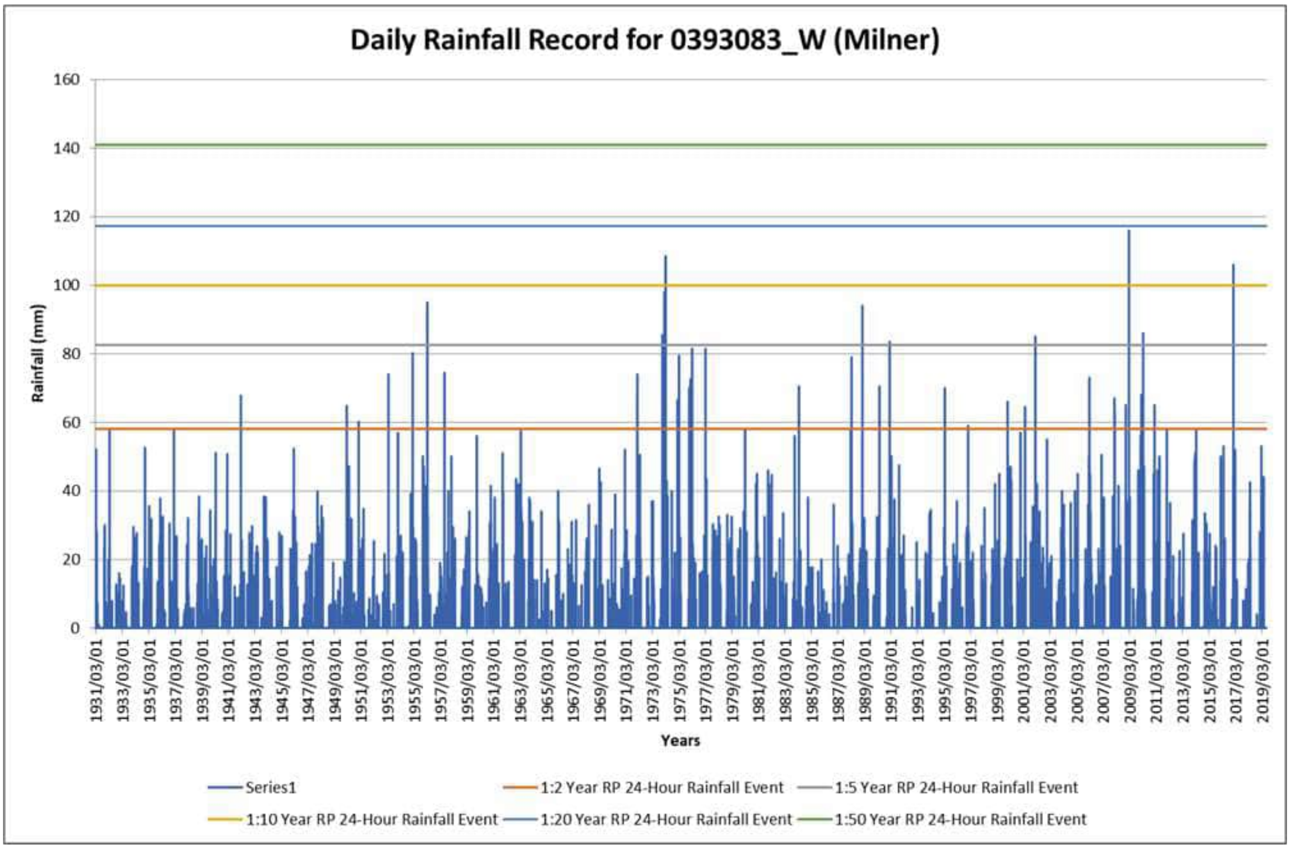

Figure 5-2: Daily rainfall record with design storm depths

We note the following from rainfall record:

- The storm depth of 116mm occurred once in the 87-year long record and is of similar magnitude to the calculated 1 in 20-yr storm event
- The average storm depth of 106mm occurred twice in the 87-year long record and is of similar magnitude to the calculated 1 in 10-yr storm event

We therefore postulate the following:

- that the 116mm occurrence is representative of a storm depth equivalent to a 1 in 100 recurrence interval; and
- the average depth of 107mm is representative of a storm depth equivalent to a 1 in 50-yr recurrence interval.

Conveyance infrastructure design based on the storm depth of 107mm would only have overtopped once in the past 50 years as required by GN 704. **It is therefore proposed that a 107mm storm depth be recommended as the design flood for the conveyance infrastructure.**

5.5 TOPOGRAPHY

In April 2020, a detailed survey (0.5 m contour interval) was provided, and this was used to complete the conceptual storm water management plan (SWMP). The general elevation of the site is between 1056 m and 1092 m above mean sea level, and topography is sloping from the southeast and northwest.

6. PROPOSED STORMWATER INFRASTRUCTURE

Figure 6-1 presents the routes of the proposed stormwater conveyance infrastructure for the site.

6.1 DESIGN METHODOLOGY

Peak flows for design of the stormwater conveyance infrastructure were estimated using the SCS Method as applied within the PCSWMM stormwater design software package. A Curve Number (CN) of 72 was applied to all catchments and the extent of the impermeable area was adjusted to distinguish between unaffected soil and a hard-impervious catchment, such as concrete paving. A Type III storm profile was applied to the 1:50 year, 24-hour rainfall depth (143.4 mm) to estimate peak flows from each catchment.

New channels/paddocks were sized to take the maximum flow calculated for the downstream end of the contributing catchment and the channel sizing was taken as uniform along the entire length. Some cut and fill may be required along the length of the channels to achieve the required gradient and to ensure that water flows freely along the channels. The infrastructure has been sized to accommodate the expected 1:50 year peak flow event.

Following confirmation of the design flows for each channel, the channels have been sized using the Manning's Equation to ensure that the flow capacity of the channel is sufficient to convey the 1:50 year rainfall event.
The Manning's equation is:

$$Q = A\frac{1}{n}R^{2/3}S^{1/2}$$

Where:

A = Area of Channel
R = Hydraulic Radius (area / wetted perimeter);
S = Longitudinal Slope of Channel; and
n = Manning's Roughness Coefficient

A Manning's 'n' coefficient of 0.014 was used

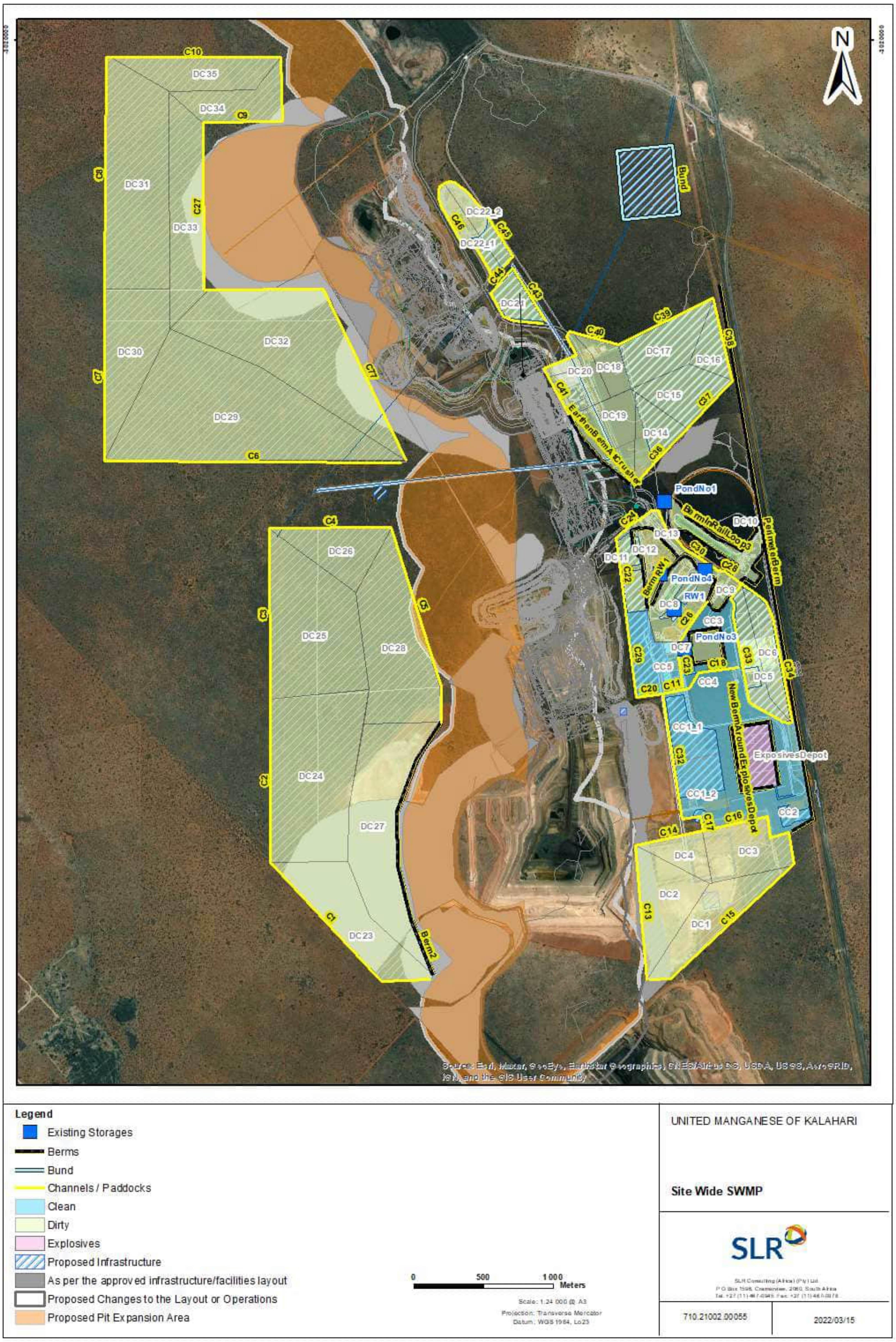

Figure 6-1: Proposed infrastructure for stormwater management

6.2 DIRTY WATER INFRASTRUCTURE

Figure 6-2 and Figure 6-3 presents the routes of the proposed stormwater conveyance infrastructure for the north and south most areas of the site. Significant conveyance infrastructure is required as the catchments in the study have a total area of 1096ha. The following concept stormwater management measures are proposed:

- Conveyance infrastructure around the perimeter of WRD clusters (existing and proposed) and stockpiles.
- Dirty water berms/paddocks should be constructed as close to the toe of the WRDs, as the WRD design will allow, with the intention of minimizing the disturbance of clean water catchments as far as practicably possible.
- The cumulative runoff will collect in the designed paddocks and be allowed to evaporate. The paddocks will be lined, and a Class D barrier is recommended which requires base preparation and compaction.
- The footprint of the proposed WRDs overlap slightly with the layout of the proposed pit extension. To reduce the volume of dirty runoff from the WRDs potentially flowing into the pit, it is proposed that footprint of the WRDs be reduced and adjusted to provide sufficient area for the infrastructure between the WRDs and pit.
- The proposed WRDs will also need to be shaped to facilitate runoff flow towards the proposed conveyance infrastructure.
- Further it is recommended that the WRDs be phased so that only sections that are operational generate dirty runoff. Areas that are complete will be rehabilitated, were practical, to generate clean runoff. Rehabilitation will be undertaken as per the requirements of the UMK approved Environmental Management Programme.

Dirty water catchments (refer to Figure 6-2 and Figure 6-3)Figure 6-1:

- The dirty water catchments are highlighted in yellow and denoted using "DC".
- There are several dirty water catchments and the runoff from these are captured in lined paddocks/berms (Class D barrier).
- The preliminary sizing at a concept level was based on the proposed infrastructure accommodating the 107mm design flood.
- An average height of 2m was used and the base width varies but exceeded 3m.
- While the concept appears sound, we recommend that the sizing be looked at in more detail during detailed design i.e., wider channels may be considered to reduce the berm height
- In addition, designing paddocks in phases to captures runoff from operational WRDs only may result in reduced sizing.

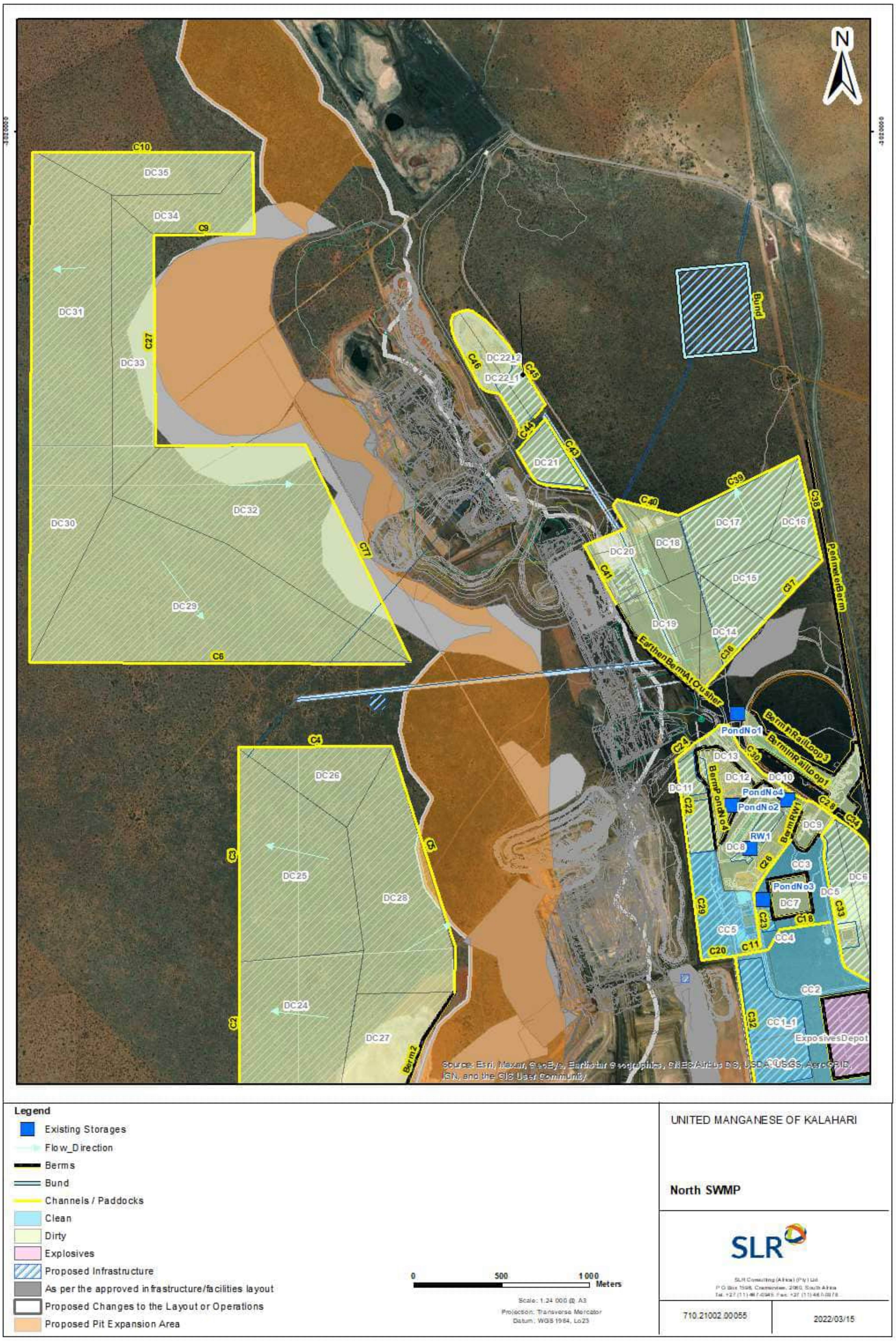

Figure 6-2: Proposed stormwater management infrastructure for northern area

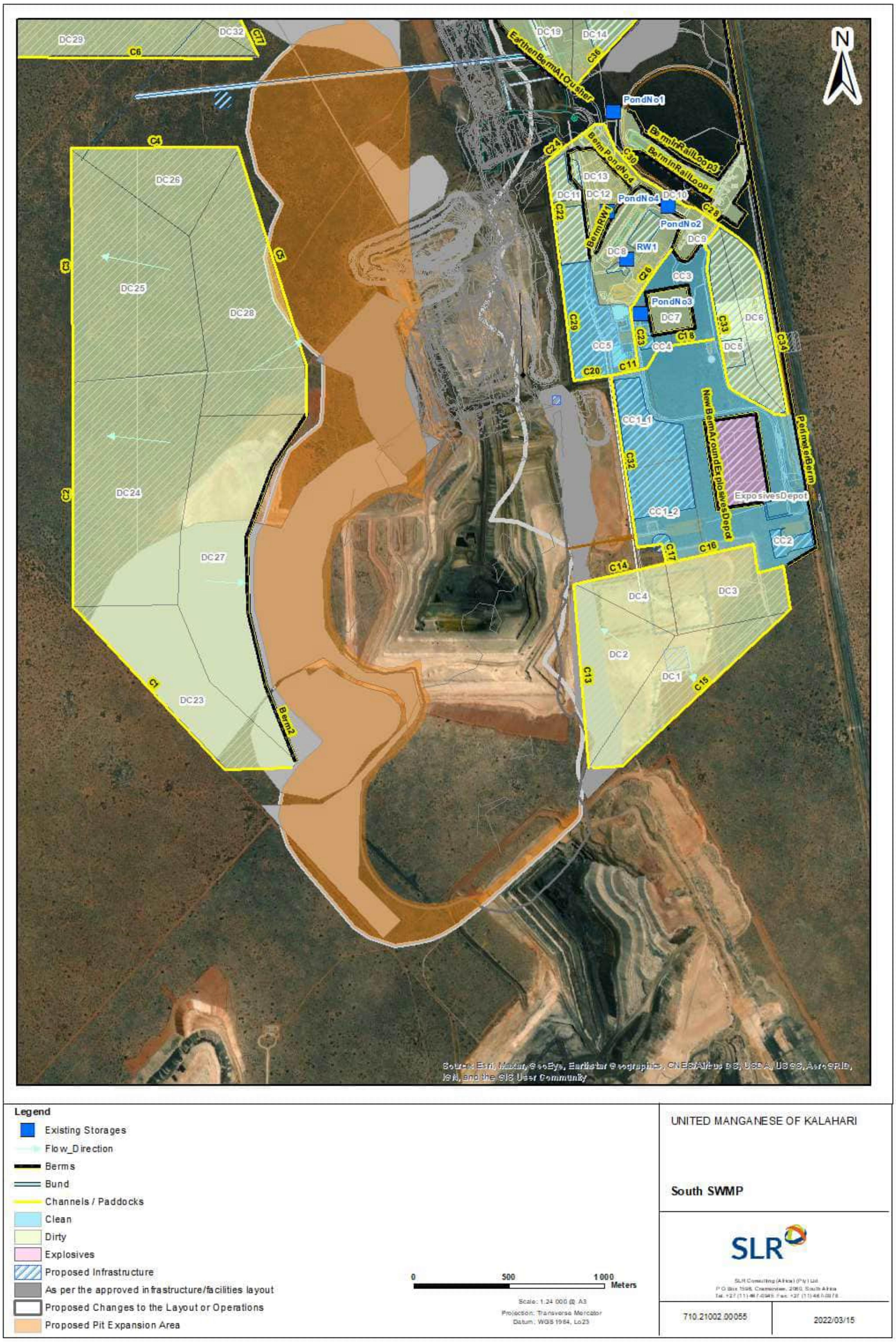

Figure 6-3: Proposed stormwater management infrastructure for northern area

Typical sections for dirty water infrastructure is shown in Figure 6-4.

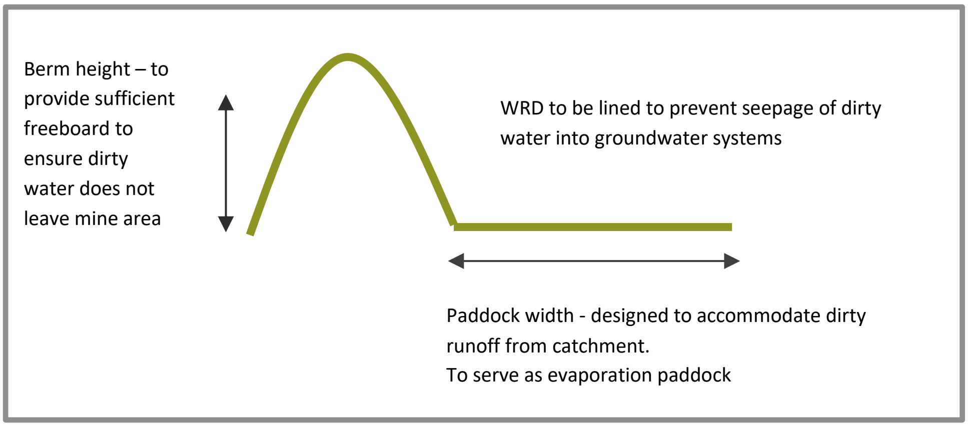

Figure 6-4: Typical pollution control paddock/bund

6.3 CLEAN WATER INFRASTRUCTURE

The clean water channels or berms need not be lined, although velocity control measures may need to be installed within unlined channels to prevent erosion and scour within the channel.

- Clean water catchments – refer to Figure 6-6
  - The offices, parking areas and explosives depot are considered to be clean water catchments and are highlighted in blue (refer to clean water catchments “CC1-5”)
  - Clean water channels or berms will be constructed around the perimeter of these areas and sized to store the flows expected from average annual rainfall.
  - During the design storm event the channels will convey the clean stormwater towards the pit
  - The average modelled depth of the channels (where applicable) is less than 2m, with widths less than 2m on average. Again, a more practical sizing will need to be considered during detailed design.
  - The explosives depot has been modelled as a separate catchment and allowance has been made in the sizing of the berms and channels along it’s perimeter to store the average annual rainfall.

Typical section for conveyance infrastructure is shown in Figure 6-5.

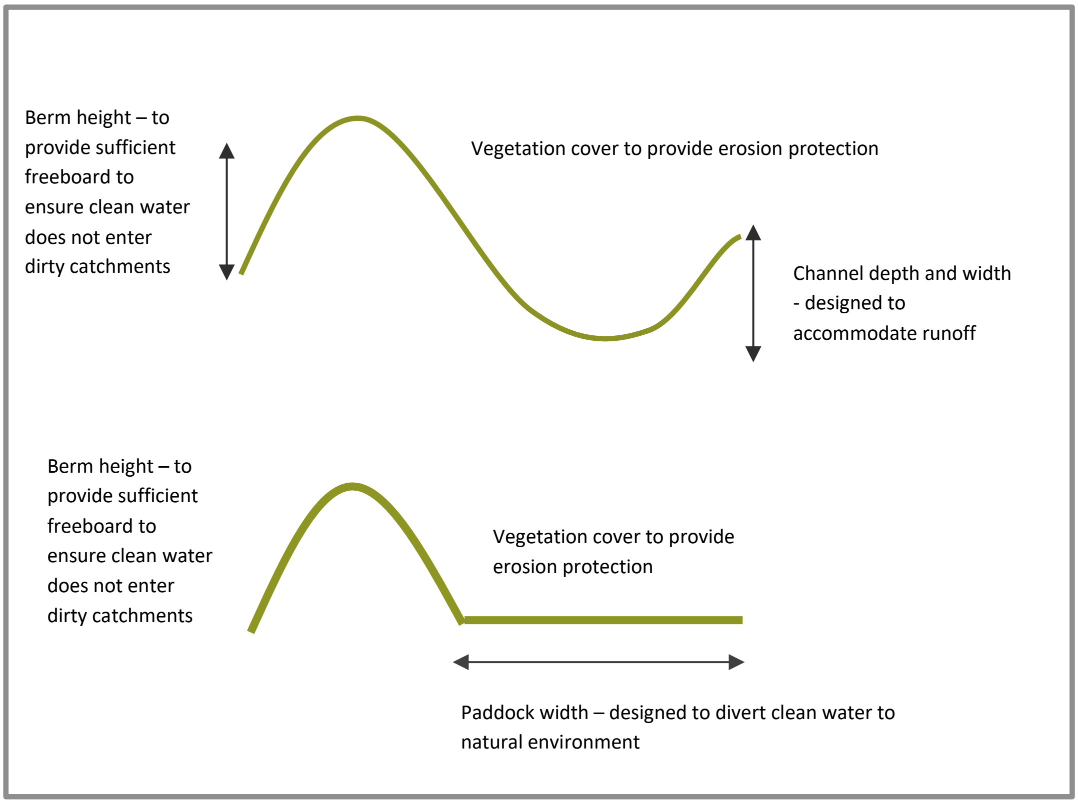

Figure 6-5: Typical cut-off earthen channel or berm for clean water management

Further details on the catchment areas and high-level sizing of the conveyance infrastructure are provided in **Appendix A.**

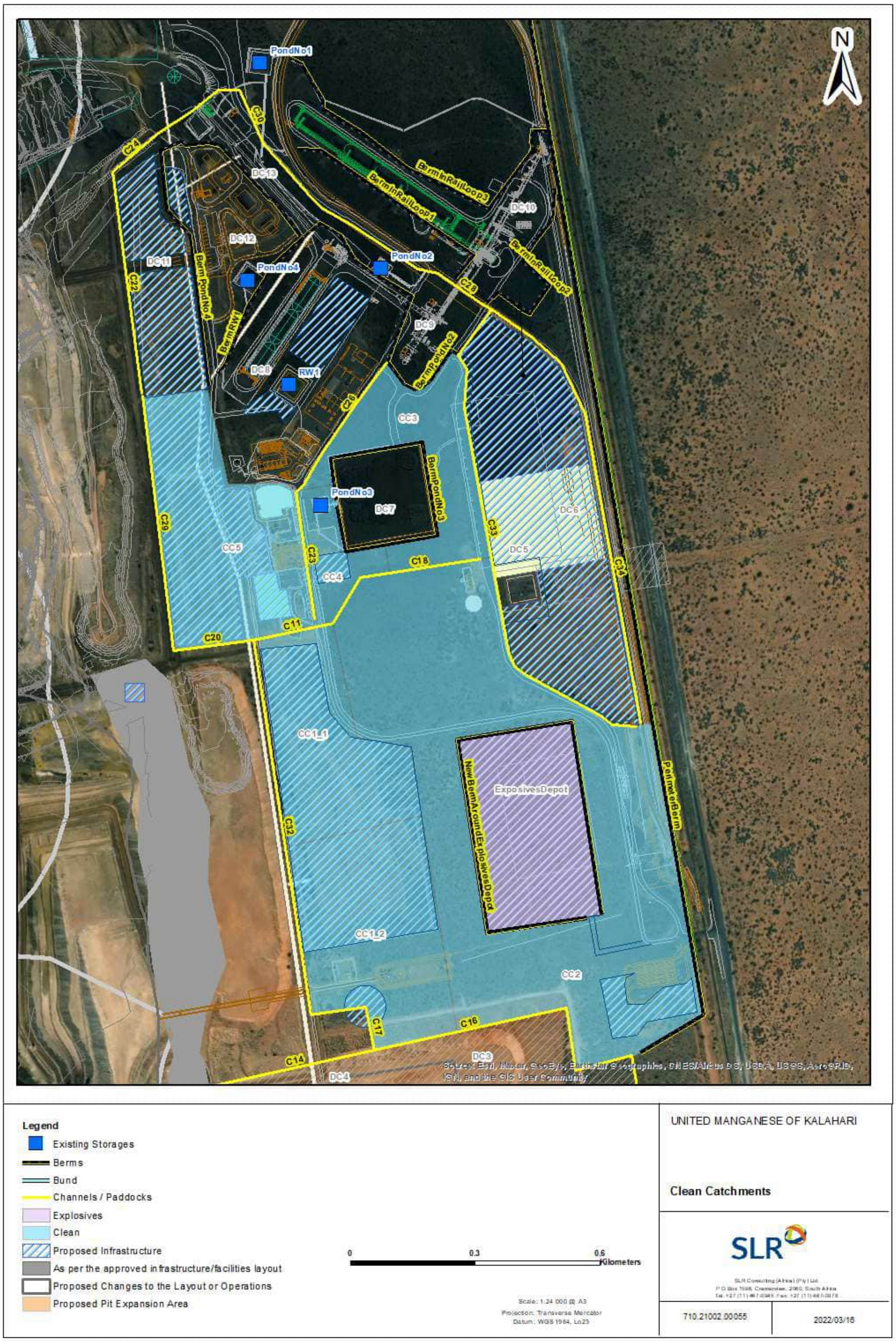

Figure 6-6: Clean water catchments and related infrastructure

7. IMPACT ASSESSMENT, MITIGATION AND MONITORING

The potential impacts of the proposed activities on surface water receptors as well as the sensitivity of the surface water resources are discussed in this section and presented along with a summary of mitigation measures. This is informed by the layout plans, the baseline hydrology and the design specifications of the stormwater management measures previously presented in this report.

Impacts are assessed cumulatively where possible, in that the assessment takes into account the currently impacted environment. These impacts include third party activities. However, the impacts of the various (surrounding/neighbouring) activities in the wider region have not been cumulatively assessed in this report.

7.1 SENSITIVITY OF WATER RESOURCES

The local surface water resources are considered to be of high sensitivity, the rationale for this sensitivity ranking is as follows:

- The mine is approximately 2 km east of the Witleegte River, a regionally significant ephemeral watercourse, flowing from south-east to north-west. The Witleegte River confluences with the ephemeral Ga-Mogara River 5.5 km north-east of the site. The Ga-Mogara River before converging with the Witleegte River flows 5.5 km west of the site (Refer to Figure 1-1). These drainage channels are significant ephemeral rivers in the area.
- Locally, surface water quality is already impacted in terms of the siltation and sedimentation, from when it does rains. The sediment washes from mine into both the watercourses could occur.

7.2 IMPACT ASSESSMENT

The impacts of the proposed activities and the infrastructure are identified and assessed based on the impact's magnitude, as well as the receptor's sensitivity, culminating in an impact significance for the most important impacts that require management.

7.3 METHODOLOGY AND APPROACH

The technical work undertaken in the previous studies as well as this stormwater management plan were used to inform the surface water impacts assessments. The specific methodologies for each section have been summarised below:

- Climate – This section presents a review of local rainfall including storm rainfall intensities and evaporation data, which are used to inform water management at the site.
- Baseline Hydrology - This section presents a description of the baseline hydrology of the site and surroundings including topography, watercourse network, catchment delineations and sensitive surface water receptors. Information was obtained from various sources of baseline information.
- Stormwater Management – This section presents recommendations on stormwater management measures to be implemented at the operational site including catchment classification (clean or dirty) and delineation, location and preliminary capacity estimation for peak flow estimation and hydraulic sizing of infrastructure.

- Impact Assessment and Mitigation – This section presents a description of identified potential impacts upon the baseline environment and a summary of the mitigation measures, assessing residual impacts and developing a monitoring programme.

The environmental impact assessment methodology rating will be the standard SLR impact assessment methodology discussed earlier.

7.4 PROPOSED ACTIVITIES

The surface water impacts associated with the proposed development are assessed according to the main stages of the project namely the construction, operation, and closure phases, as well as the major activities within those phases. The potential impacts and risks associated with the project activities and their interactions are presented in Table 7-1.

Table 7-1: Summary of project activities, interaction, and potential impacts to surface water resources

Activity	Interaction	Impact Description
Construction		
Site clearing, stripping and stockpiling soil resources, preparations and construction of new surface infrastructure.	Water quality	Deterioration of water quality as a result of the following: • Clearing the surface and site preparations, for the new infrastructure, result in exposure of soil surfaces and soil stockpiles to erosion factors. When a large area of vegetation is cleared and topsoil disturbed, exposing a large area of loose material, susceptible to erosion. During rainfall events, runoff from the exposed site will transport the soil material into the nearby watercourses. • Water contamination can result from poor waste management during the construction phase if not adequately managed. Typically, the following pollution sources exist at the mine: fuel and lubricants, sewage, mine/plant residue (crusher, plant areas and stockpiles), dirty water circuit, chemicals, non-mineralised waste (hazardous, general), and erosion of particles from exposed soils in the form of suspended solids. • The extension of the mine footprint area would result in additional sources of pollution, especially the proposed infrastructure and associated crushing, screening, conveying and tipping.

Activity	Interaction	Impact Description
Development and operation of surface infrastructure plant area, WRDs, stockpiles and crushing plant	Water quantity	• Reduction of Catchment Yield - project infrastructure will have a negative impact on drainage patterns and subsequent catchment yield. • In addition, with construction of stockpiles, plant areas, crushers and WRDs, re-profiling the surface for stormwater management an alteration of the natural site drainage will result. • Although the region is generally very dry, significant rainfall events do occur and these events cause temporary flow of surface water.
Operational Phase		
Development and operation of surface infrastructure plant area, WRDs, stockpiles and crushing plant	Water quality	• Water quality deterioration as a result of discharge of dirty water into the catchment and when extreme events do occur, some of the structures may overtop. • Potential seepage from the development and operation of surface infrastructure plant area, WRDs, stockpiles and crushing plant; and • Potential spillages from the stormwater management system and at the plant in an extreme event. Although this impact will be least expected, the deterioration of water quality immediately downstream into the local watercourses could be experienced.
Water discharge	Water quantity	• Informed by the SWMP, there is potential for the discharge of water into the pit or watercourse from the channels, depending on average climatic conditions.
Mine decommissioning and closure		
Ceaseation of the mines and the removal and demolition of surface infrastructure and rehabilitation	Water quality	• Surface runoff resulting in water quality deterioration due to sedimentation and potential pollutants. • Removal and handling of hazardous waste offsite and waste storage facilities, damage to waste handling facilities resulting water quality deterioration.

Activity	Interaction	Impact Description
Removal of surface infrastructure and rehabilitation	Water quantity	• With adequate rehabilitation and closure some of the catchment is returned to a self-sustaining system and therefore contributes again to runoff from the catchment. Return of natural drainage patterns as a result of freely draining topography

7.5 IMPACTS RATING

The impacts of the proposed activities and infrastructure mentioned in previous sections are assessed based on the impact's magnitude, as well as the receptor's sensitivity, culminating in impact significance for the most important impacts that require management.

The proposed mining project designs include various mitigation by design measures embedded in the SWMP model assessments. Theoretically without these measures the impacts on the environment would be much higher, although the mine would almost certainly not be allowed to proceed without compliance with current best practice and relevant industry guidelines presented in this and other reports.

The potential unmitigated impacts (unrealistic worst-case scenario), and residual impacts of the project after considering the design mitigation measures proposed within this report are qualitatively assessed in this section and presented in Table 7-2.

Table 7-2: Summary of Qualitative Impact Assessments

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
Impact on Baseline Surface Water Quality – Unmitigated	Without considering stormwater and sediment and silt management during construction, the project could cause pollution of water resources through sediment transport during initial earthworks.	Without mitigation, the project could have a severe impact on the run-off water quality in the ephemeral streams. (H)	Impacts could be long term lasting 10+ years but not permanent. (M)	Water quality impacts could extend region wide but would lessen with distance downstream, due to dilution and filtering within the watercourses. (M)	Moderate	Without mitigation there could be highly likely chance of impacting the quality of surface water resources. (H)
Impact on Baseline Surface Water Quality - Mitigated	A stormwater management plan developed in accordance with GN 704 and other good practices and including sediment and erosion prevention management should be designed and constructed to ensure that dirty water collected and does not discharge or spill into clean water more frequently than once in 50 years and that effluent guidelines are achieved 95% of the time.	Considering the mitigation measures discussed within this report, the proposed infrastructure will have a low severity of impact on the quality of surface water resources. (L)	The low impacts of the mine will continue long term (10+ years). (M)	Any impacts would be localised within the holding facilities. (L)	Low	Probability of impacts is unlikely as mitigation measures are designed for 1:50 year events. (L)
Impact on Quality of Surface Water - Unmitigated	Without mitigation, the project could have a severe impact on the surface water quality by discharge of dirty stormwater runoff (plant area, stockpiles and WRDs) into the clean catchments, and spillages during operation of the mine.	Impacts could be long term for the lifetime of the project – High.	Impacts could stretch far downstream – High.	High.	Without mitigation there could be a high probability of impacting the quality of surface water resources.	High.

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
Impact on Quality of Surface Water - Mitigated	Considering the proposed mitigation measures discussed in this report the site will have a low severity on the surface water quality, pollution sources will be enclosed and not contribute to dirty water run-off and spill prevention and cleaning measures will be in place.	The low impacts will continue for the life of the project.	Impacts will be local only.	Low.	Probability of impacts are Low.	Low.
Impact on catchment runoff Unmitigated	Without considering any mitigation measures or water management measures, the collection of stormwater, physical alteration of drainage lines will reduce catchment runoff flows and flood flows to the watercourses.	The project area is minor compared to the size of the overall Ga-Mogara and Witleegte streams, catchments and the severity of reduction in runoff flows is low. (L)	Impacts could last the project life 10+ years (M).	Impacts could affect only the local catchment (L).	Low.	Reduction in catchment runoff flows is likely, especially in the rainy season (L).
Impact on catchment runoff mitigated	The proposed stormwater management measures remain in place throughout the project as such; collection of stormwater will continue with the project and may reduce baseline flows into the water resources systems.	The project area is small compared to the catchment of the Ga-Mogara and Witleegte watercourses, the severity of reduction in runoff flows is low. (L)	Impacts could last the project life 10+ years (M).	Impacts could affect only the local dams and the catchment to a small extent (L).	Low.	Reduction in catchment runoff flows is likely, especially in the rainy season (L).
Impact on Baseline Flows Unmitigated	Without considering the mine's water management (storm water controls), the project could impact on the baseline flows within the Ga-Mogara and Witleegte watercourses either through	This implies a moderate impact to downstream water resources. (M)	Impacts could be long-term, extending for the life of the mine. (M)	Impacts could be felt locally in the Ga-Mogara and Witleegte watercourses beyond the site boundary.	Medium.	Mining projects often have a significant impact on baseline flows in local watercourses,

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
	potentially increasing the flows by an unquantified discharge from stormwater infrastructure.			(M)		consequently possible impacts could be expected. (M)
Impact on Baseline Flows <u>Mitigated</u>	The proposed SWMP presents recommendations for collecting and re-using water wherever possible, providing the project with processing water before requiring make up water abstraction.	The use of alternative water sources would reduce the impact on the base flow however with a potential of the impact to river water flow regimes, the impact remains Moderate (M).	Impacts will last for the project life and would be reversible over time (M).	Impacts will be felt further downstream in the Ga-Mogara and Witleegte watercourses. (M)	Medium.	Despite the low process water requirements, the impacts on the baseflow may still occur on the baseflow due to the proximity with the river. (M)

7.6 MITIGATION

Mitigation is by design of measures developed to ensure legislative and design standards compliance have been discussed in detail in the previous sections, and a summary of these measures and additional mitigation measures recommended to further reduce any residual impacts on both surface water drainage quality and quantity is presented below.

Mitigation by design measures:

- Stormwater management by mainly:
    - The concept of the proposed stormwater management plan is to allow the dirty runoff, within the mine area, to flow across the dirty catchments of the site as surface flow before discharging into lined conveyance infrastructure.
    - Confidence on the minimum risk to the environment is further provided in that the leachate from the proposed WRDs is considered non-hazardous.
    - The WRDs, on the western side of the pit, need to be sloped as much as possible to allow stormwater to flow towards the infrastructure provided.
    - Reuse of stormwater from dirty catchments in the processing plant or for dust suppression.
    - The collection of dirty stormwater and water management strategy defined where the reuse of dirty water will be prioritised, thereby ideally reducing the impacts from the project on the surface water resources through planning for discharge of excess mine water; and
    - Management of silt.

In addition to the measures presented and discussed throughout this report, the following management measures should be implemented:

- Infrastructure design: the design of all onsite access roads, plant areas, stockpiles, WRDs etc. should consider stormwater management and erosion control during both the construction and operational phases.

- Good housekeeping practices should be implemented and maintained by clean-up of accidental spillages, as well as ensuring all dislodged material like run-of-mine stockpile is kept within the confined storage footprints. In addition, clean-up material and materials safety data sheets for chemical and hazardous substances should be kept on site for immediate clean-up of accidental spillages of pollutants.

- Regularly scheduled inspection and maintenance of water management facilities, to include inspection of drainage structures and liners for any in channel erosion or cracks; de-silting of silt traps/sumps and PCDs; and any pumps and pipelines should be maintained according to manufacturer's specifications.

- Vehicles or plant equipment servicing should be undertaken within suitably equipped facilities, either within workshops, or within bunded areas, from which any stormwater is conveyed to a pollution control dam, preferably after passing through an oil and silt interceptor.

- Pollutant Storage – any substances which may potentially pollute surface water should be stored within a suitably sized bunded area and where practicable covered by a roof to prevent contact with rainfall and/or runoff.

- Water Conservation and Water Demand Management (WC/WDM) measures to ensure that as much as is possible, water should be collected and reused, minimising the release of any treated storm flows whilst also reducing the abstraction of water from external and potentially clean water sources (boreholes); and
- From operations onwards, grading of disturbed area and, application of the final layers of growth medium, should be along the contour as far as can be achieved in a safe and practical manner; and vegetation of disturbed areas including seeding should be performed immediately following application of the growth medium to avoid erosion.

All measures implemented for the mitigation of impacts, should be regularly reviewed as best practice and as compliance with various licences issued on site by authorities.

8. CONCLUSIONS AND RECOMMENDATIONS

The following recommendations apply to this study:

8.1 SWMP

- A conceptual stormwater management plan has been developed in line with GN 704. Clean water from the catchments upstream of mining infrastructure is diverted around the proposed infrastructure. Dirty stormwater will be collected.
- It is recommended that the catchments of the current PCDs in the Plant Area (Pond 1, Pond 2, Pond 3, Pond 4 and RW 1) are bermed off to ensure that the stormwater is directed towards the relevant PCDs.
- Clean water evaporation paddocks are recommended around the offices and parking areas to store clean water runoff. The water will then be allowed to evaporate under average flow conditions and will spill over into the adjacent pit for peak flow conditions.
- The existing PCDs that are not linked to dirty water areas should be utilised to manage in-pit water when it is required to be pumped out.
- It is proposed that the layout or positioning of the WRDs be reassessed to ensure the overlap is eliminated and to provide space for the proposed stormwater infrastructure. The proposed WRDs also need to be sloped as much as possible to allow stormwater to flow towards the proposed infrastructure.
- The reuse of dirty water will be prioritised thereby reducing the impacts from the project on the surface water resources through planning for discharge of excess mine water and storing for use in low water supply periods.
- Further details of the SWMP should be confirmed during the detailed design phase of the project. These include but are not limited to geotechnical investigation to determine ground conditions, pumping requirements, cost estimate and determining spatial restrictions to accommodate the sizing of the conveyance infrastructure. This task can be undertaken in discrete packages of design work.

8.2 IMPACTS ASSESSMENT ON WATER RESOURCES

- Impacts of the proposed infrastructure on the surface water quality and quantity have been identified and mitigation measures recommended. Any substances which may potentially pollute surface water should be stored within a suitably sized bunded area and where practicable covered by a roof to prevent contact with rainfall and/or runoff. In addition to these mitigation measures embedded in the design standards, additional mitigation measures are recommended.
- All measures implemented for the mitigation of impacts, should be regularly reviewed as best practice and as compliance with various licences issued on site by authorities. The project can continue if all mitigation and monitoring measures are to be implemented.

9. LIMITATIONS

In view of the data available for the study, the limitations for future detailed studies have been detailed in this section.

9.1 LIMITATIONS

Although the study undertaken is considered adequate for the current scope of work and purpose - a conceptual level of design which allows for the identification of potential fatal flaws in the proposed infrastructure (in line with the current and plant expansions), the following limitations exist:

- Understanding of the proposed infrastructure is based on a plan layout only, as opposed to typical design details or cross sections. Consequently, it is not clear whether certain infrastructure such as conveyors will be raised above ground or not, which may constrain the route of proposed infrastructure.
- The proposed infrastructure will be finalised to optimize the earth works volumes, spatial constraints and positioning during the next phase of study once more detail is considered.

10. REFERENCES

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APPENDIX A: CATCHMENT AND INFRASTRUCTURE SIZING SUMMARY

Catchment characteristics

Name	Area (ha)	Flow Length (m)	Slope (%)	Imperv. (%)
CC1	28.3159	566.318	0.4	25
CC2	48.66	442.364	0.4	10
CC3	9.9067	147.861	0.4	25
CC4	3.7937	102.532	0.4	25
CC5	16.5117	330.234	0.3	25
DC1	24.7145	214.909	18	15
DC10	11.7006	195.01	0.4	10
DC11	9.0846	162.225	0.3	25
DC12	8.9399	198.664	0.2	25
DC13	5.2692	94.093	0.3	25
DC14	12.6593	342.143	15	15
DC15	16.8794	375.098	15	15
DC16	8.3011	247.794	15	15
DC17	20.7532	345.887	15	15
DC18	8.0872	437.146	2	50
DC19	19.0315	396.49	2	50
DC2	24.9947	416.578	18	15
DC20	14.348	422	2	50
DC21	8.4015	300.054	0.8	10
DC22	15.554	707	0.8	10
DC23	35.3691	353.691	18	15
DC24	74.0005	616.671	18	15
DC25	63.6337	731.422	18	15
DC26	20.9201	394.719	18	15
DC27	60.1002	500.835	18	15
DC28	53.6563	447.136	18	15
DC29	110.1571	688.482	18	15
DC3	21.2977	425.954	18	15
DC30	36.1003	451.254	18	15
DC31	71.1894	450.566	18	15
DC32	81.5134	543.423	18	15
DC33	36.1075	249.017	18	15
DC34	17.988	276.738	18	15
DC35	22.9143	238.691	18	15
DC4	9.4779	305.739	18	15
DC5	12.134	121.34	15	15
DC6	12.3081	123.081	15	15
DC7	5.0213	200.852	2	25
DC8	18.5598	272.938	0.2	25
DC9	4.3248	144.16	0.4	25
ExposivesDepot	12.8939	257.878	0.4	25

Infrastructure sizing for design flood

Name	Length (m)	Roughness	Cross-Section	Geom1-Depth (m)	Geom2 - Base width (m)	Slope - Geom3	Slope - Geom4	Max. |Flow| (m^3/s)	Max. |Velocity| (m/s)
Berm2	1950.501	0.014	TRAPEZOIDAL	3	6	2	2	6.503	0.63
C1	400	0.014	TRAPEZOIDAL	3	6	2	2	7.197	0.52
C10	1261.231	0.014	TRAPEZOIDAL	2.5	5	2	2	7.084	0.59
C11	194.19	0.014	TRAPEZOIDAL	3	5	2	2	2.202	0.4
C13	968.641	0.014	TRAPEZOIDAL	1.5	2	2	2	4.997	2.27
C14	500.132	0.014	TRAPEZOIDAL	1.5	2	2	2	6.359	1.85
C15	1365.668	0.014	TRAPEZOIDAL	1.5	2	2	2	5.391	1.56
C16	997.408	0.014	TRAPEZOIDAL	1.5	2	2	2	8.153	2.14
C17	373.813	0.014	TRAPEZOIDAL	1.5	2	2	2	13.177	2.47
C18	421.094	0.03	TRAPEZOIDAL	3	5	2	2	3.283	0.57
C2	1179.204	0.014	TRAPEZOIDAL	3	6	2	2	13.612	0.97
C20	194.416	0.03	TRAPEZOIDAL	3	5	2	2	2.025	0.36
C22	511.881	0.014	TRAPEZOIDAL	1.5	2.5	2	2	1.463	0.67
C23	309.749	0.014	TRAPEZOIDAL	2.5	3	2	2	0.379	0.09
C24	430.487	0.014	TRAPEZOIDAL	1.5	2.5	2	2	1	0.38
C26	380.04	0.014	TRAPEZOIDAL	2.5	3	2	2	1.568	0.44
C27	1203.821	0.014	TRAPEZOIDAL	2.5	5	2	2	8.246	0.78
C28	293.104	0.014	TRAPEZOIDAL	1.5	2.5	2	2	1.531	0.42
C29	615.726	0.014	TRAPEZOIDAL	3	5	2	2	2.018	0.42
C3	1229.951	0.014	TRAPEZOIDAL	3	6	2	2	16.063	1.18
C30	536.178	0.014	TRAPEZOIDAL	1.5	2.5	2	2	1.027	0.42
C32	883.985	0.014	TRAPEZOIDAL	3	5	2	2	0.741	0.16
C33	1236.208	0.014	TRAPEZOIDAL	1.5	2.5	2	2	2.339	0.75
C34	1101.144	0.014	TRAPEZOIDAL	1.5	2.5	2	2	2.585	0.83
C36	735.823	0.014	TRAPEZOIDAL	2	5	2	2	1.106	0.18
C37	471.992	0.014	TRAPEZOIDAL	2	5	2	2	1.631	0.22
C38	610.242	0.014	TRAPEZOIDAL	2	5	2	2	1.036	0.14
C39	762.778	0.014	TRAPEZOIDAL	2	5	2	2	1.4	0.26
C4	876.342	0.014	TRAPEZOIDAL	3	6	2	2	11.194	0.97
C40	365.245	0.014	TRAPEZOIDAL	2	5	2	2	2.424	0.33
C41	833.564	0.014	TRAPEZOIDAL	2	5	2	2	5.074	0.75
C43	451.789	0.014	TRAPEZOIDAL	1.5	2	2	2	0.319	0.36
C44	728.964	0.014	TRAPEZOIDAL	1.5	2	2	2	0.73	0.59
C45	855.332	0.014	TRAPEZOIDAL	1.5	3	2	2	0.549	0.42
C46	865.011	0.014	TRAPEZOIDAL	1.5	3	2	2	0.515	0.41
C5	1467.768	0.014	TRAPEZOIDAL	3	6	2	2	7.427	0.72
C6	2138.576	0.014	TRAPEZOIDAL	2.5	5	2	2	11.993	0.93
C7	1235.72	0.014	TRAPEZOIDAL	2.5	5	2	2	11.749	0.85
C77	2226.651	0.014	TRAPEZOIDAL	2.5	5	2	2	9.279	0.85
C8	1677.129	0.014	TRAPEZOIDAL	2.5	5	2	2	12.64	1.01
C9	1039.838	0.014	TRAPEZOIDAL	2.5	5	2	2	6.362	0.66
EarthenBermAtCr	671.227	0.014	TRAPEZOIDAL	2	5	2	2	4.63	0.68

Infrastructure sizing for average annual rainfall

Name	Length (m)	Roughness	Cross-Section	Geom1-Depth (m)	Geom2 - Base width (m)	Slope - Geom3	Slope - Geom4	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)
Berm2	1950.501	0.014	TRAPEZOIDAL	2.5	2.5	2	2	1.746	0.45
C1	400	0.014	TRAPEZOIDAL	2.5	2.5	2	2	2.294	0.41
C10	1261.231	0.014	TRAPEZOIDAL	2.5	2.5	2	2	1.512	0.42
C11	194.19	0.014	TRAPEZOIDAL	2	2	2	2	0.751	0.31
C13	968.641	0.014	TRAPEZOIDAL	1	1	2	2	1.621	1.65
C14	500.132	0.014	TRAPEZOIDAL	1	1	2	2	2.017	1.83
C15	1365.668	0.014	TRAPEZOIDAL	1	1	2	2	1.605	1.11
C16	997.408	0.014	TRAPEZOIDAL	1	1	2	2	2.371	1.75
C17	373.813	0.014	TRAPEZOIDAL	1	1	2	2	3.988	2.46
C18	421.094	0.03	TRAPEZOIDAL	2	2	2	2	1.196	0.46
C2	1179.204	0.014	TRAPEZOIDAL	2.5	2.5	2	2	3.741	0.69
C20	194.416	0.03	TRAPEZOIDAL	2	2	2	2	0.698	0.27
C22	511.881	0.014	TRAPEZOIDAL	1	1.5	2	2	0.558	0.53
C23	309.749	0.014	TRAPEZOIDAL	1.5	2	2	2	0.121	0.09
C24	430.487	0.014	TRAPEZOIDAL	1	1.5	2	2	0.338	0.33
C26	380.04	0.014	TRAPEZOIDAL	1.5	2	2	2	0.642	0.4
C27	1203.821	0.014	TRAPEZOIDAL	2.5	2.5	2	2	2.133	0.51
C28	293.104	0.014	TRAPEZOIDAL	1	1.5	2	2	0.439	0.27
C29	615.726	0.014	TRAPEZOIDAL	2	2	2	2	0.763	0.36
C3	1229.951	0.014	TRAPEZOIDAL	2.5	2.5	2	2	4.167	0.8
C30	536.178	0.014	TRAPEZOIDAL	1	1.5	2	2	0.338	0.39
C32	883.985	0.014	TRAPEZOIDAL	2	2	2	2	0.34	0.16
C33	1236.208	0.014	TRAPEZOIDAL	1	1.5	2	2	0.677	0.52
C34	1101.144	0.014	TRAPEZOIDAL	1	1.5	2	2	0.754	0.58
C36	735.823	0.014	TRAPEZOIDAL	1.5	2	2	2	0.57	0.14
C37	471.992	0.014	TRAPEZOIDAL	1.5	2	2	2	0.759	0.18
C38	610.242	0.014	TRAPEZOIDAL	1.5	2	2	2	0.942	0.25
C39	762.778	0.014	TRAPEZOIDAL	1.5	2	2	2	0.851	0.24
C4	876.342	0.014	TRAPEZOIDAL	2.5	2.5	2	2	2.808	0.69
C40	365.245	0.014	TRAPEZOIDAL	1.5	2	2	2	1.141	0.36
C41	833.564	0.014	TRAPEZOIDAL	1.5	2	2	2	2.124	0.67
C43	451.789	0.014	TRAPEZOIDAL	1	1	2	2	0.084	0.25
C44	728.964	0.014	TRAPEZOIDAL	1	1	2	2	0.196	0.41
C45	855.332	0.014	TRAPEZOIDAL	1	1.5	2	2	0.15	0.31
C46	865.011	0.014	TRAPEZOIDAL	1	1.5	2	2	0.139	0.29
C5	1467.768	0.014	TRAPEZOIDAL	2.5	2.5	2	2	1.692	0.53
C6	2138.576	0.014	TRAPEZOIDAL	2.5	2.5	2	2	3.306	0.66
C7	1235.72	0.014	TRAPEZOIDAL	2.5	2.5	2	2	2.803	0.53
C77	2226.651	0.014	TRAPEZOIDAL	2.5	2.5	2	2	2.471	0.58
C8	1677.129	0.014	TRAPEZOIDAL	2.5	2.5	2	2	3.241	0.7
C9	1039.838	0.014	TRAPEZOIDAL	2.5	2.5	2	2	1.516	0.45
EarthenBermAtCrush	671.227	0.014	TRAPEZOIDAL	1.5	2	2	2	1.933	0.59

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