BOOYSENDAL PLATINUM (PTY) LIMITED, BOOYSENDAL SOUTH EXPANSION PROJECT (EMP, EIA) :

SPECIALIST: HYDROLOGICAL STUDY

Booysendal Platinum (Pty) Ltd

Issued to: Booysendal Platinum Mine (Pty) Ltd

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0.0 EXECUTIVE SUMMARY

Letsolo Water and Environmental Services cc was appointed to conduct the Hydrological Study for Booysendal Platinum (Pty) Ltd. This report forms part of the submission for the Environmental Authorizations for Booysendal South Expansion Project (Phase 1 and 2).

The purpose of the expansion is to increase mining of the platinum group metals (PGM) from the UG2 and Merensky Reefs. Booysendal South Expansion Project Phase 1 & 2 specifically focuses on four development area. Namely:

- BS1/2;
- Merensky Portals and the Emergency Escape Portal
  - BCM1; and
  - BCM2;
- BS4; and
- BS4 Valley Boxcut.

Booysendal consist of two Mining Rights (MR), namely the Booysendal North MR and the Booysendal South MR (old Everest mine). These MR are managed as one operation divided into five operational areas. Booysendal North (the existing mining operation), BCM1, BCM2 and BS1/2 (all four of these areas are located on the Booysendal North MR), while the Valley Boxcut and the existing Everest mine (BS4) is located on the Booysendal South Mining Right.

The northern section of the Booysendal MR (BN, BCM1, BCM2 and emergency escape portal) falls in the Limpopo Province, while the southern section (BS1/2) and the Booysendal South MR in the Mpumalanga Province.

0.1 Phase 1 of the Booysendal South Expansion Project

The first phase of the Booysendal South Expansion Project involved the development of a portal complex at BS1/2, two adits at BCM1 and BCM2, upgrade of storm water management measures at BS4 and the Valley Boxcut, reworking of the tailings and backfilling of the underground workings at BS4 and linear infrastructure components (road, aerial rope conveyor (ARC), 132kVA power line) between the operational areas. Environmental authorisation (EA) for this Phase 1 of the Booysendal South Expansion Project was granted on 05 January 2018.

0.1.1 Phase 1 activities associated with BS1/2:

These activities include the development of the BS1/2 mine consisting of mining terrace, portal, seven adits, workshops, offices and water infrastructure.

For this report, the assessed activities associated with BS1/2 are as follows:

- Infilling of more than 5 cubic meters within the 100-year flood line of the Groot Dwars River for the establishment of the portal terrace and the main river crossing over the Groot Dwars River;
- Diversion of two unnamed tributaries of the Groot Dwars River upstream of the BS1/2 Shaft Complex;
- Stockpile and terracing for the BS1/2 portal within the 100m flood line of an unnamed tributary of the Groot Dwars River;
- Construction of a pollution control dam, a sewage treatment plant and a drinking water treatment plant, mine dewatering, process water tanks and water storage tanks.
- Construction of a crusher plant and an associated conveyor system which will transport the ore to a new silo and from there to an Aerial Rope Conveyor system at the edge of the BS1/2 terrace;
- Construction of an Aerial Rope Conveyor ARC system (ARS) from BS1/2 to BS4. The conveyor will cross the Groot Dwars River and several drainage lines;
- Access road (13,9m wide) from BS1/2 to BN;
- 132kVA powerline from BN to BS1/2;
- Construction of a bridge across the Groot Dwars River;
- Storage facilities for diesel, dangerous and hazardous chemicals;
- Oil separators and settlers for storm water; and
- Mining of the Merensky portals. There are two Merensky portals;
    - Merensky portal central north (BCM1); and
    - Merensky portal central south (BCM2).

0.1.2 Phase 1 activities associated with BS4.

Phase 1 activities associated with BS4 include the following:

- Reworking and replacing of tailings on the existing Tailings Storage Facility (TFS1);
- Backfilling of the underground workings with tailings;

- Upgrade the storm water management system at BS4 and the Valley Boxcut in line with the Storm Water Management Plan (SWMP) developed by SLR in 2011;
- Construction of a 13,9m wide access road between BS4 and BS1/2 development, including several watercourse crossings;
- An ARC system between BS4 and BS1/2;
- Temporary access roads and laydown areas; and
- A pipeline from the TKO dam to the Valley boxcut.

0.2 Phase 2 of the Booysendal South Expansion Project

Phase 2 activities for the Valley Boxcut, Booysendal North, and BS4 are discussed below.

0.2.1 Future activities associated with the Valley Boxcut:

These activities include the following:

- Establishing additional surface infrastructure to allow for additional access of the existing ore body as well as act as an emergency exit and air intake for the underground mine.
- The additional infrastructure will include a new decline, referred to in this report as the valley decline.
- Roads and access points - a service road will be extended from the terrace to the valley decline.
- Power lines.
- Domestic and industrial waste disposal facilities - Domestic and industrial waste produced by the mine is collected on site in demarcated areas and disposed of off-site at Holfontein (hazardous waste) and Lydenburg (domestic waste) by a waste contractor (Waste Technologist).
- Sewage treatment - A sewage treatment facility is planned. The facility will be located at the decline and will service the change houses and ablution facilities at the decline. The sewage treatment plant will be designed to cater for 200 employees and will have a treatment capacity of 60 m3/month of sewage.
- Storm water dam - Dirty runoff from the decline shaft area will be pumped to a storm water dam located immediately downstream of the decline area. The storm water dam will have a 5 000 m3 capacity to cater for the 1:50 year storm event.

- Potable water supply - Potable water at the mine is sourced from boreholes. The water is pumped to storage tanks before being used. Approximately 46 m3/day (1 380 m3/month) of potable water is used by the mine.
- Process water supply - Process water at the mine is sourced from boreholes (through dewatering activities), groundwater inflows into the workings, storm water runoff from the mining and plant area, rainfall inputs to the pit and the TKO dam.
- Workshops, administration and other buildings – These facilities needed for the project include: fencing, security and access control; a bus off-loading and loading area; offices and changehouses with ablution facilities; a control room; stores and workshops; fuel storage (approximately 100 m3) and handling point; explosives delivery and handling facility; parking area for mine equipment and vehicles; and compressors.

0.2.2 Phase 2 activities associated with Booysendal North MR

BN MR activities include the following:

- Development of identical surface infrastructure at BCM1 and BCM2;
- Retaining the 11kVA powerline from BN to BS1/2;
- Process and clean water pipelines between BS1/2 and BN;
- Access roads to the BCM1 and BCM2 Adits;
- An ARC system from BS1/2 to BN; and
- Surface conveyors between BCM1, BCM 2 and the ARC loading station;A crusher between BCM1 and BCM2;
- An emergency escape portal is planned just east of the BCM1 and BCM2 complexes. It will serve as a return airway system for BS1/2, BCM1 and BCM2 and as an emergency escape portal. This is to comply with the mine health and safety requirements. The emergency escape portal will have a development footprint area of 1.3Ha. Access will be gained from the main access road onto a 4m wide bitumen road.

0.2.3 Phase 2 activities associated with BS4:

Booysendal South Mining Right (BS4) involves

- Backfilling plant at BS4;
- Slurry pipeline from the process plant to the backfill plant and the underground workings;

- Three emergency backfill ponds along the slurry line; and
- Process water lines between the backfill and process plant, the underground workings and the return water dam (RWD).

The life of mine of the Booysendal South Expansion Project is approximately 40 years. The total BS reserve is estimated at 105.88 Mt.

Detailed Civil Designs for proposed infrastructure were not available when this study was concluded. It may be necessary to update the Storm Water Management Section of this report as soon as the Civil Designs are released. In order to ensure consistency, Hydrological data used for the hydrological impact assessment must also be used for the detailed civil design calculations.

The detailed civil study is scheduled to commence in June/July 2018. In order to adapt to the same data used for design flood calculations, design rainfall depth for the 1:50 years and 1:100 years, 24 hours storm event, were sourced from the South African Weather Services Database, Station 0554516W – Beetgeskraal.

In hydrological terms, the ARC has far less hydrological impacts when compared to road haulage. The pylons will be spaced at the closest 221m interval.

0.3 Terms of Reference for Hydrological Impact Assessment

This Hydrological Impact Study Report is to allow for the amendment of the Environmental Management Programme, Environmental Authorisations and an Integrated Water Use License Application. The scope of work is to ensure the protection of the surface water resources. The content of the detailed report will ensure that:

- Effect is given to the objectives of the National Water Act, 1998 (Act 36 of 1998) (NWA).
- Systems are in place to enable effective management of impacts on the water resources.
- Consistent and sustainable implementation of water management hierarchy at facilities that have a potential to impact on the water resource.
- Water Balance Studies and Storm Water Management Plans are kept up to date and aligned with plans to demonstrate continual improvement in water resource protection and management.

- Water and salt balance is developed though which long term water quality can be monitored.
- Essential input into the Integrated water and Waste Management Plan (IWWMP) is obtained.
- Surface water monitoring requirements and parameters is assessed and updated if required.

0.4 Current Impacts from Phase 1 Construction Activities

Phase 1 activities have already commenced. The change in catchment characteristics has the highest impact on surface water. The following current impacts were noted:

- Although it is at a smaller scale, deterioration of water quality due to the removal of the vegetation cover. This occurs when loose sediments get in contact with water in the event of storm events and results in higher concentration of Total Dissolved Solids (TDS) and Suspended Solids (TSS);
- The activities at BS1/2 confirm that a change in flow regime due to the diversion of clean storm water from the upstream catchment area is a Hydrological impact. This occurs because of the reduction of clean water catchments;
- Increase in Hydrological Yield due to the increase in bare surface area;
- Erosion/sediment transport due to the loosening of soil at the access road; and
- Change in catchment characteristics by either artificial catchment divides like berms/channels or removal of vegetation cover.

Vegetation clearance for Phase 2 development may result in an increase in sediment transport, whilst the development itself may result in impacts on water quality.

0.5 Sensitivities

The South African water management areas were revised in line with Government Gazette No. 35517, regulations 547 of 20 July 2012. The study area falls within Water Management Area 2 (WMA2) - Olifants. The Olifants Water Management Area was previously Water Management Area 4. The Olifants River is the most significant River in WMA2. The Olifants Catchment covers about 54 570 km^2 and is subdivided into 9 secondary catchments. The Olifants River originates near Bethal in the Highveld of Mpumalanga. The area of influence for this study is Department of Water and Sanitation (DWS) Quaternary Catchment B41G. The most prominent river in catchment B41G is the Dwars River. Quaternary Catchment B41G has been classified as a Freshwater Ecosystem Priority Area (FEPA).

De Brochen Dam is located downstream of BN on the farm De Brochen 7JT. This dam is a significant surface water body located downstream of the project area. The Groot Dwars River and the De Brochen Dam are the most sensitive surface water resources due to their close proximity to the proposed and current activities at Booysendal Mine.

0.6 Legislative Requirements

For this Hydrological Assessment, the principal Act of relevance is NWA which provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis, upon which to develop tools and means to give effect to the protection of water resources.

The legal platform, on which the Hydrological Impact Assessment is based, is summarized briefly by the following main legislation and Guidelines prescribed by the Department of Water and Sanitation (DWS).

The study was conducted in line with the requirements of the NWA as well as the Best Practice Guidelines (BPG) for the Protection of Water Resources and "Regulations 704" as published in Government Gazette, Volume 408, No 20119 of June 1999 (Also known as General Notice 704, 04 June 1999).

Applicable Best Practice Guidelines which were incorporated into the Hydrological Study are as follows:

- BPG A4 – Pollution Control Dams;
- BPG G1 – Storm Water Management;
- BPG G2 – Water and Salt Balance;
- BPG G3 – Water Monitoring; and
- BPG H2 – Pollution Prevention and Minimization of Impacts.

GN 704 is aimed at the protection of water resources specifically related to mining. The main purpose of GN 704 is to ensure that:

- Effect is given to the objectives of the NWA within the mining sector.
- Systems are in place at all mines to enable effective management of impacts of mining on the water resources.
- IWWMPs for mines are kept up to date and aligned with mining plans to demonstrate continual improvement in water resource protection and management.

- Regional and cumulative impacts are adequately accounted for during mining phases.

0.7 Area of Influence

The area of influence in hydrological terms was assessed for 4 tiers as follows:

- Tier 1 - Water Management Area
- Tier 2 - DWS Quaternary Catchment Areas
- Tier 3 - Site Delineated Catchment Areas
- Tier 4 - Affected surface water resources

The Geographical Information System (GIS) was used to obtain the quaternary catchment areas delineated by the DWS. Survey Data, 1:50 000 vector data sourced from the National Surveyor General was used to delineate smaller catchment areas that may be impacted by the proposed expansion. 27 catchments were delineated from the origin of B41G to De Brochen Dam.

This delineation was conducted utilising contour and river data. There are 27 drainage lines for the delineated catchment areas. It was deemed necessary to delineate smaller catchments as there are several river crossings at different catchment areas associated with especially the linear infrastructure components of the Project.

The Groot Dwars River, upstream of the De Brochen Dam is the direct area of influence. The De Brochen Dam could potentially be influenced by the deterioration in water quality. Therefore, it was assessed as the indirect area of influence.

0.8 Water and Salt Balance

The Water and Salt Balance analysis was conducted in line with the Best Practice Guidelines, BPG G2. Once all the water volume data was assessed and confirmed, by the mathematical equations, water quality was then introduced to the spreadsheet calculations. Water quality data was sorted for each unit with water quality monitoring data. It is important to note that with salt load calculations, the monitoring point with the poorest water quality data may not necessarily reflect the worst salt loads. Another determining factor is the volumes concerned.

The Water Balance for BCM1, BCM2, Valley boxcut, BS1/2 and BS4 is used to illustrate the cumulative flow of water through the system. It assists to determine if water will be required in the system or if excess water will be produced which needs to be handled and for which provision will need to be made.

The Water and Salt Balance report was split into two. The first part was the compilation of the Water balance. The secocond part was the compilation of the Salt Balance. The Water Balance reports were compiled by DRA Projects (Pty) Ltd. (Ref: Booysendal North, Central and South Integrated Water Balance report for Booysendal South Feasibility Study Project GBP-ENG-REP-001, Compiled by DRA Projects (Pty) Ltd – Revised March 2018). The Salt Balance was compiled by Letsolo Water and Environmental Services cc.

0.9 Storm Water Management Plan (SWMP)

Storm water management measures for Phase 1 and 2 involves the control of surface runoff and the separation of clean and dirty water. The volume and rate of runoff both substantially increase as land development occurs. Storm water runoff occurs when precipitation from rain flows over the land surface.

The addition of surface infrastructure including roads and building rooftops that prevent water from soaking into the ground result in the increases of runoff volume created during storms. Therefore, storm water management measures were recommended for the assessed activities based on the potential hydrological yield. The 1:50 and 1:100 years flood volumes were used. As part of authority consultation process, the DWS was consulted and the sizing of dirty water infrastructure was also discussed. The DWS indicated that consideration also has to be taken for the need of potential sizing of storm water infrastructure, including the Pollution Control Dams (PCD) to contain the 1:200 year, 24 hour storm event.

The only concern with containment of a 1:200-year storm event is the capacity of dams and the surface area required to contain the storm water runoff. The potential risk of flooding is minimized at Booysendal by separating operational water volumes from contaminated water volumes by designing a separate PCD. The normal day to day water management will be concentrated at the PCD. The PCD will be operated as empty as far possible.

All the dirty water from the operational areas will be directed to the PCDs. The dams have been sized according to the catchment areas of the portals and dirty water areas. The capacity of the dams will be able to accommodate a 1:200 year flood event and has been designed with the required 0.8m freeboard. Further details regarding the sizing of PCD are contained in Table 7-2.

0.10 Impact Assessment

Underground mining activities have lesser impacts on surface water resources when compared to opencast activities. However, due to the need of support services which may be located on the surface, it is necessary to ensure that reasonable mitigation measures are in place.

As part of the hydrological assessment, potential impacts associated with the Booysendal South Expansion Project Phase 1 and Phase 2 were identified. These potential impacts were considered for the current (Phase 1) and future (Phase 2) activities.

The impact identification assessment methodology was provided by Amec Foster Wheeler and is in line with international best practice and the requirements stipulated in Regulation 982 of 4 December 2014 (as amended 07 April 2017) promulgated in terms of Section 24 of National Environmental Management Act, 107 of 1998 (NEMA) and the External Guidelines issued by the DWS on Generic Water Use Authorisation Application Process, 2007.

0.11 Mitigating Measures

Reasonable measures as recommended in this report must be implemented in order to reduce the impact on surface water resources. These measures include the implementation of the SWMP developed for the Project in Section……...

0.12 Monitoring Requirements

Surface water samples must be collected on a monthly basis. A report summarizing the findings must be produced monthly. This report is an internal report which is used to keep records of changing water qualities as well as to notify the mine management team of the changes in water quality and areas of concerns. Trend analysis of water quality results must be done.

0.13 Professional Opinion

The proposed activity is recommended.

Underground mining activities have lesser impacts on surface water resources when compared to opencast activities. However, due to the need of support services which may be located on the surface, it is necessary to ensure that reasonable mitigation measures are in place. Should these measures be implemented then there is no reason why the project should not be allowed to go ahead.

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List of Abbreviations and Acronyms

Abbreviation	Description
BPG	Best Practice Guidelines
CA	Competent Authority
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
FEPA	Freshwater Ecosystem Priority Area
GN R	General Notice Regulation
IEM	Integrated Environmental Management
I&APs	Interested and Affected Parties
LoM	Life of Mine
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MPRDA	Mineral and Petroleum Resources Development Act, 28 of 2002
NEMA	National Environmental Management Act, 107 of 1998
NWA	National Water Act, 36 of 1998
OWMA	Olifants Water Management Area
SAWS	South African Weather Services
SWMP	Storm Water Management Plan
RSA	Republic of South Africa
ToR	Terms of Reference
WMA	Water Management Area

1.0 INTRODUCTION

Letsolo Water and Environmental Services cc was appointed to conduct the Hydrological Study for Booysendal Platinum (Pty) Ltd. Booysendal embarked on expanding its Booysendal Operation through the Booysendal South Expansion Project with the aim to increase mining of the PGM minerals from the UG2 and Merensky Reefs. The purpose of the expansion is to increase mining of the platinum group metals (PGM) from the UG2 and Merensky Reefs. Booysendal South Expansion Project Phase 1 & 2 specifically focuses on four development area. Namely:

- BS1/2;
- Merensky Portals and the Emergency Escape Portal
  - BCM1; and
  - BCM2;
- BS4; and
- BS4 Valley Boxcut.

The Booysendal Platinum Mine (Pty) Ltd project area is located in the Limpopo and Mpumalanga Provinces of South Africa. Booysendal consist of two Mining Rights (MR), namely the Booysendal North MR and the Booysendal South MR (old Everest mine). These MR are managed as one operation divided into five operational areas. Booysendal North (the existing mining operation), BCM1, BCM2 and BS1/2 (all four of these areas are located on the Booysendal North MR), while the Valley Boxcut and the existing Everest mine (BS4) is located on the Booysendal South Mining Right.

Dams with a safety risk are not anticipated for this project as none of the dams have a capacity ≥ 50 000m^3 and a dam wall exceeding 5m.

The Booysendal Operations currently consist of the active Booysendal North (BN) mine which is a fully operational 220ktpm underground mine with plant complex and associated infrastructure. The intention is to double the mine's capacity through the development of the Booysendal BS1/2 (located approximately 6km south of the current BN operation), BCM1, BCM2, and processing at BS4

The life of mine (LoM) of the Booysendal South (BS) Expansion Project is approximately 40 years. The total BS reserve is estimated at 105.88Mt.

Hydrological data used for the hydrological impact assessment is also used for the detailed civil design calculations. In order to adapt to the same data used for design flood calculations, design rainfall depth for the 1:50, 1:100 and 1:200 years, 24 hours storm event, were sourced from the South African

Weather Services Database, Station 0554516W – Beetgeskraal. This is the closest weather station to the Project site.

1.1 Phase 1 of the Booysendal South Expansion Project

The first phase of the Booysendal South Expansion Project involved the development of a portal complex at BS1/2, two adits at BCM1 and BCM2, upgrade of storm water management measures at BS4 and the Valley Boxcut, reworking of the tailings and backfilling of the underground workings at BS4 and linear infrastructure components (road, aerial rope conveyor, 132kVA power line) between the operational areas. Environmental authorisation (EA) for this Phase 1 of the Booysendal South Expansion Project was granted on 05 January 2018.

1.1.1 Phase 1 activities associated with BS1/2:

These activities include the development of the BS1/2 mine consisting of mining terrace, portal, seven adits, workshops, offices and water infrastructure. The activities associated with BS1/2 are as follows:

- Infilling of more than 5 cubic meters within the 100-year flood line of the Groot Dwars River for the establishment of the portal terrace and the main river crossing over the Groot Dwars River;
- Diversion of two unnamed tributaries of the Groot Dwars River upstream of the BS1/2 Shaft Complex;
- 132kVA powerline from BN to BS1/2;
- Stockpile and terracing for the BS1/2 portal within the 100m flood line of an unnamed tributary of the Groot Dwars River;
- Construction of a PCD, a sewage treatment plant and a drinking water treatment plant, mine dewatering, process water tanks and water storage tanks.
- Construction of a crusher plant and an associated conveyor system which will transport the ore to a new silo and from there to an ARC at the edge of the BS1/2 terrace;
- Construction of an ARC system from BS1/2 to BS4. The conveyor will cross the Groot Dwars River and several drainage lines;
- Construction of a bridge across the Groot Dwars River;
- Storage facilities for diesel, dangerous and hazardous chemicals;
- Oil separators and settlers for storm water;
- Various water infrastructure at BS1/2 including:
    - Raw water tank of 8,500m³;

  - Process water storage tank of 812m³;
  - Potable water storage tank of 10m³;
  - Potable water treatment plant with a throughput capacity of 15m³/h;
  - Sewage treatment plant with a capacity of 30m³/h; and
  - pollution control dam with a capacity of 14,000m³;
- Pipeline from BS4 to BS1/2 with a design capacity of 80m³/h but less than 120cm in diameter;
- Construction of a 13,2-meter-wide with a servitude of 30 meters from BN to BS1/2 and on to BS4. Vegetation clearance of the servitude and construction of 14 culverts commenced. The road crosses an unnamed tributary of the Groot Dwars River and a number of drainage lines; and
- Mining at BCM1 and BCM2

1.1.2 Phase 1 activities associated with BS4.

Phase 1 activities associated with BS4 include the following:

- Reworking and replacing of tailings on the existing Tailings Storage Facility (TFS1);
- Backfilling of the underground workings with tailings;
- Upgrade the storm water management system at BS4 in line with the Storm Water Management Plan developed by SLR in 2011, as basis for the upgrades. The following upgrades were considered. Some of these upgrades were done:
  - Upgrade of the storm water drainage at and downstream of the portal;
  - Upgrade of the clean and dirty water separation system upstream of the existing TSF1 and to the east of the existing portal and workshop complex;
  - Upgrade and lining of the plant PCD;
  - Decommissioning and rehabilitation of the workshop PCD;
  - Upgrade of the northern portal PCD;
  - Upgrade of the sewage treatment plant at the workshop; and
  - Construction of a PCD at the Valley Boxcut.
  - Water supply pipeline from the TKO dam to BS1/2 (with a view to abstracting water from the dam);
  - Increase in the size of the run of mine ore stockpile (ROM);
  - Silt trap at the upstream point of the conveyor system.
- A 13,9m wide access road between BS4 and the BS1/2 development, including several watercourse crossings;
- An ARC system between BS4 and BS1/2;

- Temporary access roads and laydown areas; and
- A pipeline from the TKO dam to the Valley Boxcut (the alignment of this pipeline is to be amended as part of the future proposed activities – see below).

1.2 Phase 2 of the Booysendal South Expansion Project

As part of the Phase 2 expansions, Booysendal plans to develop portals with surface infrastructure at BCM1 and BCM2, develop an Emergency Escape Portal east of BCM1 and BCM2, an ARC and water pipelines between BS1/2 and BN and a Backfill Plant with surface pipelines at BS4. This development requires the following activities:

1.2.1 Phase 2 activities associated with BS1/2

These activities include the following:

- Retaining the construction phase 11 kVA powerline from BN to BS1/2;
- Process and clean water pipelines between BS1/2 and BN;
- An Aerial Rope Conveyor (ARC) system from BS1/2 to BN.

1.2.2 Phase 2 activities associated with Booysendal North Mining Right:

These activities include the following:

- Development of identical surface infrastructure at BCM1 and BCM2;
- Retaining the 11kVA powerline from BN to BS1/2;
- Process and clean water pipelines between BS1/2 and BN;
- Access roads to the BCM1 and BCM2 Adits;
- An ARC system from BS1/2 to BN; and
- Surface conveyors between BCM1, BCM 2 and the ARC loading station; A crusher between BCM1 and BCM2;
- An emergency escape portal is planned just east of the BCM1 and BCM2 complexes. It will serve as a return airway system for BS1/2, BCM1 and BCM2 and as an emergency escape portal. This is to comply with the mine health and safety requirements. The emergency escape portal will have a development footprint area of 1.3Ha. Access will be gained from the main access road onto a 4m wide bitumen road.

1.2.3 Phase 2 activities associated with BS4:

Booysendal South Mining Right (BS4) involves:

- A Backfill Plant at BS4;
- Slurry pipelines from the Process Plant to the Backfill Plant and the underground workings;
- Three emergency backfill ponds along the slurry line; and
- Process water lines between the Backfill and Process plant and the return water dam (RWD).

Refer to Figure 1-1 for overall layout of the Booysendal South Expansion Project.

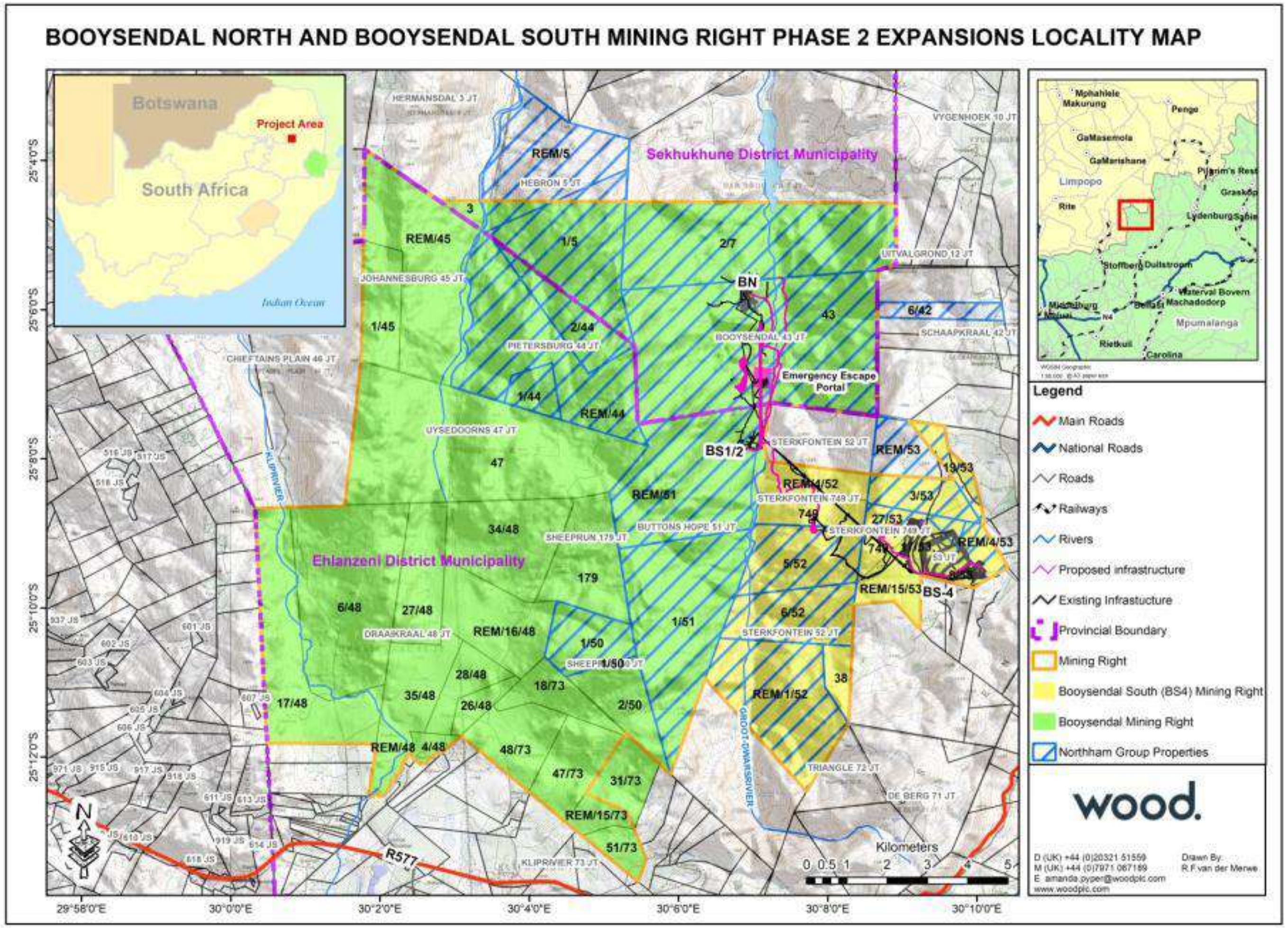

Figure 1-1: Integrated Booysendal Operation

1.3 Legal Requirements

This section contains the national and international requirements related only to Hydrological specialist field.

1.3.1 South African Legal Framework

For this Hydrological Assessment, the principal Act of relevance is the NWA which provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis, upon which to develop tools and means to give effect to the protection of water resources.

The Department of Water and Sanitation (DWS) published the Best Practice Guidelines for Impact Prediction (BPG G4). Various tools and techniques have been developed to enable the assessment of future water quality impacts from mining operations to be made. BPG G4 – Impact Prediction, is the relevant tool for the identification and rating of potential Impacts. A standard template used for this study is in line with the Best Practice Guidelines as it considers the impact prediction methodologies and processes recommended in the guidelines. The methodologies include the following:

- Undertaking the site visit;
- Collection of background information;
- Implementation of sampling and analytical programme;
- Review of data;
- Impact predictions;
- Recommend management options; and
- Develop a monitoring and validation program.

It is important to understand that these tools were generally developed to answer very specific questions that are relevant to the regulatory environment.

The legal platform, on which the Hydrological Assessment is based, is summarized briefly by the following main legislation and Guidelines (prescribed by the DWS, previously known as the Department of Water Affairs and Forestry):

General Notice 704 (GN704) of 1999, contains regulations specifically related to mining activities and is aimed at the protection of water resources. Specifically related to this proposed project the following restrictions are applicable in terms of GN704:

Activity 4: "No person in control of mine or activity may:

- 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 meters from watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become water-logged, undermined, unstable or cracked – this specifically relates to the BS1/2 and the proposed main road crossing across the Groot Dwars River;
- Except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within 1:50 year flood line or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest; -
- 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
- Use any area or locate any sanitary convenience, fuel 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."

The following Best Practice Guidelines (BPGs) of 2006 were considered in conducting the Hydrological Assessment.

- BPG A4 – Pollution Control Dams;
- BPG G1 – Storm Water management
- BPG G2 – Water and Salt Balance;
- BPG G3 – Water Monitoring; and
- BPG H2 – Pollution Prevention and Minimization of Impacts.

1.4 Site location

As it can be seen in Figure 1-2, the Booysendal Project is located in the Limpopo and Mpumalanga Provinces of South Africa. The Project is located on the farms Booysendal 43JT, Remaining extent (RE) of the farm Buttonshope 51JT, Portion 4, 1, and 5 of the farm Sterkfontein 52JT, the farm Sterkfontein 749TJ, the RE of Portion 4 and 15 and Portions 8, 19, and 27 of the farm De Kafferskraal 53JT. The project area falls within DWS Quaternary Catchment B41G.

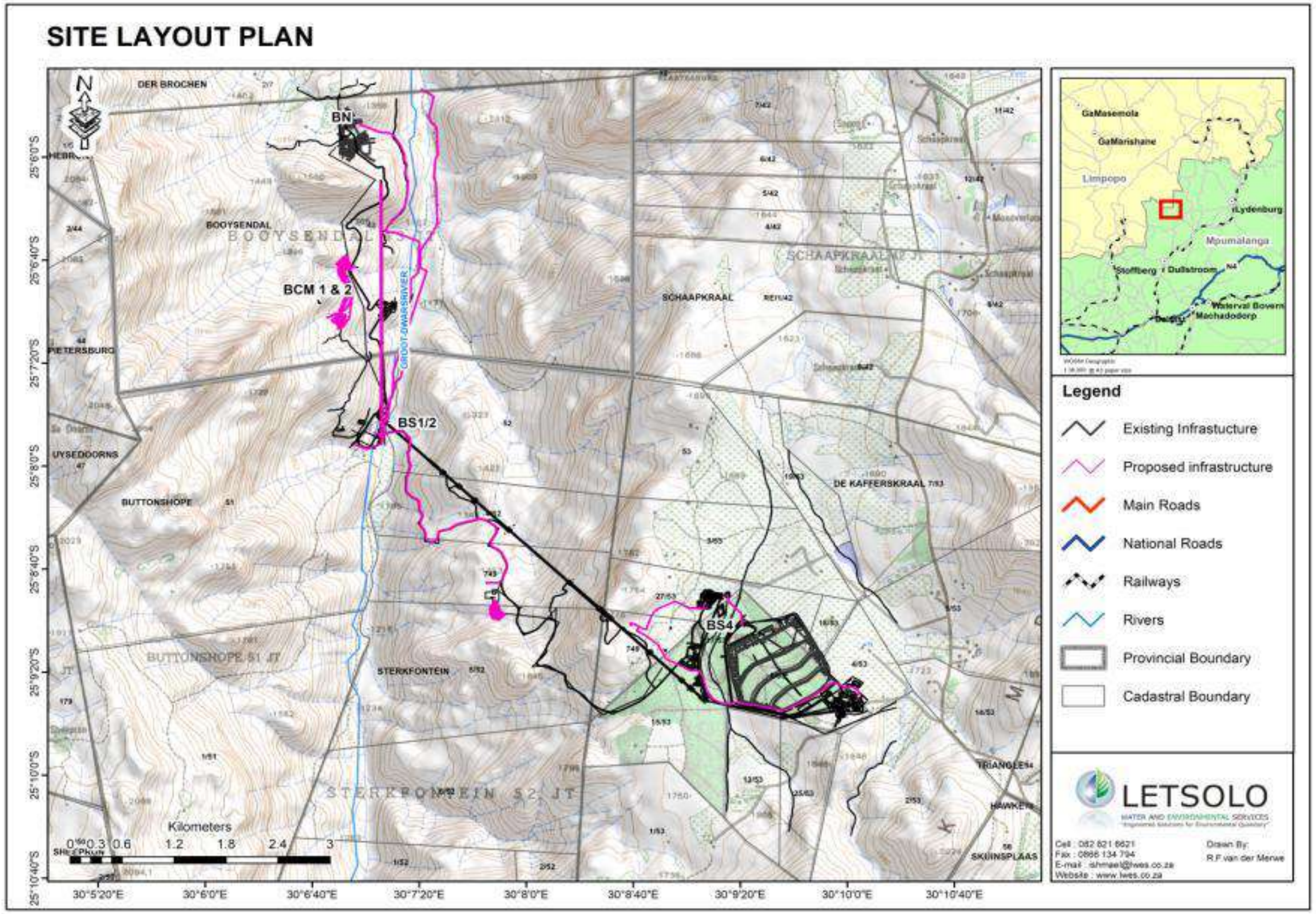

Figure 1-2: Site Location

1.4.1 Resource Water Quality Objectives

The following water quality standards and guidelines were considered during the Hydrological Assessment:

Resource Water Quality Objectives (RWQOs) are the water quality components of the Resource Quality Objectives (RQOs), defined by the NWA, “as clear goals relating to the quality of the relevant water resources’’. The integrated Resource Directed Measures (RDM) manual (DWAF, 1999) defines RQOs as “a numerical or descriptive statement of the conditions which should be met in the receiving water resource in order to ensure that the water resource is protected.” Thus, the RWQOs outline both water user needs with respect to water quality, as well as their needs with respect to the disposal of water containing waste to the resource (a water use need). RWQOs are aimed at ensuring that local priorities are appropriately balanced with broader spatial and temporal perspectives (WMA and national level).

The determination of RWQOs are influenced by socio-economic need to utilise the capacity of water resources, on the one hand, and on other hand, by the need to protect the water resources in order to ensure healthy functioning aquatic ecosystem together with water that is fit to use by recognised sector. RWQOs are pre-requisite for water quality.

The Groot Dwars River is the most significant surface water resource in Quaternary Catchment B41G. When we consider the Integrated Unit of Analysis as contained in the classes of water resources and resource quality objectives for the Olifants catchment, dated 17 March 2016, B41 G falls within the Steelpoort River Catchment (Technically referred to as Integrated Unit of Analysis – IUA 6) As indicated in Table 1-1 below, For IUA 6, there are no objectives for Nutrients, Salts, and System Variables and Pathogens. Only toxins are considered.

Table 1-1: Resource Water Quality Objectives (RWQO) – Catchment Based

Intergrated Unit Analysis No.			IUA 1				IUA 2	IUA 3	IUA 4	IUA 5	IUA 6	IUA 7	IUA 8	IUA 9	IUA 10	IUA 11	IUA 12	IUA 13
Intergrated Unit Analysis Identity.			Upper Olifants River catchment				Wilge River Catchment Area	Selons River area including Loskop Dam	Elands River Catchment Area	Middle Olifants up to Flag Boshielo Dam	Steelpoort River Catchment	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	Spekboom Catchment	Orighstad River Catchment	Lower Olifants	Ga-Selati River Area	Lower Olifants within Kruger National Park	Blyde river Catchment Area
Water Resource Classes			III				II	II	III	III	III	III	II	III	II	III	II	I
River name			Olifants (Released from Witbank Dam)	Olifants (EWR Site 1 - EWR1) (Existing)	Klipspruit (Confluence with Olifants)	Olifants	Wilge (ERW site - ERW4, Outlet of IUA2) (Existing	Olifants (Outlet of Quaternary - Outlet of IUA3)										
River Water Quality: Sub Components			Numerical Maximum Limits in mg/l (Unless stated otherwise stated)															
	Nutrients	PO4	0.125	0.125	0.125	0.015					0.125			0.125				
		NO3 & NO2	4	4		0.7								4				
		Total Ammonia	0.1	0.1														
	Salts	SO4	500		500	80	200	200								500		
		EC	111		111	55		111								111		
	System Variables	Alkalinity	> or = 60		> or = 60													
		Turbidity	10		10													
		Dissolved Oxygen	> or = 6.5		> or = 6.5													
		Suspended Solids														50	25	
	Toxins	F	3		3		2.5	3			2		3			2.5		
		Al	0.15		0.15		0.105	0.15			0.063		0.15			0.105		
		As	0.13		0.13		0.095	0.13			0.058		0.13			0.095		
		Cd Hard	5		5		3	5			1.6		5			3		
		Cr (vi)	200		200		121	200			68		200			121		
		Cu Hard	8		8		6	8			4.9		8			6		
		Hg	1.7		1.7		0.97	1.7			0.53		1.7			0.97		
		Mn	1.3		1.3		0.99	1.3			0.68		1.3			0.99		
		Pb Hard	13		13		9.5	13			5.8		13			9.5		
		Se	0.3		0.3		0.022	0.3			0.013		0.3			0.022		
		Zn	36		36		25.2	36			14.4		36			25.2		
		Cl	5		5		3	5			1.8		5			3		
		Endosulfan	0.2		0.2		0.13	0.2			0.08		0.2			0.13		
		Atrazine	100		100		78.5	100			48.8		100			78.5		
	Pathogens	E-coli							130 counts	130 counts								

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The determination of RWQOs provides the basis for water quality reconciliation, water quality allocation, benchmarking during water quality foresight, and determination of water quality stress. RWQOs also allow for meaningful water quality scenario analysis, intervention planning and strategy establishment: aforementioned all being central to Water Quality Planning (WQP). RWQOs for the Groot Dwars River as indicated in the current Integrated Water Use License (IWUL) for BS4 are included in Table 1-2.

Table 1-2: Resource Water Quality Objectives (RWQO) (IWUL)

Variable	RWQO
Ph	Range 5-9.5
TDS	520
Ca	25
Mg	25
Na	9
K	46
Cl	62
SO4	70
Nitrate as N	6
Cr6	0.14

RWQOs provide the basis for determining the allocable water quality and are typically set at a finer resolution than RQOs to provide greater detail upon which to base the management of water quality. RWQOs forms part of the mechanism to make the definition of pollution in terms of the NWA operational in the current context of resource directed water quality management (DWAF, 2006a). As such, this allows for different levels of impact for different water resources though aligned with catchment visions.

1.4.2 South African Bureau of Standards

South African Bureau of Standards (SABS) SANS 241-1:2015 Drinking Water Standards - ANS 241: 2015 was published in March 2015. SANS 241-1 is applicable to all water services institutions and sets numerical limits for specific determinants to provide the minimum assurance necessary for drinking water, it is deemed to present an acceptable health risk for lifetime consumption. SANS 241-2015 assists with the interpretation and application of the standard;

1.4.3 DWA Water Quality Guidelines

DWS South African Water Quality Guidelines Volume 7 for Aquatic Ecosystems (1996d) – These guidelines are aimed at protecting and maintaining the health of aquatic ecosystems, and differ from those of other water uses (DWAF 1996d). It is difficult to determine the effects of changes in water quality on aquatic ecosystems as the cause-effect relationships are not well understood. Therefore, water quality criteria have to be derived indirectly through extrapolation of the known effects of water quality on a very limited number of aquatic organisms (DWAF 1996d). Certain quality ranges are required to protect and maintain aquatic ecosystem health. In terms of protecting aquatic ecosystems, changes in water quality should be prevented rather than mitigated, as it is seldom possible to mitigate the effects of poor water quality for aquatic ecosystems to the same degree as for other uses.

1.5 Specialist Expertise

(a) Details of the specialist who prepared the report;

Details of the specialist who prepared this report are summarised as follows:

Surname	: Phalane
First Names	: Ishmael Letsolo
Specialty	: Hydrology
Entity	: Letsolo Water and Environmental Services
Identity no	: 800602 5393 082
Nationality	: South African
NQF Level 5	: Baccalaureus Technologiae: Civil Engineering
Professional Registration	: Engineering Council of South Africa Reg No. 201480763
	: Water Institute of South Africa
	: Institute of Directors of South Africa

(b) The expertise of that specialist to compile a specialist report including a curriculum vitae;

Mr Phalane has more than 14 years' experience in the field of Hydrological Engineering (Hydraulics, Water Quality and Quantity). Over the years Mr Phalane gained valuable experience in the implementation of the National Water Act, 1998 (Act 36 of 1998), National Water Resource Strategy, implementation of the General Authorizations as well as Water Use License Authorizations.

Mr Phalane has extensive experience in Hydrological Impact Assessment for Environmental Impact Assessments (EIA's), Environmental Management Program Reports (EMPR's), Site Management Plans, Water Balance Calculations, Mine Closure Applications and Water Conservation/Demand Management Principles.

Mr Phalane was appointed as a Technical manager by the Department of Water and Sanitation (DWS) during the Revision of Government Notice 704 (GN704) for the period starting on the 10th of January 2013 and ending on the 31rst of December 2013.

Mr Phalane was also part of the technical team assessing the Water Use License Applications on Behalf of the Department of Water and Sanitation (Letsema Backlog Project). Specifically, to review Storm Water Management Plans (SWMP), Hydrological Impact Assessment Reports (HIAR), Water

Quality Management Reports (WQMR), Integrated Water And Waste Management Plans (IWWMP) and Section 27 Water Use Motivations. Mr Phalane also compiled the Record of Recommendation to be considered and approved by the Director General (DWS), on behalf of the Regional Director (DWS) (01 April 2013 – 31 March 2014).

Mr Phalane was part of the negotiation team during the transfer of Sand-Vet Government Water Scheme to Sand Vet Water User Association in 2001. In the field of Civil Engineering Mr Phalane gained valuable experience in calculation and analysis of hydrological data and liaison with different organizations in the private, governmental and international sectors, through negotiations with Irrigation Boards. He is practical and have the ability to, logically and strategically, resolve a problem and to work under pressure of a deadline.

As a director, Mr Phalane is involved in strategic decision making in line with the company's vision, mission and values to ensure long term sustainability of the company during the recession time and beyond by being competitive, by developing staff as well as personal development in top management.

In today's engineering industry, new technologies and practices are making a significant difference on how projects get delivered. But the application of new tools, technologies, and practices may seem confusing. With his extensive experience, Mr Phalane has the ability to assist.
(Please refer to Table 1-3 below for details regarding professional registration)

Table 1-3: Professional Registration

Class	Professional Society	Year of Registration
Member	Engineering Council of South Africa Civil Engineering Technologist (ECSA - registration no: 201480763)	2014
Member	Institute of Directors South Africa	2007
Member	Water Institute of South Africa	2005

1.5.1 Declaration of Independence:

I, Ishmael Phalane, act as the independent specialist in the environmental authorisation and EMP amendment processes for Booysendal Mine South expansion. I will perform the work relating to the environmental authorisation applications in an objective manner, even if this results in views and findings that are not favorable to the applicant.

I declare that there are no circumstances that may compromise my objectivity in performing such work. I have expertise in conducting the Hydrological Impact Assessment specialist study and report relevant to the environmental authorisation applications. I confirm that I have knowledge of the relevant environmental Acts, Regulations and Guidelines that have relevance to the proposed activity and my field of expertise and will comply with the requirements therein.

I have no, and will not engage in, conflicting interests in the undertaking of the activity.

I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has, or may have, the potential of influencing any decision to be taken with respect to the application by the competent authority; and
the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

All particulars furnished by me in this report are true and correct. I realise that a false declaration is an offence in terms of regulation 48 of the National Environmental Management Act, 107 of 1998 (NEMA) and is punishable in terms of section 24F of the Act.

Signature of the environmental assessment practitioner:

Letsolo Water and Environmental Services cc
Name of company:

03 May 2018
Date:

1.6 Scope of work and purpose of the study

The scope of work for the Hydrological Assessment and Storm Water Management Plan allows for the following:

Analysis of the Physical Hydrological conditions for DWS Quaternary Catchment B41G and its larger surrounding areas (up and downstream catchments including the De Brochen Dam) with specific focus on the area of influence (AoI). The physical hydrological conditions include defining flow as high/low/pond/dam/pumped and recording of physical parameters including water temperature and electrical conductivity (EC);

Evaluation of the physical hydrological conditions such as slope, permeability and vegetation cover, for delineated site specific catchment areas. These physical characteristics were used to calculate the peak flows for the 1:50, 1:100 and 1:200 years storm event;

- To propose management and mitigating measures that will ensure that the natural environment is preserved and protected as far as possible:
  - Flood lines were delineated to assess the location of proposed infrastructure in detail. GN 704 provides regulations for the location of dirty water infrastructure (and mine infrastructure). In instances where dirty water or mining infrastructure is located within the 100m buffer or the 1: 100 years flood area mitigation and management were proposed;
  - A SWMP was developed in compliance with BPG G1 –SWMP to assist in the protection of the water resources;
- Surface water catchments were identified and delineated in development area;
  - Catchment areas were delineated for the river crossings during the designs of culvert crossings to determine the required culvert sizes;
- Analysis of the catchments and sizing of storm water control measures to ensure that clean and dirty water is separated (collected, contained, and controlled) effectively;
  - Dirty Water Catchment Areas were delineated. Storm water management measures for the collection of contaminated water were recommended. This includes the sizing and location of the PCDs. Clean water trenches were designed to reduce the dirty water volumes by proper separation of clean and dirty water.
- Flood calculations for the 1:50, 1:100and 1:200-year flood events to determine design requirements;

- Determination of the current status of any surface water resources which are in the affected area or may be affected by the activities in terms of existing resource objectives, inclusive of water quality and in-stream flow;
- Water Quality Management:
  - Historic water quality data is based on monitoring points located near Booysendal North and South. Additional monitoring points were created for the sake of the Hydrological Impact Assessment. Eight (8) additional water monitoring points were recommended and samples were collected at these points. Water was analysed for chemical and microbiological indicators. The interpretation of the analysis report will be included in the Hydrological Impact Assessment.
- Review and summarise other technical reports for studies conducted simultaneously with the Hydrological Impact Assessment;
- Water and Salt Balance Calculations:
  - Incorporates water sources and losses values based upon design volumes for the water abstracted, discharged, process water intake, outflow to and return water to other facilities;
  - Incorporates accurate values determined from suitable measurement or modeling of rainfall, runoff, seepage and evaporation;
  - Compile a diagram that delineates the affected area into clean and dirty areas; and
  - Routing and directing clean storm water runoff to the nearest receiving watercourse.
- Risk assessment and Mitigation Measures
  - Identify potential risks for the construction, operational and decommissioning phase;
  - Maximises the application of pollution prevention measures, based on assessment of the long-term impacts of applied closure management actions on the water resource in accordance with impact prediction procedures;
  - Define monitoring programmes that should be implemented to collect data to allow for scheduled future updates and improvements in accuracy of the impact predictions;

Civil Engineering Designs by the DRA design engineers will commence in June/July 2018. After the finalization of the detailed designs, the Stormwater Management section of this report should be amended.

1.7 Purpose of the Study

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

- Effect is given to the objectives of the NWA.
- The hydrological regime applicable to the Project is understood.
- Systems are in place to enable effective management of impacts on the water resources.
- Consistent and sustainable implementation of water management hierarchy at the proposed facilities that have a potential to impact on the water resource.
- To undertake the Hydrological impact assessment and Water and Salt Balance and to propose management measures

1.8 Report Structure

This report is structured as follows:

0.0 EXECUTIVE SUMMARY
1.0 INTRODUCTION
2.0 PROJECT DESCRIPTION
3.0 DATE AND SEASON OF THE SITE INVESTIGATION
5.0 STATUS QUO
6.0 SENSITIVITIES
7.0 STORM WATER MANAGEMENT PLAN
8.0 FLOOD LINE DELINEATION
9.0 WATER AND SALT BALANCE
10.0 IDENTIFICATION OF AREAS TO BE AVOIDED
11.0 ASSUMPTIONS MADE AND ANY UNCERTAINTIES
12.0 POTENTIAL IMPACTS
13.0 MITIGATION MEASURES
14.0 CONDITIONS FOR INCLUSION IN THE EMPR
15.0 MONITORING REQUIREMENTS
16.0 REASONED OPINION
17.0 PUBLIC PARTICIPATION
18.0 CONCLUSION
19.0 RECOMMENDATIONS
20.0 REFERENCES

2.0 PROJECT DESCRIPTION

Booysendal embarked on expanding its Booysendal Operation through the Booysendal South Expansion Project with the aim to increase mining of the PGM minerals from the UG2 and Merensky Reefs. The Booysendal South Expansion Project specifically focusses on four development areas (BS1/2, BCM and BCM2, BS4 and BS4 Valley Boxcut) with linear and supporting infrastructure between the various development areas. The EA for Phase 1 of this larger expansion project has already been granted on 05 January 2018 and construction activities are ongoing.

Booysendal has identified further expansion needs (Phase 2) which require an amendment of the EMP and authorisation for listed activities in terms of Section 24 of the NEMA, listed activities in terms of the National Environmental Management: Waste Act 59 of 2008 (NEMWA) and an IWULA process under the National Water Act, 36 of 1998 (NWA) for all proposed future and current Section 21 water uses. The IWULA process, EA and EMP Amendment processes are carried out concurrently.

The Booysendal South Expansion Project (Phase 1 and Phase 2) consists of the following components:

- Phase 1 activities associated with BS1/2;
- Phase 1 activities associated with BS4;
- Phase 2 Activities associated with BS1/2;
- Phase 2 activities associated with Booysendal North Mining Right;
- Phase 2 activities associated with BS4 ; and
- Future activities associated with the Valley Boxcut.

The above-mentioned activities are covered explicitly in Paragraph 1 – Introduction. As indicated in Paragraphs 2.4.1 and 2.4.2, other activities relating to this project includes the Construction of the ARC and Main Access road.

2.1 Aerial Rope Conveyor

The system has the potential to transport 25,000t/h. It is an ideal system to use in mountainous deep valley terrains, as this in which the Project is located. It allows for the spanning of a flat belt system with corrugated walls to carry the ore. This design assists in limiting any spillage of ore off the belt. The belt moves through wheels fitted to fixed axles on either end of the belt. The transport ropes are elevated off the ground on tower structures.

The ARC also allows for limited ground disturbance due to the spares spacing of the towers (tower spacing's of 1km is possible), which in this environmental sensitive area is especially important and can span across environmental sensitive areas thereby limiting impacts. A total of Six (6) towers for the entire project studty area are either located within 100m, within drainage lines or within delineated wetlands.

Storm water management measures in this regard are discussed further in the report.

2.2 Main Access Road

A new access road is required from BN, via the BS1/2 to BS4. Construction of this road commenced as part of Phase 1 and is nearly finalised.

The road will be a two way hard top single carriageway road. The road will run from BN, past BS1/2 to BS4. Several drainage line crossings are applicable to this road of which the major crossing is across the Groot Dwars River.

. The road is 13.9m wide. Passing lanes and arrestor beds will be included in the design. Several alternative alignments for the road have been considered.

3.0 DATE AND SEASON OF THE SITE INVESTIGATION

Two field investigations were conducted.

- An initial scoping phase site visit; and
- Second site visit for Impact Assessment.

3.1 Initial site visit

The initial site visit was conducted on 07 and 08 December 2015 to gain a general understanding of site conditions and the hydrology of the study area.

3.2 Second Site Visit

The second site visit was conducted on 08 and 09 February 2016 to conduct further investigations. The site investigation made allowance for the following:

- Identification of nearby streams;
- Collection of water quality samples;
- Records of the pre-development state;
- Identification of areas that may be hydrological affected by the proposed development;
- Logging of areas of interest for mapping purposes; and
- Characterisation of tributaries in terms of their perennial or non-perennial nature.

4.0 DESCRIPTION OF THE METHODOLOGY

This report is a compilation of several Surface Water Related studies. Various specialist reports were developed in support of the Project and Project components.

Table 4-1: Related Studies

Specialist Study	Report Version and Company/ Specialist	Purpose of the Study
Water Balance Report	Booysendal Central and South Integrated Water Balance Report for Booysendal Central Environmental Management Plan Report, February 2016, compiled by DRA	<u>Water Management:</u> Estimate of water requirements. Estimate efficient re-use of water. Estimated required surplus water. Guide for the design of storage and conveyance of water. Provides the information for defining & driving water management strategies. Paragraph 9 covers the Annual Water Balance for BS1/2, BCM1, BCM2 and BS4.
Storm Water Management Plan	Storm Water Technical Report: Booysendal Central Expansion (temporary road), February 2016, compiled by SNA Civil and Structural Engineers (Pty) Ltd;	Focussed on temporary access road. Protection of surface water resources during storm events. Clean and dirty water separation. Sizing of water infrastructure. Related paragraphs are covered in the paragraphs as follows: • Paragraph 7.2 – Phase 1 BS1/2 Clean Water Diversion Channels. • Paragraph 7.3 - Phase 1 BS4 Activities • Paragraph 7.4 – Phase 2 BS1/2 Dirty Water Infrastructure • Paragraph 7.5 – Phase 2

		BCM1 and BCM 2 • Paragraph 7.6 – phase 2 BS4 Activities
Flood Calculation	Everest Box Cut and Flows Layout Map, 25 May 2009, Plan Number T9887CT-123-01, Compiled by BVI Consulting Engineers.	Guidance with regards to the location of infrastructure.
Storm Water Management Plan	Storm Water Technical Report: Booysendal Central Expansion (Permanent road), April 2016, compiled by SNA Civil and Structural Engineers (Pty) Ltd;	Focussed on the main access road Protection of surface water resources during storm events. Clean and dirty water separation Sizing of water infrastructure
Flood line Delineation Study Flood line	Booysendal Flood line Layout Map, Compiled by SNA Civil and Structural Engineers (Pty) Ltd, Drawing Number: SNA-TP1506-W01.	Guidance with regards to the location of infrastructure. The flood lines covered the following areas: • Groot Dwars River near Booysendal North; • Everest Stream near BS4.
	Booysendal Flood line Layout Map, Compiled by DRA, Drawing Number: MO413-30000G005.	Guidance with regards to the location of infrastructure. The flood lines covered the following areas: • Groot Dwars River at BS1/2; • Groot Dwars River near Booysendal North;
Storm water Management Plan	Booysendal Central Rainfall Data and sizing of PCD, Holley and Associate (Pty) Ltd, dated 22 October 2015.	Protection of surface water resources during storm events. Clean and dirty water separation Sizing of water infrastructure

Aquatic Ecosystem Assessment	Booysendal Platinum (Pty) Limited, Booysendal South Expansion Project (EMP, EIA and S24G): Specialist Aquatic Ecosystem Assessment Phase 2 – March 2018	Investigations on the Habitat, Biota and Water Quality of the River System.
Groundwater Study	Northam Platinum Booysendal BS1/2 and BS4 complex development - Groundwater EIA study. Future Flow Groundwater and Project Management Solutions	Groundwater Impact Assessment

Additional work conducted by Letsolo Water and Environmental Services cc includes the following:

- Standardizing hydrological data to ensure that there is a common source for hydrological data for all surface water related studies;
- The legal requirement regarding the sizing and site location of hydraulic structures is adhered to;
- Effect is given to the objectives of the NWA as well as subsequent GN 704;
- Some structures are already constructed. This report also reviews the existing infrastructure against GN 704 and Best Practice Guidelines;
- Assess historic water quality Trends as a means of compiling baseline water quality information.

The following sub-sections provide a description of the methodologies used for:

- Flood calculations;
  - Culvert Sizing;
  - Detailed road design.
- Impact Assessment;
- Water Quality Monitoring;
- Water and Salt Balance;
- Flood line delineation. and
- Storm Water Management Plan

4.1 Methodology for flood calculations for culvert sizing and clean and dirty water infrastructure components

Flood calculation methods were applied for the sizing of culverts at river crossings, sizing of proposed clean and dirty water management infrastructure, as well as to determine if existing infrastructure can manage to collect, convey and contain contaminated water.

Several entities were appointed to conduct flood calculations. The common Hydrological Method applied was the Rational Method. This method is highly dependent of field observations data. To determine the flood volumes following the rational method the following needs to be considered:

- run-off coefficient;
- Slope;
- Vegetation; and
- Permeability.

The Rational method was selected as the most reliable method for site specific flood calculations, based on the size of the catchment as well as the reliability of input data. The Rational method is based on a simplified representation of the law of conservation of mass. Rainfall intensity is an important input in the calculations; because uniform aerial and time distributions of rainfall have to be assumed.

This procedure affords the designer the opportunity to take changes in slope and vegetation cover of the catchment into account. Generally, the average area slope is preferred because it averages out the effect of very steep slopes at the head of the catchment with that at the outlet which is generally shallower.

Field observation data were used to calculate the Runoff Coefficient.

The runoff coefficient (c) represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception; all of which affect the time distribution and peak rate of runoff. The runoff coefficient is the variable of the Rational method, least-susceptible to precise determination and requires judgment and understanding on the part of the designer. This coefficient differs from site to site as it depends on site conditions, as observed during the site visit. The conditions that have an impact on the runoff coefficient are slope, vegetation cover and permeability.

The 1085m (10% and 85% of the hydraulic length) height difference refers to the difference between elevation height at 10% and 85% of the length of the watercourse. This height difference is then divided by the length of the watercourse to determine the 1085 slope.

The flood calculations are based on the information obtained from the following Weather Stations:

- 0554516 (Beetgeskraal);
- 0553762 (Roossenekal);
- 0593419 (Martenshoop);
- 0553859 (Tonteldoos);
- 0554614 (Zwagershoek) and
- 0554560 (Rustenburg).

The distance weighted average Mean Annual Precipitation (MAP) of these stations was determined to be 728mm. The arithmetic mean MAP of these stations was determined to be 730mm. The latter, which is the worst-case scenario, was used in the runoff computations.

4.1.1 An important consideration in runoff calculations is that of time of concentration (ToC). It is the determinant of the intensity of rainfall that is likely to fall. For these relatively steep catchments it is vital to determine the ToC realistically. Flood calculations for sizing culverts

The drainage for the permanent hard top road between BN (via BS1/2) and BS4 was designed in accordance with the *South African Drainage Manual* issued by SANRAL. The Manual has recommended storm return periods for different classes of road. The drainage for the road was designed to cater for the 1:10-year storm, an event which has a 10% probability of occurring in accordance with the drainage manual for a Class 3 rural minor arterial. The drainage elements were designed in accordance with *South African Drainage Manual* issued by SANRAL. The drainage of the road comprises the following elements:

- Cross drainage;
- Side drains;
- Chutes; and
- Erosion protection.

Culverts, side drain, chute and erosion protection design was based on analysis. The catchment areas are relatively small and the Rational Method was considered appropriate for the calculations of peak runoff. This method is a simple technique for estimating a design discharge for small drainage basins.

Where:

Discharge = Runoff Factor(C) X Intensity of rain (I) X Area of Catchment (A) (Q=CxIxA).

The first step in the process was to position culverts at low points identified from the long-sections of the road and to determine the extent of the catchments contributing to the flow arriving at the culvert.

The second step was to delineate the catchments with the aid of 1:50 000 topographical maps, mining survey maps and contour maps from the Chief Surveyor General.

The third step was to determine the runoff factor based on the characteristics of the catchments such as size, slope, infiltration, vegetation and impervious areas. The catchments are situated on the hillside which is relatively steep and results in very short response times.

4.1.2 Dirty water volumes for dirty water channels and Pollution Control Dam

The Rational Method was used to size the dirty water collection channel as well as the PCD.

The same method use d for the sizing of culverts, is also used to determine the capacity of the PCD.
In most algorithms and formulae for runoff calculations there is a measure of how much water is likely to flow off the particular catchment. It is a complex number and is made up of a landscape cover weighted average. Research by others showed that rock cover in a catchment reduces runoff up to a threshold value of about 60% and after that it increases runoff. In this instance the rock cover is more than the threshold value. Based on research guidelines a C value of 33% was selected. This is conservative bearing in mind that urban environments have a C value of 40%.

4.2 **Methodology for Impact Rating**

An aspect and impact matrix was used during the Scoping Phase to assist in identifying potential interactions between environmental and social receptors and Project activities. Where interactions were deemed likely, the interaction were further rated to determine if impacts could potentially be created which should be further investigated during the specialist investigation phase. The matrix made provision for the identification of potential interactions for all phases of the Project (either positive or negative).

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

- Direct impacts – interactions and impacts which could be caused by an activity or action and occur at the same time and place (e.g. direct footprint of project infrastructure locations);
- Indirect impacts – interactions and impacts caused by an action and occur later in time or farther removed in distance, or which may cause an impact on another environmental or social receptor or component but are still reasonably foreseeable, e.g. soil erosion due to exposure of surfaces is the direct impact and siltation of surface water as a result of the erosion, is the indirect impacts; and
- Cumulative impacts - impact on the environment, which results from the incremental impact of the action when added to other past, present, associated and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Where cumulative impacts can be expected,

To ensure consistency, Similar Impact Rating Definitions were applied for current and future activities.

4.2.1 Impact Rating Definitions

Likelihood, duration, extent, magnitude, sensitivity and significant ratings should be based on the following scoring scheme:

Table 4-2: Likelihood:

1 = Unlikely	2 = Possible	3 = Likely	4 = Definite Likelihood
Low probability of occurrence with the implementation of management measures	Possible that impact may occur from time to time	Distinct possibility that impacts will occur if not managed and monitored	Impacts will occur even with the implementation of management measures

Table 4-3: Duration:

1 = Short term	**2 = Medium Term**	**3 = Long Term**	**4 = Permanent**
Possible to immediately or within a short period of time mitigate / immediate or fairly quick progress with management implementation <3 yr	Impacts reversible within the Life of Mine +3 to 5 yrs	Impacts will only cease after the operational life +/- 50 yrs	Long term, beyond mine closure or irreplaceable

Table 4-4: Extent:

1 = Localised	2 = Confined to site	3 = Wider area of Influence	4 = National / International
Localised to specific area of activities	Confined to the site	The extent of the impacts will affect the wider area of Influence	Importance of the impact is of provincial or national importance

Table 4-5: Magnitude:

1 = Low	**2 = Minor**	**3 = Moderate**	**4 = High**
Minor deterioration Nuisance Will not cause any material change to the value or function of the receptor Emissions comply with legal limits Emissions contained within footprint	Moderate deterioration, partial loss of habitat / biodiversity/ social functions or resources, Emissions at times exceed legal limits Emissions reach outside project footprint	Reversible although substantial illness, injury, loss of habitat, loss of resources Notable deterioration of functions Impact on biodiversity Causes a change in the value or function	Mainly irreversible Causes a significant change in the environment affecting the viability, value and function of the receptors Substantial impact on biodiversity Death/ loss of receptors

		of receptor but does not fundamentally affect its overall viability Emissions regularly exceed legal limits Emissions will affect the wider region	Emissions do not comply with regulations, Extinction of Red List species

Table 4-6: Sensitivity:

1 = Low	2 = Moderate Low	3 = Moderate	4 = High
Areas already subjected to significant degradation Non-designated or locally designated sites/habitats Non-sensitive receptor with regards to the impact type (e.g. noise receptors) No vulnerable communities	Partially degraded area Sensitive receptors present Small number of vulnerable communities present	Regionally designated sites / habitats Regionally rare or endangered species Moderately sensitive receptor with regard to the impact type Some vulnerable communities present	Nationally or internationally designated sites/habitats Species protected under national or international laws / conventions High sensitivity with regard to the impact type High number of vulnerable communities present High dependency

Table 4-7: Significance

		Likelihood + duration + extent + sensitivity			
		Low (+ / -) ≤4	Minor (+/ -) 5 – 8	Moderate (+ / -) 9 – 12	High (+ / -) 13 – 16
Magnitude	Low (1)	Not significant	Not significant	Minor	Moderate
	Minor (2)	Not significant	Minor	Minor	Moderate
	Moderate (3)	Minor	Moderate	Moderate	High
	High (4)	Moderate	High	High	High

4.3 Methodology for Water Quality Monitoring

Internationally recognised Water Quality Monitoring methodology was applied for the study area. It is very important to ensure that each sample bottle is correctly identifiable, filled accordingly and does not leak.

4.3.1 Sampling Methods and Guidelines

Samples were collected and preserved immediately after collection to ensure that the samples are maintained in a condition representative of their in-situ state. The sampling and sample preservation was undertaken according the following guidelines:

- SABS ISO 5667-2: 1991 Guidance on sampling techniques; and
- SABS ISO 5667-3: 1994 Guidance on the preservation and handling of samples.

4.3.2 Sample bottling and labelling

All samples were collected utilizing sterilized bottles. Before a sample was collected, a prescribed sampling bottle was labelled in correspondence with the monitoring point from which sampling was done. The bottle was rinsed at least three times with water to be sampled, before it was filled.

Sampling date and time was also recorded on each sample bottle

4.3.3 Sample collection, field measurements, storage and transportation measurements

As recommended in SANS 241:2015, after samples have been collected, sampling bottles were stored in a cooler box at a temperature below 23^{0}C and then transported to the Laboratory within 48 hours of sampling for screening. The location of points were digitised using a handheld GPS for the location (x:y) as well as elevation (z).

The following field in-situ parameters were recorded on site: pH; EC, TDS and temperature.

4.3.4 Instruments

The following instruments were used on site:

- pH/EC/TDS meter for measuring field physical parameters;
- Thermometer for measuring water temperature when a sample was collected;
- GPS for digitizing location of points;
- Camera for site pictures; and
- Cooler box for preserving samples.

4.3.5 Analyses

A SANAS accredited laboratory, AquaStrata Laboratories (Pty) Ltd. was used for water quality analysis.

4.4 Methodology for Salt Balance

The applied methodology for the Water and Salt Balance is as follows:

- To build a platform by means of spreadsheet based calculations which are imported into Aquachem for further simulation of salt loads;
- To create a system that can be used as a management tool to assist the environmental manager to achieve the objectives as outlined in the Integrated Water and Waste Management Plan (IWWMP).
- To quantify current salt loads in the system in order to be able to quantify future impacts on salt loads. The salts assessed for this project are Sodium, Sulphate, TDS and Chlorine;

- To identify critical knowledge gaps and to further understand the water system in future.

Annual flow calculations were conducted based on the MAR. Once all the water volume data was assessed and confirmed, by the mathematical equations, water quality was then introduced to the spreadsheet calculations. Water quality data was sorted for each unit with water quality monitoring data.

It is important to note that with salt load calculations, the monitoring point with the poorest water quality data may not necessarily reflect the worst salt loads. Another determining factor is the volumes concerned.

The same basic principles for the water balance are applicable to the salt balance, i.e. the conservation of mass across a system:

Total salt load in = Total salt load out

Where:

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

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

4.5 Methodology for Flood line Delineation

Flood lines were delineated by another entity and output data was provided to Letsolo in order to align the outcomes of the Flood line Delineation Studies. The following reports were reviewed and included in this Hydrological Impact Assessment:

- Booysendal South Expansion Flood Line Determination Report, March 2017, Compiled by SNA Civil and Structural Engineers (Pty) Ltd;
- Booysendal Flood line Layout Map, Compiled by SNA Civil and Structural Engineers (Pty) Ltd, Drawing Number:SNA-TP1506-W01;
- Booysendal Flood line Layout Map, Compiled by DRA, Drawing Number:MO413-30000G005;
- SLR Consulting (Pty) Ltd, 2017. Hydrological Assessment - Project Number: E017-19, Report Number: 1.
- Booysendal South Rainfall Data and sizing of PCD, Holley and Associate (Pty) Ltd, dated

The public domain and internationally accepted software package HEC-RAS developed by the US Army Corps of Engineers was used to hydraulically model the river system. The system consists of three components i.e. flow data, geometric data and simulation options. The software provides graphical output of the flow in the river as well as tabulated output of the calculated results. A list of errors and warnings are also provided as an output in order to carefully evaluate and interpret the obtained results.

The procedure involved the following:

- Estimation of the catchment area;
- Flood peak analysis was undertaken to determine the 1:100-year recurrence interval flood peaks for the effective catchment;
- The flood peaks and cross sections derived from contours of the study area were used as inputs to the HEC RAS backwater programme to determine the surface water elevations for the 1:100-year floods peaks; and
- The flood lines were plotted on a layout map.

The catchment area of the Groot Dwars River is predominantly mountainous with numerous ravines that discharge storm water into the river. The streams are at a steep grade with a relatively short response time which results in a complex hydrological model. Ideally the flood should be calculated based upon individual hydrograph nesting of all the minor contributing catchments. This would offer the opportunity to test storm movement in the downstream direction which would be the worst-case scenario.

The adopted procedure to determine the 1:100yr flood lines is described below.

4.5.1 Effective catchment

The first step in the process was to determine the extent of the B41G Quaternary Catchment contributing to the flow arriving at the zone of interest. In this instance that is about 13 km downstream along the river. The catchment as a whole has a plan area of 70 km^2.

The second step is to determine the characteristics of the catchments such as size, slope, infiltration, vegetation and impervious areas. The catchments are situated on the hillside which is relatively steep which results in very short response times. The delineation was carried out with the aid of 1:50000 topographical maps, mining survey maps and contour maps from the Chief Surveyor General.

4.5.2 River analysis

The river analysis was carried out with the HEC-RAS software package, which is an industry standard. The input data required is basically the flood peak and river characteristics such as stream profiles or cross sections, streambed roughness values as well as overbank conditions. The package then generates water levels along the river for each of the cross sections. This then represents the flood height for a particular flood event from which the lines can be drawn on a plan of the river.

Considering the sources of hydrological data as well as hydrological calculation methods applied, the flood lines produced are acceptable.

4.6 Methodology for Detailed Permanent Road Design

The following methodology was applied for Permanent Road Design by SNA Engineers. Roads for maintenance purposes will not be tarred while permanent roads at the operations will be tarred. The total clearance requirement was indicated as 1.03Ha for access roads.

4.7 Methodology for SWMP

In order to produce a reliable SWMP, several study reports were consolidated to centralize the findings and actions. The common approach guided by the Best Practice Guidelines are as follows:

- Undertaking Conceptual designs where considerations of preliminary sizes of water reticulation systems and structures were noted;
- Checking adequacy of the available information, such as mine plan, water balance report;
- Hydrological characteristics for flood (peak flows) calculations through Utility Programs for Drainage (UPD) software; and
- Detailed designs for storm water management infrastructure i.e. trenches, channels and a sump were undertaken through UPD.

5.0 STATUS QUO

5.1 Climate

Booysendal Operation is located in the temperate region with warm summers and cold winters. Winds are topographically induced due to the steepness which leads to anabatic and katabatic winds. Rainfall occurs between October and March and is usually in the form of intense thunderstorms leading to large volumes of run-off in the Dwars River Valley. Evaporation exceeds rainfall making it a water deficit area.

The DWS, Hydrological Information Systems was consulted to obtain rainfall and evaporation data. Rainfall data from Station B4E003, for a period starting from 01 October 1971 to 01 January 2016, was used to calculate the average monthly rainfall and evaporation data.

5.1.1 Rainfall data

Many different rainfall data sources and consequent data sets exist for rainfall representation over South Africa. Each data source and data set has its own unique advantages and disadvantages. Different hydrological rainfall-runoff simulation and peak flow estimation models exist as well as different methods for estimations which require different rainfall parameters with specific required detail and accuracy.

MAP is representative of the average rainfall that occurs over an area during any given year. This rainfall is obtained by taking the total rainfall received over time at a specific point including any extreme periods and/or events and averaging it. According to the rainfall data from Station B4E003, the average annual rainfall for the study area is 730mm.

5.1.2 Evaporation data

As in the case of rainfall and runoff it is also necessary to analyze the Mean Annual Evaporation (MAE) based on A-Pan Evaporation Calculation Method. Data for evaporation is measured at dams and mostly stations that are operated by DWS; these stations provide such data. Gross annual evaporation ‘A’ pan evaporation for the study area is 1756.3mm/a. **Table 5-1** below provides details on the rainfall and Evaporation data for the study area.

Table 5-1: Rainfall and Evaporation Data (REF – DWS Hydrological Information System Station Number B4E003) Period starting on 01 October 1971 and ending on 01 January 2016

Month	Average Monthly Rainfall (mm)	Average Evaporation (mm)
January	133.4	182.1
February	82.1	157.5
March	70.8	150.5
April	49.1	122.1
May	14.7	105.9
June	7.2	89.4
July	5	104.9
August	9.7	139.2
September	24.4	169.6
October	71.4	185.9
November	133.3	167.6
December	128.9	181.6
Total	730	1756.3

5.1.3 Temperature

The average daily maximum temperature at the site (based on Lydenburg information, which is the closest station measuring temperature) is 22.9°C and the minimum 9.5°C. Temperature extremes of 34.5°C have occurred in summer and 5.9°C in winter. There was no sufficient data for temperature at Station B4E03. Therefore, **Table 5-2 and Figure 5-1** shows the average monthly minimum and maximum temperatures for Lydenburg.

Table 5-2: Lydenburg Temperature data

SAWS	July	August	September	October	November	December	January	February	March	April	May	June
Minimum (^{0}C)	2.7	4.8	8.1	10.8	12.7	14.1	14.7	14.2	12.9	10	6	2.8
Maximum (^{0}C)	18.8	20.9	23.6	24	24.2	25.2	25.9	25.5	24.8	22.6	20.8	18.3

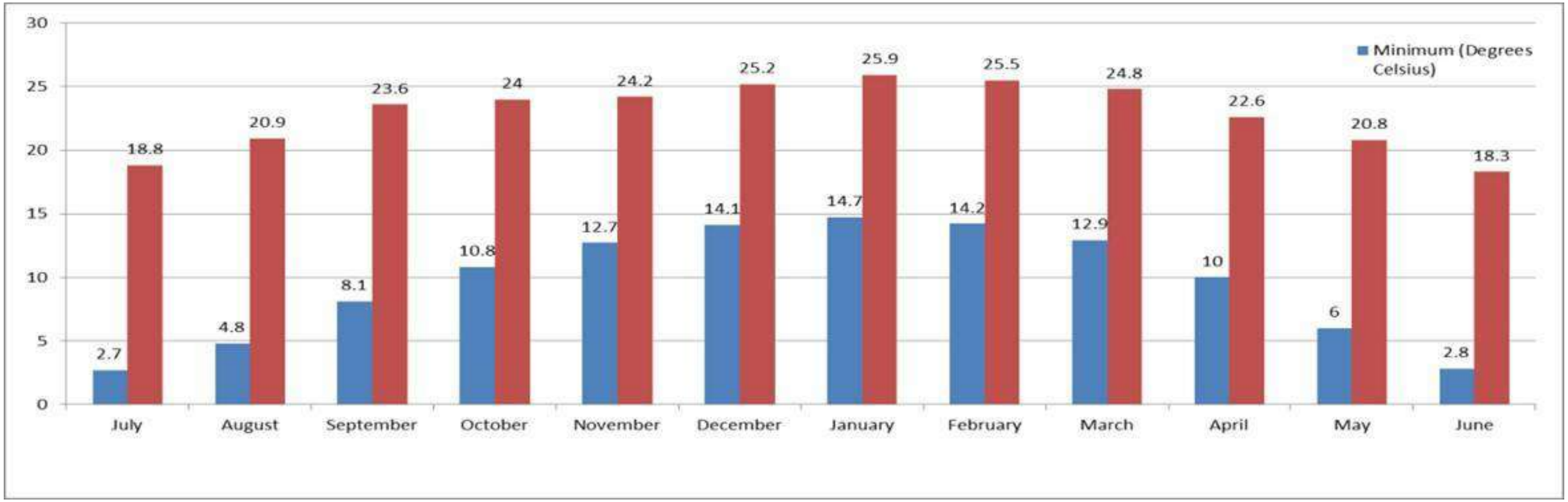


Figure 5-1: Temperature data (Source: http://www.windfinder.com)

5.1.4 Wind

The wind field over the region generally reflects topographical flows. The prevailing wind directions on the site are north-westerly and south-easterly due to the topographical orientation of valleys and ridges in the area.

Calm wind conditions occur on average 28% of the time, with no seasonal pattern observed. However, there is a distinct diurnal pattern, with over 50% of calm winds recorded during the night hours. The average surface wind speed is 2.5 m/s, with a maximum observed wind speed of 7.9 m/s.

5.1.5 Design Rainfall data

It is important to align datasets in order to ensure consistency throughout the project. Hydrological data used for the hydrological impact assessment is also used for the detailed civil design calculations. Common hydrological characteristics of B41G are summarized as follows:

Surface Area	:443.6km^2
Mean Annual Precipitation (MAP)	: 721 mm/a
Mean Annual Runoff (MAR)	: 66mm/a

In order to adapt to the same data used for design flood calculations, design rainfall depth for the 1:50 years and 1:100 years, 24 hours storm event, were sourced from the South African Weather Services Database, Station 0554516W – Beetgeskraal.

Please note that data from the DWS is used for average monthly rainfall and evaporation, whereas, data from the SAWS is used for design calculations as the design rainfall depth is already calculated.

The design rainfall for the 50, 100 and 200-year return period are summarized as follows:

- 128mm for the 50 years return period;
- 145mm for the 100 years return period; and
- 162 mm for the 200 years return period.

A return period, also known as a recurrence interval is an estimate of the likelihood of an event, such as a flood or a river discharge flow to occur. It is a statistical measurement typically based on historic data denoting the average recurrence interval over an extended period of time, and is usually used for risk analysis. In this instance, it is used for sizing the dirty water management infrastructure as well as to determine if the proposed infrastructure falls within the flood line.

5.1.6 Topography

The topography of the BS1/2, BCM1, BCM2, the Emergency Escape Portal, the Valley Boxcut and BS4 sites is dominated by the Groot Dwars valley, the base of which is approximately 1,200m above mean sea level (AMSL). The eastern side of the valley, which is where BS4 is situated, features a plateau at approximately 1,700m AMSL. The western side of the Groot Dwars valley features a broken ridge line at about 2,000m AMSL. The Groot Dwars valley has steep sides in the vicinity of the project, with gradients in excess of 10% accounting for over half of the total catchment area (upstream of De Brochen Dam).

Figure 5-2 provides a n indication of the topography of the study area.

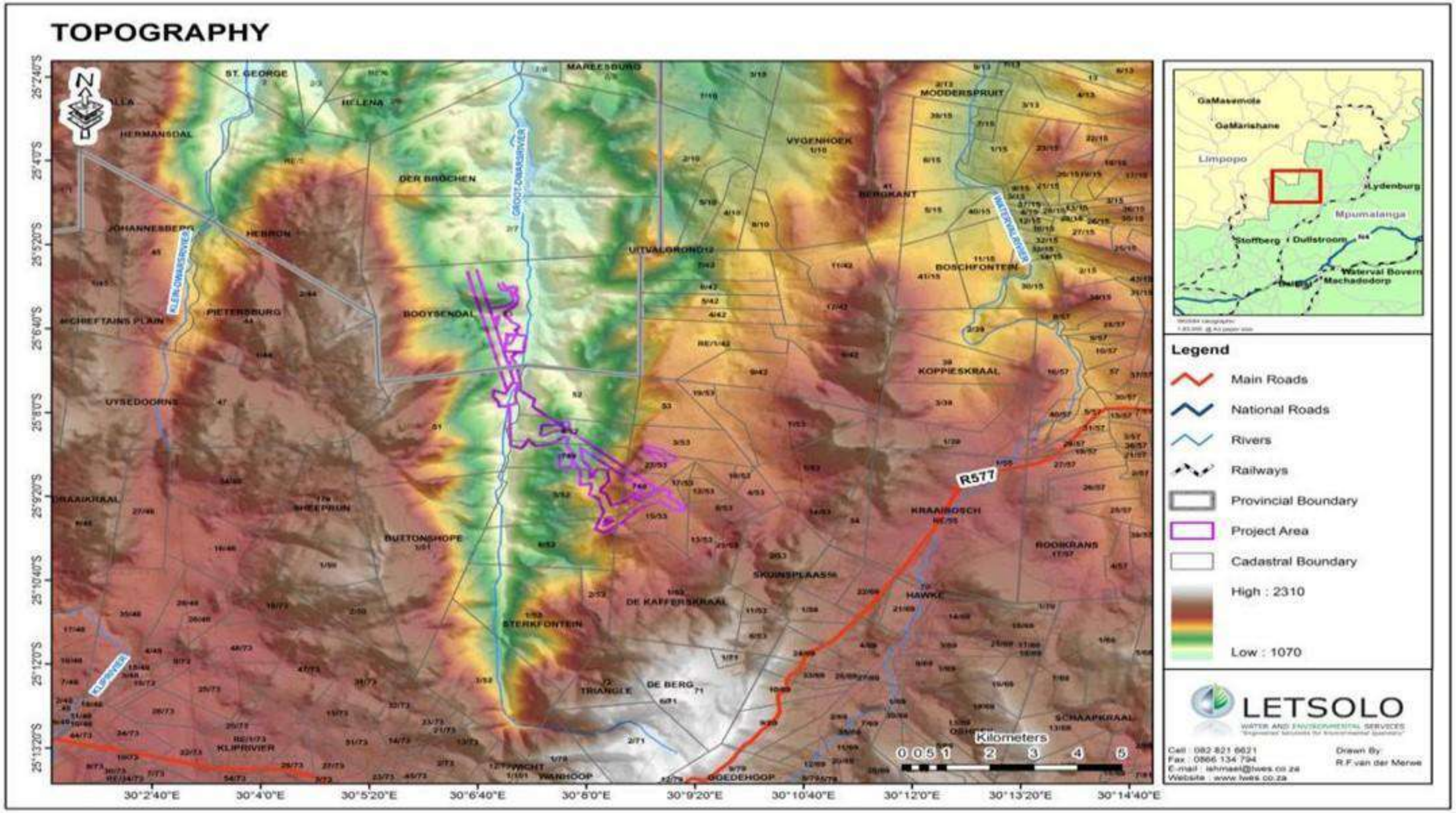


Figure 5-2: Site Topography

5.1.7 Water quality

(Reference: Surface and groundwater quality Booysendal south expansion project phase 2: specialist impact assessment report, February 2018)

With reference to the natural water systems within the mining operations indicated water quality with a fairly neutral to alkaline pH-values as well as very low to low anion and cation loads. The natural water quality fluctuates with the changes in seasons as well as rainfall in the area. Slightly higher Al concentrations were recorded at several of the natural water systems, however this seems to be a natural occurrence and the measured Al concentrations are most likely in a suspended state (due to the neutral pH at all the localities) rather than in solution as would be the case under more acidic pH conditions.

5.1.7.1. Groot Dwars River

The Groot Dwars River valley lies west of the current mining operations. Surface water drainage via the Valley areas will directly reach the Groot Dwars River as described in the typography, but any surface drainage at the Booysendal South - North Box cut area and processing areas (Plant and TSF) will reach the Groot Dwars River via the Kraalspruit approximately 6 kilometres downstream. The localities included in this section are NBS GD1, NBS GD2, NBS GD3, NBS GD4, NBSW01, NBSW02 and NBSW03.

5.1.7.2. BS4 Water Quality

The process water quality at BS4 indicate similar water quality than what was measured at the natural water systems, as the process facilities have not been operational as the BS4 mining area has been under care-and-maintenance. The NBPW03, Frog dam, is a process water locality situated in the valley and process water from BN is stored for re-use. The water quality at the aforementioned process water locality is an indication of typical process water, with very high to elevated anions and cations, and more alkaline pH-values.

5.1.7.3. Tributaries and Dams

The Western (NBS W1 & NBS W2) and Eastern tributaries (NBS E3, NBS E2 and NBS E1) flows around the BS4 operations, where both flow towards the TKO1 and TKO2 dams downwards to

Everest Tributary (NBSW03) into the Groot Dwars River which forms part of the BN monitoring project. This locality is vital as any spills or seepage that occurs at BS-4 will be picked up at this downstream locality.

5.1.8 Catchment description

The study area falls within the Olifants Water Management Area (OWMA), within DWS Quaternary Catchment B41G. The Olifants OWMA covers about 54 570 km^2 and is subdivided into 9 secondary catchments.

(More details are covered in Paragraph 7)

6.0 SENSITIVITIES

Because of the steep topography, runoff volumes and velocities after rainfall events are high, as well as highly erosive. Most of the runoff reaches the floodplain of tributaries of the Groot Dwars River and end up in the Groot Dwars River system. These river systems are susceptible to erosion. Because of this high runoff rate, the seasonal flow regime within the Groot Dwars River is likely to be highly variable, reflecting the rainfall and runoff, with the aquatic biota responding accordingly. Water quality variables are also likely to fluctuate according to these seasonal variations, reflecting the degree of dilution and runoff (which may contain contaminants or eroded sediments).

The Groot Dwars River and its tributaries in close proximity to development footprints are the closest sensitive receptor located near the study area. Due to the pristine nature of surface water resources upstream of BS1/2, and the Groot Dwars River being declares a FEPA, the study area is considered to be a sensitive catchment.

7.0 STORM WATER MANAGEMENT PLAN

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

The objectives of the Storm Water Management Plan include the following:

- Clean water must be kept clean and routed to a natural watercourse by a system separate from the dirty water system;
- Dirty water must be collected and contained in a system separate from the clean water system;
- The plan must be sustainable over the life cycle of the mine; and
- The statutory requirements of various regulatory agencies and the interest of stakeholders must be considered and incorporated.

For each activity, the following steps, which are in line with the BPG procedure, were discussed:

- Objectives of the SWMP
- Technical situation analysis and evaluation
- Conceptual design
- Assess the suitability of the existing infrastructure
- Infrastructure changes that are required
- Detailed design of all required infrastructure
- Operational, management and monitoring systems and responsibilities
- SWMP
- Implement, manage and monitor the SWMP
- Review/audit the SWMP and systems at regular intervals

7.1 Catchment Characteristics

The area of influence in hydrological terms was assessed for 4 tiers as follows:

- Tier 1 - Water Management Area;
- Tier 2 - DWS Quaternary Catchment Areas;
- Tier 3 - Site Delineated Catchment Areas; and
- Tier 4 - Affected surface water resources.

7.1.1 Water Management Area

The Olifants Catchment covers about 54 570 km^2 and is subdivided into 9 secondary catchments. The Olifants River originates near Bethal in the Highveld of Mpumalanga. The river initially flows northwards before curving in an easterly direction through the Kruger National Park and into Mozambique where it joins the Limpopo River before discharging into the Indian Ocean. WMA4 falls within three provinces, namely: Gauteng, Mpumalanga, and the Limpopo Province.

7.1.2 Quaternary Catchment Area

The GIS) was used to obtain the quaternary catchment areas delineated by the DWS. As it can be seen in **Figure 7-1** below, the project area falls within DWS Quaternary Catchment B41G.

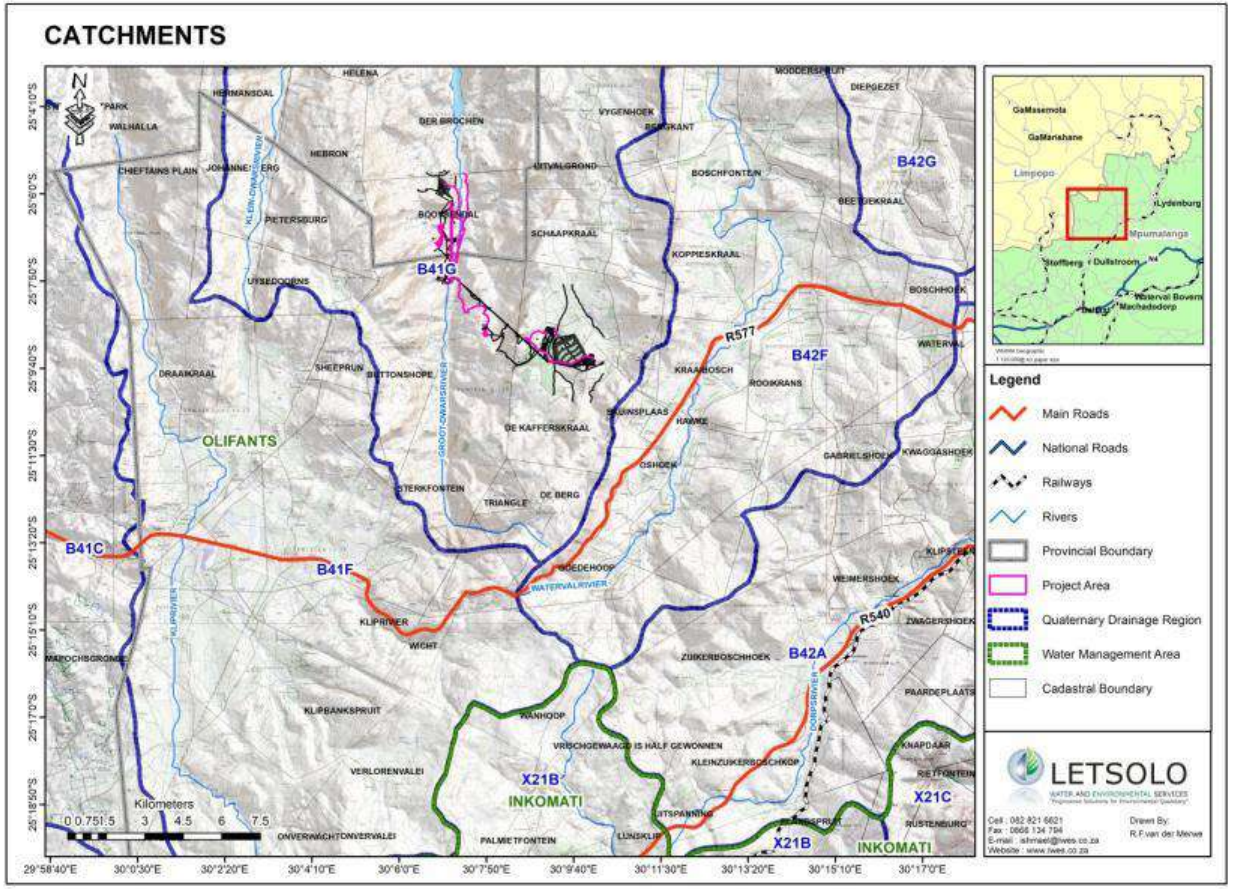


Figure 7-1: DWS Quaternary Catchments

7.1.3 Affected Water Course

There are 27 drainage lines for the delineated catchment areas within the AoI of the Expansion Project. It was deemed necessary to delineate smaller catchments as there are several river crossings at different catchment areas. The Groot Dwars River is the most significant water resource in this study area. The hydraulic length of the Groot Dwars River is approximately 28.2km, measured from its origin down to the inlet of the De Brochen Dam. De Brochen Dam is located downstream of the farm Booysendal 43JT, on the Farm De Brochen 7JT. This dam is a significant surface water body located downstream of the project area. Water quality investigation based on the historic data is detailed in Section 9 of this report. The stretch of the Groot Dwars River upstream of the Der Brochen Dam is regarded as highly sensitive.

7.1.4 Site Delineated Catchments

As it can be seen on **Figure 7-2 and Table 7-1**, Survey Data, 1:50 000 vector data sourced from the National Surveyor General was used to delineate 27 smaller catchment areas that may be impacted by the proposed expansion. This delineation was conducted by utilising contour and river data.

Flood calculations for delineated catchments

Site specific hydrological characteristics for the Groot Dwars River Catchment are summarized as follows:

Surface Area	:176.5km^2
Mean Annual Rainfall	: 721 mm/a
Mean Annual Runoff	: 66mm/a
Longest Watercourse	: 28.2km (measured to the inlet of the De Brochen Dam)
10-85 Slope	:0.017 (m/m)

Table 7-1: Site delineated catchments

Catchments	Area (KM^2)	Change in height (m)	Hydraulic Length (km)	Slope (m/m)
1	9.4	854	6.53	0.130781
2	7.3	797	4.488	0.177585
3	1.57	198	0.807	0.245353
4	2.45	478	2.07	0.230918
5	4.69	402	1.54	0.261039
6	11.5	887	7.015	0.126443
7	2.35	517	1.63	0.317178
8	1.06	332	1.63	0.203681
9	7.13	721	3.95	0.182532
10	5.66	471	2.85	0.165263
11	0.147	6	0.0783	0.076628
12	2.41	163	1.16	0.140517
13	5.1	561	2.24	0.250446
14	3.61	300	1.93	0.155440
15	5.75	417	1.92	0.217188
16	9.42	260	3.75	0.069333
17	1.19	174	1.25	0.139200
18	38.2	1083	20.12	0.053827
19	7.39	870	4.11	0.211679
20	11.4	885	4.06	0.217980
21	1.08	166	1.15	0.144348
22	1.95	213	1.36	0.156618
23	8.66	374	4.79	0.078079
24	1.7	479	2.85	0.168070
25	2.93	480	3.89	0.123393
26	4.48	370	3.144	0.117684
27	4.77	371	3.96	0.093687

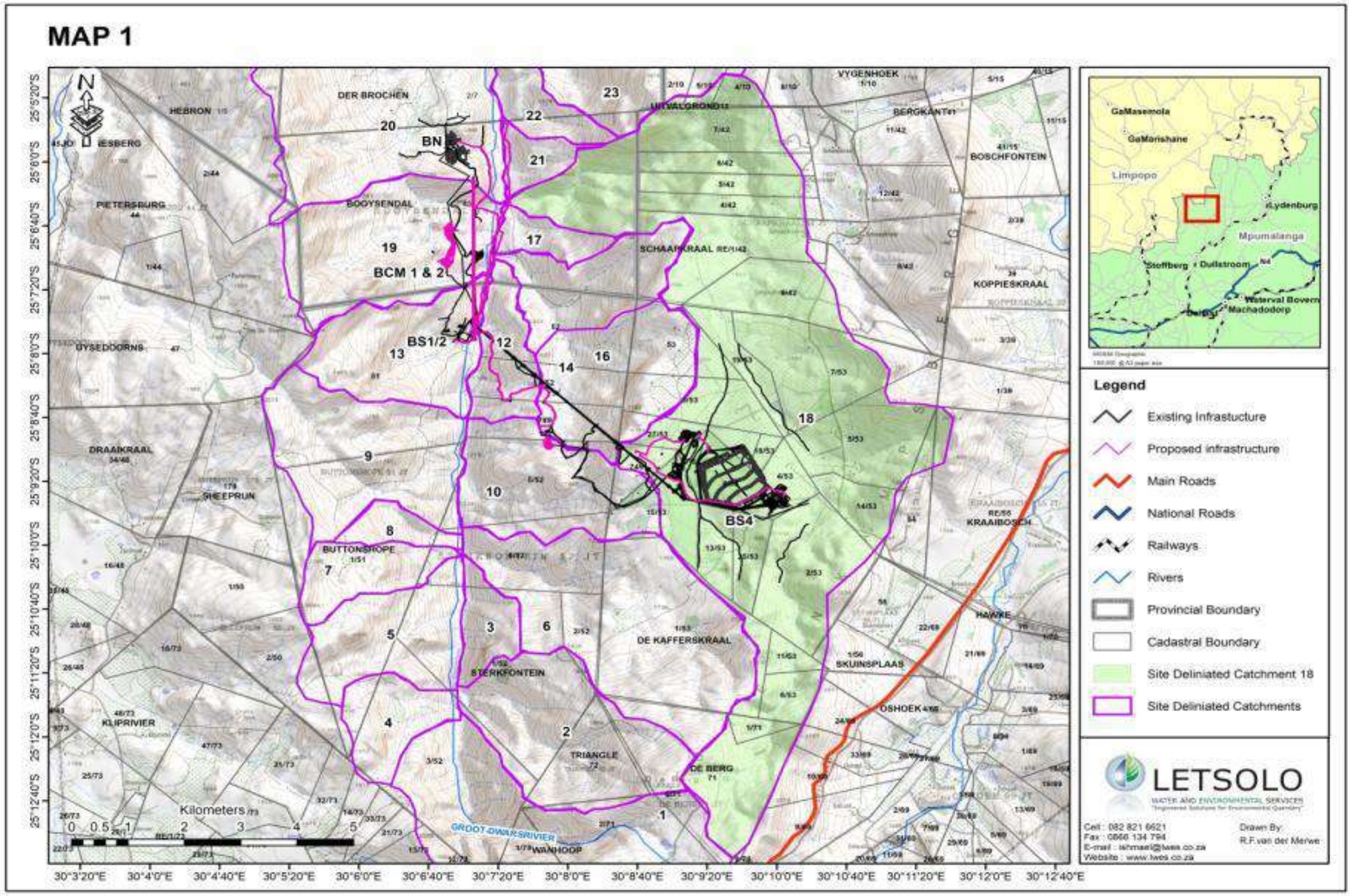


Figure 7-2: Site Delineated Catchments

7.1.5 Mean Annual Runoff for Groot Dwars River

The Mean Annual Runoff (MAR) for the B41G DWS Quaternary Catchment, Groot Dwars River and the BS1/2 Bridge crossing, are indicated in Table 7-2 below. The Groot Dwars River was separated from other catchments because it is the parent catchment and the MAR for site specific calculations are influenced by the findings in Table 7-2 below. It is worth noting that the MAR for site delineated is important for the calculations of slat loads in the river systems. Therefore, catchments is discussed under Water and Salt balance Calculations.

Table 7-2: Mean Annual Runoff

		Mean Annual Runoff (m^3/month)			Mean Annual Runoff (m^3/day)		
Description	Mean Annual Runoff (%)	B41G Quaternary Catchment	Groot Dwars River at De Brochen Dam	Groot Dwars River at BS1/2 Bridge Crossing	B41G Quaternary Catchment	Groot Dwars River at De Brochen Dam	Groot Dwars River at BS1/2 Bridge Crossing
Surface Area (km^2)		433.6	176.5	70	433.6	176.5	70
January	18%	5229572	2128735	844258	168696	68669	27234
February	11%	3218500	1310114	519592	103823	42262	16761
March	10%	2775515	1129793	448077	89533	36445	14454
April	7%	1924828	783515	310742	62091	25275	10024
May	2%	576272	234576	93033	18589	7567	3001
June	1%	282256	114894	45567	9105	3706	1470
July	1%	196011	79788	31644	6323	2574	1021
August	1%	380261	154788	61389	12266	4993	1980
September	3%	956533	389364	154422	30856	12560	4981
October	10%	2799036	1139368	451874	90291	36754	14577
November	18%	5225652	2127139	843625	168569	68617	27214
December	18%	5053163	2056926	815778	163005	66352	26315
Total	100%	28617600	11649000	4620000	923148	375774	149032

7.1.6 Flood calculations for the Site Delineated Catchments

Based on the Rational, Alternative Rational and Standard Design Flood Method, the peak flows for the Groot Dwars River were determined. The Peak flows are summarised in Table 7-3 below:

Table 7-3: Peak Flows for Groot Dwars River Flood Delineation

Method	Peak Flow 20-year(m^3/s)	Peak Flow 50-year(m^3/s)	Peak Flow 100-year(m^3/s)
Rational	256	341	429
Alt Rational	359	474	576
Standard Design Flood	300	445	568

It can be seen in Table 7-3, the order of magnitude of the methods are similar. The rounded-up flood peak volume of 600m^3/s was then further increased to compensate for possible underestimation of the impervious area of the 70km^2 catchment. A peak flow of 700m^3/s was used for the 100-year flood line delineation.

Please note that the Peak flows are totally separate from the MAR. MAR represents what happens during the average year and peak flows represents what is likely to happen if we experience a storm event for a specific return period. In this case, the 1:100 years storm event. The Flood Calculations for the entire system is summarized as follows:

Table 7-4: Peak Flow for Site Delineated Catchments

Catchments	Area (KM^2)	1:100 years Peak flow (m^3/s)	Associated infrastructure
De Brochen	176.5	700.0	
1	9.4	37.3	No activities intended in this catchment.
2	7.3	29.0	No activities intended in this catchment.
3	1.57	6.2	No activities intended in this catchment.
4	2.45	9.7	No activities intended in this catchment.
5	4.69	18.6	No activities intended in this catchment.
6	11.5	45.6	No activities intended in this catchment.
7	2.35	9.3	No activities intended in this catchment.
8	1.06	4.2	No activities intended in this catchment.
9	7.13	28.3	No activities intended in this catchment.
10	5.66	22.4	No activities intended in this catchment.
11	0.147	0.6	No activities intended in this catchment.
12	2.41	9.6	No activities intended in this catchment.
13	5.1	20.2	BS1/2
14	3.61	14.3	No activities intended in this catchment.
15	5.75	22.8	No activities intended in this catchment.
16	9.42	37.4	No activities intended in this catchment.
17	1.19	4.7	No activities intended in this catchment.
18	38.2	151.5	BS4and related activities
19	7.39	29.3	BCM 1 and BCM 2
20	11.4	45.2	BN
21	1.08	4.3	No activities intended in this catchment.
22	1.95	7.7	No activities intended in this catchment.
23	8.66	34.3	No activities intended in this catchment.
24	1.7	6.7	No activities intended in this catchment.
25	2.93	11.6	No activities intended in this catchment.
26	4.48	17.8	No activities intended in this catchment.
27	4.77	18.9	No activities intended in this catchment.

After the comprehensive catchment analysis, the Storm water management plan in line with the Best Practice Guidelines was produced. The plan was divided for Phase 1 and Phase 2 activities.

7.2 Phase 1: BS1/2 SWMP

Phase 1 storm water management measures are discussed for each activity due to the diverse nature of the catchments activities. Some activities are clean water catchment but may pose storm water related impacts like erosion.

7.2.1 Diversion of two unnamed tributaries of the Groot Dwars River upstream of the BS1/2 Shaft Complex

Two river diversion channels are constructed upstream of BS1/2 Shaft Complex to divert flow of a river from its natural course. These diversion channels do not impound water. Instead, the water is diverted into an artificial water course and return to the river after passing through BS1/2 surface infrastructure, It is worth noting that there are no transfers of water from one catchment to another. Water is returned to the catchment of origin.

7.2.1.1. Objectives of the SWMP

The objective of the trench is to divert storm water run-off around the BS1/2 works area, thereby protecting the clean water from entering potential dirty water areas. The Objectives of the SWMP for the Operational and the Decommissioning Phase are described in Table 7-5.

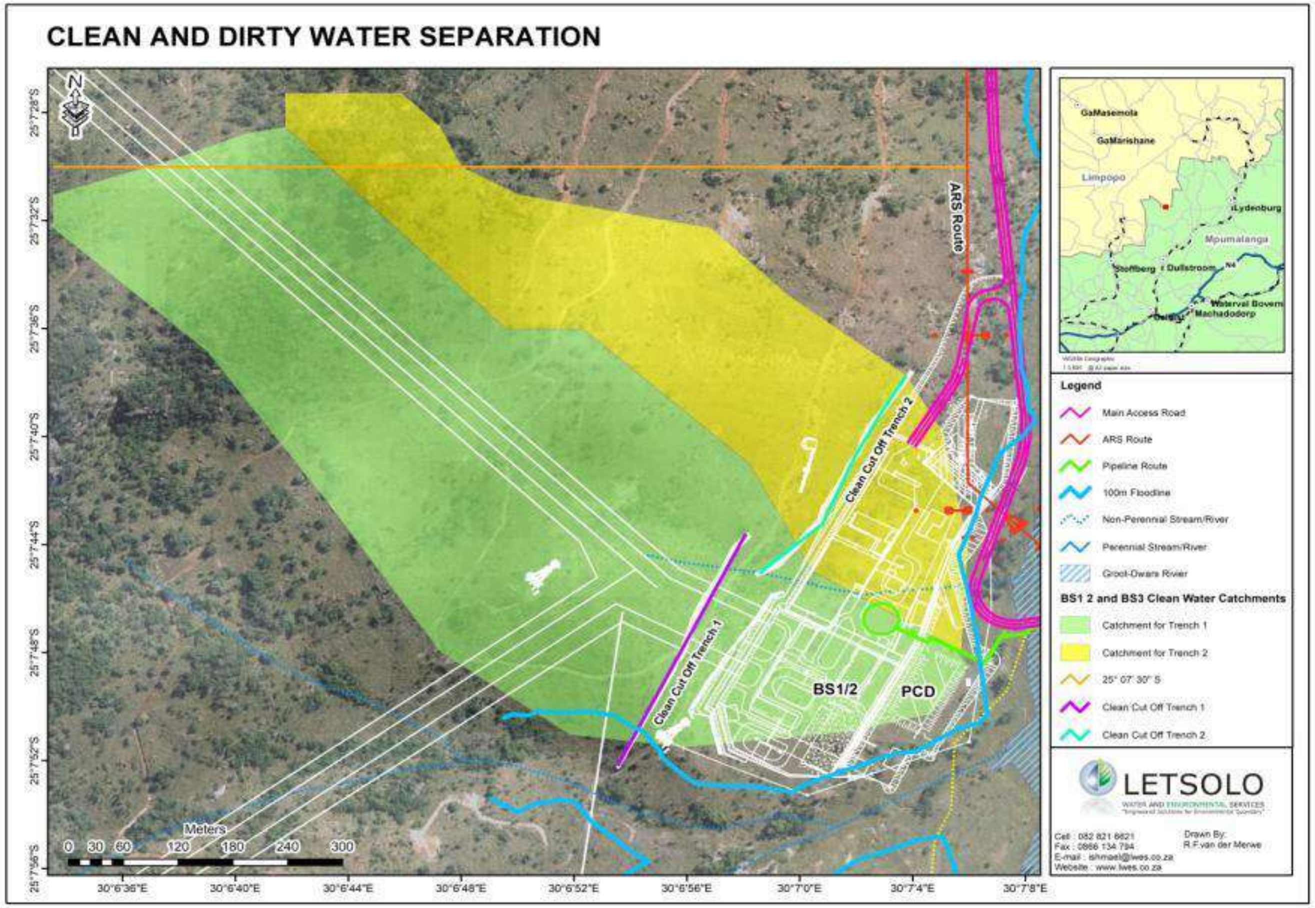


Figure 7-3: Clean Water Cut Off Trenches

Table 7-5: Objectives of the SWMP for BS1/2 activities

Project Phase	Objectives and related Storm water management measures
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Clean run-off will be diverted around BS1/2 into the nearest natural drainage path before it discharges into the Groot Dwars River. 2. Two clean water diversion channels (Trench 1 and 2)are recommended to divert upstream runoff away from BS1/2 surface activities. 3. Trench 1 flows in a south-westerly direction and discharges into a natural drainage line. 4. Trench 2 flows in a north easterly direction and encourage overland flow before water can naturally drain into the Groot Dwars River. 5. High flow velocities are associated with erosion. The channel slopes are designed to have energy dissipaters at release points to reduce flow velocities. 6. The mine must ensure that there are erosion control measures like Rip Rap at the release points to minimize erosion. 7. The operation/management of the diversion system must continuously assess silt build up and to ensure that the design capacity is not compromised by silt and vegetation. 8. Storm water control infrastructure is designed to account for the 1:50 year storm event. 9. The diversion channels must be operated to accommodate the 1:50 years flood.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of the diversion channel is undertaken in a way that conforms to Best

	Practice Guidelines for SWMP; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. All diversion channels associated with the diversion must be removed. 2. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 3. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 4. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.2.1.2. Technical situation analysis and evaluation

There are two non-perennial drainage lines dissecting the proposed expansion area, which required diversion. There is a significant volume of surface runoff from the upstream area, which is located at a higher relatively steep elevation against the hill. The diversion channels are constructed upstream of the dirty water catchment area, at the BS1/2 boxcut. Separation of clean and dirty water is the key milestone for storm water management. In order to size the clean water cut-off trench, the contributing effective catchment area was delineated. Letsolo Water was provided with the detailed design of the cut off trench.

7.2.1.3. Conceptual design

Flood calculation for the upstream catchment area, contributing to the clean water volume upstream of the cut off trench, was calculated using the Rational Method. The results are summarized in Table 7-6 as follows:

Table 7-6: Clean Water Catchment Flood Calculations

Description	Recurrence interval	Area (m^2)	Area (km^2)	Longest water course (km)	Tc (hrs)	Point rainfall (mm)	Point intensity (mm/h)	C - runoff factor	Flood vol Vr (m^3)
Catchment Upstream of Cut-Off Trench	5	79000	0.079	0.37	0.34	76	224	0.775	5235
Catchment Upstream of Cut-Off Trench	10	79000	0.079	0.37	0.34	91	268	0.775	6268
Catchment Upstream of Cut-Off Trench	20	79000	0.079	0.37	0.34	106	313	0.775	7301
Catchment Upstream of Cut-Off Trench	50	79000	0.079	0.37	0.34	128	377	0.775	8816
Catchment Upstream of Cut-Off Trench	100	79000	0.079	0.37	0.34	145	428	0.775	9987
Catchment Upstream of Cut-Off Trench	200	79000	0.079	0.37	0.34	162	478	0.775	11158

7.2.1.4. Assess the suitability of the existing infrastructure

In view of Tables 7-6 (recommended sizes) and 7-7 (Actual Size) below, it is concluded that the channel was sized according to the requirements of GN 704.

The diversion channel is following the natural contours and it discharges into a natural drainage line to the south and north. At the end of the day, there is no loss in catchment yield because Storm water is ultimately collected in the same site delineated catchment area.

The diversion channels were designed to handle the 1:50 years, 24 hours storm event.

7.2.1.5. Infrastructure changes that are required

In order to determine if there are any changes required for the diversion channel, flood calculations were conducted based on the effective catchment. The conceptual sizing of these channels was compared with the actual constructed channel.

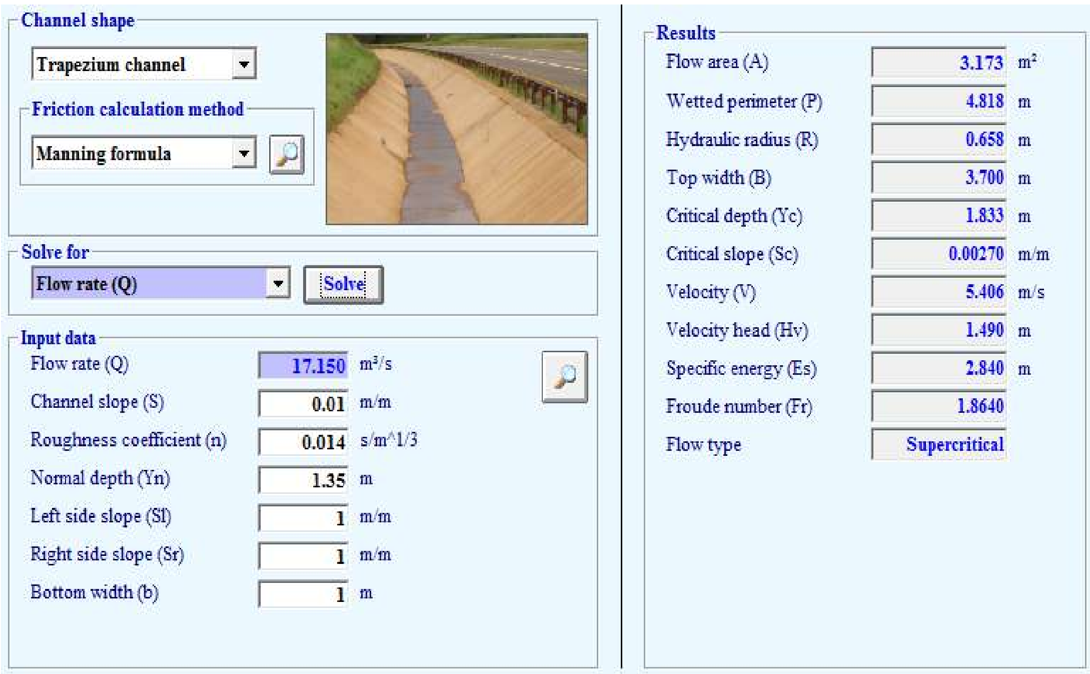
The following hydrological characteristics were critical for the sizing of the cut off drain.

- Catchment Area : 783 838.0m^2 or 78.384 ha
- Slope of catchment: : 1/3 or 33.35%
- MAP: : +/- 730mm per year.
- Height difference: : 509m
- Design storm event: : 1:50 year return period.

The rational method was used in order to determine the 1:50 year peak flow. The drain was designed to handle the 1:50 years, 24 hours storm event. Channel design is different from the storage facilities. The channel will only experience the peak flow for a very short period de[ending on the Time of Concentration. For storage facilities it is common to over design because usually, there will be some water stored prior to the storm event.

Desired capacities were compared to the actual channel constructed on site. Flood calculations conducted by Letsolo Water and Environmental Services cc are included in **Table 7-7 below.**

Table 7-7: Conceptual design of the clean water cut-off trench 1 and 2



Based on the calculations above and the actual channel on site, there are no further changes required for the diversion channel.

7.2.1.6. Detailed design of all required infrastructure

The dimensions of the constructed channel are included in **Table 7-8 below.**

Table 7-8: Detailed Designs of the clean water cut-off trench

Description	1 in 50 years (24 hours)	Unit of Measurement
Bottom width	1	m
Water depth	1.35	m
Side slope 1	1	1:01
Side slope 2	1	1:01
Top width	3.7	m
Manning coefficient	0.014	
Longitudinal	0.01	m/m

slope		
Flow velocity	5398	m/s
Flow rate	17.127	m^3/s

7.2.1.7. Operational, Management and Monitoring Systems and Responsibilities

Channels located in steep areas usually get silted up. Silt build up reduces the design capacity of a channel. Visual inspections should be conducted on a regular basis. More especially after significant storm events.

7.2.1.8. Implement, Manage and Monitor the SWMP

During the operational phase, these cut off channels must be inspected on a regular basis in line with the measure included in Section 7.2.2.1.

7.2.1.9. Review/audit the SWMP and Systems at Regular Intervals

It is common practice to conduct an audit on water infrastructure on an annual basis. In instances where the channels show signs of failure, the necessary corrective actions will be implemented in line with the identified source of failure.

7.2.2 Stockpile and terracing for the BS1/2 portal within the 100m buffer line of an unnamed tributary of the Groot Dwars River

In order to access the stockpile, heavy machines had to cross the stream. Therefore, there was a temporary infill of the stream with culverts at the bottom to allow for free drainage and to minimize the impact of ponding. Some stockpiles are also in close proximity to streams and pose a risk of being eroded into the streams.

The terrace and stockpiles are associated with loose material and steep slopes. In hydrological terms, steep areas result in high flow velocities which increase the potential for erosion.

7.2.2.1. Objectives and SWMP

The objective of the plan is to ensure that the stockpiles do not impact negatively on the water resources. The Objectives of the SWMP for the terracing and stockpile are discussed in Table 7-9:

Table 7-9: Objectives of the SWMP for stockpile at BS1/2.

Project Phase	Objectives and related Storm water management measures
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil.
Operational Phase - Storm water management measures	1. Operation of any infrastructure near surface water bodies MUST be undertaken in a manner that compliments good engineering/environmental practice. This can be achieved by the construction of vegetated berms. 2. Constructing Soil Stockpiles on impervious surfaces presents challenges for sediment control (limited effectiveness) and should be avoided. 3. Terraces constructed for access to a soil stockpile can create a flow path for Storm water runoff. Sediment control practices along the terrace entrance/exit may be required. The construction or installation of benches, or slope interrupters are recommended to provide additional slope stability and erosion control. 4. After storm events, the areas must be inspected for damages. Should there be any damage, the mine must a. Repair damaged areas, b. clean-out silted up areas, c. replace perimeter controls, d. Implement area inlet protection, and stabilization methods. e. Repair rills and gullies as needed.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources;

	3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. Stockpiles and terrace areas, including infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 6. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. 7. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.2.2.2. Technical situation analysis and evaluation

The stockpiles must be at slope not steeper than 1:3 in order to reduce the velocity of Storm water and also to prevent the development of erosion gullies.

7.2.2.3. Conceptual design

A berm must be constructed around the affected area in order to discourage free movement of water which may result in erosion. A berm with a height of 800mm will be sufficient.

7.2.3 Construction and operation of a BS1/2 PCD

A PCD is located at the most downstream point of the dirty water catchment area on the BS1/2 terrace. This location was selected in order to ensure that dirty water can gravitate to the PCD without the need of pumps and sumps.

7.2.3.1. Objectives and SWMP

All the dirty water from the BS1/2 will be directed to the PCD. (Please note that this section only refers to the BVS1/2 PCD)The dam has been sized according to the catchment area of the portal and will have a capacity of 14,000m^3. The capacity of the dam will be able to accommodate a 1:200-year flood event and has been designed with the required 0.8m freeboard.

The Objectives of the SWMP are explained in Table 7-10.

Table 7-10: Objectives of the SWMP for PCD

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: a. Spill prevention and clean-up, 3. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and

	suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 5. The regular maintenance of silt traps must be undertaken to ensure these remain clear of debris, especially after each runoff event. 4. Clean water must be diverted around all major construction sites 6. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with Storm water. 7. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: a. Spill prevention and clean-up, 3. No discharge is anticipated directly from the PCD. 4. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated.

	5. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 6. The regular maintenance of silt traps must be undertaken to ensure these remain clear of debris, especially after each runoff event. 5. Clean water must be diverted around all major construction sites 7. Storm water control infrastructure is designed to account for the 1:50 year storm event. 8. All vehicles will be maintained at a designated workshop at the Processing Plant, which will include an oil/grease trap. 9. Chemicals and fuels will be stored in bunded areas with emergency spill response equipment. 10. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. All rehabilitation activities must be limited to the already disturbed area. 2. No further removal of vegetation would be allowed. This has specific reference to the vegetation which has been removed by the construction of this PCD. 3. Demolish all concrete structures i.e. dirty water channels and silt traps; 4. Remove any silt that accumulated in the dam in line with the Hazardous waste management strategy for the operation; 5. Remove liners and following waste classification testing dispose appropriately; 6. Particular attention must be given to any possible contaminants (for example vehicle fuel, cleaning chemicals, any mine waste products)

	since the soil is very permeable and the site is located in a flood plain. All potential contaminants must be stored off site and any spills remediated immediately by removal and correct disposal of the contaminated soil. 7. Flattened earth walls and backfill excavations with material removed during construction; and 8. Profile footprint to be free draining with no low points to accumulated water 9. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 10. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 11. All channels and lHDPE liners associated with the PCD must be removed. 12. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.2.3.2. Technical situation analysis and evaluation

Holley and Associates (Pty) Ltd, hereafter referred to as H&A, was appointed to conduct hydrological calculations for the sizing of the PCD at BS1/2. The Rational Method was used for flood calculations. GN 704 requires the following:

- Capacity: dirty water systems are to be designed, constructed, maintained and operated so that they are not likely to spill into a clean water system or the environment more frequently than once in 50 years.
- Conveyance: all water systems are to be designed, constructed, maintained and operated so that they convey a 1:50 year flood event.

- Freeboard: as a minimum, any dirty water dams are to be designed, constructed, maintained and operated to have 0.8m freeboard above full supply level.
- Collect and re-use: ensure that dirty water is collected and re-used as far as practicable.
- Diversion: minimise flow of any surface water or floodwater into mine workings.

7.2.3.3. Conceptual design

The Dam was designed in line with the requirements of GN 704. The following dam properties were provided by H&A.

Dam Location:

Latitude	: $25^0$07'17.97"
Longitude	: $30^0$07'42.49"
Dirty Water Capacity	: 8842m^3
Design Capacity including Freeboard	: 13206m^3
Liner Requirements	:1.5mm HDPE

Provision has been made for a water treatment plant downstream of the PCD. This will ensure that the water is treated to the requirements to be set by DWS, should release into the environment be required. The mine will, however, be managed as a no-discharge mine.

As indicated in Table 7-11 below, the following design criterion was applied:

Flow Rate = Area * Run-off factor*Design Rainfall (1 in 50years, 24 hours storm event)

Table 7-11: Sizing of BS1/2 Process Water Dam

This Calculation caters for Dam Capacity Only

Description	1 in 100 years (24 hours)	Unit of Measurement
Catchment area	86 340	m^2
Rainfall data	0.128	m
Run-off factor	80	%
Dam full capacity	9 500	m^3

Sizing of Dam using Frustum of Pyramids

Description	1 in 100 years (24 hours)	Unit of Measurement
h-depth	2	m
Area bottom(A2)	3969	m^2
Area top(A1)	5041	m^2
Volume	9 500	m^3

Sizing of 0.8m Freeboard using Frustum of Pyramids

Description	1 in 100 years (24 hours)	Unit of Measurement
h-depth	0.8	m
Area bottom(A2)	5041	m^2
Area top(A1)	5505.64	m^2
Volume	4217	m^3

7.2.3.4. Assess the suitability of the existing infrastructure

As part of the authorities consultation process, the DWS was consulted and the sizing of dirty water infrastructure was also discussed. The DWS indicated that the Pollution Control Dams must be sized to contain the 1:200 year storm event, 24 hour storm event.

7.2.3.5. Infrastructure changes that are required

The only concern about containment of a 1:200-year storm event is the capacity of dams and the surface area required to contain such a dam. The potential risk of flooding is minimized at Booysendal by designing a separate process water dam, thus separating operational water volumes from contaminated water volumes.

7.2.3.6. Detailed design of PCD

The dam capacities were upgraded from a 1:50 year storm event presented in Table 7-12 to 1:100-year storm event.

Table 7-12: Proposed Design capacities by the Department of Water and Sanitation

Description	1 in 100 years (24 hours)	1 in 200 years (24 hours)	Unit of Measurement
Catchment area	86 340	86 340	m^2
Rainfall data	0.145	0.162	m
Run-off factor	80%	80%	%
Dam design at full capacity	10 013.44	11189.664	m^3

The allowance made for the 0.8m freeboard, is enough to contain the 1:200 years flood volume. However, freeboard volume will be utilized in the event of a 1:200 years storm event.

(REFER TO APPENDIX 1 –DAM (DETAILS AND SECTION)

7.2.3.7. Operational, Management and Monitoring Systems and Responsibilities

The normal day to day water management will be concentrated at the PCD. The PCDs will be operated as empty as possible. The operation manual must be produced together with the detailed design report.

The 40 years LoM was used to determine the probability of occurrence. The probability of occurrence was determined as follows:

A 100-year flood is a flood event that has a 1% probability of occurring in a period of 100 years. The 100-year flood is also referred to as the 1% flood, since its annual exceedance probability is 1%, or as having a return period of 100-years. The 100-year flood is generally expressed as a flow rate. Based on the expected 100-year flood flow rate in a given river or surface water system, the flood water level can be mapped as an area of inundation. The resulting floodplain map is referred to as the 100-year floodplain, which may figure very importantly in building permits, environmental regulations, and flood insurance.

Similarly, 50-year-flood event has a 2% probability and the two hundred year flood event has a 0.5% probability. The life of mine is less than 100 years. For a 40 years life of mine, the following probabilities were made:

- 80% probability of the occurrence of a 1:50 years storm even during the life of mine;

- 40 % probability of the occurrence of a 1:100 years storm even during the life of mine; and
- 20 % probability of the occurrence of a 1:200 years storm event during the life of mine.

Should the storm event greater than the 1:200-year storm event occur, there is allowance to pump water to BN.

7.2.4 Construction of an ARC for Phase 1 (from BCM1 and BCM2) and Phase 2 (BS1/2 to BN).

An ARC will serve to transport ore from BS1/2, BCM1, BCM2 and BN to the process plant at BS4. The ARC will cross the Groot Dwars River and several drainage lines and wetlands in some instances. However, this infrastructure is located way above the ground. The only concern is at the tower where it is located in watercourses of within 100m from watercourses

Due to the nature of the activities, this paragraph combines both Phase 1 and Phase 2 ARC.

7.2.4.1. Objectives and SWMP

In relation to Phase 1 (BCM1 and BCM2), The ARC consists of seven (7) towers. As adviced by DRA, Vegetation clearance of more than 300m^2 is anticipated at the tower footprint, anchor block and drive station areas.

The ARC allows for limited ground disturbance due to the spacing of the towers (tower spacing's of 1km is possible), which in this environmental sensitive area is important.

The objectives are explained in Table 7-13 below.

Table 7-13: Objectives of SWMP for ARC

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to

management measures	and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: b. Spill prevention and clean-up, c. Storage of fuels and chemicals d. Plant and vehicle repairs – the repair and washing of vehicles near surface water bodies in and around the project area must be prohibited. e. All Project vehicles must be washed at designated wash bays on site. Wash bays on site will include oil/grease and sediment traps for grey water, before this water is returned into mine processing.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Infilling and excavations within a drainage line will be required at Tower 3, which is in a non-perennial drainage line of the Groot Dwars River and Tower 6 and 7 which are both located within 100m from the Groot Dwars River and delineated riparian wetland. 2. All disturbed areas must be rehabilitated and re vegetated.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption;

	6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. ARC infrastructure must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. 5. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 6. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.2.4.2. Conceptual design

The tower footprint areas will be excavated to an average depth of 2.0m which may vary depending on the underlying geology. Once the excavation is done concrete foundations will be laid. The height of the towers ranges between 2.36 to 37.50m from ground level.

7.2.4.3. Assess the suitability of the existing infrastructure

The spacing between the towers limits impacts. Spillages from the ARC may impact negatively on the water resources. The following corrective measures were considered to manage this potential impact:

- Spillages will be avoided through vibrating feeders with controlled feed to the conveyor, belts scales, feeder limits;
- A spillage conveyor with reloading facility onto the ARC will avoid spillages at the loading points; and

- Where the ARC crosses roads, and against steep gradients a cover will be constructed to capture any potential spillages.

7.2.4.4. Infrastructure changes that are required

The final design report was not yet concluded at the time of finalization of this report.

7.2.4.5. Detailed design of all required infrastructure

The designs are not yet finalised. Conveyor designs will be in accordance with international standard ISO 5048 and installation in terms of the Mine Health and Safety Act Regulation 8.9(1-10).

7.2.4.6. Operational, Management and Monitoring Systems and Responsibilities

A maintenance methodology will be developed to ensure effective long-term maintenance and integrity of the system. Maintenance on the aerial conveyor will be undertaken using an aerial inspection car.

From a hydrological point of view the concerns with the towers in the watercourse are the impacts on wetlands, potential siltation of water courses, negative impacts on water quality and the aquatic biodiversity.

The impact is very minimal and will only occur during the construction phase. Therefore, the mitigation measure is to manage the area of impact as minimum as possible. After construction, the impacted area must be vegetated.

Please refer to Figure 7-4 for the location of Towers for the BS1/2 to BN Section.

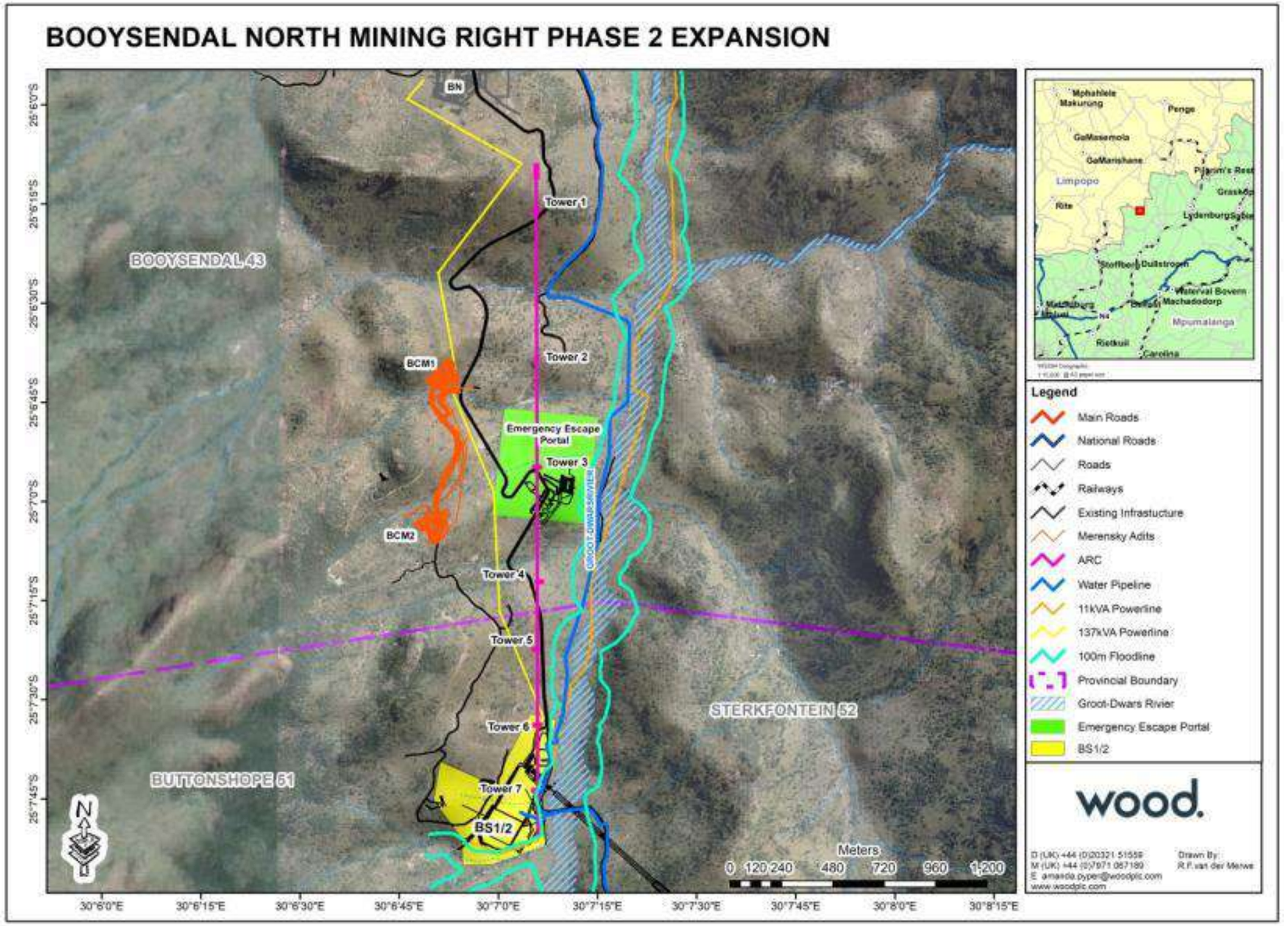


Figure 7-4: BS1/2 to BS4 ARC route and location of Towers

7.2.5 Construction of a bridge across the Groot Dwars River;

The bridge is required to enable vehicle movement from BS4 to BS1/2 and onto BN. The bridge is located on the Groot Dwars River.

7.2.5.1. Objectives of the SWMP

No ponding of water is anticipated. The bridge is designed in a way that it will overtop should there be excessive flow in the Groot Dwars River. For biodiversity reasons, the bridge must also not force water to pond upstream of the crossing. Ponds at river crossings usually result in the unintended impact of restricting movement of fish.

The objectives are explained in Table 7-14.

Table 7-14: Objectives of the SWMP for bridge crossing

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The bridge must make allowance of the fish pass. 2. The Contractor, after consultation with the ECO, will be required to notify the Department of Water and Sanitation in writing to provide the department with a construction programme, prior to any work commencing in proximity of the water courses or drainage features. 3. Extreme caution shall be taken during construction owing to the high erodability river embankments. 4. No construction materials or pollutants, such as cement, shall be allowed to fall/ flow into water features. 5. No washing of vehicles will be allowed in the watercourses. 6. Any activity which brings about the run-off of sediments into the natural watercourse shall be forbidden. 7. The flow of the river may not be affected during construction and under no circumstances will watercourses be blocked. 8. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the

	construction phase of the Project is developed. 9. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: f. Spill prevention and clean-up, g. Plant and vehicle repairs – the repair and washing of vehicles near surface water bodies in and around the project area must be prohibited. 10. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 11. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 12. Chemicals and fuels will be stored in bunded areas together with emergency spill response equipment. 13. The regular maintenance of bridge must be undertaken to ensure these remain clear of debris, especially after each runoff event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Where practical, existing vegetation, trees and shrubs should be left intact. Minimizing vegetation removal upstream of the bridge also tends to control turbulence of the flow into, through, and out of the bridge. 2. For storm events that exceed the design, the bridge will overtop. Such overflow approaches allow floods that exceed the design flow to overtop the roadway, thereby reducing the threat to the bridge structure itself. Protection of the approaches from overflow damage should be considered. 3. Conduct regular inspections for the following a. Determination of the backwater associated bridge openings

	b. Determination of the effects on flow distribution and velocities c. Measurement and estimation of scour potential. 4. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 5. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must address the following: a. There must be procedures in place for spill prevention and clean-up;
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. Concrete and infrastructure associated with the bridge must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase.

7.2.5.2. Technical situation analysis and evaluation

The peak flows for the Groot Dwars River were determined by using the Rational, Alternative Rational and Standard Design Flood methods for comparison purposes. These are the same peak flows which were used for the Flood line delineation.

The Peak flows are summarized in Table 7-15.

Table 7-15: Peak Flows for Groot Dwars River Flood Delineation

Method	Peak Flow 20-year(m^3/s)	Peak Flow 50-year(m^3/s)	Peak Flow 100-year(m^3/s)
Rational	256	341	429
Alt Rational	359	474	576
Standard Design Flood	300	445	568

7.2.5.3. Conceptual design

It can be seen in Table 7-15, the order of magnitude of the methods are similar. The rounded-up flood peak volume of 600m^3/s was then further increased to compensate for possible underestimation of the impervious area of the 70km^2 catchment. A volume of 700m^3/s was used for the 100-year flood line delineation. The peak flows at the position of the bridge crossing are:

- 1:20 260m^3/s;
- 1:50 300m^3/s; and
- 1:100 461m^3/s.

7.2.5.4. Assess the suitability of the existing infrastructure

In order to avoid ponding, the bridge crossing where vehicles move was designed to overtop under justifiable flood conditions.

7.2.5.5. Infrastructure changes that are required

Based on the detailed designs, there are no further changes required.

7.2.5.6. Detailed design of all required infrastructure

Good design practice was applied through a combination of basic engineering principles, experience and judgment in order to furnish the best possible structure to suit the identified bridge crossing site.

The bridge is designed to make allowance of the fish pass. The fish pass is located on the edges of the bridge structure to facilitate fishes' natural migration. This fish pass enable fish to pass around the barriers by swimming and leaping up a series of relatively low steps (hence the term ladder) into the waters on the other side. Considering the MAR of the Groot Dwars River, The velocity of water falling over the steps is enough to attract the fish to the ladder

(PLEASE REFER TO APPENDIX 2 – BRIDGE DESIGN)

7.2.6 Storage facilities for diesel, dangerous and hazardous chemicals

Impervious base, Emergency valves and bund walls are a legal requirement particularly around tanks, storage vessels and other plants that contain liquids which may be dangerous or hazardous to the environment.

7.2.6.1. Objectives and SWMP

It is reasonably easy to construct a "water-tight" bund around a tank. More objectives are discussed in Table 7-16.

Table 7-16: Objectives of the SWMP for Storage facilities

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not

	impact the environment. This must include the following: a. Spill prevention and clean-up, b. Storage of fuels and chemicals c. Plant and vehicle repairs – the repair and washing of vehicles near surface water bodies in and around the project area must be prohibited. d. All Project vehicles must be washed at designated wash bays on site. Wash bays on site will include oil/grease and sediment traps for grey water, before this water is returned into mine processing. 3. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 5. Chemicals and fuels will be stored in bunded areas together with emergency spill response equipment. 6. The mine must manage sewage treatment system in a manner that results in zero discharge of raw sewage to the environment.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. A concrete base and a sealed wall of masonry, brickwork, concrete or even prefabricated steel provides the holding capacity. 2. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 3. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The

	EMS must address the following: b. There must be procedures in place for spill prevention and clean-up; c. Storage of fuels and chemicals; d. Vehicle and plant washing; e. Vehicle and plant repairs. 4. Spill prevention, control and containment measures included into the EMS for construction must be reviewed to amend operational procedures. 5. All oil/water separators will be maintained in good working order. 6. No washing of Project vehicles in any surface water bodies in and around the Project Area. 7. All Project vehicles will be washed at designated wash bays on site. Wash bays will include oil/grease and sediment traps. 8. Suitable clean-up of areas where spillage of soil contaminants occurs and appropriate disposal thereof. 9. No *ad hoc* maintenance of vehicles in and around the surface water bodies. 10. All vehicles will be maintained at a designated workshop at the Processing Plant, which will include an oil/grease trap. 11. Chemicals and fuels will be stored in bunded areas with emergency spill response equipment. 12. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend

water management measures	decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase.

7.2.6.2. Technical situation analysis and evaluation

Diesel, dangerous and hazardous material will be stored on site. Regulations require a holding capacity of 110% of the capacity of the maximum capacity, of the biggest tank within the bund or 25% of the total capacity of all the tanks within the bund whichever is the greatest.

7.2.6.3. Conceptual design

Most companies embarked on an upgrading programme involving the construction of "water-tight" bunds, to retain any oil leakage and to prevent further pollution and contamination. They immediately encountered the problem of water build-up from rain being retained by the now "water-tight" bund; the unwanted rain-water reduces the holding capacity of the bund. In relation to Booysendal, the storage areas must be inspected regularly. Once the water level reaches more than 10% of the holding capacity of the bund, it is no longer fit for purpose and the water must be removed.

A concrete base and a sealed wall of masonry, brickwork, concrete or even prefabricated steel provides the holding capacity.

Oil floats on water and, if still clean enough to see through, has a different refractive index than the water below, making the oil/water interface difficult to judge. This makes manual pumping difficult and unsafe. Removing the entire contents for disposal as hazardous waste is expensive and environmentally unacceptable.

7.2.6.4. Assess the suitability of the existing infrastructure

The infrastructure is in the process of being constructed. As such, visual inspections must be conducted at the storage areas during the LoM and to ensure that construction is carried out in accordance with the recommendations included here. The water is also likely to be, at best, moderately contaminated with a small film of oil on top of it or, at worst, substantially contaminated by a thick layer of oil.

Spillages of hazardous chemicals onto soils or its escape or migration into the surrounding areas must be managed as emergency incidents. Spill kits must be made available at all time.

Oil water separators are typically considered very simple systems. However, several factors that could potentially affect safety, efficiency, and proper management must be given careful consideration prior to the installation or modification of any oil water separator or separation system:

The effectiveness of any oil water separator is affected by the flow rate. The slower the flow, the better the results. Should the failure of the oil separator be only observed during wet seasons, energy dissipaters should be considered at the inlet of the oil separator.

If too much oil accumulates in the receiving and middle chambers, it may flow into the outlet chamber and end up being discharged to the environment. Proper oil water separator design will allow for the removal and storage of accumulated oil from the separator to ensure that the accumulated products do not affect the operation of the separator.

Water from the wash bays also reports to the oil separator. Detergents and soaps designed to remove oily grime from equipment, vehicles, or other components can adversely affect the operation of a gravity oil water separator. These types of surfactants, or "emulsifying" agents, are specifically formulated to increase the dispersal of oil into water, which is why they are such good cleaners.

When these soapy waters enter an oil water separator, it takes significantly longer for the oil to separate, if it can, from the water. Excessive use of detergents can render an oil water separator inefficient by completely emulsifying oils into the wastewater stream and allowing them to pass through the system.

Oil/water separators must be monitored and maintained by competent personnel who understand how the systems operate.

7.3 Various water infrastructure at BS1/2

Various water reticulation and related infrastructure will be constructed at BS1/2. This includes a raw water tank of 8,500m³; process water storage tank of 812m³; potable water storage tank of 10m³; potable water treatment plant with a throughput capacity of 15m³/h; sewage treatment plant with a capacity of 30m³/h.

These areas must be managed as clean water catchments.

Sewage system must be designed to exclude Storm water runoff in order to reduce treatment costs.

Sewage treatment is the process of removing contaminants from wastewater. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce an environmentally safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer).

Advantage of using package sewage treatment facility is that sewage is treated close to where the sewage is created to avoid collection and transportation by a network of pipes and pump stations.

The disadvantage of the package plant is that it requires a precise control of timing and chemical mixing. This precision is typically achieved with computer controls linked to sensors. Such a complex, fragile system is unsuited to places where controls may be unreliable, poorly maintained, or where the power supply may be intermittent.

The sludge accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. Other objectives are discussed in Table 7-17.

Table 7-17: Objectives of the SWMP for various infrastructure at BS1/2

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction

measures	phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: a. Sewage handling and treatment, b. Storage of sludge c. sediment traps for grey water, before this water is returned into mine processing. 3. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 5. Chemicals and fuels will be stored in bunded areas together with emergency spill response equipment. 6. The mine must manage sewage treatment system in a manner that results in zero discharge of raw sewage to the environment. 7. Treated sewage must conform to recognised standards as will be in the Water Use Licence, before discharge.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. The sludge accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. 2. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 3. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must

	address the following: a. There must be procedures in place for spill prevention and clean-up; b. Sewage handling and treatment procedures; c. Storage sludge; d. Vehicle and plant washing; e. Vehicle and plant repairs. 4. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. Infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase.

7.4 Phase 1 activities associated with BS4

The activities associated with

7.4.1 Reworking and replacing of tailings on the existing TFS1

7.4.1.1. Objectives and SWMP

In order to ensure that all runoff from TSF1 external embankments is contained, a series of paddocks are constructed around the perimeter of the TSF. These paddocks will retain SS entrained within the runoff to ensure that water quality discharge limits, as might be imposed by the DWS are met.

Any clean runoff arising from the upstream catchment area will be intercepted and diverted around the TSF by means of lined storm water diversion ditches. The design of these diversion structures is conceptual at this stage and will form part of the overall storm water management plan which will have to be updated for the project once all designs become available.

Objectives are discussed in Table 7-18.

Table 7-18: Objectives of the SWMP for reworking of TFS1.

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: d. Spill prevention and clean-up, 3. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned

	immediately and the contaminated area will be rehabilitated.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Some of the potential impacts and risks posed by mining remain long after mining operations cease. In particular, tailings facilities may pose physical and chemical risks in perpetuity. 2. The integrity of the surface run off control systems must be maintained for the effective separation of clean and dirty water systems. 3. Leak detection measures must be in place. The establishment of slurry and water pipelines is critical to the project, as the tailings will be recovered through hydraulic mining techniques. 4. Water from the dirty water catchment must be managed as dirty water in line with the BPG. Rain water falling on the side slopes on TSFs that would normally have been part of the normal surface run off is retained in toe-paddocks where it eventually becomes part of the hydrological cycle via evaporation and infiltration. 5. Dirty water and process water will be recycled as far as practically possible. 6. Pumping equipment should be adequately maintained. 7. An appropriate water management plan for TFS1 must be amended annually. The amendment must take the following into consideration: a. Surface hydrology and hydrogeological data, including the delineation of tailings site catchment area(s) and all potential water sources, both natural and process, are used in the development of a water/contaminant balance and design of tailings facility components. b. Establish and document design parameters, then monitor actual experience to identify variances, validate projections, and anticipate potential problems.

	c. Design Flood: The appropriate Environmental Design Flood and Inflow Design Flood need to be identified, with reference to current design standards and in consultation with regulatory agencies. Design flood considerations should be consistently applied throughout all phases of the life cycle, d. Storage requirements, operating freeboard and spillway design are based on the hydrology of the watershed. e. Water Balance: Annual water balance study. Specify requirements for ongoing data collection for the ore processing facility and for tailings facility water balance calibration purposes. f. Water calculation to estimate fresh water needs and maximum pond storage requirements should be conducted and then updated at a frequency appropriate to the facility-specific conditions. Operational water balance should also be calculated and updated as appropriate. 8. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 9. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must address the following: a. There must be procedures in place for spill prevention and clean-up; b. Sewage handling and treatment procedures; c. Storage of fuels and chemicals; d. Vehicle and plant washing; e. Vehicle and plant repairs.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.;

	2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All pipeline and pumping infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. Development of closure plans and performance objectives for closure and post-closure. a. A conceptual closure plan, developed with a low level of detail at the project conception and planning phase, should become more detailed and elaborated at the design phase. b. The conceptual close plan should then be refined, elaborated, verified, and updated periodically during the initial construction and operating phases of the life cycle of the tailings facility, and in preparation for decommissioning, closure, and post-closure. c. The closure plan and objectives should be considered in the assessment of alternatives to select the tailings facility location. d. The potential physical and chemical impacts and risks of the tailings facility are key considerations.

7.4.1.2. Technical situation analysis and evaluation

A 200mm thick horizon of grouted stone pitching shall be installed across the edge of the dissipater spillway for erosion control. The spillway shall contain a 1.0m hydraulic step to reduce the flow velocity of fluid entering from the decant pipeline.

The downstream retention bund within the sediment trap shall consist of compacted fill with a 300mm thick reinforced concrete slab (class 25Mpa/19mm). The slab shall contain 1 steel mesh layer with at least 50mm cover.

7.4.2 Rehabilitation and upgrade of the storm water management system at BS4

This paragraph includes the PCDs, new Dirty Water Chanel and the proposed upgrade of the dirty water channel. As part of the implementation of the SWMP conducted by SLR in 2011, the old dirty water collection channel at BS4 Processing Plant (Hereafter referred to as Plant 1) will be rehabilitated.

Please note that the location of infrastructure is clearly indicated in the following appendices:

Appendix 3a	BS4 Dirty Water Channel
Appendix 3 b	BS4 Plant 1 PCD
Appendix 3c	BS4 Plant 2 PCD
Appendix 3d	BS4 New Dirty Water Channel.

The overall BS4 SWMP is indicated in Appendix 3.

Objectives of the SWMP are discussed in Table 7-19.

The dirty water collection channels are required to collect contaminated water from the dirty water catchment to discharge it in the plant PCD.

Table 7-19: Objectives of the SWMP – Rehabilitation and upgrade of Storm water channel

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The old stone pitched dirty water drain posed a risk of infiltration of dirty water. This channel is rehabilitated and upgraded to a concrete lined channel. 2. Replacement of stone pitching must be with impervious concrete slabs. 3. Clean water must be diverted around all major construction sites 4. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 5. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water	1. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend

management measures	operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 2. Storm water control infrastructure is designed to account for the 1:50 year storm event. 3. All civil engineering requirements for all roads so as to prevent any impedance of surface water flows will be implemented. 4. Where the channel cross the road, There must be regular maintenance of culverts to ensure they remain clear will also be undertaken.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	6. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 7. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 8. All pipeline and pumping infrastructure associated with the project must be removed. 9. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 10. On gentle slopes, water will be encouraged to flow off the

	rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 11. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.4.2.1. Technical situation analysis and evaluation

The old stone pitched dirty water drain posed a risk of infiltration of dirty water. This channel is rehabilitated and upgraded to a concrete lined channel. The dimensions of this channel are similar to the dimensions of the new dirty water channel presented in Paragraph 7.3.2.3.

7.4.2.2. Conceptual design

The dirty water channel at BS4 is designed to collect and transport 0.949m^3/s during storm events. The design criterion for the new dirty water channel at BS4 is indicated in Tables 7-20 and 7-21.

Table 7-20: New Plant 1 Dirty Water Channel Dimensions

Top Width	1800mm
Bottom Width	600mm
Side Slope 1	1:1m/m
Side Slope 2	1:1m/m
Slope	1:100m/m
Depth	600mm

Table 7-21: Conceptual design for the New Plant 1 Dirty Water Channel

Channel shape: Trapezium channel

Friction calculation method: Manning formula

Solve for: Flow rate (Q) — Solve

Input data

Flow rate (Q)	0.949	m³/s
Channel slope (S)	0.01	m/m
Roughness coefficient (n)	0.035	s/m^1/3
Normal depth (Yn)	0.6	m
Left side slope (Sl)	1	m/m
Right side slope (Sr)	1	m/m
Bottom width (b)	0.6	m

Results

Flow area (A)	0.720	m²
Wetted perimeter (P)	2.297	m
Hydraulic radius (R)	0.313	m
Top width (B)	1.800	m
Critical depth (Yc)	0.484	m
Critical slope (Sc)	0.02345	m/m
Velocity (V)	1.318	m/s
Velocity head (Hv)	0.089	m
Specific energy (Es)	0.689	m
Froude number (Fr)	0.6655	
Flow type	Subcritical	

7.4.2.3. Assess the suitability of the existing infrastructure

The sizing and designs of the dirty water channel are suitable for the clean and dirty water management purpose.

The old dirty water drain at BS4 Plant 1 is upgraded.

All dirty water channels discharge into the silt trap before water is stored in a PCD. A silt trap, also known as a sediment basin, is a temporary pond built upstream of the PCD to capture eroded or disturbed soil that is washed off during rain storms. The sediment-laden soil settles in the pond of the silt trap before the runoff is discharged from the silt trap into the PCD. Silt traps are often used in conjunction with erosion controls and other sediment control practices.

Essential sediment abundance is prevalent in the construction industry which gives insight to future endeavors. In essence lateral buckling occurs under traverse load or at critical loads. The advantage about the small surface area is that evaporation losses are minimised.

7.4.2.4. Infrastructure changes that are required

(Please note that the infrastructure referred to in this paragraph are indicated in drawings attached as Appendix 3a to 3d)

The following upgrades were considered. Some of these upgrades were done:

- Upgrade of the storm water drainage at and downstream of the portal;
    - This upgrade was conducted to reduce the potential of infiltration of dirty water from the dirty water catchment.
- Upgrade of the clean and dirty water separation system upstream of the existing TSF and to the east of the existing portal and workshop complex;
    - A clean water cut off trench was designed to ensure that water from the external catchment is released back to the environment.
- Upgrade and lining of the plant pollution control dam (PCD);
    - The HDPE liner has a design life. The PCD at the processing plant was upgraded and re-lined.
- Upgrade of the northern portal PCD;
- Upgrade of the sewage treatment plant at the workshop; and
- Construction of a PCD at the Valley Boxcut.
- Water supply pipeline from the TKO dam to BS1/2 (with a view to abstracting water from the dam);
- Increase in the size of the ore stockpile (ROM);
- Silt trap at the upstream point of the conveyor system.

7.4.2.5. Decommissioning and rehabilitation of workshop PCD

The Workshop PCD was reclaimed after operations and the area was shaped to form a stable landform congruent with the surrounding landscape. The expectation is that as rehabilitation of the PCD footprint is implemented, the size of the contact water catchment reduces until there is no further need for containment. Closure actions for the dam was as follows:

- All rehabilitation activities were limited to the already disturbed area.
- No further removal of vegetation would be allowed. This has specific reference to the vegetation which has been removed by the construction of this PCD.

- All concrete structures were demolished;
- Silt that accumulated in the dam was removed in line with the Hazardous waste management strategy;
- Liners were removed;
- Earth walls were flattened and excavations were backfilled with material removed during construction; and
- The footprint must be profiled to be free draining with no low points to accumulated water.

7.4.3 A 13,9m wide access road between BS4 and BS1/2

The access road from BN, via BS1/2 to BS4 crosses a number of natural streams, most of which are seasonal except for the Groot Dwars River crossing (discussion included in Section7-1) as well as numerous wetlands. To prevent impacts on the natural watercourses and to manage erosion and damage to the road, concrete culverts need to be constructed to convey storm water from one to the other side of the road. Normally such an activity would trigger water use activities under Section 21 c and I of the NWA. The construction of the culverts will result in disturbance of the bed and banks of the natural streams. Road design and construction has to ensure the protection of the water resources.

7.4.3.1. Objectives of the SWMP

The access road needs to be constructed in such a manner that water from the access road must be released to the environment without posing the risk of erosion. In addition to the hydraulic function, a culvert must also support the watercourse, embankment and/or roadway, and protect traffic from flood hazards to the extent practicable.

Objectives are discussed in Table 7-22.

Table 7-22: Objectives of the SWMP for access road

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 3. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 4. The regular maintenance of culverts must be undertaken to ensure these remain clear of debris, especially after each runoff event.

	5. The Mine must ensure that the any infrastructure constructed in and across surface water run-off channels will be undertaken in a manner that compliments good engineering/environmental practice. This will include e. The installation of appropriately sized and spaced culverts to avoid flow interruption; f. Properly located culverts to avoid the increase of sediment loads in the rivers. g. Where possible, construction of infrastructure in and across surface water run-off channels must be conducted in the dry season, when no flash-floods are expected. 4. Clean water must be diverted around all major construction sites 6. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 7. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. For erosion protection, culvert outlets were designed. In such a pronounced topographic area it is essential to take care of and prevent erosion and sediment transport. To achieve this objective the culvert outlets will be treated with rock gabion mattresses supported by stone pitching or rock riprap where necessary. 2. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend

	operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 3. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must address the following: f. There must be procedures in place for spill prevention and clean-up; g. Sewage handling and treatment procedures; h. Storage of fuels and chemicals; i. Vehicle and plant washing; j. Vehicle and plant repairs. 4. Storm water control infrastructure is designed to account for the 1:50 year storm event. 5. Clean run-off will be diverted around the Project Site into the nearest natural drainage path. 6. The diversion channels must be operated to accommodate the 1:50 years flood. 7. Spill prevention, control and containment measures included into the EMS for construction must be reviewed to amend operational procedures.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the

measures	decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All pipeline and pumping infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 6. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.4.3.2. Technical situation analysis and evaluation

Hydrological approach assumes that the culvert will have no effect on flow rates. The goal is to have a culvert that will result in no significant damage on the environment by reducing flow velocity on the outlet side and reducing erosion. This may be achieved by providing short-term storage of water in the channel and on the land upstream from the road crossing.

7.4.3.3. Conceptual design

The drainage system consisting of cut off trenches and culverts were designed for the 1:10-year event and consists mainly of the following elements:

- Transverse storm water drainage of water flowing towards the road in natural streams and water courses (including wetlands);
- Cut-off drains above areas where the road is in cut by way of rocks, berms and retaining walls;
- Road surface storm water run-off drainage comprising lined side drains and pipe system; and

- Sub-surface water drainage especially where the road is in cut.

The culvert crossings for the access road are summarized in Table 7-23 below:

Table 7-23 Culvert Crossings for Access Road – New Section

Catchment	Surface Area	Culverts	Chainage
A1	0.340	1X0.6m	3.26km
		2X0.9m	3.470km
			From 3.180 to 3.420km
A2	0.080	2X0.6m	3.660km
A3	0.120	No Culverts	
A4	0.030	1X0.9m	3.880km
A5	0.020	1X0.6m	4.120km
		1X0.6m	4.180km
		1X0.6m	4.220km
A6	0.025	1X0.6	4.340km
A7	0.027	No Culvert	
A8	0.030	1X0.6m	4.440km
		1X0.6m	4.500km
A9	0.040	1X0.6m	4.600km
A10	0.115	1X0.9m	4.680km
A11	0.037	Berm	From 4.990 to 5.130km
A12	0.008	2X1.2m	5.200km
A13	0.106	1X0.6m	5.320km
		1X0.6m	5.380km

(PLEASE REFER TO APPENDIX 4a – NEW SECTION CULVERT CROSSINGS FOR ACCESS ROAD APPENDIX 4b – CULVERT SCHEDULE ISSUED FOR CONSTRUCTION)

Where the road is in cut and where soil retaining structures are required, training walls are proposed to divert most of the surface water away from the cut face.

Sub-surface drains below the concrete lined side drains are to be constructed. Where a Storm water drainage pipe system is also required, the pipes are designed to be bedded on clean stone with sand backfill to serve the purpose of sub-surface drainage in other instances a pipe and stone drain wrapped in geotextile is to be constructed.

7.4.3.4. Assess the suitability of the existing infrastructure

The main access road will be a hard-top road. This reduces the potential for erosion. Where the road is in high fill, storm run-off from the road surface was designed to drain into concrete lined side drains, Type F, along the side adjacent to the cutting.

The detailed Civil Engineering Designs for culvert crossings were compiled by DRA Projects (Pty) Ltd. These culverts are suitable as they do not result in negative effects like water ponding and the release water velocity will not result in erosion.

7.4.3.5. Detailed design of culverts

The design requirements for the main access road from a storm water management point of view include side drains.

The road has a constant cross fall to the upstream side of the road. Concrete lined side drains have been provided. The concrete lined drains are necessitated by the steep grades on the road and to protect the side of the road against erosion.

At the terminal points of the chutes the water will be channeled down to the culvert inlets by way of concrete lined chutes. Energy breaker blocks are to be constructed at the bottom of the chutes.

7.5 Phase 2 Storm Water Management Measures associated with BS1/2

As demonstrated in Figure 7-5, BS1/2 infrastructure falls within Catchment 13. Catchment 13 covers approximately 5km^2 and can yield up to 20.2m^3/s for a 1:100 years storm event, 24 hour storm event.

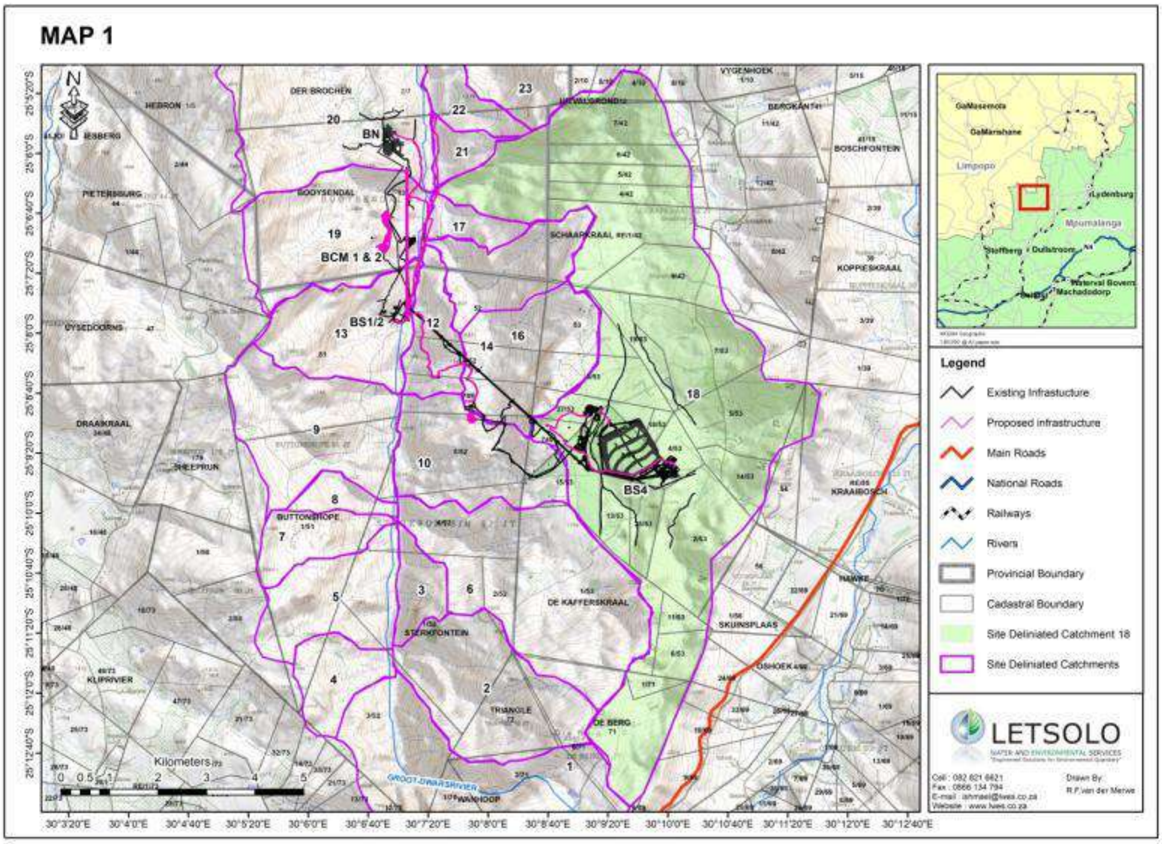


Figure 7-5: BS1/2 Infrastructure falling in Catchment 13

7.5.1 11 kVA powerline from BN to BS1/2

As seen in Figure 7-5, the power line traverse through Catchments 13, 19 and 20. The power line has low impact on storm water. The power line does not result in the reduction, diversion or ponding of water.

However, at areas where the power lines cross the rivers, it is recommended that the main poles be located outside the 1:100 years flood lines in order to reduce the potential risks of flooding and reduction in pole stability. Erosion control measures should include rehabilitation and re-vegetation post construction and rehabilitation monitoring.

The objectives are discussed in Table 7-24.

Table 7-24: Objectives of the SWMP for powerline

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: h. Spill prevention and clean-up, i. Storage of fuels and chemicals j. Plant and vehicle repairs – the repair and washing of vehicles near surface water bodies in and around the project area must be prohibited. k. All Project vehicles must be washed at designated wash bays on site. Wash bays on site will include oil/grease and sediment traps for grey water, before this water is returned into mine processing. 3. For significant spillages, Areas where spillage of soil contaminants

	occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 5. Chemicals and fuels will be stored in bunded areas together with emergency spill response equipment. 6. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. All oil/water separators will be maintained in good working order. 2. No washing of Project vehicles in any surface water bodies in and around the Project Area. 3. All Project vehicles will be washed at designated wash bays on site. Wash bays will include oil/grease and sediment traps. 4. Suitable clean-up of areas where spillage of soil contaminants occurs and appropriate disposal thereof. 5. No *ad hoc* maintenance of vehicles in and around the surface water bodies. 6. All vehicles will be maintained at a designated workshop at the Processing Plant, which will include an oil/grease trap. 7. Chemicals and fuels will be stored in bunded areas with emergency spill response equipment. 8. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and	***Objectives and Targets for the Decommissioning and Closure Phase***

Closure Phase - Objectives	7. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 8. To ensure protection of surface water resources; 9. To maintain as far as possible, the MAR of the Groot Dwars River; 10. To avoid/minimise adverse surface water quality impacts; 11. To avoid/minimise adverse surface water impacts due to flow interruption; 12. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All powerlines and infrastructure associated with the project must be removed. 4. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.5.2 Process and clean water pipelines between BS1/2 and BN

As seen in Figure 7-5, the proposed pipelines also traverse through Catchments 13, 19 and 20.

The source of portable water is the current Lebalelo pipeline for which Booysendal holds an existing allocation. From this source raw water is stored within the 10meg dam before it is purified. The pipeline will follow the same alignment as the process water pipeline and will run above ground The pipeline will have a diameter of 250mm with a throughput of less than 120l/s, therefore outside of thresholds of the NEMA listed activities.

Two alternative routes were proposed as follows:

- Alternative 1: Pipelines to run along the main access road;
- Alternative 2: Pipelines to run along the existing gravel access road next to the Groot Dwars River; and

The purpose of the process water line is to pump excess water from the PCD at BS1/2 during high rainfall events to BN, thereby avoiding overtopping and spillage into the Groot Dwars River.

From a Hydrological point of view, Alternative 2 is the preferred option as the road has already been disturbed and that storm water and erosion control measures are already installed on site.

The pipeline does not result in the reduction, diversion or ponding of water.

7.5.2.1. Conceptual design

A HDPE process water pipeline will be constructed from the BS1/2 portal complex to BN. The purpose of the pipeline will be to transfer excess water from the 14,000m^3 PCD at BS1/2 and the PCDs at BCM1 and BCM2 in the event of high rainfall to the 2.6megaliter (Ml) cement dam at BN to avoid spillage of untreated process water into the Groot Dwars River.

The pipeline will have a diameter of 250mm with a through flow of less than 120l/s, therefore outside of a NEMA activity. Potable water will be provided from the 2.6Ml storage tank at BN to BS1/2. Potable water will also be off take at BCM1 and BCM2.

7.5.2.2. Assess the suitability of the existing infrastructure

During the construction phase a corridor along the existing gravel access road running next to the Groot Dwars River will be cleared. The total clearance will be 7.5Ha for the pipeline. The pipelines will run above ground. The potable water line will be a steel pipe with a 210mm diameter.

The location of process water pipelines near surface water resources comes with the responsibility to preserve the environment. Due to the length of the pipeline, a catchment wide assessment was conducted as the pipeline cross several catchment areas.

For aboveground pipelines, it is easy to conduct visual inspection during the time when water is pumped from the PCD and conveyed through this pipeline.

The following measures are emphasized:

- Appropriate and adequate protection of existing natural structures such as river banks in the vicinity of the pipelines will be incorporated into the design,
- Where crossing or running alongside river or stream courses, the existing river/stream bank structure will be maintained to reduce disturbance to the river flow.

The objectives are discussed in Table 7-25.

Table 7-25: Objectives of the SWMP for clean water pipeline

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. Clewn water [pipelines pose a risk of erosion during spillages. Inspections must be conducted for leaks and pipe bursts.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts;

	2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Damage pipelines that could result in water under pressure leaving terrain and impacting on natural undisturbed areas.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All pipeline and pumping infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion.

	6. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.5.3 Access roads to the BCM1 and BCM2 Adits

The design of culvert crossings is underway for the Phase 2 access roads. Designs for the Phase 1 access roads have been completed.

7.5.3.1. Objectives and SWMP

Phase 1 objectives (Table 7-26) for Access road from BS4 to BS1/2 are as follows:

Table 7-26: Objectives of the SWMP for access roads

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: a. Spill prevention and clean-up, b. Storage of fuels and chemicals c. Plant and vehicle repairs – the repair and washing of vehicles near surface water bodies in and around the project area must be prohibited. d. All Project vehicles must be washed at designated wash bays on site. Wash bays on site will include oil/grease and sediment traps for grey water, before this water is returned into mine processing. 3. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned

	immediately and the contaminated area will be rehabilitated. 5. Chemicals and fuels will be stored in bunded areas together with emergency spill response equipment. 6. The regular maintenance of culverts must be undertaken to ensure these remain clear of debris, especially after each runoff event. 7. Clean water must be diverted around all major construction sites 8. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 9. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Where the discharge exceeds the capacity of the selected pipes, box culverts are used to minimise the footprint of the intervention. 2. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 3. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must address the following: a. There must be procedures in place for spill prevention and clean-up; b. The mine must ensure that the spacing of culverts and discharge points are such that water quantity is

	not compromised. 4. All civil engineering requirements for all roads so as to prevent any impedance of surface water flows will be implemented. 5. The regular maintenance of culverts to ensure they remain clear will also be undertaken.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All pipeline and pumping infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.5.3.2. Technical situation analysis and evaluation

Culverts come in many sizes and shapes including round, elliptical, flat-bottomed, pear-shaped, and box-like constructions. The culvert type and shape selection is based on a number of factors including: requirements for hydraulic performance, limitation on upstream water surface elevation, and roadway embankment height. Pipe and box culverts were designed for the temporary road.

7.5.3.3. Conceptual design

The drainage for the road was designed by SNA in accordance with the *South African Drainage Manual* issued by SANRAL. The manual has recommended storm return periods for different classes of road. The drainage for the road was designed to cater for the 1:10-year storm, an event which has a 10% probability of occurring in accordance with the drainage manual for a Class 3 rural minor arterial.

7.5.3.4. Assess the suitability of the existing infrastructure

The structures would normally trigger an application in terms *of section 21 c and i* with the purpose of safeguarding the objectives of the NWA. These streams are mainly seasonal and in most streams there are no evidence of aquatic life in them since they are fast flowing when it rains. In this instance the proposed culverts pose no threat to quality, quantity or availability of water. Essentially the culverts will be constructed on the level of the existing stream bed but will not result in flow reduction. The drainage elements were designed in accordance with *South African Drainage Manual* issued by SANRAL.

7.5.3.5. Detailed design of all required infrastructureBSM1, BCM2 Access Roads

Cross drainage is provided by means of concrete pipes and concrete box culverts, depending on the discharge from the catchment. For ease of maintenance and in compliance with SANRAL standards, pipes of between 450 and 900mm diameter were selected as minimum.

Where the discharge exceeds the capacity of the selected pipes, box culverts are used to minimise the footprint of the intervention.

7.5.3.6. SWMP

Culvert crossings are recommended in order to manage storm water on temporary and permanent roads. Proper designs of culverts reduce sediment transport and road damage.

(PLEASE REFER TO APPENDIX 5 – ACCESS ROAD DESIGN)

7.6 Phase 2 activities associated with BCM1 & BCM2

These activities include the following:

- Development of surface infrastructure at BCM1 and BCM2 which includes dirty water channels, wash bays, oil separators, STPs, PCDs;
- An emergency escape portal is planned just east of the BCM1 and BCM2 complexes. It will serve as a return airway system for BS1/2, BCM1 and BCM2 and as emergency escape portal. This is to comply with the mine health and safety requirements. The emergency escape portal will have a development footprint area of 1.3Ha. Access will be gained from the main access road onto a 4m wide bitumen road.

7.6.1 BCM1 and BCM2

As part of further project development, Booysendal identified the need for surface infrastructure components at BCM1 and BCM2.
As seen in Figure 7-2, BCM1 and BCM2 fall within Catchment 19. Catchment 19 covers a surface area of 9.39km^2 and can yield up to 29.3m^3/s.

7.6.1.1. Objectives of the SWMP

Infrastructure at BCM1 will be identical to Infrastructure at BCM2. The flood calculations were conducted in order to quantify the dirty water volume from BCM1 and 2.

The following characteristics were used for flood calculations:

Area	= 14 000m^2
Change in elevation	= 13m
Hydraulic Length	= 100m

The objectives are summarized in Table 7-27.

Table 7-27: Objectives of the SWMP for BCM1 and BCM2

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 2. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: a. Spill prevention and clean-up, b. Sewage handling and treatment, c. Storage of fuels and chemicals d. Plant and vehicle repairs – the repair and washing of vehicles near surface water bodies in and around the project area must be prohibited. e. All Project vehicles must be washed at designated wash bays on site. Wash bays on site will include oil/grease and sediment traps for grey water, before this water is returned into mine processing. 3. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 4. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 5. Chemicals and fuels will be stored in bunded areas together with emergency spill response equipment. 6. The mine must manage sewage treatment system in a manner that results in zero discharge of raw sewage to the environment. 7. Treated sewage must conform to recognised standards as will be in the Water Use Licence, before discharge. 8. The regular maintenance of culverts must be undertaken to ensure these remain clear of debris, especially after each runoff event.

	9. The Mine must ensure that the any infrastructure constructed in and across surface water run-off channels will be undertaken in a manner that compliments good engineering/environmental practice. This will include a. The installation of appropriately sized and spaced culverts to avoid flow interruption; b. Properly located culverts to avoid the increase of sediment loads in the rivers. c. Where possible, construction of infrastructure in and across surface water run-off channels must be conducted in the dry season, when no flash-floods are expected. 10. Clean water must be diverted around all major construction sites 11. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 12. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must address the following: c. There must be procedures in place for spill prevention

	and clean-up; d. Sewage handling and treatment procedures; e. Storage of fuels and chemicals; f. Vehicle and plant washing; g. Vehicle and plant repairs. 3. The mine must ensure that the spacing of culverts and discharge points are such that water quantity is not compromised. 4. The operation/management of the sewage package plant must continuously assess pump rates, pump cycles and monitor the final effluent volumes. 5. Storm water control infrastructure is designed to account for the 1:50 year storm event. 6. All civil engineering requirements for all roads so as to prevent any impedance of surface water flows will be implemented. 7. The regular maintenance of culverts to ensure they remain clear will also be undertaken. 8. Construction of any infrastructure in and across surface water run-off channels will be undertaken in a manner that compliments good engineering/environmental practice. 9. Clean run-off will be diverted around the Project Site into the nearest natural drainage path. 10. The diversion channels must be operated to accommodate the 1:50 years flood. 11. Stockpiles must be located away from run-off channels. 12. Spill prevention, control and containment measures included into the EMS for construction must be reviewed to amend operational procedures. 13. All oil/water separators will be maintained in good working order. 14. No washing of Project vehicles in any surface water bodies in and around the Project Area. 15. All Project vehicles will be washed at designated wash bays on site. Wash bays will include oil/grease and sediment traps. 16. Suitable clean-up of areas where spillage of soil contaminants occurs and appropriate disposal thereof. 17. No *ad hoc* maintenance of vehicles in and around the surface water bodies.

	18. All vehicles will be maintained at a designated workshop at the Processing Plant, which will include an oil/grease trap. 19. Chemicals and fuels will be stored in bunded areas with emergency spill response equipment. 20. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All pipeline and pumping infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 6. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded

	areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

Surface infrastructure at each of the Adits include:

- Construction of a terrace;
- Conveyors:
- A dip conveyor system which will transport ore from the underground to the crusher feed conveyor from where the ore will be transferred to the crusher plant located between BCM1 and BCM2.
- Silo with a capacity of 4,200t.
- The crusher with a capacity of 50 tonnes;
- Infrastructure at the terrace areas will include the following:
  - An office complex.
  - A workshop and oil separator;
- A brick change house (for 300 people) and access control building;
- Transformer and substation;
- Emulsion storage tanks;
- Oil and hydraulic fluids storage areas;
- A concrete bunded waste collection area;
- Security fencing with access control;
- A STP) with a throughput capacity of 24m^3/day at BCM1 and 23m^3/day at BCM2;
- A high-density polyethylene (HDPE) lined PCD and settler will be constructed at each of the adit complexes. The PCDs are correctly sized in line with GN 704. The combined capacity of the PCD (2,500m^3) and settler (1,000m^3) is 3,500m^3;
- Fire water and potable water storage tanks with a combined indicative volume of 80m^3 at BCM1 and 80m^3 at BCM2;
- Compressors;
- Off-stream water storage will be less than 50,000m^3 and therefore falls outside the ambit of a NEMA listed activity.

7.6.1.2. Conceptual design

The flood calculations are covered in Table 7-28 . Also refer to Figure 7-6 and 7-8 for the proposed infrastructure.

Table 7-28: Runoff Coefficient

RATIONAL METHOD

C1=Cs+Cp+Cv	0.00
C2	0.5785
C_T	**0.58**

Area Dividing Factor		
Rural %	Urban %	
0%	100%	100%

Rural - C1						Urban - C2	
Surface Slopes		Permeability		Vegetation			
Vlei's & pan's (<3%)	0	Very permeable	0	Dense Bush	0	Lawn and parks	5
Flat areas (3 to 10%)	0	Permeable	0	Cultivated land	0	Industrial	65
Hilly areas (10 to 30%)	0	Semi-permeable	0	Grass land	0	Business/residential	15
Steep areas (>30%)	0	Impermeable	0	Bare surface	0	Streets	15
Total %	**0**	**Total %**	**0**	**Total %**	**0**	**Total %**	**100**

COMPONENT	CATERORY	MAP(mm) <600	600-900	>900
SURFACE SLOPE IN %	<3	0.01	0.03	0.03
Cs	3 TO 10	0.06	0.08	0.11
	10 TO 30	0.12	0.16	0.20
	>30	0.22	0.26	0.30
PERMEABILITY OF	Very permeable	0.03	0.04	0.05
THE SOIL	Permeable	0.06	0.08	0.10
Cp	Semi-permeable	0.12	0.16	0.20
	Impermeable	0.21	0.26	0.30
	Dense Bush	0.03	0.04	0.05
VEGETATION	Cultivated land	0.07	0.11	0.15
Cv	Grass land	0.17	0.21	0.25
	Bare surface	0.26	0.28	0.30

MAP (mm) 730

C1	
Vlei's & pan's (<3%)	0.00
Flat areas (3 to 10%	0.00
Hilly areas (10 to 30	0.00
Steep areas (>30%)	0.00
Cs	**0.00**
Very permeable	0.00
Permeable	0.00
Semi-permeable	0.00
Impermeable	0.00
Cp	**0.00**
Dense Bush	0.00
Cultivated land	0.00
Grass land	0.00
Bare surface	0.00
Cv	**0.00**

C2				
Lawns	**Range**	**Factor**	**% of area**	
Sandy, flat <2%	0.05 - 0.10	0.07	100%	
Sandy, steep >7%	0.15 - 0.20	0	0%	
Heavy, flat <2%	0.13 - 0.17	0	0%	
Heavy, steep >7%	0.25 - 0.35	0	0%	
			100%	0.07
Industrial	**Range**	**Factor**	**% of area**	
Light	0.50 - 0.80	0	0%	
Heavy	0.60 - 0.90	0.7	100%	
			100%	0.7
Residential	**Range**	**Factor**		
Houses	0.30 - 0.50	0	0%	
Apartments	0.50 - 0.70	0	0%	
Business	**Range**	**Factor**		
Downtown	0.70 - 0.95	0	0%	
Neighborhood	0.50 - 0.70	0	0%	
			0%	0
Streets	**Range**	**Factor**	**% of area**	
Asphalt	0.70 - 0.95	0.8	100%	
Concrete	0.80 - 0.95	0	0%	
Brick	0.70 - 0.85	0	0%	
			100%	0.8

Table 7-29: Peak Flows Calculations

Recurrence interval	Area (m^2)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Peak flow (m^3/s)
2	14,000	0.17333	0.022	0.58	**0.09**
5	14,000	0.173333	0.022	0.58	**0.13**
10	14,000	0.173333	0.022	0.58	**0.18**
20	14,000	0.173333	0.022	0.58	**0.24**
50	14,000	0.173333	0.022	0.58	**0.39**
100	14,000	0.173333	0.022	0.58	**0.58**

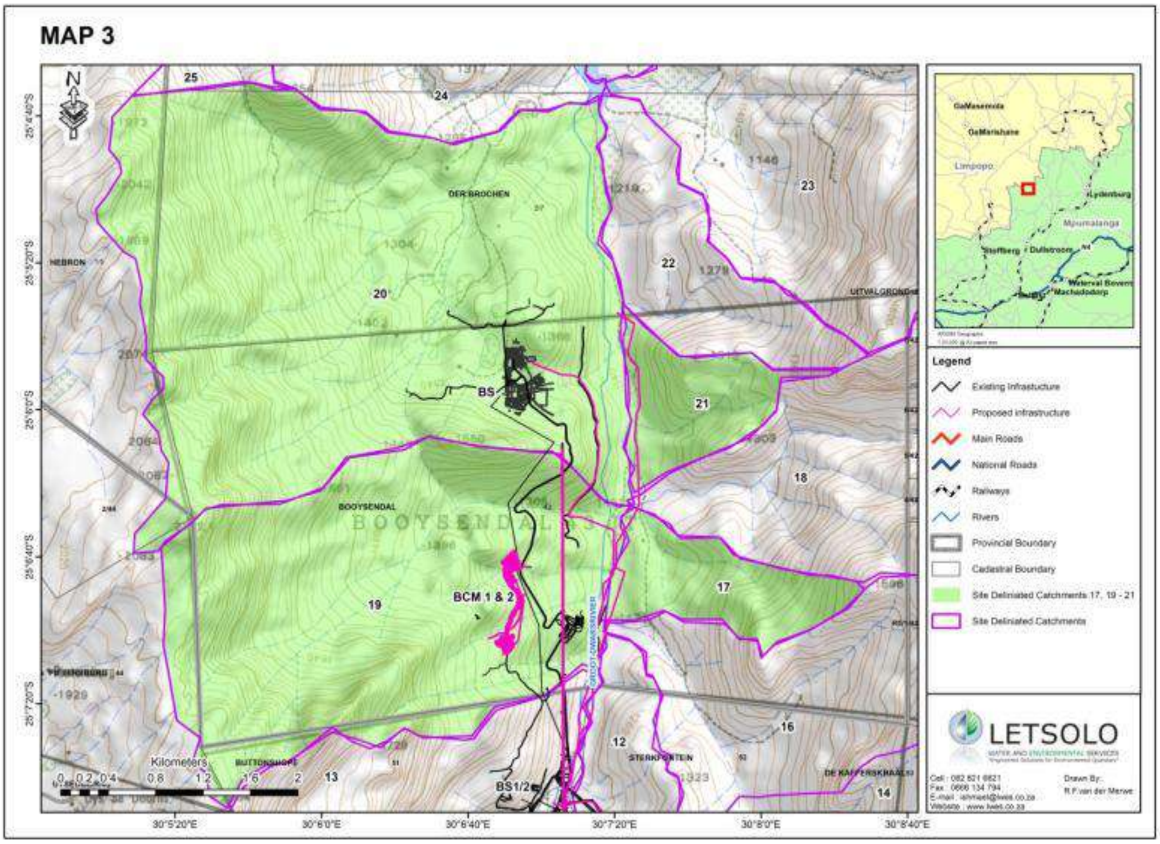


Figure 7-6: BCM 1 and BCM 2 Infrastructure falling within Catchment 19

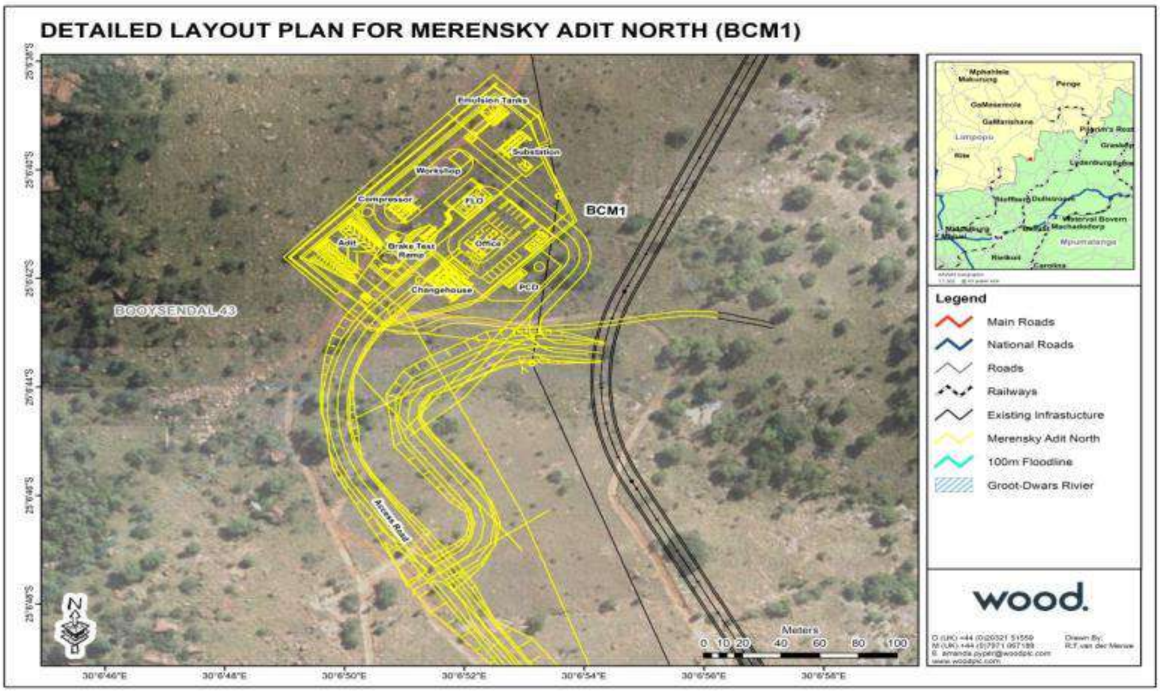


Figure 7-7: BCM 1 Infrastructure

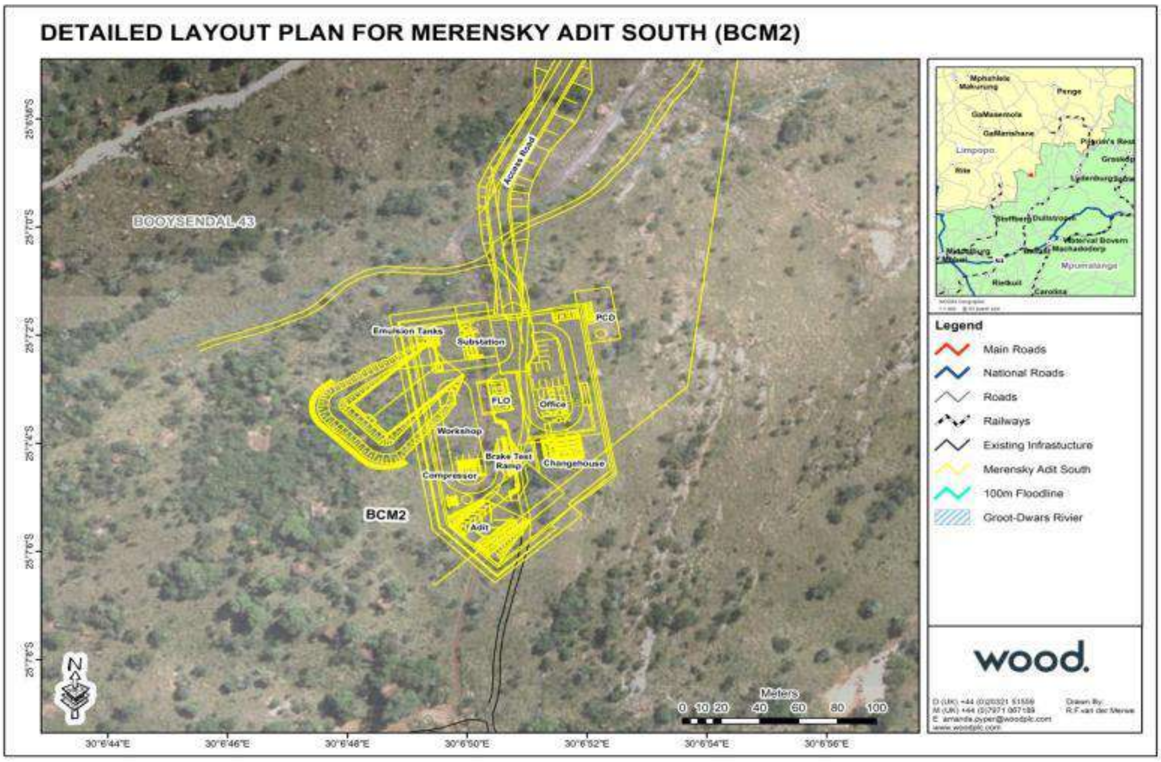


Figure 7-8: BCM 2 Infrastructure

7.7 Phase 2 Activities associated with BS4:

As seen in Figure 7-9 below, BS4 is located in the middle of Catchment 18. Catchment 18 covers a surface area of 38.2km^2 and can yield up to 151.5m^3/s for a 1 in 100years, 24-hour storm event.

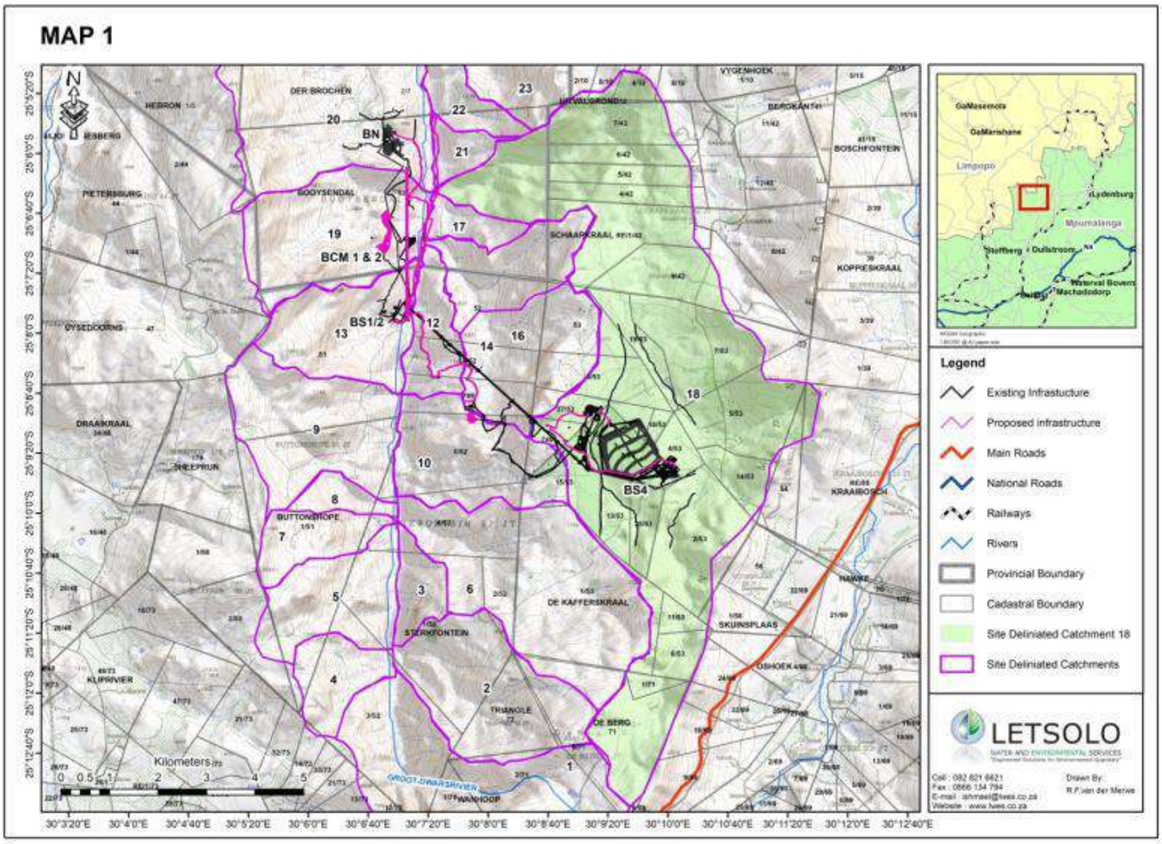


Figure 7-9: BS4 infrastructure falling within Catchment 18

7.7.1 BS4 Backfill Plant

Sustainable Slurry and Backfill Solutions completed a concept study considering un-cemented hydraulic fill as backfill medium to fill the old mined out areas at the BS4 mine.

7.7.1.1. Objectives and SWMP

Un-cemented cyclone classified tailings (CCT) was selected as backfill medium. The objectives are summarized in Table 30 below.

Table 7-30: Objectives of the SWMP for Backfill Plant

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 2. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water	1. Clean run-off will be diverted around the Project Site into the nearest natural drainage path.

management measures	2. The diversion channels must be operated to accommodate the 1:50 years flood. 3. RoM and Product Stockpiles must be located away from channels to minimize siltation in channels.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Equipment and infrastructure associated with the project must be removed. 2. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase.

7.7.1.2. Technical situation analysis and evaluation

The process plant at BS4 comprise a de-slime cyclone plant to remove the fines fraction (slimes) followed by a spiral plant to extract the chrome product. The spiral tailings is fed to floatation plant and the coarse floatation tailings from the plant is subsequently fed to a guard cyclone. The coarse floatation tailings will be diverted before the guard cyclone to become the feed stream to the backfill operations.

7.7.1.3. Conceptual design

There is a significant benefit in utilizing the coarse floatation tailings as feed stream to the backfill plant, as the tailings are already de-slimed and the coarse fraction will only require dewatering before being deposited underground.

The concept backfill plant flow sheet comprises the following major components:

- Dewatering cyclone located in the Process Plant.
- Dewatering cyclone underflow storage tank.

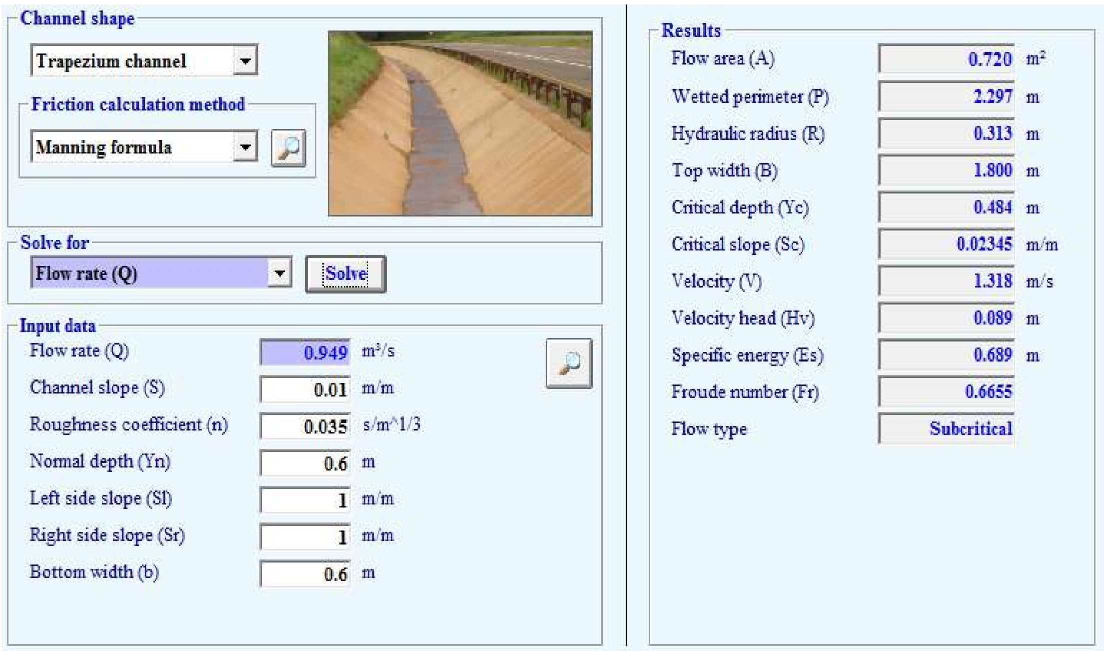
7.7.2 BS 4 Plant 1 – New Dirty Water Drain

The dirty water channel at BS4 is designed to collect and transport 0.949m^3/s during storm events. The design criterion for the new dirty water channel at BS4 is indicated in Tables 7-31 and 7-32 below.

Table 7-31: New Plant 1 Dirty Water Channel Dimensions

Top Width	1800mm
Bottom Width	600mm
Side Slope 1	1:1m/m
Side Slope 2	1:1m/m
Slope	1:100m/m
Depth	600mm

Table 7-32: Conceptual design for the New Plant 1 Dirty Water Channel



The objectives are discussed in Table 33.

Table 7-33: Objectives of the SWMP for the new dirty water drain at BS1

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. Clean water must be diverted around all major construction sites 2. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 3. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 2. Storm water control infrastructure is designed to account for the 1:50 year storm event. 3. All civil engineering requirements for all roads so as to prevent any impedance of surface water flows will be implemented. 4. Where the channel cross the road, There must be regular maintenance of culverts to ensure they remain clear will also be undertaken.

Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 7. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 8. To ensure protection of surface water resources; 9. To maintain as far as possible, the MAR of the Groot Dwars River; 10. To avoid/minimise adverse surface water quality impacts; 11. To avoid/minimise adverse surface water impacts due to flow interruption; 12. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	12. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 13. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 14. All pipeline and pumping infrastructure associated with the project must be removed. 15. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 16. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 17. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.7.3 BS 4 Plant 1 – PCD

As indicated in Table 7-34 below, flood calculations were conducted to size the pollution control dam at BS4 Plant 1.

Table 7-34: Flood Calculations for the sizing of Plant 1 Dirty Water Volume

Recurrence interval	Area (km^2)	Longest water course (km)	Tc (hrs)	Point rainfall (mm)	Point intensity (mm/h)	C - runoff factor	Adjusted Peak flow (m^3/s)	Flood vol Vr (m^3)
5	0.094	0.27	0.26	76	294	0.80	4.920	6858
10	0.094	0.27	0.26	91	353	0.80	5.891	8212
20	0.094	0.27	0.26	106	411	0.80	6.862	9565
50	0.094	0.27	0.26	128	496	0.80	8.286	11551
100	0.094	0.27	0.26	145	562	0.80	9.386	13085
200	0.094	0.27	0.26	162	628	0.80	10.487	14619

In View of Table 7-34 above, the dirty water channel must be designed to contain 8.282m^3/s and the PCD must be able to contain 11 551m^3 (1:50 year flood volume).

The PCD Final Dimensions are summarized as follows:

Table 7-35: Plant 1 PCD Conceptual design

Description		Size	Unit of Measurement
Plant 1	Catchment area	94000	m^2
	Rainfall data	0.162	m
	Run-off factor	0.8	
	Dam capacity	12182.4	m^3

As it can be seen in Tables 7-35, Plant 1 PCD is designed in line with the requirements stipulated in GN 704.

Table 7-36: Flood Calculations for the sizing of Plant 2 Dirty Water Volumes

Recurrence interval	Area (km^2)	Longest water course (km)	Tc (hrs)	Point rainfall (mm)	Point intensity (mm/h)	C - runoff factor	Adjusted Peak flow (m^3/s)	Flood vol Vr (m^3)
5	0.045	0.19	0.25	76	304	0.80	2.432	3283
10	0.045	0.19	0.25	91	364	0.80	2.912	3931
20	0.045	0.19	0.25	106	424	0.80	3.392	4579
50	0.045	0.19	0.25	128	512	0.80	4.096	5530
100	0.045	0.19	0.25	145	580	0.80	4.640	6264
200	0.045	0.19	0.25	162	648	0.80	5.185	6998

In View of Table 7-36 above, the Dirty Water Channel Must be Designed to contain 4.096 m^3/s and the PCD must be able to contain 5530m^3 (1:50 year flood volume).

The PCD final dimensions are summarised as follows:

Table 7-37: Plant 2 PCD Conceptual design

Description		Size	Unit of Measurement
Plant 2	Catchment area	45000	m^2
	Rainfall data	0.162	m
	Run-off factor	0.8	
	Dam capacity	5832	m^3

A culvert crossing exists near the PCD in order to allow traffic flow from the west to the east, and vice versa, of the PCD.

Hydrological approach assumes that the culvert will have no effect on flow rates. Culvert detailed designs takes an opposite design approach. The goal is to have a culvert that will result in no significant damage. This may be achieved by providing short-term storage of water in the channel and on the land upstream from the road crossing. In addition to the hydraulic function, a culvert must also support the embankment and/or roadway, and protect traffic from flood hazards to the extent practicable.

The dimensions of the culvert crossings are indicated in Table 7-38 below:

Table 7-38: Culvert Pipe Dimensions

Culvert pipe Diameter	600mm
Thickness	150m thick Type D2
Scarity & Compact	150mm insitu material to 92% MMDD

The objectives are discussed in Table 7-39.

Table 7-39: Objectives of the SWMP for BS4 Processing Plant PCD

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	6. To avoid/minimise adverse surface water quality impacts; 7. To avoid/minimise adverse surface water impacts due to flow interruption; 8. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	8. The mine must establish the Environmental Management System (EMS) to ensure that a process for rapid and efficient response to and management of hazardous material spills during the construction phase of the Project is developed. 9. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: a. Spill prevention and clean-up, 10. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 11. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 12. The regular maintenance of silt traps must be undertaken to ensure these remain clear of debris, especially after each runoff event. 9. Clean water must be diverted around all major construction sites 13. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with Storm water.

	14. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 6. To avoid/minimise adverse Mean Annual Runoff impacts; 7. To avoid/minimise adverse surface water quality impacts; 8. To avoid/minimise adverse surface water impacts due to flow interruption; 9. To avoid/minimise silt transportation due to loosened soil. 10. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	11. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 12. The EMS must be in such a way that it define the procedures for handling hazardous materials/chemicals in a manner that does not impact the environment. This must include the following: h. Spill prevention and clean-up, 13. No discharge is anticipated directly from the PCD. 14. For significant spillages, Areas where spillage of soil contaminants occurs must be excavated (to the depth of contamination) and suitably rehabilitated. 15. If any other minor spillage occurs, the spillage must be cleaned immediately and the contaminated area will be rehabilitated. 16. The regular maintenance of silt traps must be undertaken to ensure these remain clear of debris, especially after each runoff event. 10. Clean water must be diverted around all major construction sites 17. Storm water control infrastructure is designed to account for the 1:50 year storm event. 18. All vehicles will be maintained at a designated workshop at the Processing Plant, which will include an oil/grease trap. 19. Chemicals and fuels will be stored in bunded areas with emergency

	spill response equipment. 20. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 7. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 8. To ensure protection of surface water resources; 9. To maintain as far as possible, the MAR of the Groot Dwars River; 10. To avoid/minimise adverse surface water quality impacts; 11. To avoid/minimise adverse surface water impacts due to flow interruption; 12. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	13. All rehabilitation activities must be limited to the already disturbed area. 14. No further removal of vegetation would be allowed. This has specific reference to the vegetation which has been removed by the construction of this PCD. 15. Demolish all concrete structures i.e. dirty water channels and silt traps; 16. Remove any silt that accumulated in the dam in line with the Hazardous waste management strategy for the operation; 17. Remove liners and following waste classification testing dispose appropriately; 18. Particular attention must be given to any possible contaminants (for example vehicle fuel, cleaning chemicals, any mine waste products) since the soil is very permeable and the site is located in a flood plain. All potential contaminants must be stored off site and any spills remediated immediately by removal and correct disposal of the contaminated soil. 19. Flattened earth walls and backfill excavations with material removed during construction; and 20. Profile footprint to be free draining with no low points to accumulated water 21. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend

	decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 22. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 23. All channels and lHDPE liners associated with the PCD must be removed. 24. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.7.4 Slurry pipelines and process water lines

There is a slurry pipeline from the process plant to the backfill plant and underground workings. There is a process water pipeline between the backfill and process plant and return water dam.

7.7.4.1. Detailed design of all required infrastructure

Identified impacts includes the impact on all, or any, matters relating to water quality, flooding, agricultural drainage, erosion, flora and fauna and any adjacent topographical features.

The approach to design and construction will encompass the following;

- Appropriate and adequate protection of the river/stream/wetland banks in the vicinity of the pipeline will be incorporated into the design.
- The existing river/stream bank structure will be maintained to reduce disturbance to the river/stream flow.
- Wherever possible, the pipelines will cross river/stream and wetlands within a road prism.
- The pipe crossings have been designed to have no impact on normal river/stream flow.
- Where pipes are laid through a flood plain (1:100 year flood line), a minimum cover level of 1 meter will be maintained.

7.7.4.2. SWMP

The slurry and process water pipelines cross a river at a certain point. When planning or designing the pipe crossing, a holistic approach that adheres to all the tenets of the reference or policy documents listed above will be adopted. The environmental sensitivity of wetland areas is acknowledged and designs undertaken will take full cognizance of the proposed impact to these areas. The details regarding the protection of wetland systems are contained in the Wetland Study Report.

The objectives are discussed in Table 7-40.

Table 7-40: Objectives of the SWMP for slurry water pipeline

Project Phase	Objectives and related Storm water management measures
Construction phase - Objectives	1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise adverse surface water impacts due to flow interruption; 3. To avoid/minimise silt transportation due to loosened soil.
Construction Phase - Storm water management measures	1. The old stone pitched dirty water drain posed a risk of infiltration of dirty water. This channel is rehabilitated and upgraded to a concrete lined channel. 2. Replacement of stone pitching must be with impervious concrete slabs. 3. Clean water must be diverted around all major construction sites 4. Management of current activities – Active areas, dirty water catchments and dirty water within the boundary of construction sites containing potential pollutants must be managed on the site such that it does not flow from the site, and mix with storm water. 5. Clean run-off must be diverted around the Project Site into the nearest natural drainage path so as to prevent flow onto the site. The diversion channels are designed to accommodate the short duration /high flow for the1:50 years storm event.
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil. 5. To review EMS compiled during the construction phase and amend if necessary to identify any water impacts due to mining activities.
Operational Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS for during construction phase must be reviewed to amend operational procedures for rapid and efficient response to and management of hazardous material spills during the operational phase. 2. Storm water control infrastructure is designed to account for the

	1:50 year storm event. 3. All civil engineering requirements for all roads so as to prevent any impedance of surface water flows will be implemented. 4. Where the channel cross the road, There must be regular maintenance of culverts to ensure they remain clear will also be undertaken.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To maintain as far as possible, the MAR of the Groot Dwars River; 4. To avoid/minimise adverse surface water quality impacts; 5. To avoid/minimise adverse surface water impacts due to flow interruption; 6. To minimise sediment transport.
Decommissioning and Closure Phase - Storm water management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the Project. 2. The revised EMS must define the procedures for handling hazardous materials / chemicals during the decommissioning and closure phase. 3. All pipeline and pumping infrastructure associated with the project must be removed. 4. Surface water monitoring will continue until a positive environmental trend is established. In order to understand what the pre-mining concentrations are, ongoing monitoring will be required pre-construction, through construction and into the operational phase. 5. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 6. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring.

	Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

8.0 FLOOD LINE DELINEATION

It is our understanding that the BS1/2 is located outside the 1:100 year flood lines of the Groot Dwars River but inside of 1:100 flood line of an unnamed tributary of the Groot Dwars River which runs directly to the south of the BS1/2. Several road crossings and ARC towers are also within 100m from drainage lines.

8.1.1 Flood Barrier

In instances where some structures fall within the 1:100 years flood line, flood barriers must be considered to protect dirty water infrastructure from potential flood damage. A flood barrier is a primarily vertical artificial barrier designed to divert flood water from a river or other waterway which may rise to unusual levels during seasonal or extreme weather events

8.1.2 Groot Dwars River

The purpose of the study is to determine the risk of inundation of mining related development adjacent to the river. A road crossing of the river had to be considered and the backwater effect of the bridge determined. Site specific hydrological characteristics for the Groot Dwars River Catchment are summarized as follows:

Surface Area	: 176.5km^2
Mean Annual Rainfall	: 721 mm/a
Mean Annual Runoff	: 66mm/a
Longest Watercourse	: 28.2km (measured to the inlet of the De Brochen Dam)
10-85 Slope	:0.017 (m/m)

Sensitivities include the 1:100 year flood lines or 100m buffers. (Discussed in detail in section 7).

8.2 1:100 years flood lines and 100m buffer areas

In order to delineate flood lines, several components of the hydrological characteristics were analysed. These are flow data, geometric data and simulation options. These components are described in more detail below.

- Area of catchment

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

- Length of longest watercourse

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

- Average slope

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

- Run-off factor

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

- 10-85 height difference

The 1085 height difference refers to the difference between elevation height at 10% and 85% of the length of the watercourse. This height difference is then divided by the length of the watercourse to determine the 1085 slope.

8.2.1 Phase 1 flood line delineation

Flood lines were delineated for Phase 1 assessment. The flood lines are based on the studies below:

- Flood lines at BS1/2:
    - Booysendal South Expansion Flood Line Determination Report, March2017, Compiled by SNA Civil and Structural Engineers (Pty) Ltd;
    - Booysendal Flood line Layout Map, Compiled by SNA Civil and Structural Engineers (Pty) Ltd, Drawing Number: SNA-TP1506-W01;
    - Booysendal Flood line Layout Map, Compiled by DRA, Drawing Number:MO413-30000G005;
- Flood lines for BS4
    - Booysendal South Expansion project Surface Water Study or BS4, June 2017, compiled by SLR Consulting South Africa (Pty) Ltd;

The delineated flood lines can be used as a flood warning to accurately predict the likelihood and timing of flooding. This guide must be used as part of planning to ensure that the proposed development is not at risk or to apply engineering techniques to reduce the risk. In the case of the Project and in line with the provision of the NWA no infrastructure must be constructed within the 1:100yr flood line or within 100m from the edge of water resources.

8.2.1.1. Phase 1 - BS1/2 1:100 years Flood line study findings

A section of the terrace to the south falls within the 100m delineation of the tributary of the Groot Dwars River. However, GN 704 requires the mine to meet the following criterion for the location of infrastructure:

- No infrastructure must be located within the 1:100 years flood lines;
- No infrastructure must be located within the 100m buffer measured from the centre of a stream.

As indicated in Figure 8-1, Infrastructure of concern with regards to the Flood lines is:

- An Emergency escape portal north of BS1/2;
- Main access road
- Potable and process water lines for BS1/2 running along the existing gravel access road along the Groot Dwars River between BS1/2 and BN;
- ARC from BS1/2 to BS4; and
- ARC from BS1/2 to BN with associated access roads.

During Phase 1 it was determined that the pollution control dam at BS1/2 is located within the 100m buffer. An exemption in accordance with GN 704 must be applied for. This activity can be listed with other identified water uses during the application for a Water Use Licence.

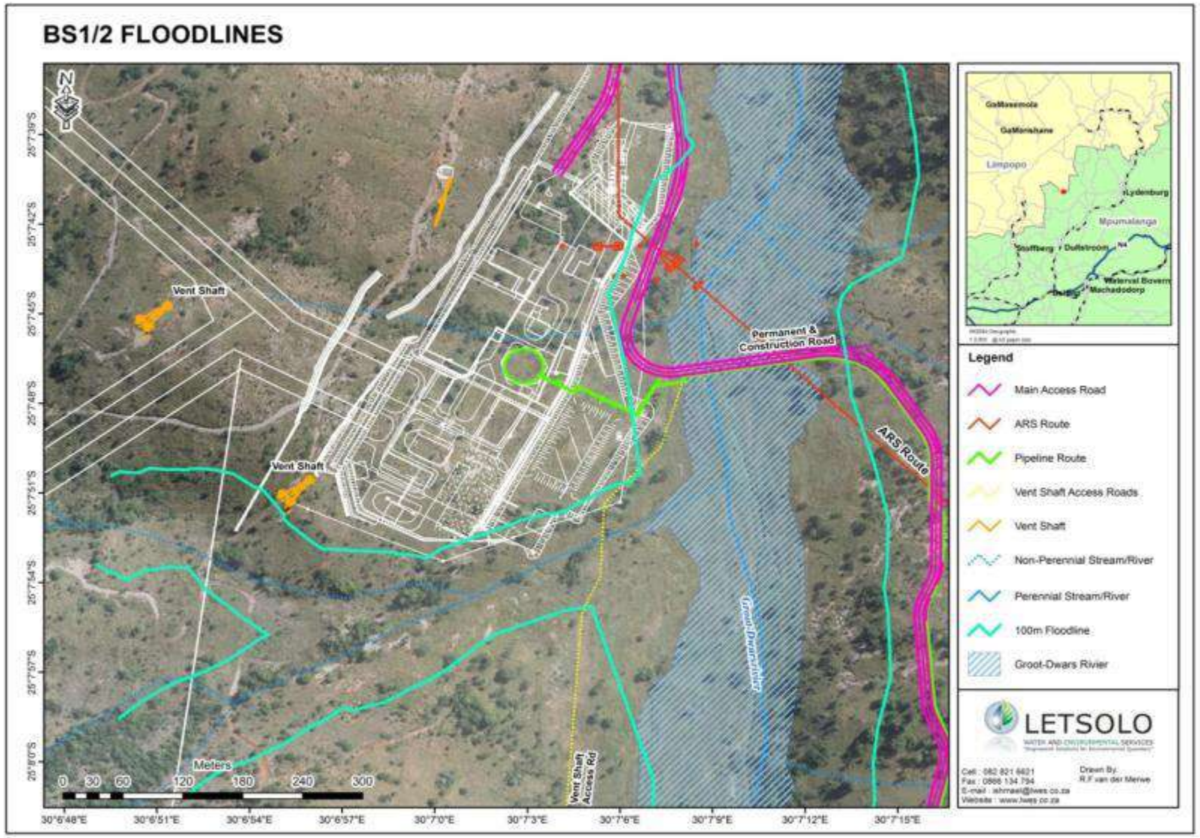


Figure 8-1: Phase 1 - BS1/2 Flood lines

8.2.1.2. Phase 1 - BN Flood lines study findings

BCM 1 and BCM 2 are activities associated with Phase 2. As it can be seen in Figure 8-2, the location of these facilities does not fall within the 1:100 years. However, a section of the terrace to the south falls within the 100m delineation of the tributary, flood lines. Infrastructure of concern with regards to the Flood lines is:

- Surface infrastructure associated with the two Merensky adits (BCM1 and BCM2), including the following:
  - workshops,
  - offices,
  - a pollution control dam (PCD),
  - clean and process water storage facilities,
  - ore stockpiles and potential oil and diesel storage bays;
- Potable and process water lines for BCM1 and BCM2 running along the existing gravel access road along the Groot Dwars River between BS1/2 and BN; and
- Aerial Ropeway Conveyor (ARC) from BS1/2 to BN with associated access roads.

There are instances were roads and pipelines cross the rivers. The river crossing is deemed a water use and these activities must fall under the Section 21 water uses in line with the requirements of the NWA.

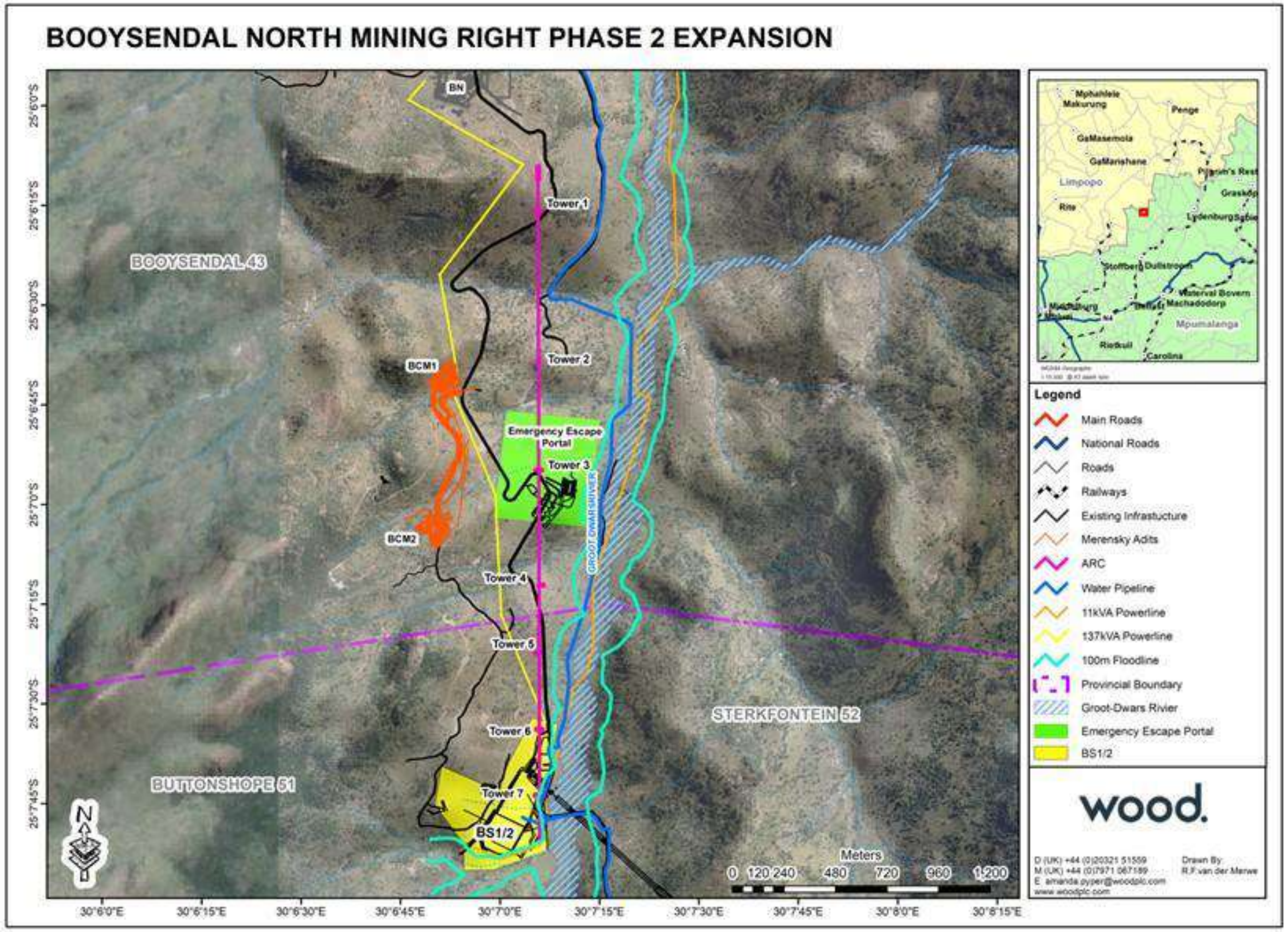


Figure 8-2: Phase 1 - Booysendal North flood lines and 100m buffer

8.2.1.3. Phase 1 - Everest Stream at BS4

Flood lines for the Everest tributary (East stream) and associated tributaries for the 1:50 year event and 1:100 year event were modelled by Metago Environmental Engineers (Pty) Ltd as part of the EMP for BS4 (June 2003), based on peak flows estimated by the SDF and Regional Maximum Flood (RMF) methods, as presented in Table 8-1.and Figure 8-3.

Table 8-1: Peak flows for Flood lines

Catchment Name	Area (km^2)	Peak Flow Rate (m^3/s)			
		1:20 year	1:50 year	1:100 year	RMF
East Stream	17.85	90	134	170	299
Upper East Stream	7.16	62	91	117	211
West Stream	8.17	55	81	103	222
Upper West Stream	3.38	37	54	69	159
Tributary of West Stream	0.67	16	21	25	92

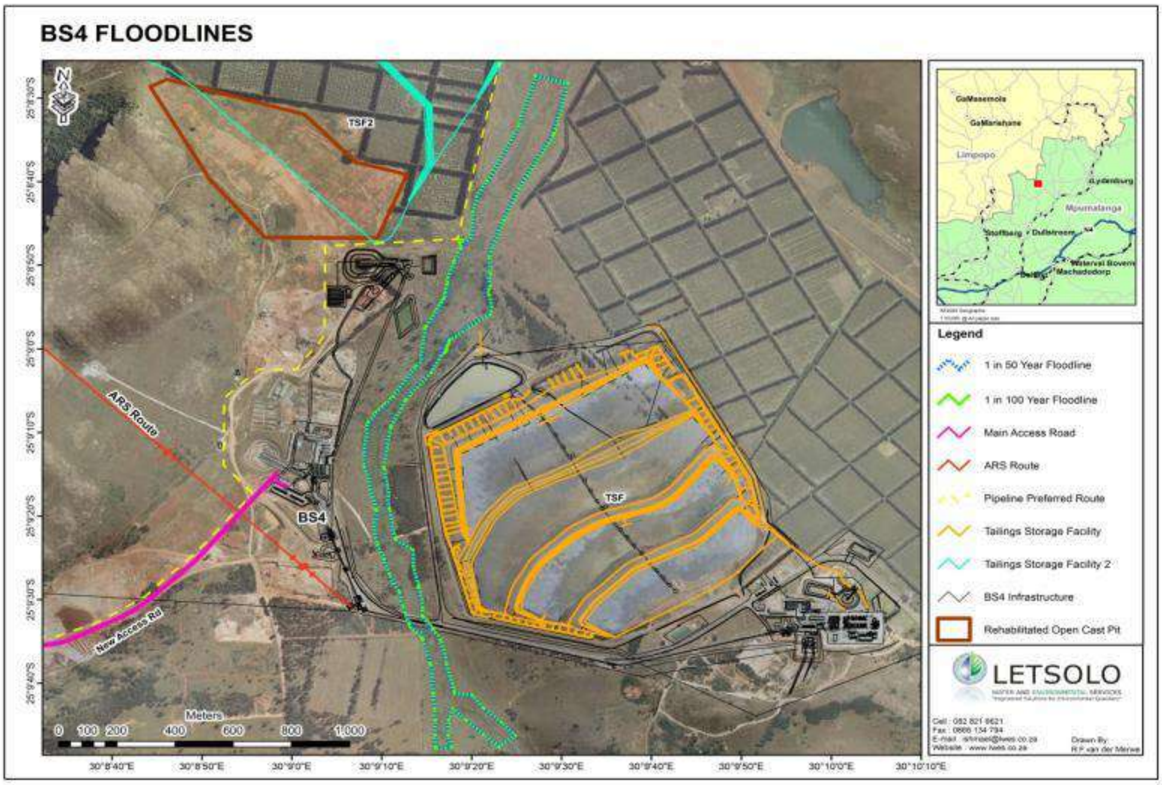


Figure 8-3: BS4 Flood lines

8.2.1.4. BS4 flood line study findings

As seen in Figure 8-4, no activities fall within the 1:100yr flood lines. However, the tailings to backfill as well as surface water pipelines cross over the streams.

Activities which were assessed for Flood lines are as follows:

- Backfill plant;
- Slurry pipelines from the process plant to the backfill plant and the underground workings;
- Three emergency dams along the slurry line;
- Process water lines between the backfill and process plant and the return water dam (RWD).

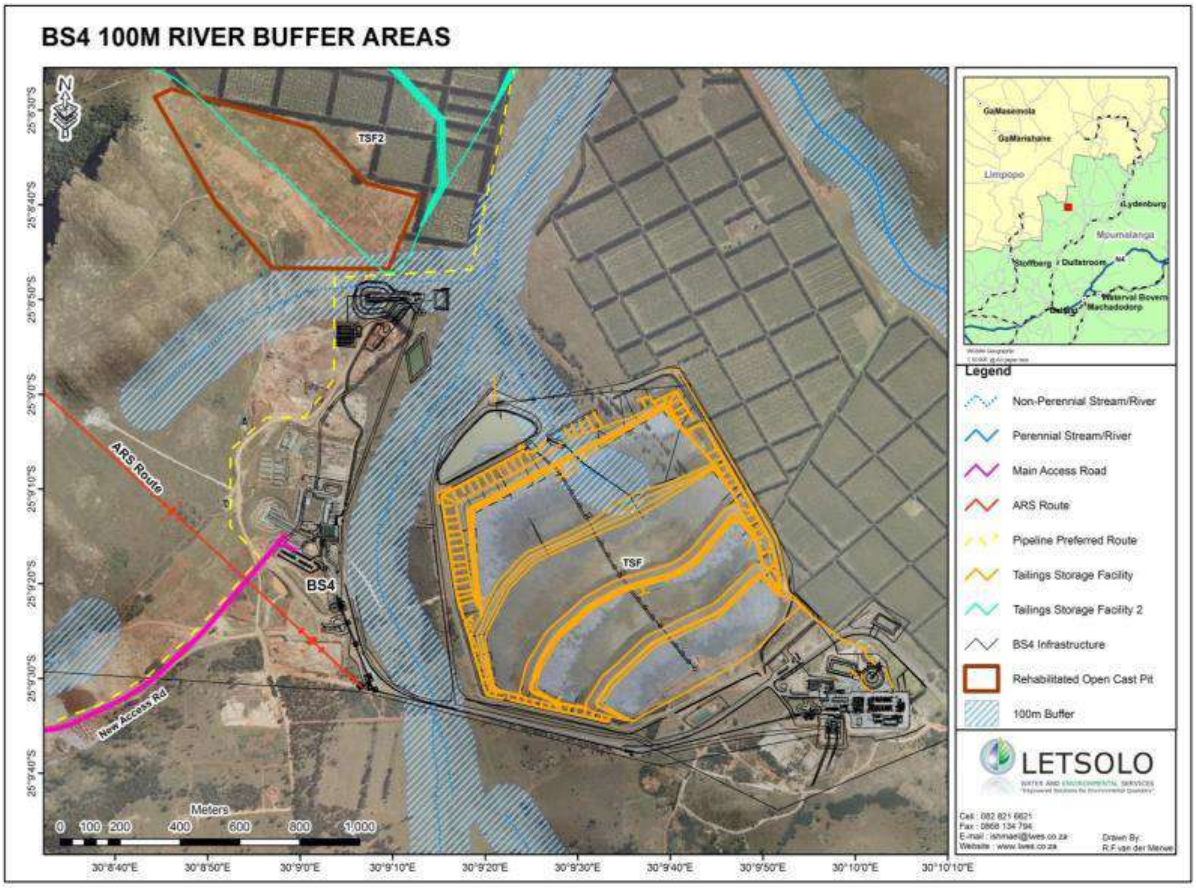


Figure 8-4: BS 4 - 100m Buffer Areas

8.2.2 BS1/2 100m buffer area

As indicated in Figure 8-5, some infrastructure falls within the 100m buffer areas of the nearby streams.

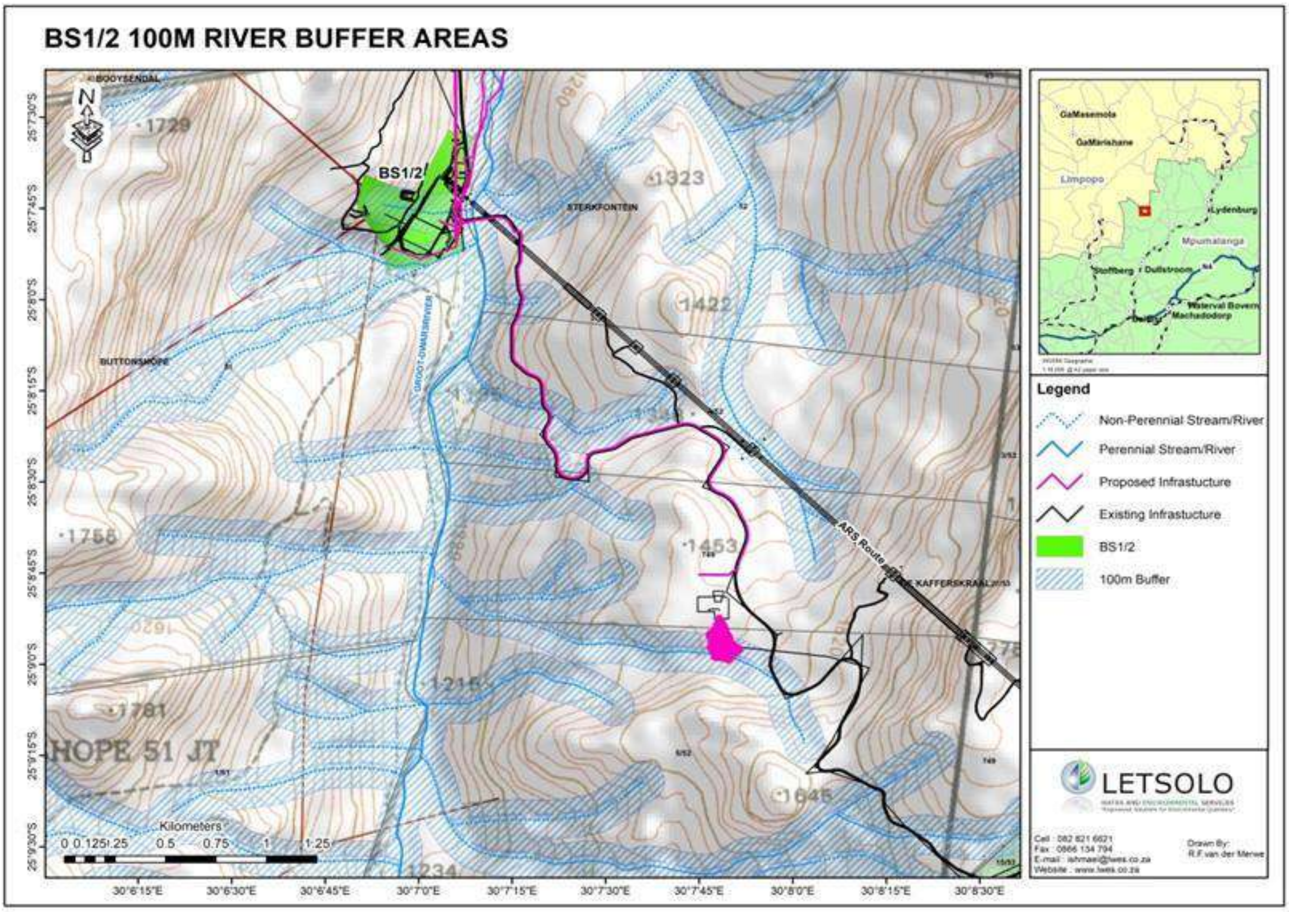


Figure 8-5: BS1/2 100m buffer

9.0 WATER AND SALT BALANCE

The Water and Salt Balance (WSB) was conducted in line with the Best Practice Guidelines, BPG G2. According to the BPG G2, the purpose of the WSB includes:

- WSB serves as the most important and fundamental tool for water management;
- It provides the information for defining & driving water management strategies;
- It assists with auditing and assessment of water systems;
- It assists with design of storage systems and management tool for simulation and evaluation of alternative strategies.

WSBWSB is dependent on the quantities and qualities.

9.1 Water Balance

Raw water to BS1/2 complex is supplied from the TKO dam, whereas raw water to BYN, BS1/2, BCM1 and BCM2 is supplied by the Lebalelo water scheme via the BYN. BS1/2 is only water positive during the 1:50 storm event.

The BYN Tsunami PCD never overflows to the environment, even during the highest rainfall month simulated. The BYC PCD does not overflow into the surrounding environment during the occurrence of the 1:50 year storm event

Excess dirty water at BYS is pumped to BYN, BYC, BCM1 and BCM2 to be used as process and mining service water make-up to reduce the Lebalelo water scheme consumption, however, doesn’t always meet the make-up requirements of these operations.

The Water Use License only considers the annual water usage. In order to avoid duplication, the wet and dry season water balances were excluded in this report but are covered in details in the Water Balance Study Report.

9.1.1 BS1/2 Annual Water Balance

The water annual water balance volumes are indicated in Table 9-1 and the flow diagram is indicated in Figure 9-1.

Table 9-1: BS 1/2 Annual Water Balance

Facility Name	Water IN		Water Out		Balance
	Water Circuit / Stream	**Quantity (m^3/a)**	**Water Circuit / Stream**	**Quantity (m^3/a)**	
Central Mining	Fissure water into mine workings	39960	Evaporation and Losses	233030	
	Potable water for domestic use	4380	Water in ore mined	111000	
	Mine Service Water	2131200	Dirty water dewatering into mine service water	1868470	
	Settler	36960	Settler		
	Dust Suppression				
	Total	**2212500**		**2212500**	
Mine Service Water Settler(MSW Settler)	Central mining dewatering	1868470	Evaporation	563	
	Central PCD decant	25232	Mine service water	2131200	
	Raw water from Lebalelo scheme	0	Excess to PCD	0	
	BS4 Box-cut DWD service make-up	238061			
	Total	**2131763**		**2131763**	
Central PCD (14000m^3)	Rainfall runoff	30135	Evaporation	4903	
	Excess from MSW settler	0	Decent to MSW settler	25232	
			Seepage	0	
	Total	**30135**		**30135**	
WTP	Raw water from Lebalelo scheme	85140	Central decline	4380	
			Change house	43800	
			Dust suppression	36960	
	Total	**85140**		**85140**	
Change House	Potable water for domestic use	43800	Sewage to sewage treatment plant(STP)	43800	
	Total	**43800**		**43800**	

STP	From change house	43800	Treated decant to river	43800	
	Total	**43800**		**43800**	
Total Water Balance		4 547 138		4 547 138	

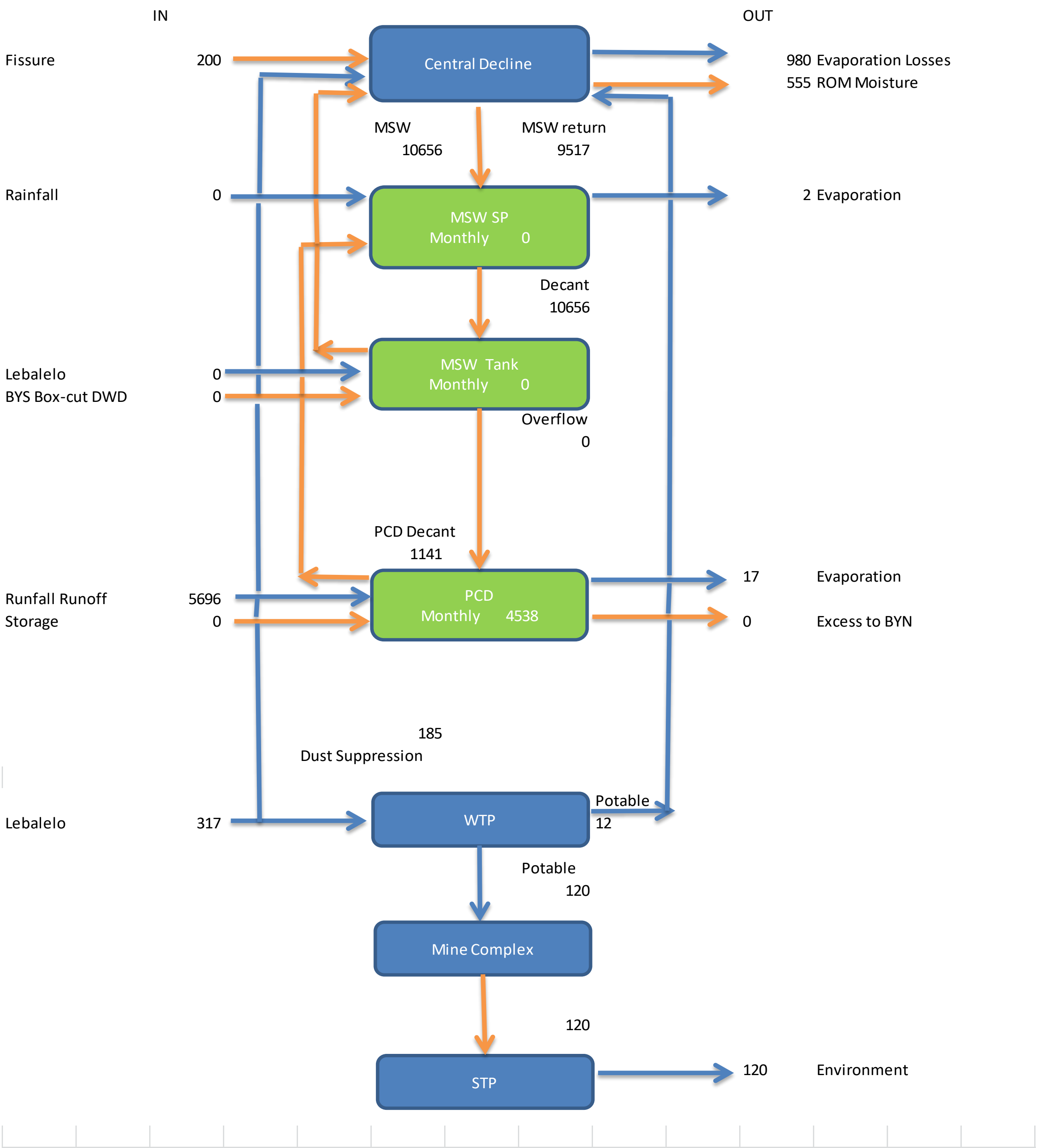


Figure 9-1: BS 1/2 Annual Water Balance

9.1.2 BCM 1 Annual Water Balance

The annual water balance volumes are indicated in Table 9-2 below and the flow diagram is indicated in Figure 9-2.

Table 9-2: BCM 1 Annual Water Balance

Facility Name	Water IN		Water Out		Balance
	Water Circuit / Stream	**Quantity (m^3/a)**	**Water Circuit / Stream**	**Quantity (m^3/a)**	
BCM 1 Mining	Fissure water into mine workings	5350	Evaporation and Losses	56010	
	Potable water for domestic use	868	Water in ore mined	14861	
	Mine service water from mine service water settler	285324	Dirty water dewatering into mine service water settler	250431	
	Dust Suppression	29760			
	Total	**321302**		**321302**	
Mine Service Water Settler(MSW Settler)	BCM1 mining dewatering	250431	Evaporation	563	
	PCD decant	5638	Mine service water	285324	
	Raw water from Lebalelo scheme	127	Excess to PCD	0	
	BS4 Box-cut DWD service make-up	29690			
	Total	**285886**		**285886**	
PCD ($2500m^3$)	Rainfall runoff	7170	Evaporation	1532	
	Excess from MSW settler	0	Decent to MSW settler	5638	
			Seepage	0	
	Total	**7170**		**7170**	
WTP	Raw water from Lebalelo scheme	39306	BCM 1 decline	868	
			Change house	8679	
			Dust suppression	29760	
	Total	**39306**		**39306**	
BYN RWR	Lebalelo Water Scheme	39434	MSW settler make-up	**127**	
			WTP	**39306**	
	Total	**39434**		**39434**	

Change House	Potable water for domestic use	8679	Sewage to sewage treatment plant(STP)	8679	
	Total	**8679**		**8679**	
STP	From change house	8679	Treated decant to river	8679	
	Total	**8679**		**8679**	
Total Water Balance		710455		710455	

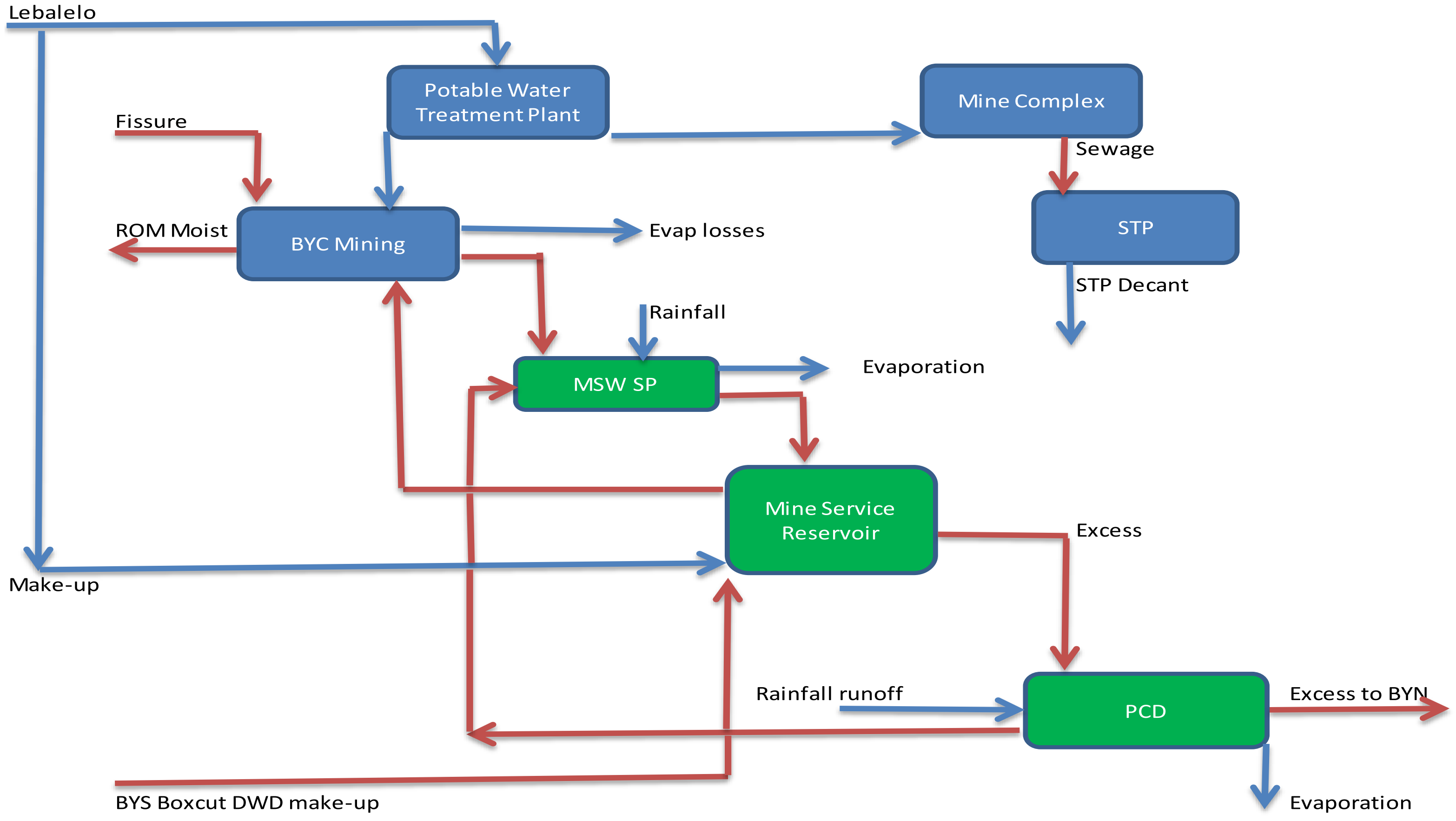


Figure 9-2: BCM1 Annual Water Balance

9.1.3 BCM2 Annual Water balance

The annual water balance volumes is indicated in Table 9-3 below and the flow diagram is indicated in Figure 9-3.

Table 9-3: BCM2 Annual Water Balance

Facility Name	Water IN		Water Out		Balance
	Water Circuit / Stream	**Quantity (m^3/a)**	**Water Circuit / Stream**	**Quantity (m^3/a)**	
BCM 2 Mining	Fissure water into mine workings	5203	Evaporation and Losses	55292	
	Potable water for domestic use	844	Water in ore mined	14454	
	Mine service water from mine service water settler	277519	Dirty water dewatering into mine service water settler	243581	
	Dust Suppression	29760			
	Total	**313327**		**313327**	
Mine Service Water Settler(MSW Settler)	BCM2 mining dewatering	243581	Evaporation	563	
	PCD decant	5638	Mine service water	277519	
	Raw water from Lebalelo scheme	847	Excess to PCD	0	
	BS4 Box-cut DWD service make-up	28016			
	Total	**278082**		**278082**	
PCD (2500m^3)	Rainfall runoff	7170	Evaporation	1532	
	Excess from MSW settler	0	Decent to MSW settler	5638	
			Seepage	0	
	Total	**7170**		**7170**	
WTP	Raw water from Lebalelo scheme	39045	BCM 2 decline	844	
			Change house	8441	
			Dust suppression	29760	
	Total	**39045**		**39045**	
BYN RWR	Lebalelo Water Scheme	39892	MSW settler make-up	847	
			WTP	39045	
	Total	**39892**		**39892**	

Change House	Potable water for domestic use	8441	Sewage to sewage treatment plant(STP)	8441	
	Total	**8441**		**8441**	
STP	From change house	8441	Treated decant to river	8441	
	Total	**8441**		**8441**	
Total Water Balance		694398		694398	

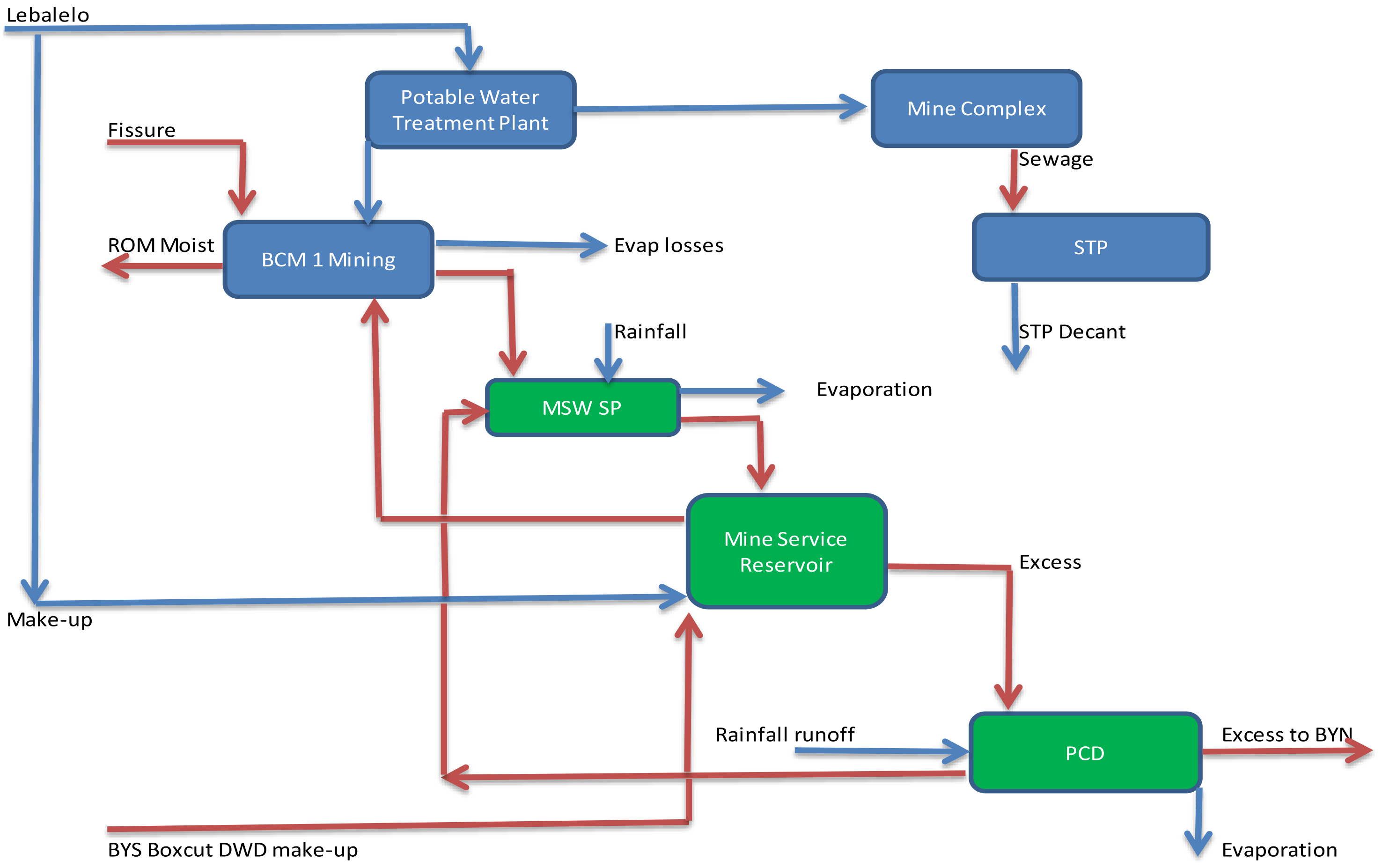


Figure 9-3: BCM2 Annual Water Balance

9.1.4 BS4 annual water balance

The annual water balance volumes are indicated in Table 9-4 below and the flow diagram is indicated in Figure 9-4.

Table 9-4: BS4 Annual Water Balance

Facility Name	Water IN		Water Out		Balance
	Water Circuit / Stream	**Quantity (m3/a)**	**Water Circuit / Stream**	**Quantity (m3/a)**	
BS4 Mining Area	Fissure water into mine workings	320288	Evaporation and Losses	10598	
	Potable water for domestic use	9636	Water in ore mined	15000	
	Mine Service Water	115200	Excess dirty water to BS4 settling pond	419525	
	Total	**445124**		**445124**	
BS4 Settling Pond	Dirty Water form mine	419525	Mine Service Water	115200	
	Portal PCD make-up	0	Excess to Boxcut DWD	304325	
	Total	**419525**		**419525**	
Box-cut DWD (35000m^3)	Rainfall	6878	Evaporation	11250	
	Excess water from BS4 settling pond	304325	Seepage	0	
	Portal PCD decant	272666	BYC mine serice water make-up	238061	
			BCM 1 Service water make-up	29690	
			BCM 2 Service water make-up	28016	
			Excess to BYN process water make-up	276851	
	Total	**583869**		**583869**	
Portal PCD (30258m^3)	Rainfall runoff	137899	Evaporation	10903	
	Return water dam excess	145670	Seepage	0	
			BS4 settling pond make-up	0	
			Decent to Box-cut DWD	272666	
	Total	**283569**		**283569**	
Return water dam (90000m^3)	Rainfall	18125	Evaporation	29648	
	TSF return water	2691681	Plant return water to process water dam	2601720	
	Raw water from TKO dam	15431	Excess to portal PCD	145670	

	Plant PDC decant	51801			
	Total	**2777038**		**2777038**	
Plant PCD (9215m³)	Rainfall runoff	55121	Evaporation	3320	
			Seepage	0	
			Decent to return water dam	51801	
	Total	**55121**		**55121**	
WTP	Raw water from TKO dam	14896	Plant potable water	5260	
			Mine potable ware	9636	
	Total	**14896**		**14896**	
TKO dam	Withdrawal limit	1152972	WTP	14896	
			Plant raw water	902791	
	Total	**1152972**		**197686**	**2352 86**
Processed Water Dam	Plant return water from return water dam	2601720	Plant process water	2600878	
	Total	**2601720**		**2600878**	**842**
Concentration Plant	Water in ore to plant	150000	Water losses through product	79497	
	Process water from process water dam	2600878	Tailings water	3564000	
	Plant raw water from TKO dam	887359			
	Potable water for domestic use	5260			
	Total	**3643497**		**3643497**	
TSF	Rainfall	466638	Decant to return water dam	2691681	
	Plant tailings water	3564000	Evaporation	412186	
			Seepage and Interstitial storage	926770	
	Total	**4030638**		**4033638**	
Total Water Balance		1600796 8		1577184 1	2361 28

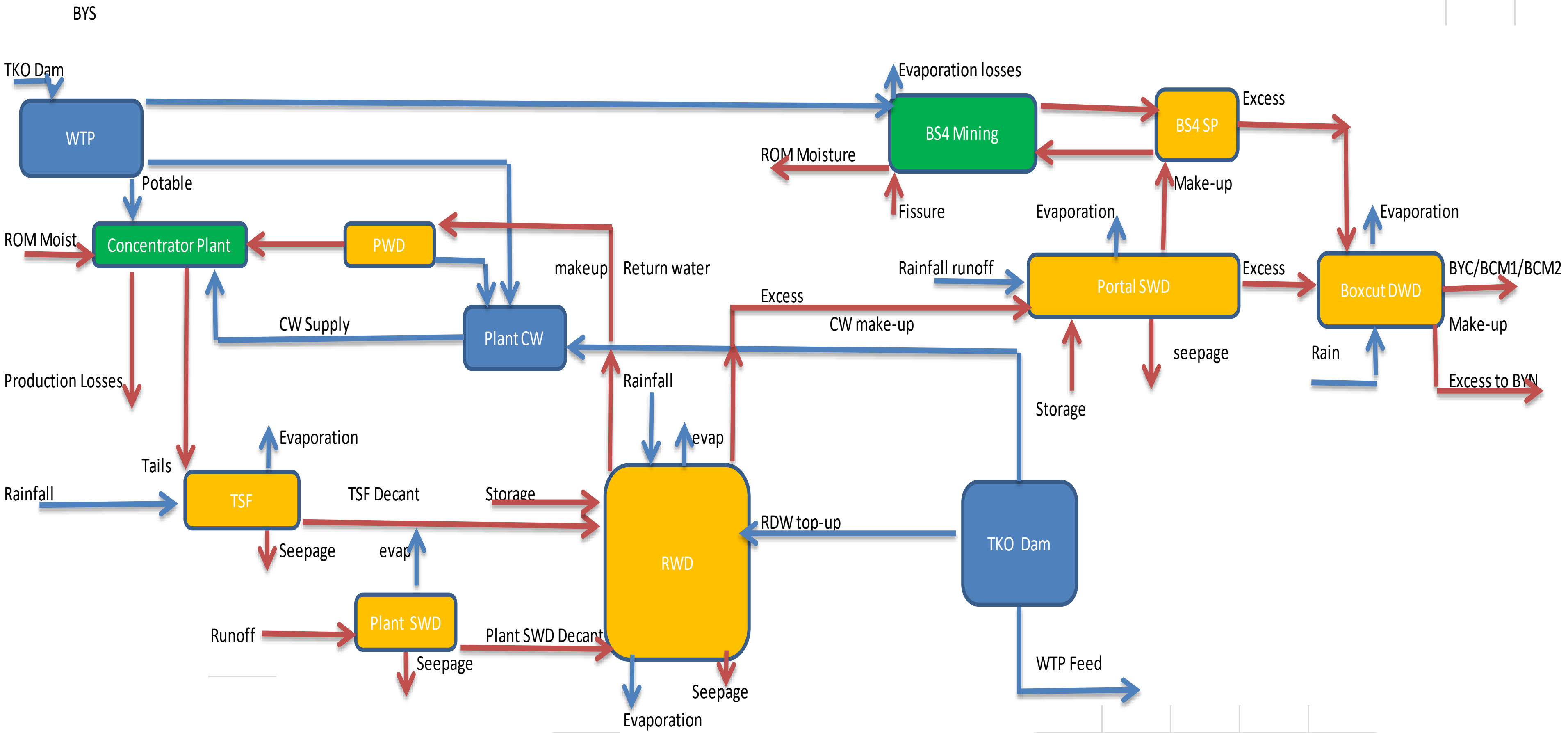


Figure 9-4: BS4 Annual Water Balance

Table 9-5: Water Balance Summary

Site	Average Wet Season	Average Dry Season
BS 1/2	Dirty water from the BS4 Valley Boxcut PCD makes up the biggest portion to water input, with a 56% (18 387m^3/month) contribution. Mine evaporation losses due to ventilation makes up the biggest portion to water loss, with a contribution of 59% (19 936m^3/month).	Dirty water from the BS4 Valley Boxcut PCD makes up the biggest portion to water input, with a 67% (21 870m3/month) contribution. Mine evaporation losses due to ventilation makes up the biggest portion to water loss, with a contribution of 59% (19 536m3/month).
BCM1	Lebalelo water scheme makes up the biggest portion to water input, with a 48% (3 280m^3/month) contribution. Mine evaporation losses due to ventilation makes up the biggest portion to water loss, with a contribution of 68% (4 647m^3/month)	Lebalelo water makes up the biggest portion to water input, with a 48% (3 295m^3/month) contribution. Mine evaporation losses due to ventilation makes up the biggest portion to water loss, with a contribution of 69% (4 696m^3/month).
BCM	Lebalelo water scheme makes up the biggest portion to water input, with a 50% (3 321m^3/month) contribution. Mine evaporation losses due to ventilation makes up the biggest portion to water loss, with a contribution of 69% (4 588m^3/month).	Lebalelo water makes up the biggest portion to water input, with a 50% (3 329m^3/month) contribution. Mine evaporation losses due to ventilation makes up the biggest portion to water loss, with a contribution of 69% (4 635m^3/month). Treated raw water for domestic use at BS4 from the TKO dam to cater for both plant and mine requirements is 1 265m^3/month (1.7m^3/h). The treated raw water requirements for domestic use from the Lebalelo scheme at BYC, BCM 1 and BCM 2 are 7 231m^3/month (9.7m^3/h), 3 338m^3/month (4.6m^3/h) and 3 316m^3/month (4.5m^3/h), respectively.

		The BS4 Boxcut DWD has on average 47 718m^3/month of water available for use as make up to the other Booysendal operations (BYN, BYC, BCM 1 and BCM 2). The average total mining service and process water make-up required across the Booysendal operations is 48 362m^3/month, which leads to a 644m^3/month deficiency to be supplemented by the Lebalelo water scheme.
BS4	Rainfall runoff makes up the biggest portion to water input, with a 44% (89 364m^3/month) contribution. Seepage and interstitial losses make up the biggest portion to water loss, with a 40% (76 898m^3/month) contribution.	Raw water from the BS4 TKO dam makes up the biggest portion to water input, with a 61% (77 377m^3/month) contribution. Seepage and interstitial storage makes up the biggest portion to water loss, with a contribution of 54% (77 696m^3/month).
Valley Boxcut		

9.2 Water Quality Management

The purpose of the water quality monitoring is to provide timely and accurate water quality data as per the DWS' requirements, as well as to inform the management team of the mine about the extent of possible mining impacts on the water resources. This data is used for a variety of purposes which may be summarized in broad terms as the determination of status and trends in resource water quality. Specific objectives of the water quality monitoring program are as follows:

- Determine whether water quality at sampling sites exceeds water quality standards as prescribed by the DWS;
- Assess the status of water quality in the surrounding areas;
- Provide analytical water quality information which describes present conditions and changes; and Provide timely data for other users.

Water quality assessment is divided into 4 sections as follows:

- Related studies;
- Historic Data as contained in the Scoping Hydrological Assessment Report;
- Average Annual Water Quality data;
- Once off samples collected during the detailed investigation phase.
  - Field parameters were recorded on site;
  - Laboratory results containing more variables

9.2.1 Related studies

In order to minimize the repetition of technical findings, the studies which have an influence on the findings and risk assessment for surface water resources were reviewed and are summarized as follows:

9.2.1.1. Aquatic Study

Reference: This study was conducted by Cleanstream Biological Services (Pty) Ltd.

Present Ecological State:

The desktop PES of the affected sub-quaternary reach of the Dwars River (B41G-721) was classified as Category C (MODERATELY MODIFIED). (It should be noted that this classification is an aggregate value applied to the overall reach and that, at a finer scale, the PES is likely to range from A/B in its upper reaches to C in the lower reaches).

Ecological Importance

The desktop assessment of the ecological importance (EI) of the sub-quaternary reach of the Dwars River (B41G-721), classified it to be of HIGH EI.

Ecological Sensitivity

The desktop assessment of the ES of the sub-quaternary reach of concern (Dwars River: B41G-721), classifies it as **VERY HIGH** ES.

The upstream reach of the Groot Dwars River was considered Category A/B (Pristine to Largely Natural) during January 2017. Water quality impacts were minimal and impacts to beds and banks were minor. There are vehicle tracks crossing the river. This has caused disturbance of beds and banks and the deposition of sediment within the channel downstream of the crossings.

There is evidence of bank erosion after flood events. This is thought to be mostly natural due to the steep slopes of the valley adjacent to the river, although there is a small farm dam in the upper catchment.

9.2.1.2. Surface and groundwater quality monitoring

Reference: This study was conducted by Aquatico Scientific (Pty) Ltd.

Water from the STP should not be released into the Groot Dwars River or its tributaries. Water recycling will be more viable over the long-term as grey water from the STP can be recycled rather than discharged.

Both the BN and BS4 mining operations are currently being monitored by purpose drilled source monitoring boreholes. Data gaps do however exist and there is most definitely room available for improvement. Additional source monitoring boreholes are also deemed necessary for the proposed new mining activities.

9.2.1.3. Groundwater study

Reference: This study was conducted by Future Flow Groundwater and Project Management Solutions (Pty) Ltd.

There are a number of perennial and non-perennial streams in the area. The major perennial streams include the Groot Dwars River, the Klein Dwars River, the Waterval River, and the Klip River. These rivers all drain in a south to north direction and are reportedly associated with major north / south striking fault zones. A large number of non-perennial streams that act as tributaries to the perennial streams also drain the area. The streams have their origin in the large number of springs that characterise the study area.

Depth to groundwater level indicates the presence of two different aquifers. The first is the weathered zone aquifer, where the depth to groundwater level ranges between surface and 12 metres below ground level (mbgl). The groundwater levels at surface represents the springs that were recorded. The depth to groundwater level in the fractured ranges between 22 and 42 mbgl.

Plotting groundwater level elevation against topographical elevation shows a 99.83% correlation is achieved. Based on this, it can be said that groundwater levels in the study area mimic topography, although at a slightly lower gradient. Groundwater flows are directed from the high lying areas towards the valleys. Groundwater flow gradients are slightly lower than topography and range between 1:5 on the valley slopes and 1:20 in the high lying plateaus and low-lying river valleys.

It is not expected that there will be any significant contamination from the BS1/2 underground mining area to the surrounding aquifers during the operational phase because mine dewatering will continue until the final end of life of mine (2042).

Recovery of the groundwater levels within the BS4 underground area will start during year 3 of the life of mine. It is expected that the water level in the BS4 underground area will rise to the level of the Valley Boxcut within 6 years from when the mine dewatering is stopped. Therefore, contaminant migration away from the BS4 area can start around year 9 of the total life of mine;

A contaminant plume is expected to migrate less than 100 m from the BS4 mining area towards the lower lying Groot Dwars River. No direct impact on the Groot Dwars River is expected during the operational phase.

9.2.2 Historic Data BS1/2

Historic data from October 2009 was provided by the mine. Recent data for a period ending on December 2017 was added to calculate average concentrations as part of the WSB.

Trend graphs were generated to indicate the change in water quality. This data was used to calculate the average annual water quality status. As it can be seen on **Figure 9-5,** the naming of monitoring points as provided by the mine was adopted.

In relation to the expansion project, Monitoring point NBSW02 is located downstream of all surface infrastructure areas. At this stage it is not necessary to assess other points which may exist downstream of NBSW01.

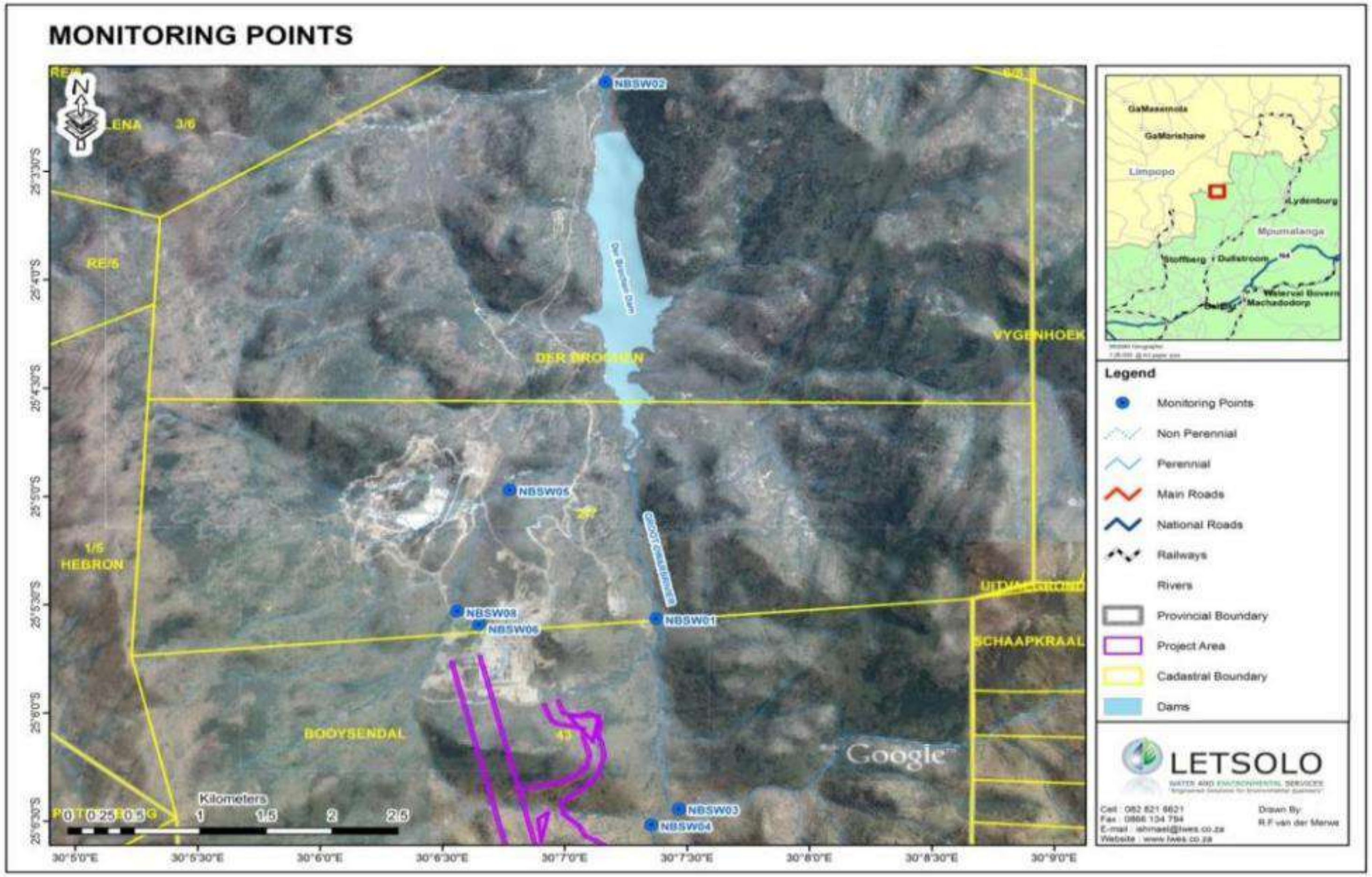


Figure 9-5: Water Quality Monitoring Points (BS1/2, BCM1 and BCM 2)

Historic data for a period starting October 2009 and ending on December 2015 was analysed. Three Water Quality Indicator Variables were selected as follows:

- Physico Chemical Parameter : Electrical Conductivity (EC)\
- Nitrogen Species Parameter : Nitrate (NO_3)
- Major Ionic Parameter : Sulphates (SO_4)

These three categories provide a good indication of the status quo.

9.2.3 Groot Dwars River

The Groot Dwars River valley lies west of the current mining operations. Surface water drainage via the Valley areas will directly reach the Groot Dwars River, but any surface drainage at the North Box cut area and processing areas (Plant and TSF) will reach the Groot Dwars River via the Kraalspruit approximately 6 kilometers downstream. The localities included in this section are NBS GD1, NBS GD2, NBS GD3, NBS GD4, NBSW01, NBSW02 and NBSW03.

- The pH-values in the Dwars River were neutral to alkaline during the baseline assessment and correlates with the other natural water systems.
- The EC, Ca, Mg, Na, K and NO3_N recorded very low concentrations even compared to the DWARS River Instream values at all the Groot Dwars River localities.

9.2.4 Western Tributary of the Groot Dwars River

The following findings were made:

- The overall water quality analysis indicates poor water quality at the Western Tributary of the Groot Dwars River (Figure 9-6), at monitoring point NBSW08. This point is located downstream of the Ore Stockpile Area and water quality may well be influenced by the ore stockpile area.
- As it is seen at monitoring point NBSW 05, water quality upstream of the Western Tributary of the Groot Dwars River improves as the concentration of indicator variables gets lesser. This may be due to a dilution effect/cumulative impact from several streams contributing to the flow and quality at NBSW 05.
    - TDS are at a concentration of 778.9mg/l, which exceed the RWQO limit of 520 mg/l. This point is located downstream of ore stockpile and the poor concentrations may be due to pollution from the stockpile area.
    - TDS concentration is reduced to a concentration of 483.2 mg/l at NBSW 05.

- The Ca concentration for both monitoring points at this tributary exceed the limit of 25 mg/l
  - 110 mg/l at NBSW08
  - 74 mg/l at NBSW05
- Overall SO_4 concentrations at this tributary are below the limit of 70 mg/l.
- The nitrates analysis, upstream and downstream, are above the limit of 6 mg/l. The possible reasons may be due to decanting.
  - NBS08 with value of 81.1 mg/l
  - 27.4 mg/l at NBSW05.

9.2.5 Historic Data BS4

The same approach and methodology applied in Paragraph 9.2.2 – Historical Water Quality Data for BS1/2 and BS4 is as follows:

9.2.6 Location of points

As indicated in Table 9-6 as well as Figure 9-6, 7 surface water monitoring points exist at BS4.

Table 9-6: Location of Surface Water Monitoring Points

ID	LABEL	X	Y	Description
1	SW 2	30.11658	-25.1511	Groot Dwars Downstream
2	SW 5	30.116	-25.1591	Groot Dwars Upstream
3	SW 6	30.16755	-25.1711	East stream Upstream
4	SW 3	30.15587	-25.1506	Northern side of TSF
5	SW 1	30.1628	-25.1421	Northern part of Kiwi farm
6	SW 4	30.16322	-25.1383	East stream Downstream
7	SW 7	30.15813	-25.13	East stream downstream

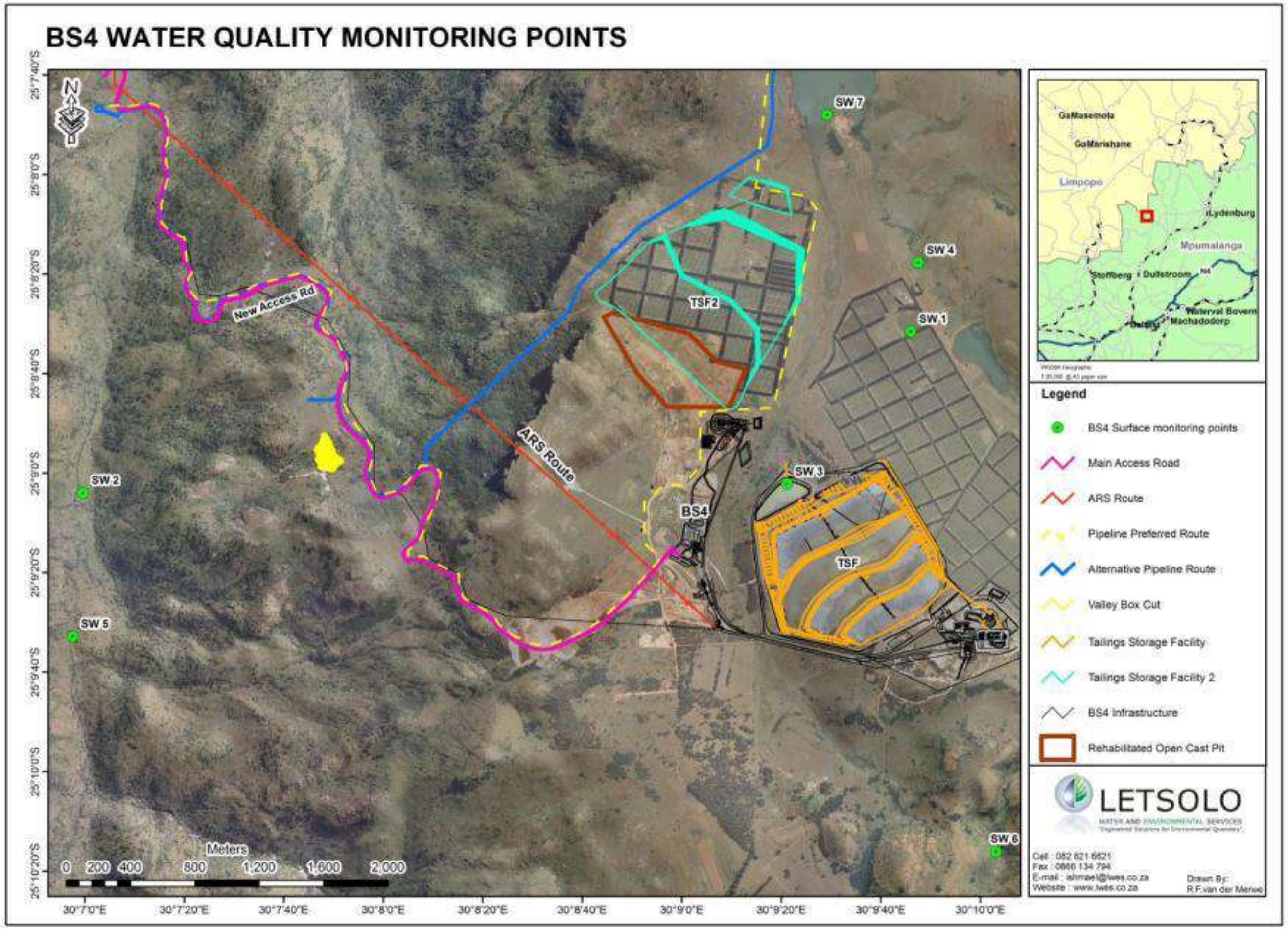


Figure 9-6: Surface Water Monitoring Points

9.2.7 Once Off Surface Water Quality Samples

Random once off samples were collected on 08 February 2016 at sampling points shown in Figure 9-7.

9.2.7.1. Field Data

Field Environmental instruments were used to determine pH, EC, TDS and Temperature. As indicated in **Table 9-7-**, no major concern was raised based on field parameters.

Table 9-7: Field Parameters

Description	pH	E.C	TDS	TEMPERATURE
RWQO	**Range 5 - 9.5**	**N/A**	**520**	
MPA	6.6	180	74	23.4
MPB	6.63	325	163	23.9
MPC	6.4	150	75	24
MPD	5.8	161	81	24.4
MPE	5.73	106	64	24.1
MPF	5.41	129	66	24.7
MPG	6.37	212	106	24.9
MPH	5.82	24	12	21.5

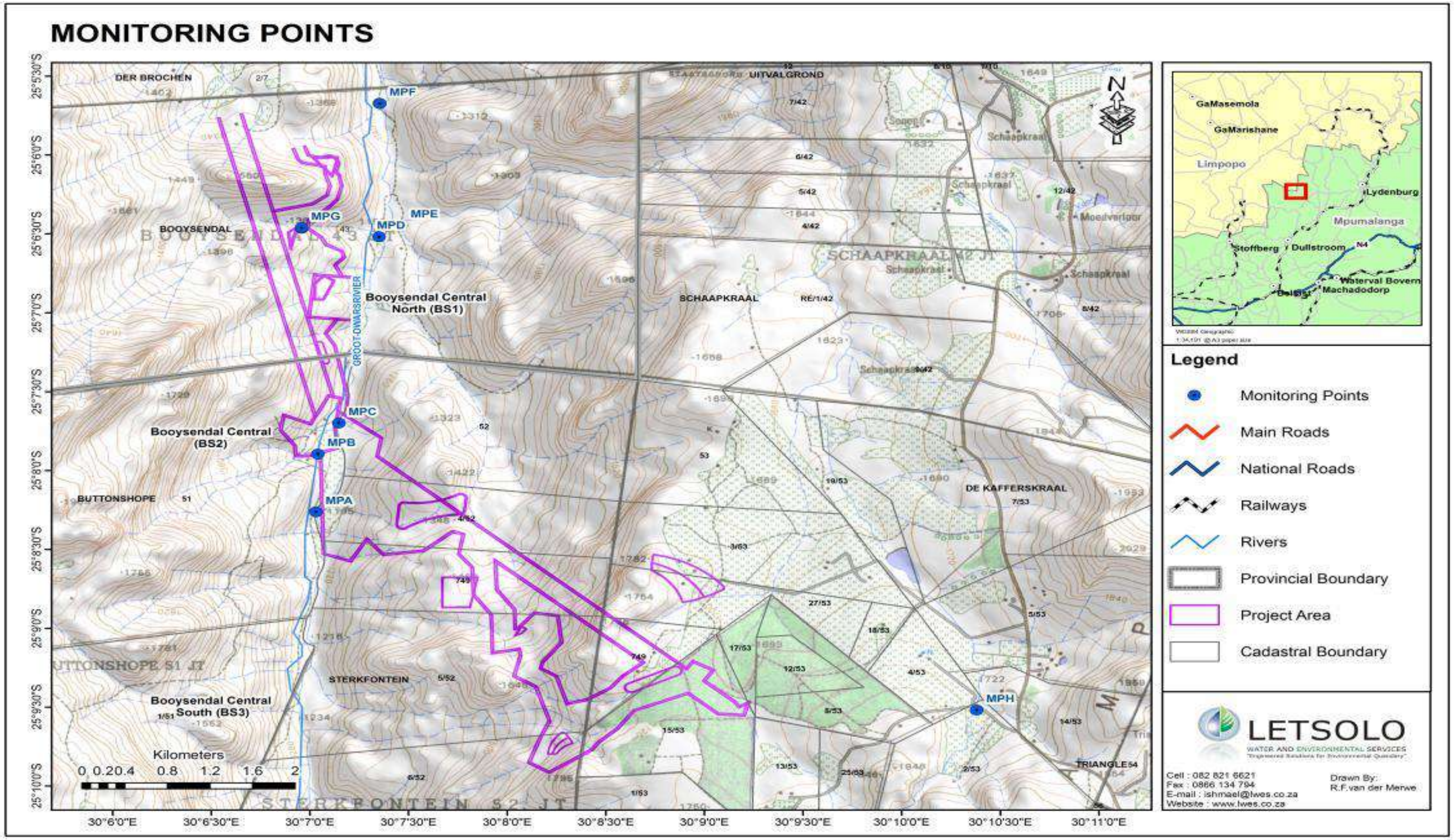


Figure 9-7: Water Quality Monitoring Points (Once off Samples)

The EC of water estimates the total amount of solids dissolved in water – (TDS. The EC of the water depends on the water temperature: the higher the temperature, the higher the EC would be.

The EC profile was produced from the field parameters in order to determine the changes in water quality, moving from upstream to downstream of the water resource.

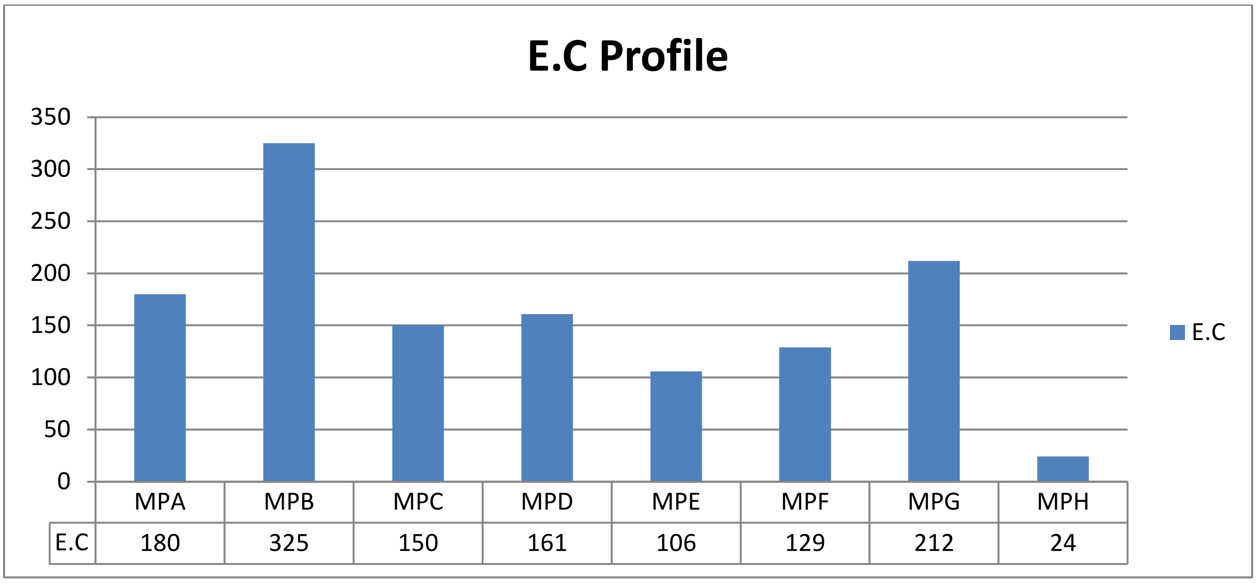


Figure 9-8: EC profile from upstream to downstream.

9.2.7.2. Lab results indicating more variables

The water quality omplies to the SANS 241:2015 limits. Water quality sampling was scheduled and undertaken on 08 and 09 February 2016, analysis results are presented in Table 9-8. The findings of the sampling exercise will assist to determine the following:

- Pre-development status quo;
- To identify clean and dirty water sources;
- To separate clean and dirty water sources;
- To quantify potential pollutants;
- To identify potential negative impacts and/or risks associated with pollutants; and
- To manage potential negative impacts and/or risks associated with pollutants.

Table 9-8: Detailed Laboratory Analysis

Variable	MP A	MP B	MP C	MP D	MP E	MP F	MP G	MP H
pH	8.48	8.47	8.32	8.29	8.14	8.42	8.35	8.27
EC (mS/m)	17.5	37.9	17.6	18.5	12.3	15.1	24.4	4.93
TDS (grav)	100	196	104	96	74	94	154	30
Ca (mg/L)	17.5	43.57	17.38	18.69	10.53	14.02	27.07	2.759
K (mg/L)	0.4068	0.1789	0.366 1	0.358	0.5964	0.462	0.063 5	0.370 7
Mg (mg/L)	10.99	23.62	11.01	11.55	8.247	9.62	14.92	1.322
Na (mg/L)	4.834	8.662	4.818	4.958	3.6	4.125	5.84	1.322
Cl (mg/L)	1.541	1.607	1.576	1.497	1.767	1.685	0.848	0.952
F (mg/L)	0.021	0.021	0.022	0.018	0.033	0.028	0.036	<0.01
NO3 (mg/L)	0.092	<0.01	0.094	<0.01	<0.01	<0.01	<0.01	<0.01
NO2 (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PO4 (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SO4 (mg/L	1.919	0.757	1.901	1.954	1.26	1.567	2.433	0.472
Cd (mg/L)	0.0023	<0.000 8	<0.00 08	<0.000 8	<0.000 8	<0.000 8	<0.00 08	<0.00 08
Co (mg/L)	<0.008	<0.008	<0.00 8	<0.008	<0.008	<0.008	<0.00 8	<0.00 8
Cr (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ni (mg/L)	<0.002	<0.002	<0.00 2	<0.002	<0.002	<0.002	<0.00 2	<0.00 2
Pb (mg/L	<0.004	<0.004	<0.00 4	<0.004	<0.004	<0.004	<0.00 4	<0.00 4
V (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Hardness (mg/L CaCO3)	89	206	89	94	60	74	129	14
SAR (Calc)	1.28	1.49	1.2	1.28	1.17	1.2	1.27	0.87
TALK (mg/L CaCO3)	79.3	193	90.4	97.2	45.9	76.7	132	16.5
COD (mg/L)	13.2	<5.1	18.8	14.1	8.37	12	<5.1	9.43
Suspended Solids (mg/L)	<1	25	<1	1	5	5	<1	<1
B (mg/L)	<0.003	<0.003	<0.00	<0.003	<0.003	<0.003	<0.00	<0.00

			3				3	3

Grab surface water samples were collected, where possible, from the center part of the various surface water bodies in order to ensure representative samples are collected. Samples were handled, stored and transported to the analytical laboratory in a cool, dark insulated container under strict chain-of-custody (CoC) protocols and documentation for sample tracking and specification of the required analytical suites.

9.2.7.3. Microbiological Analysis

Coliforms are bacteria that are naturally present in the environment and used as an indicator that other, potentially harmful, bacteria may be present. Total coliforms in the distribution system may indicate a potential pathway for contamination but in and of themselves do not indicate a health threat. However, coliforms found in more samples that are above SANS 5221 limits are a warning of potential problems.

The activities of coliform bacteria are dependent on all the physical, chemical and biological interactions of the aquatic environment, which determine their growth rate and survival. These organisms can cause diseases such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever. They should not be detectable in treated water supplies. If found, they suggest inadequate treatment or post- treatment contamination. However, many of these bacteria may originate from growth in aquatic environment.

Total coliforms are a group of bacteria commonly found in the environment, for example in soil or vegetation, as well as the intestines of mammals, including humans. Total coliform bacteria are not likely to cause illness, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms. Escherichia coli (E. coli) is the only member of the total coliform group of bacteria that is found only in the intestines of mammals, including humans.

The presence of E. coli in water indicates recent fecal contamination and may indicate the possible presence of disease-causing pathogens, such as bacteria, viruses, and parasites. Although most strains of E. coli bacteria are harmless, certain strains, such as E. coli 0157:H7, may cause illness. Sources of Total coliform and Escherichia Coliform contamination in groundwater can include:

- Agricultural runoff;
- Effluent from septic systems or sewage discharges;
- Infiltration of domestic or wild animal faecal matte;r

- Domestic animals or wildlife; and
- Poor well maintenance and construction (particularly shallow dug wells) can also increase the risk of bacteria and other harmful organisms getting into a well water supply.

Table 9-9 provides summary of DWA guidelines.

Table 9-9: ***DWA guidelines for bacterial activity in water***

TARGET WATER QUALITY	Below Detection Limit: A range of 0 and 5, negligible risk of microbial infection.
TOTAL COLIFORMS	A range of between 5 and 100 is indicative of inadequate treatment, post-treatment contamination or growth in the distribution system. Risk of infectious disease transmission with continuous exposure and slight risk with occasional exposure.
	A range greater than 100 is indicative of poor treatment, post-treatment contamination or definite growth in the water distribution system. Significant and increasing risk of infectious disease transmission.
FAECAL COLIFORMS	A range between 0 and 10 has a slight risk of microbial infection with continuous exposure. A range between 10 and 20 has a risk of infectious disease transmission with continuous exposure
	A range greater than 20 has a significant and increasing risk of infectious disease transmission. As faecal coliform levels increase, the required amount of water ingested to cause infection decreases.

Escherichia coli (E. coli) is an anaerobic bacterium of the genus Escherichia that is commonly found in the lower intestine of warm-blooded organisms. Most E. coli strains are harmless, but some serotypes can cause serious food poisoning in their hosts, and are occasionally responsible for product recalls due to food contamination.

As indicated in **Table 9-10**, E Coli was analysed at 4/8 water quality monitoring points. The points were selected as follows:

- MP A: The most upstream point
- MP E: Everest stream
- MP F: downstream of Everest stream

- MP H : Upstream of Everest.

The most upstream points (MP A and MPH) which are located far from mining activities indicated higher counts than the points located closer to the mining activities. This may be due to a higher number of cattle and wild animals as one moves upstream.

Table 9-10: E.Coli and Total Coli (CFU/100ml)

Description	E.Coli (CFU/100ml)	Total Coliforms (CFU/100ml)	Total Coliform Negligible risk
MPA	61	200	5
MP B	NR	NR	5
MP C	NR	NR	5
MP D	NR	NR	5
MP E	6	26	5
MP F	5	45	5
MP G	NR	NR	5
MP H	42	59	5

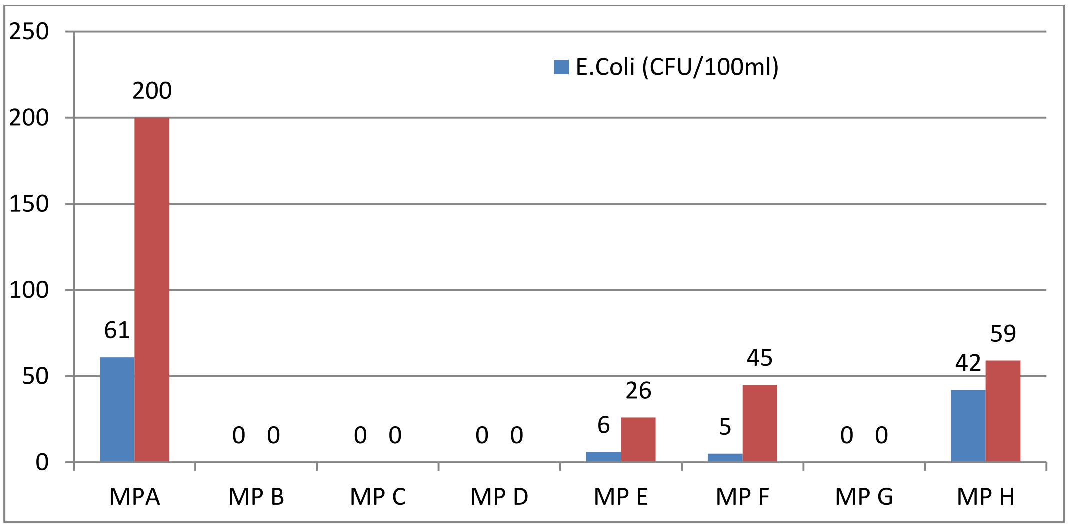


Figure 9-9: E.Coli and Total Coli (CFU/100ml)

9.3 WSB BS1/2

The WSB for BS1/2 is summarized as follows:

9.3.1 Location of points

Each of the water circuits must have a salt concentration, which was used together with the flow rate to determine the salt load of each circuit. Monitoring points with both volume and concentration data were selected as relevant for the salt balance calculations. Please refer to Figure 9-7 for the location of monitoring points.

9.3.2 Selection of Variables

The “salt concentration” may either refer to the concentration of a specific salt or the TDS concentration. The concentrations of the various salts and the TDS are determined fairly accurately in a laboratory.

It is important to ensure that the variable selected is a conservative salt such as Na, Cl, etc. Although TDS or EC includes non-conservative salts, it is often used for salt balance purposes. Salts such as sulphate are generally not used in mining water salt balances, unless sulphate generation from pyrite oxidation is explicitly included as a salt load input. It is, however, more appropriate to use TDS, EC and sulphate in salt balances when pollution loads and discharge compliance requirements are under consideration.

Elements such as calcium, phosphate, nitrate, heavy metals and other compounds are regarded as non-conservative salts as they are usually subject to biological metabolisation or chemical precipitation.

The selected indicator variables are TDS, sulphate and nitrates.

9.3.3 Salt Load Calculations

It is important to note that with Salt loads calculations, the monitoring point with the poorest water quality data may not necessarily reflect the worst salt loads. Another determining factor is the volumes concerned.

The systems were assessed as follows:

- The Groot Dwars River; and
- Western Tributary.

Findings:

- There are higher salt loads at MPB and MPD (where MPA referes to Monitoring Point A and MPB refers to Monitoring Point B) due to the nature of the crossings. There are no culverts at these monitoring points. Culverts reduce the potential of elevated concentrations of TDS and Sodium (Figure 9-10).
- TDS accounts for high salt loads. High TDS loads is a confirmation of various inorganic salts dissolved in water (Figure 9-11 below);
- There were low concentrations of sulphates, sodium and chloride.

<u>Sulphates</u>

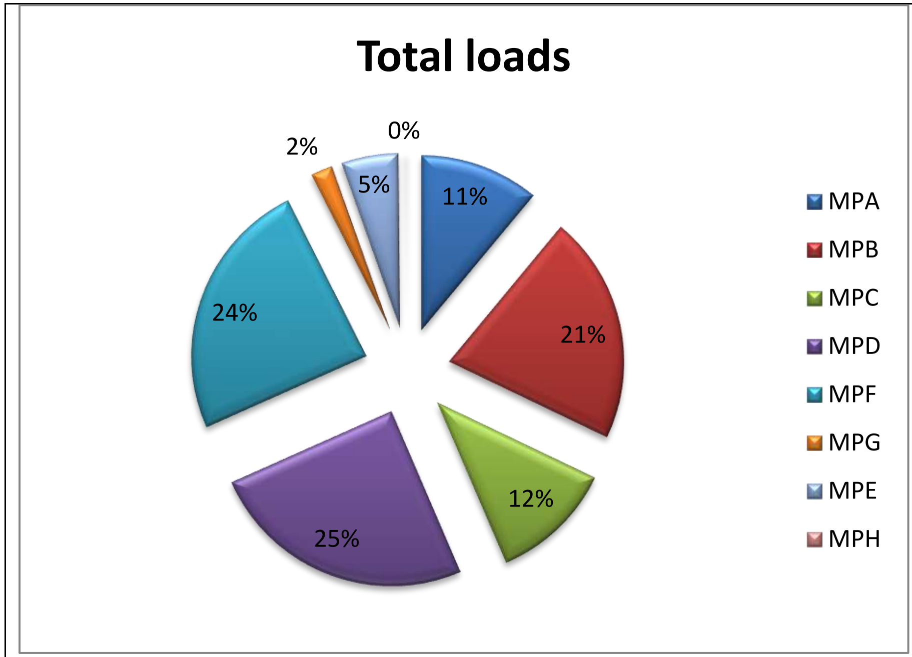
- Sulphate is a common constituent of water and results from the dissolution of mineral sulphates in a rock and soil.
- Sulphates are discharged from acid mine waste and many other industrial processes.

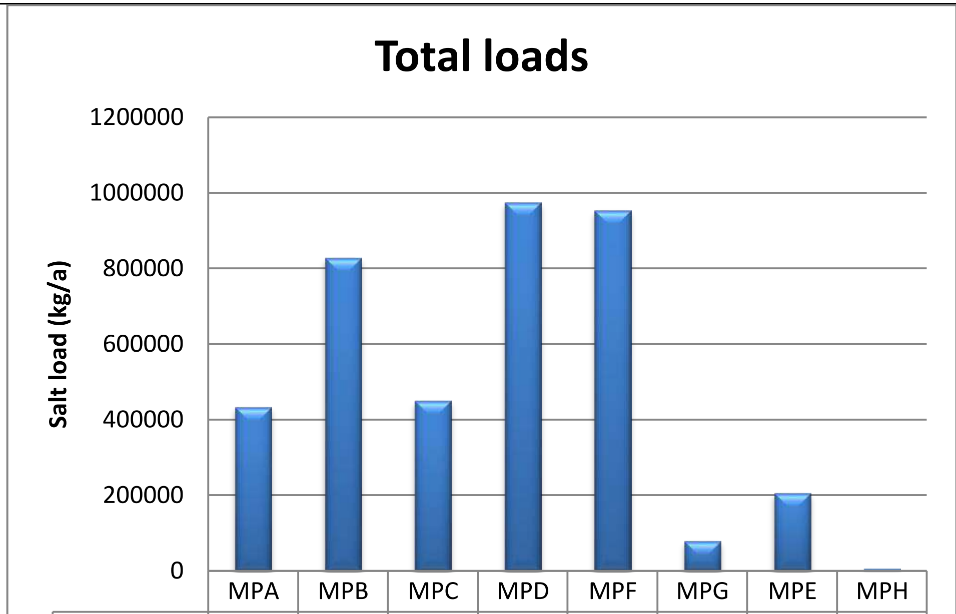
<u>Sodium</u>

- At concentrations greater than 200mg/l, sodium gives a slightly salty taste in water.
- Sodium can be removed from water together with other ions which constitute the Total Dissolved Solids.

<u>Chloride</u>

- Chloride is of concern in water supplies because of elevated concentration accelerate corrosion of metals and shorten lifetime of equipment and structures.





	MPA	MPB	MPC	MPD	MPF	MPG	MPE	MPH
Total loads	433668	829045	449690	975435	954324	78950	206075	6023

Figure 9-10: Total Salt Loads

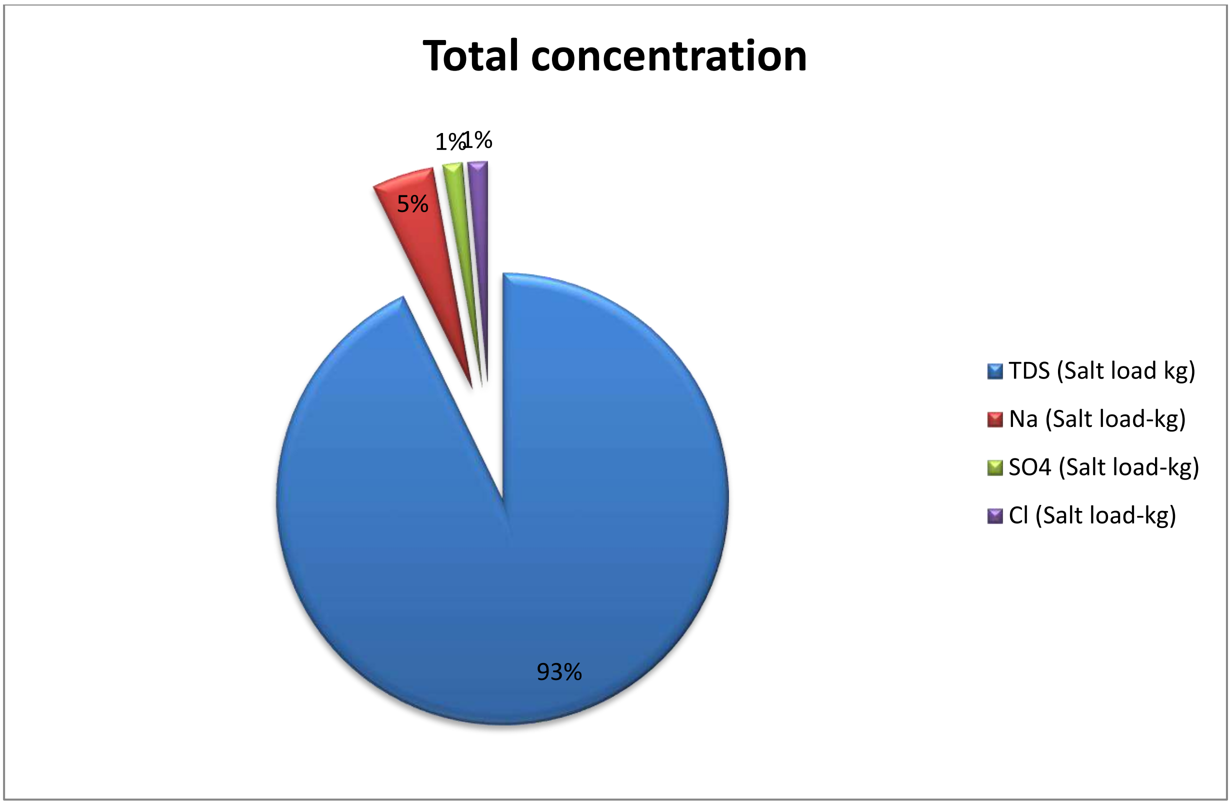


Figure 9-11: Comparison of salts

As indicated in Table 9-11 the results indicate that there is an increase in loads. This is due to the deterioration of water quality as there is diffuse pollution in the form of decanting from the old Everest Mine, into the Everest Stream.

The summary of the Salt load calculations are as follows:

Table 9-11: Salt Loads for the Groot Dwars River

Monitoring Points	Area (km^2)	Flow Vol (m^3/a)	TDS (Salt load kg)	Na (Salt load-kg)	SO4 (Salt load-kg)	Cl (Salt load-kg)	Total loads
MPA	60.767	4004545	400455	19358	7685	6171	433668
MPB	60.767	4004545	784891	34687	3031	6435	829045
MPC	60.767	4004545	416473	19294	7613	6311	449690
MPD	141.767	9342445	896875	46320	18255	13986	975435
MPF	142.847	9413617	884880	38831	14751	15862	954324
MPG	7.39	487001	74998	2354	1185	413	78950
MPE	38.2	2517380	186286	12169	3172	4448	206075
MPH	2.28	150252	4508	1301	71	143	6023
Total concentration	**514.785**	**33924332**	**3649365**	**174315**	**55763**	**53769**	**3933212**

9.4 WSB BS4

As indicated in Table 9-12, two monitoring points located on Everest Stream. In order to determine the correct flows, for each monitoring point, the effective catchments were delineated in order to quantify the flows at each point.

Table 9-12: Effective Volumes

Catchment Characteristics and Flow Details				
System	**Monitoring Point**	**Effective Catchment Names**	**Effective Catchment Area (km^2)**	**MAR at a rate of 66mm/a (m^3/annum)**
Everest stream	MP H	20% of Catchments 18	7.64	504240
	MP E	Catchments 18	38.2	2521200

You will notice that the MAR increases as one moves downstream.

9.4.1 Salt Load Calculations

As indicated in **Table 9-13 to 9-14**, MPE is located downstream of MPH on the Everest stream. The results indicate that there is an increase in loads moving from MPH to MPE. This deterioration in water quality is due to diffuse pollution in the form of decanting from the old Everest Mine, into the Everest Stream.

Table 9-13: Effective Volumes

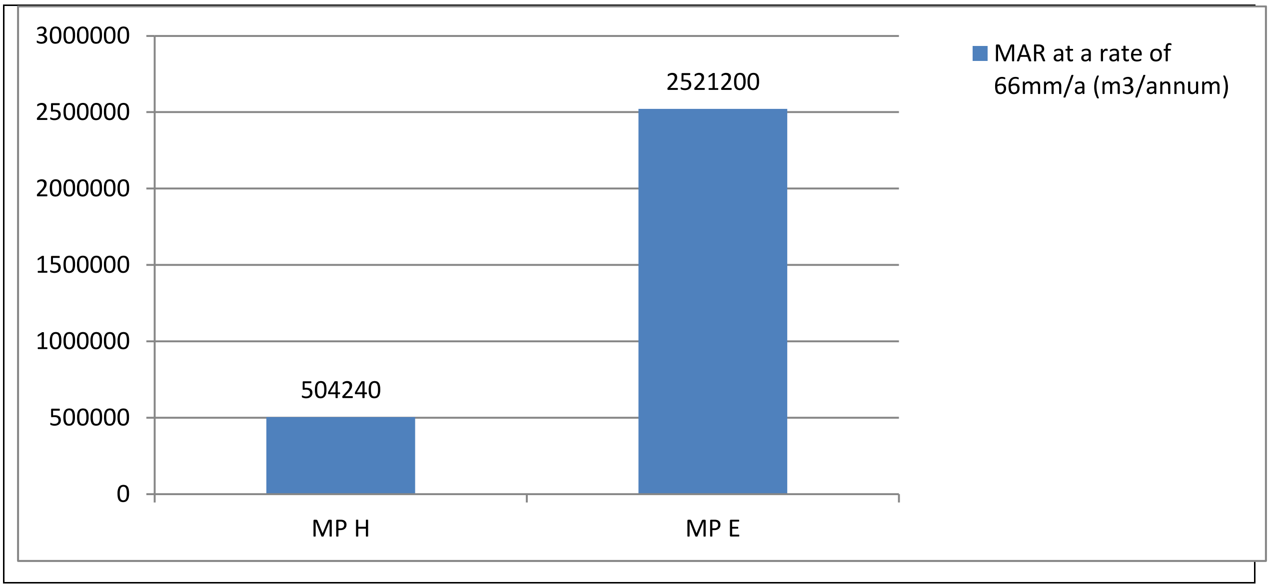
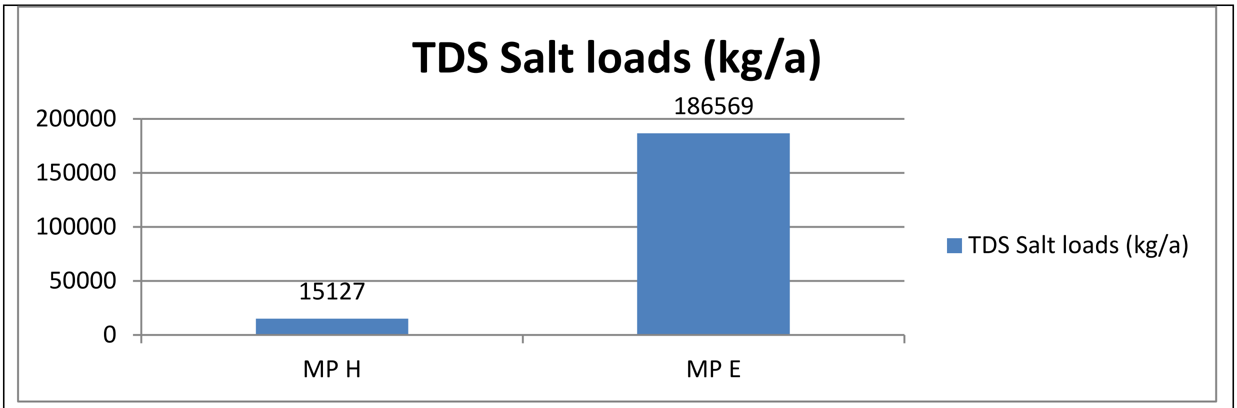
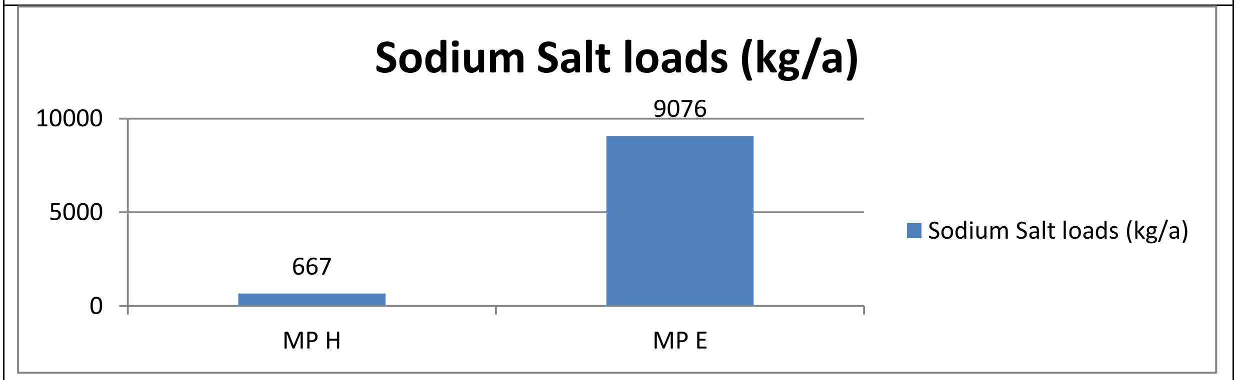
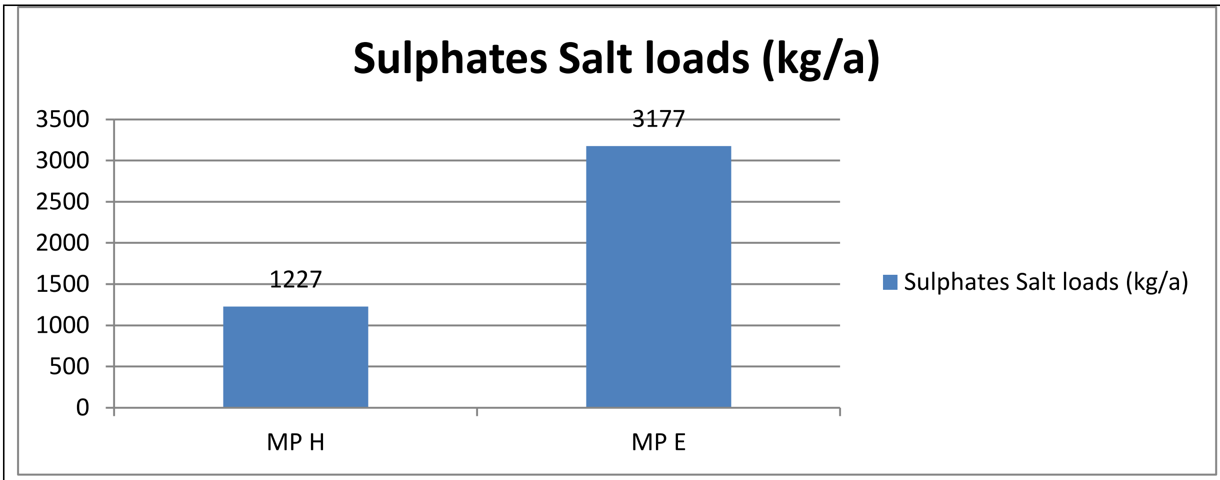


Table 9-14: Salt Loads for the Everest Stream indicating an increase in salts at MPE







The summary of the salt load calculations are as follows:

The following salt balance (loads of waste) findings were made:

- Based on the data presented, water quality for Groot Dwars river is of good quality when compared against SANS 241-1 of 2015.
- The same observation was made for these monitoring points assessed against the RWQOs.

The findings of Stream 1 located west of the mining area, are summarized as follows:

- Upstream segment of the Groot Dwars River (Upstream of BS1/2) accounts for 25% of the total salt retained in the system.
- Western tributary of the Groot Dwars River accounts for 27% of Total Salts
- Downstream of BS1/2 accounts for 48% of total salts.
- Total Dissolved Solids (TDS) account for 72% .

It is highly recommended that the mine should:

- Continue monthly surface water and quarterly ground water quality monitoring in order to determine the seasonal and time relevant variations;
- The SWMP report was compiled concurrently with the water and salt balance.

Systematically upgrade capacity/storage and flow monitoring.

Table 9-15: Salt Loads for the Everest Stream indicating an increase in salts at MPE

Salt Loads Calculations							
System	**Monitoring Point**	**Sodium Concentrations (mg/l)**	**Sodium Salt loads (kg/a)**	**Sulphates Concentrations (mg/l)**	**Sulphates Salt loads (kg/a)**	**TDS Concentrations (mg/l)**	**TDS Salt loads (kg/a)**
Everest stream	MP H	1.322	667	0.472	1227	30	15127
	MP E	3.6	9076	1.26	3177	74	186569

10.0 IDENTIFICATION OF AREAS TO BE AVOIDED

The location of dirty water management infrastructure must be outside the 1:100-year flood lines. Water use activities associated with the river crossings and storage of mine water trigger the need to obtain water use authorisations.

These proposed water uses must be authorised by the DWS before any water use can commence.

11.0 ASSUMPTIONS MADE AND ANY UNCERTAINTIES

11.1 Mining Method Assumptions

Ore will be extracted by board and pillar method. This mining method has less hydrological impacts as the topography remains unchanged.

12.0 POTENTIAL IMPACTS

12.1 Phase 1 Potential Impacts

The following sub-sections contain a description of the activities which resulted or can result in impacts on the hydrological regime specifically related to the activities which have already commenced. This is followed by an assessment of the impacts related to these activities

12.1.1 Potential impacts because of activities which has already commenced

The identified potential impacts for the activities which have already commenced are as follows:

- Deterioration of water quality: Waste streams (e.g. process water, effluent etc.) will be generated during the construction, operation and decommission phases. If waste is not properly managed, Storm water which gets in contact with waste will be contaminated. This can be identified in the WSB as the activity progress.
- Hazardous waste like grease and oil may impact on surface runoff and quality.
- Change in flow regime: A clean water diversion channel were constructed upstream of the BS1/2 in order to separate clean and dirty water. This resulted in the change in flow direction as water will be collected with artificial infrastructure.

  Increase in Hydrological Yield: Vegetation cover reduces hydrological yield. Vegetation were removed. Due to an increased percentage of bare surfaces, there is a higher potential for hydrological yield.

- Erosion/sediment transport: Vegetation protects the surface by restricting the movement of sediments. Although no erosion gullies were identified during the site visit, As vegetation is removed, soil will be loosened and this will result in a higher potential for sediment transport during storm events.

- Failure of dirty water infrastructure and flooding of artificial infrastructure: During the operational phase, the PCD and the dirty water channels must be designed, constructed and maintained in line with the requirement of GN 704. Spillages from the dirty water systems may impact negatively on the chemical and microbiological characteristics of the receiving water resources.

- Change in catchment characteristics: The current clean water catchment area will be changed to be classified as a dirty water catchment area. This will result in a lesser MARf volume because contaminated runoff will not be allowed to freely flow to the environment.

12.1.2 Area 1: BS1/2

Activities which have commenced and may have an impact on surface water resources are as follows:

- Infilling of more than 5 cubic meters within the 100-year flood line of the Groot Dwars River for the establishment of the portal terrace and the main river crossing over the Groot Dwars River;
- Diversion of two unnamed tributaries of the Groot Dwars River upstream of the BS1/2 Shaft Complex;
- Stockpile and terracing for the BS1/2 portal within the 100m flood line of an unnamed tributary of the Groot Dwars River;
- Construction of a pollution control dam, a sewage treatment plant and a drinking water treatment plant, mine dewatering, process water tanks and water storage tanks which requires authorization in terms of the National Water Act, 36 of 1998 for Section 21 b, f, g and j water uses; and
- Construction of a bridge across the Groot Dwars River.

12.1.3 Area 3: BS4

Construction of the following activities have commenced at BS4 and were approved under the Section 24G EA

- Reworking and replacing of tailings on the existing TSF1 at BS4;
- Upgrade the storm water management system at BS4 using the SWMP developed by SLR in 2011, as basis for the upgrades. Increase in the size of the ore stockpile (ROM);
- Silt trap at the upstream point of the conveyor system.

12.1.4 Valley Boxcut Area

These activities include the following:

- Mining operations - Establishing additional surface infrastructure to allow for additional access of the existing ore body as well as act as an emergency exit and air intake for the underground mine.

- The additional infrastructure will include a new decline, referred to in this report as the valley decline.
- Roads and access points - a service road will be extended from the terrace to the valley decline.
- Power lines.
- Domestic and industrial waste disposal facilities - Domestic and industrial waste produced by the mine is collected on site in demarcated areas and disposed of off-site at Holfontein (hazardous waste) and Lydenburg (domestic waste) by a waste contractor (Waste Technologist).
- Sewage treatment - A sewage treatment facility is planned. The facility will be located at the decline and will service the change houses and ablution facilities at the decline. The sewage treatment plant will be designed to cater for 200 employees and will have a treatment capacity of 60 m^3/month of sewage.
- Storm water dam - Dirty runoff from the decline shaft area will be pumped to a storm water dam located immediately downstream of the decline area. The storm water dam will have a 5 000 m^3 capacity to cater for the 1:50 year storm event.
- Potable water supply - Potable water at the mine is sourced from boreholes. The water is pumped to storage tanks before being used. Approximately 46 m^3/day (1 380 m^3/month) of potable water is used by the mine.
- Process water supply - Process water at the mine is sourced from boreholes (through dewatering activities), groundwater inflows into the workings, storm water runoff from the mining and plant area, rainfall inputs to the pit and the TKO dam.
- Workshops, administration and other buildings – These facilities needed for the project include: fencing, security and access control; a bus off-loading and loading area; offices and change houses with ablution facilities; a control room; stores and workshops; fuel storage (approximately 100 m3) and handling point; explosives delivery and handling facility; parking area for mine equipment and vehicles; and compressors.

12.2 Risk rating tables

The following tables (Table 12-1 to 12-2) cover the risk ratings for each phase and activity.

Table 12-1: BS4 Positive Impacts

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	1. Upgrade and lining of PCDs; 2. Decommissioning and rehabilitation of Workshop PCD; and 3. Silt trap for the conveyor belt.		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	CO, OP, CP Positive Impact		
Type of Impact	1. Potential improvement in water quality within downstream surface water receptors; 2. Potential improvement in quality within downstream surface water receptors; 3. Potential improvement in quality within downstream surface water receptor; and 4. Potential improvement in water quality within downstream surface water receptors.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	3
Duration	Long-term	3	3
Extent	Area of influence Everest Stream, tributary of the Groot Dwars River.	3	3
Receptor Sensitivity	Moderate	3	3
Magnitude	Moderate	3	3
Impact Significance	Moderate	Moderate 12 3	Moderate 12 3
Mitigating and Monitoring Requirements			

Required Management Measures	1. The PCD must be operated in such a manner that it can contain the 1:50 year's storm event volume without overtopping.
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Positive Impact

Table 12-2: Deterioration of water quality

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	1. Upgrade of STP; 2. Water supply pipeline from TKO Dam to BS1/2; 3. Increased size of ROM Pad; 4. Discharge of fissure water from Valley Box Cut; and 5. Construction of Valley Box Cut PCD.		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	CO, OP, CP		
Nature of Impact	Negative		
Type of Impact	1. Potential deterioration in water quality within downstream surface water receptors. 2. Potential change in flow regime. 3. Potential erosion risk. 4. Potential negative impact on quality of local surface water receptors.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term	3	2
Extent	Area of influence Everest Stream, tributary of the Groot Dwars River.	3	1
Receptor Sensitivity	Moderate	3	2

Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 12 3	Minor 7 2
Mitigating and Monitoring Requirements			
Required Management Measures	1. The final effluent must meet the regulated discharge quality concentration in line with RWQO. 2.		
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through proper design and maintenance of hydraulic structures and through management measures		

12.3 Potential impacts of proposed activities

This section contains a summary and a motivation of the potential interactions and impacts which may be associated with the project activities, specifically related to the hydrological specialist field.

The proposed activities are summarised as follows:

- Area 1: BS1/2
  - Aerial Rope conveyor system between BS1/2 and BN; and
  - Emergency Escape Portal north of the main BS1/2 portal.
- BCM1 and BCM2Area 3: BS4
  - The future TSF 2 and RWD to the north on the kiwi farm footprint; and
  - Return water pipeline from the RWD to the plant

12.3.1 BS1/2 Impact Rating

The purpose of this section is to assess the potential impacts identified t
The tables 12-3 to 12-6 below were produced in order to rate each impact.

Table 12-3: Deterioration of water quality

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Construction of roads and supporting infrastructure in or close to drainage lines. Operation and maintenance of dirty water infrastructure. Spillages of chemicals and hydrocarbons.		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	CO, OP, CP Negative		
Type of Impact	Direct: due to the close proximity of the Groot Dwars River, pollution incidents may directly result in the deterioration of water quality.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term The management of dirty water infrastructure is required from the construction the post closure phase.	3	2
Extent	Area of influence The Groot Dwars Rivers a significant stream in the catchment. In the event of pollution, pollutants will be easily washed further downstream.	3	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 12 3	Minor 7 2
Mitigating and Monitoring Requirements			

Required Management Measures	The clean and dirty water flow areas on a mine site were identified and flood volumes quantified. The mine must locate any sanitary convenience, fuel depots for any infrastructure which causes or is likely to cause pollution of a water resource outside the 1:50 year flood line of any watercourse or estuary. Dirty water channel should be designed to collect contaminated water and to dispose it into the PCD. Storage areas for chemicals and hydrocarbons, workshops need to be constructed according to best practice Spills should be cleaned up immediately Maintenance of all dirty water systems Regular cleaning of clean water diversion systems Emergency response measures must be put in place Dirty water should be re-used in the process.
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Impact can be managed through proper design and maintenance of hydraulic structures and through management measures

Table 12-4: Change in flow regime

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Site Establishment and construction of required infrastructure		
Risk/ Impact	1. Change in flow regime 2. Increase in hydrological yield 3. Change in catchment characteristics		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	CO, OP		
Nature of Impact	Negative		
Type of Impact	Direct: artificial infrastructure like channels and berms, may have a significant impact on the flow regime due to the change in flow direction and velocity.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	2	1
Duration	Long-term As part of clean and dirty water separation, Water management infrastructure will be required for the life of mine.	3	2
Extent	Area of influence	2	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate significance	Moderate 10 3	Minor 6 2
Mitigating and Monitoring Requirements			
Required Management Measures	The location of mining infrastructure must be outside the 1:100 years Flood lines or where the 1:100 yr Flood lines are not known outside of the 100m lines.		

	The proposed infrastructure may not impede or divert the flow, unless authorized by the DWS. Efforts should be made to minimize the dirty water catchment . Dirty water channel should be designed and constructed to collect contaminated water and to dispose it into the PCD.
Required Monitoring (if any)	WSB balance studies must be conducted and amended annually. The outcomes of the study must be used as a management tool as well as a means of investigating the latest technologies for water management.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Impact can be managed through management programs.

Table 12-5: Spillages from dirty water infrastructure

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	Maintenance and operation of dirty water infrastructure. Flood events		
Risk/ Impact	Spillages from dirty water infrastructure.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	CO, OP		
Nature of Impact	Negative		
Type of Impact	Direct: Dirty water management measures as discussed in this report must be implemented.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term The management of dirty water	3	2

	infrastructure is required from the construction to post closure phase.		
Extent	Area of influence The Groot Dwars River is a significant stream in the catchment. In the event of pollution, pollutants will be easily washed further downstream.	3	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate The magnitude will depend on the location of infrastructure components.	3	2
Impact Significance	Moderate significance	Moderate 12 3	Minor 9 2
Mitigating and Monitoring Requirements			
Required Management Measures	The PCDs must be designed, constructed, maintained and operated in such a way that it is not likely to spill into any clean water system more than once in 50 years. All PCDs must have a minimum freeboard of 0.8m above full supply level. All dirty water infrastructure needs regular maintenance Oil separators and dirty water trenches have to be cleaned regularly, SWMP must be compiled and adhered to throughout the Project Discharges from the final effluent must comply to the conditions that will be raised by the DWS when the IWUL is issued.		
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through proper Storm Water Management Measures.		

Table 12-6: Erosion

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	Site preparation and vegetation clearance		
Risk/ Impact	Vegetation clearance for mine infrastructure can directly impact on sediment transport. Loose particles are erodible. Exposed areas during operation and at closure and final		

	rehabilitation can contribute to erosion		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	CO, OP, CP Negative		
Type of Impact	Direct: clearance will directly lead to impact		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Possible	2	1
Duration	Short Term	2	1
Extent	Site	2	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 9 3	Minor 7 2
Mitigating and Monitoring Requirements			
Required Management Measures	Vegetation stripping must be limited to the minimum width required; The topography of all disturbed areas must be rehabilitated, in such a manner that it blends with the surrounding natural area. This will reduce soil erosion and improve natural re-vegetation; The necessary flood attenuation and erosion control structures have to be put in place		
Required Monitoring (if any)	A maintenance schedule for the removal of silt on water management infrastructure must be established.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through Erosion Control Measures programs.		

12.3.2 BS4 Impact Rating

The potential impacts of the future infrastructure and activities upon local surface water receptors have been identified, as presented in Table 12-7 below.

Table 12-7: BS4 Impact Rating

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	1. Return water pipeline from RWD to Plant 2. Backfill Plant		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	CO, OP, CP Negative		
Type of Impact	• The transportation of process water may have a negative impact on the environment should there be any leaks or pipe bursts. Potential negative impact on quality of local surface water receptors. • Potential negligible impact in quality of downstream surface water receptors. • Potential change in flow regime. • Potential erosion risk.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	4	2
Duration	Long-term	3	2
Extent	Area of influence	3	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 13 3	Minor 9 2
Mitigating and Monitoring Requirements			

Required Management Measures	1. Pipeline failure may cause a uncontrolled discharge of dirty water to a surface water environment causing a pollution, short term increase in flows and potential erosion risks near the failure point.
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Impact can be managed through proper design and maintenance of hydraulic structures and through management measures

12.4 Phase 2 : BS1/2 Operational Area

The potential impacts of the future infrastructure and activities upon local surface water receptors have been identified, as presented in Table 12-8 and 12-9 below.

Table 12-8: BS1/2 Positive Impacts

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	4. Upgrade and lining of PCDs; 5. Decommissioning and rehabilitation of Workshop PCD; 6. Silt trap for the conveyor belt; and 7. Upgrade of sewage treatment plant.		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	CO, OP, CP		
Nature of Impact	Positive Impact		
Type of Impact	5. Potential improvement in water quality within downstream surface water receptors; 6. Potential improvement in quality within downstream surface water receptors; 7. Potential improvement in quality within downstream surface water receptor; and 8. Potential improvement in water quality within downstream surface water receptors.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	3
Duration	Long-term	3	3
Extent	Area of influence Everest Stream, tributary of the Groot Dwars River.	3	3
Receptor Sensitivity	Moderate	3	3
Magnitude	Moderate	3	3
Impact Significance	Moderate	Moderate 12 3	Moderate 12 3
Mitigating and Monitoring Requirements			

Required Management Measures	1. Increased PCD capacity will reduce probabilities of spillage. 2. Lining of the PCD will reduce seepage of dirty water, which may migrate towards surface water receptors. 3. Workshop PCD will be replaced with a fit for purpose lined facility with suitable capacity which reduces the probability of a spillage. 4. Rehabilitation will remove a source-pathway-receptor linkage. 5. Removal of silt from storm water upstream of surface water receptor, if silt trap is maintained properly. 6. Improvement in quality of effluent discharged to surface water receptor.
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Positive Impact

Table 12-9: Deterioration of water quality

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	Construction of potable and process water lines for BS1/2 and sourced from the existing Lebalelo allocation, running along the existing gravel access road along the Groot Dwars River between BS1/2 and BN; and Aerial Ropeway Conveyor (ARC) from BS1/2 to BN with associated access roads		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	CO, OP, CP		
Nature of Impact	Negative		
Type of Impact	1. Potential negligible impact in quality of downstream surface water receptors. 2. Potential erosion risk. 3. Potential negative impact on quality of local surface water receptors. 4. Potential negative impact on quality of local surface water receptors. 5. Potential improvement in water quality within downstream surface water receptors.		

	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term	3	2
Extent	Area of influence Everest Stream, tributary of the Groot Dwars River.	3	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 12 3	Minor 7 2
Mitigating and Monitoring Requirements			
Required Management Measures	1. Pipeline failure may cause a uncontrolled discharge of water into a downstream receptor causing a short term increase in flows and potential erosion risks near the failure point. 2. Increase in quantity of a potential pollution source, drainage from which may enter surface water receptors. 3. Quality of water collecting within underground mine workings is typically high in suspended solids, nitrates and possibly various other pollutants.		
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through proper design and maintenance of hydraulic structures and through management measures		

12.4.1 Area BCM 1 and 2

The identified potential impacts (also refer to Table 12-10 and 12-11) for the activities which already commenced are as follows:

- Deterioration of water quality: Waste streams (e.g. process water, effluent etc.) will be generated during the construction, operational and decommissioning phases. If waste is not properly managed, Storm Water which gets in contact with waste will be contaminated.
- Hazardous waste like grease and oil may impact on surface runoff and quality.

- Failure of dirty water infrastructure and flooding of artificial infrastructure: During the operational phase, the PCD and the dirty water channels must be designed, constructed and maintained in line with the requirement of GN 704. Spillages from the dirty water systems may impact negatively on the chemical and microbiological characteristics of the receiving water resources.

Table 12-10: Spillages from dirty water infrastructure

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Construction of surface infrastructure associated with the two BCM1 and BCM2, including conveyor systems, workshops, offices, a pollution control dams (PCD) each, clean and process water storage facilities, ore stockpiles and potential oil and diesel storage bays.		
Risk/ Impact	Spillages from dirty water infrastructure.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	CO, OP		
Nature of Impact	Negative		
Type of Impact	Direct: Pollution of water resources		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term The management of dirty water infrastructure is required from the construction to post closure phase.	3	2
Extent	Area of influence The Groot Dwars River is a significant stream in the catchment. In the event of pollution, pollutants will be easily washed further downstream.	3	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate The magnitude will depend on the location of infrastructure components.	3	2

Impact Significance	Moderate significance	Moderate 12 3	Minor 9 2
Mitigating and Monitoring Requirements			
Required Management Measures	The pollution control dam must be designed, constructed, maintained and operated in such a way that it is not likely to spill into any clean water system more than once in 50 years. The pollution control dam must have a minimum freeboard of 0.8m above full supply level. All dirty water infrastructure needs regular maintenance Oil separators and dirty water trenches have to be cleaned regularly SWMP must be compiled and adhered to for the Project		
Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through proper Storm Water Management Measures.		

Table 12-11: Erosion

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	Site preparation and vegetation clearance		
Risk/ Impact	Vegetation clearance for mine infrastructure can directly impact on sediment transport. Loose particles are erodible. Exposed areas during operation and at closure and final rehabilitation can contribute to erosion		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	CO, OP, CP Negative		
Type of Impact	Direct: clearance will directly lead to impact		
	Define Significance Categories	Significance Prior to	Significance With

		Mitigation	Mitigation
Likelihood/ probability	Possible	2	1
Duration	Short Term	2	1
Extent	Site	2	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 9 3	Minor 7 2
Mitigating and Monitoring Requirements			
Required Management Measures	Vegetation stripping must be limited to the minimum width required; The topography of all disturbed areas must be rehabilitated, in such a manner that it blends with the surrounding natural area. This will reduce soil erosion and improve natural re-vegetation; The necessary flood attenuation and erosion control structures have to be put in place		
Required Monitoring (if any)	A maintenance schedule for the removal of silt in water management infrastructure must be established.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through Erosion Control Measure programs.		

12.4.2 Area BS4

This section contains a summary and a motivation of the potential interactions and impacts which may be associated with the project activities, specifically related to the hydrological specialist field.

The proposed activities are summarised as follows:

- Area 3: BS4
  - Return water pipeline from the RWD to the plant

12.4.3 BS4 Impact Rating

The potential impacts of the future infrastructure and activities upon local surface water receptors have been identified, as presented in Table 12-12 below.

Table 12-12: BS4 Impact Rating

Impact Component	Impact 1	Significance prior to Mitigation	Significance with Mitigation
Activity	Backfill plant; Slurry pipelines from the process plant to the backfill plant and the underground workings; Three emergency ponds along the slurry line; Process water lines between the backfill and process plant and the return water dam (RWD).		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	CO, OP, CP Negative		
Type of Impact	• Potential negative impact on quality of local surface water receptors. • Potential alteration of flow regime within local watercourses or drainage pathways. • Potential negligible impact in quality of downstream surface water receptors. • Potential change in flow regime. • Potential erosion risk. • Spillage of dirty water from dirty water storage facilities		

	during design exceedance or pump failure event. • Pipeline failure may cause an uncontrolled discharge of dirty water to a surface water environment causing a pollution, short term increase in flows and potential erosion risks near the failure point.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	4	2
Duration	Long-term	3	2
Extent	Area of influence	3	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 13 3	Minor 9 2
Mitigating and Monitoring Requirements			
Required Management Measures	1. Some of the potential impacts and risks posed by mining remain long after mining operations cease. In particular, tailings facilities may pose physical and chemical risks in perpetuity. 2. The integrity of the surface run off control systems must be maintained for the effective separation of clean and dirty water systems. 3. Leak detection measures must be in place. The establishment of slurry and water pipelines is critical to the project, as the tailings will be recovered through hydraulic mining techniques. 4. Water from the dirty water catchment must be managed as dirty water in line with the BPG. Rain water falling on the side slopes on TSFs that would normally have been part of the normal surface run off is retained in toe-paddocks where it eventually becomes part of the hydrological cycle via evaporation and infiltration. 5. Dirty water and process water will be recycled as far as practically possible. 6. Pumping equipment should be adequately maintained.		

Required Monitoring (if any)	Monthly surface water quality monitoring must be conducted on the proposed monitoring points.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Impact can be managed through proper design and maintenance of hydraulic structures and through management measures

13.0 MITIGATION MEASURES

13.1 Mitigation and Management

Potential mitigation measures are discussed for each identified impact. The effectiveness of these measures has to be updated continually as required. This will include the update of the SWMP included in this report to form an overall SWMP to be implemented on site.

13.1.1 General Storm Water Management Measures

13.1.1.1. Waste Management

Waste is categorized as either general or hazardous. This information is important for evaluating the potential for material recovery and reuse.
A waste management area will be constructed at BS1/2. This will make provision for the separation of waste streams. Hazardous waste will be bunded and roofed. Waste disposal will be done under the same contract used for BN.

13.1.1.2. Oil Separator at the workshop area

. As part of SWMP, the following measures should be implemented:

- Impermeable concrete slab to prevent infiltration of contaminated water;
- Cut-off trench to restrict clean runoff from coming into contact with contaminated water stored in the grease and oil sump; and
- Regular inspection at the oil separator and silt trap.

Oils originating from the oil separator and used oils, diesel and other hydrocarbons will be stored in a specially prepared waste management area from where the waste will be transported to BN for disposal under the current waste management license for the Operation. The extent of the surface workshop will decrease once the underground workshop has been constructed. The same best practice will be implemented for the underground workshop.

Provision has also been made for a wash-bay. The design of the wash-bay is in accordance with best practice and will be bunded, with a cut-off trench on the open side and will link to the oil separator and silt trap. The dirty water from the silt trap and oil separator will be directed to the PCD. Depending on the characteristics of the fines, it will either be disposed of at the BN TSF or will be processed as part of the ore.

13.1.1.3. Sanitation

A package type waste water treatment plant will be constructed. The plant treatment capacity will be $15m^3$/hour x 2 (for BS1/2 and BS4). The treated effluent will be recycled in the process.

The disadvantage of the package plant is that it requires a precise control of timing and chemical mixing. This precision is typically achieved with computer controls linked to sensors. Such a complex, fragile system is unsuited to places where controls may be unreliable, poorly maintained, or where the power supply may be intermittent.

13.1.2 Management Measures for the entire BS1/2

The aim of storm water management measures is to mitigate impacts on water resources by fulfilling the requirements of the NWA and more particularly GN 704.

There are many erosion and silt control measures in place across the construction sites. The effectiveness of these measures and the requirement for additional measures must be routinely monitored and reported on as the construction program progresses.

Hydro-seeding and benching of the permanent road embankments, should be prioritised in areas closest to the river and where there is minimal vegetated buffer in place between the road and the river.

Permanent drainage will be installed along the permanent road, formalising management of storm water in these areas. A series of cross drain (culverts beneath the road surface) will soon be installed to convey flow from the side drains along the hillside of the road to the outside / road shoulder and into the vegetated slopes below. On average cross drains will be installed every 200m allowing for dispersion of runoff from the road surface, rather than higher flows at fewer outfall points which would cause more erosion downstream.

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

- Only environmentally friendly materials must be used during the construction phase to minimize pollution;
- Vegetation stripping must be limited to the minimum width required;
- The topography of all disturbed areas must be rehabilitated, in such a manner that it blends with the surrounding natural areas and that it reduces potential standing water or concentration of water. This will reduce soil erosion and improve natural re-vegetation;
- Storage of contaminated water is deemed a water use and the DWS must be consulted for an authorization prior to the construction phase;
- The disturbed area and footprint of the mine's operations must be kept as small as possible;
- During the operational phase, uncontaminated surface water from the site must be allowed to freely flow to the environment without channeling the water

13.1.2.1. Deterioration of water quality - Separation of water applicable to BS1/2

The objective is to keep, as far as possible, water of differing qualities separate on a mine, so as to minimize the water management requirements. The practical implications of these water management regulations on a mine are as follows:

- The clean and dirty water flow areas on a mine site should be identified and flood volumes quantified.
- Efforts should be made to minimize the dirty water catchment. Clean water cut-off trenches upstream of the dirty water areas need to be constructed to protect clean water.
- Dirty water channel should be designed to collect contaminated water and to dispose it into the PCDs;
- Dirty water should be utilized locally for re-use in the process;
- Contain the outer footprint caused by the mining activities to the predetermined, demarcated area;
- Ensure that the disturbed areas, against the steep slopes especially, are well stabilised to prevent potential erosion, secondary and cumulative impacts;
- Apply and manage the clean and dirty water separation system; and
- Ensure that effective monitoring and management systems are in place.

13.1.3 Mitigation measures for BS4 activities including the Valley Boxcut

13.1.3.1. Dirty Water Management

SLR developed a SWMP for the existing infrastructure at BS4, the design principles for which include:

- Dirty storm water from the processing plant area will be collected by a perimeter drainage ditch, and conveyed beneath the road to a containment pond;
- Dirty storm water from the workshop and shaft area will be collected by a perimeter ditch, and conveyed beneath the road to one of two containment ponds;
- Dirty storm water from the tailings storage facility will be collected and conveyed towards a containment dam; and
- All dirty storm water will be recycled within the mining operation and only where there remains a shortage in water volume will water be abstracted from cleanwater sources to meet the operational demands of the site; and
- All clean storm water will be diverted around dirty water areas.

Both Plant PCD1 and Plant PCD2 include a silt trap upstream of the dam, and an engineered spillway for design exceedance event.

13.1.4 BCM 1 and BCM 2 Mitigation measures

The management measures are as follows:

- The waste water must flow through a screen to remove all solids. These solids must be periodically removed and will be disposed at a licensed facility.
- A component of the sludge from the clarifier must be returned to the start of the process to provide microorganisms back into the process.
- The bulk of the sludge must be removed to the sludge holding tank where it must be further digested. The water component from the clarifier must be disinfected to remove harmful microorganisms and pumped to the PCD for re-use.
- The capacity of the STP must be able to accommodate the volume of effluent to be generated.
- The STP needs to be inspected and maintenance done annually.
- Sludge needs to be removed bi-annually or more frequently if deemed necessary.
- Water must be treated to meet the special limits included in the existing BN IWUL.

STP is comprised of an upfront manual screen, a buffer tank containing duty/standby submersible pumps with VSD’s, an ultrasonic level controller, submersible mixer and a discharge electro-magnetic flow meter. The reactor includes an anoxic zone with a submersible mixer, an aerobic zone with duty/standby blowers with diffusers and three integrated clarifiers. Manual desludging is carried out from each clarifier and directed to a sludge holding tank. Phosphorous removal via ferric chloride dosing is included. Clarified effluent from the reactors is dosed with ferric chloride and fed into a settling tank that contains lamellar packs to increase sedimentation surfaces. Desludging of the precipitate to the sludge holding tank occurs manually. Disinfection is achieved through chlorine dosing into a contact tank before final effluent discharge.

It is anticipated at this stage that a modular pre-engineered and pre-fabricated STP will be installed on site. The volumes required for the sewage treatment plant are still being finalised but will be sized to accommodate the full component of employees and contractors on site.

14.0 CONDITIONS FOR INCLUSION IN THE IWUL AND EA

14.1 Annual Update of the Water and Salt Balance

The WSBWSB must be updated annually in order to quantify the mine's contribution to the Groot Dwars River Salt Loads. The update of the WSBWSB requires water quality data as well as water quantity data.

In relation to the expansion project, the following Studies must be continuous as is with the operational activities at BN:

- Monthly Surface Water Quality Monitoring. There are some monitoring points which are monitored twice a month for operational reasons. This more frequent monitoring interval may not be changed;
- Installation of water flow meters for the monthly collection of flow meter readings. In instances where there is reasonable infrastructure (Electricity and Security) for self-recording flow meters, the mine may install such self-recording flow meters which are approved in terms of SANS Standards;
- The Water Balance must be updated (as far as possible) in line with the Component Water Balance Attached in Appendix A:

14.2 Sizing and location of infrastructure

The PCD must be sized to contain the 1:200 years storm event.

14.2.1 Location of infrastructure

Except if the activity is authorized by the DWS, GN 704, Activity 4 states that "No person in control of mine or activity may:

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

- Except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within 1:50 year flood line or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest;
- 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
- Use any area or locate any sanitary convenience, fuel 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."

14.2.2 Capacity of the Pollution Control Dam

The PCD must be designed, constructed, maintained and operated in such a way that it is not likely to spill into any clean water system more than once in 50 years.

The PCDs must have a minimum freeboard of 0.8m above full supply level.
An emergency procedure needs to be put in place according to which potential spillages will be handled.

14.3 Management and Monitoring Programme

Water quality monitoring is recommended to monitor the performance of these infrastructures.
Surface water samples must be collected on a monthly basis. A report summarizing the findings must be produced monthly.
The current surface water quality monitoring program (for Booysendal North) must be amended to include the additional water monitoring points. The additional points were comprehensively located in order to monitor quality from other small streams.

This plan can be used as a management tool to ensure that potential impacts on surface water resources are managed according to the hierarchy of water and impact management. This tool will ensure that negative impacts are identified at the early stages and that the appropriate action is implemented for the protection of water resources.

Water Management System must be implemented for proper record keeping. This system must be populated with Water Quality Objectives (like RWQO published by the DWS) as well as monthly water quality results.

14.4 Restrictions on use of material

As indicated in GN 704, regulation 5, 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.

14.5 Storm Water Management

Items to be considered for inclusion in the Water use Licence during construction.

- No washing of Project vehicles in any surface water bodies in and around the Project Area.
- All Project vehicles will be washed at designated wash bays on site.
- Wash bays will include oil/grease and sediment traps.
- Suitable clean-up of areas where spillage of soil contaminants occurs and appropriate disposal thereof.
- All vehicles will be maintained at a designated workshop at the Processing Plant, which will include an oil/grease trap.
- Chemicals and fuels will be stored in bunded areas with emergency spill response equipment.
- The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
- Clean water runoff will be diverted around all major construction sites and dirty water (water collected within active parts of the mining process) within the boundary of construction sites.
- All employees and contractors will be trained regarding proper methods for transporting, transferring and handling hazardous substances.

15.0 MONITORING REQUIREMENTS

15.1 Data management and reporting

During field, laboratory, and data evaluation operations, effective data management is the key to providing consistent, accurate, and defensible data and data products. The management and reporting of field and laboratory data will generally follow the procedures outlined in the Best Practice Guidelines.

15.1.1 Monthly

Surface water samples must be collected on a monthly basis. A report summarising the findings must be produced monthly. This report is an internal report which is used to keep records of changing water qualities as well as to notify the mine management team of the changes in water quality and areas of concerns. Trend analysis of water quality results should be done

15.1.2 Quarterly

The quarterly report must be produced to summarise the 3 months observations and analysis. This report will be submitted to the authorities in order to indicate compliance or challenges in relation to water quality changes. The quarterly report must include the following components:

- Brief compliance assessment description;
- Brief description of monitoring actions performed;
- Flow characteristics (low/high flows);
- Field parameters including odour and color observations;
- Highlight significant issues that require immediate corrective/ preventative action;
- Geographical presentations in a form of GIS maps indicating monitoring points and surface infrastructure; and
- Time dependent graphs for the selected water quality variables.

15.1.3 Annually

The annual report must consist of all the active environmental components. The following components should be included:

- Statutory/Regulatory Requirements;
- Monitoring Points and nearby surface Infrastructure;

- 12 months data captured;
- The compliance interpretation based on Resource Quality Objectives and SANS 241:2015 (Or any later version of SANS 241); and
- Recommendation of corrective measures.

15.1.4 Water Quality Parameters

The variables indicated in Table 15-1 below, must be considered as the minimum requirement.

Table 15-1: Analytical Parameter Schedule Summary

Analyses		Unit
Physio-Chemical Parameters		
- pH	pH	pH unit
- Electrical Conductivity	EC	mS/m
- Total Dissolved Solids	TDS	mg/L
- Total Alkalinity	T-Alk	mg $CaCO_3$/L
Inorganic and Metal Parameters		
Major Ionic Constituents		
- Calcium	Ca	mg/L
- Magnesium	Mg	mg/L
- Potassium	K	mg/L
- Sodium	Na	mg/L
- Sulphate	SO_4	mg/L
- Chloride	Cl	mg/L
Fluoride and Phosphorus Constituents		
- Fluoride	F	mg/L
- Orthophosphate	PO_4 as P	mg/L
Metals/Metalloids Constituents		
- Aluminium	Al	mg/L
- Arsenic	As	mg/L
- Barium	Ba	mg/L
- Beryllium	Be	mg/L
- Boron	B	mg/L
- Cadmium	Cd	mg/L
- Cobalt	Co	mg/L
- Copper	Cu	mg/L
- Chromium (total)	Cr	mg/L
- Iron	Fe	mg/L
- Manganese	Mn	mg/L
- Molybdenum	Mo	mg/L
- Nickel	Ni	mg/L
- Lead	Pb	mg/L
- Strontium	Sr	mg/L
- Vanadium	V	mg/L
- Zinc	Zn	mg/L
Nitrogen-Species Parameters		
- Ammonium	NH_4 as N	mg/L

Analyses		Unit
- Nitrate	NO_3 as N	mg/L
- Nitrite	NO_2 as N	mg/L

Note/s:
- mS/m - milli Siemens per metre
- mg/L - milli grams per Litre
- mg $CaCO_3$/L - milli grams calcium carbonate per Litre

16.0 REASONED OPINION

The proposed activity is recommended.

Underground mining activities have lesser impacts on surface water resources when compared to opencast activities. However, due to the need of support services which may be located on the surface, it is necessary to ensure that reasonable mitigation measures are in place.

The surface activities require proper mitigation measures during the operational phase.

17.0 PUBLIC PARTICIPATION

The main concerns raised during the Public Participation Process

18.0 CONCLUSION

Detailed Civil Designs for proposed infrastructure were not available when this study was concluded. It may be necessary to update the Storm Water Management Section of this report as soon as the Civil Designs are released. In order to ensure consistency, Hydrological data used for the hydrological impact assessment must also be used for the detailed civil design calculations.

The purpose of the expansion is to increase mining of the PGM minerals from the UG2 and Merensky Reefs. Booysendal South Expansion Project Phase 2 specifically focuses on four development areas, namely:

- BS1/2
- Merensky Portals
  - BCM1; and
  - BCM2,
- BS4; and
- BS4 Valley Boxcut.

Between the above-mentioned development areas, there will be a hydraulic link to be made possible by the pipelines. Other facilities relating to the expansion project which will serve as a link include the potable and service water pipelines, Aerial Rope Way, access roads and power lines.

The life of mine of the Booysendal South Expansion Project is approximately 40 years. The total BS reserve is estimated at 105.88 Mt.

In hydrological terms, the aerial ropeway, powerline and pipelines has far less hydrological impacts when compared to other mine related activities.

BS1/2 is located outside the 1:100 year flood lines of the Groot Dwars River but inside of 100m buffer of an unnamed tributary of the Groot Dwars River which runs directly to the South of the BS1/2.

BCM 1 and BCM 2 have similar proposed infrastructure. In line with Water Use Efficiency principles, the dirty water catchment area must be managed as small as possible. Smaller dirty water catchment areas are associated with low dirty water volumes which will require smaller design capacity of the pollution control dam (PCD).

18.1 Legislative requirements

The study was conducted in line with the requirements of the National Water Act, 1998 (Act 36 of 1998) as well as the Best Practice Guidelines for the Protection of Water Resources and “Regulations 704” as published in Government Gazette, Volume 408, No 20119 of June 1999 (Also known as General Notice 704, 04 June 1999).

18.2 Is the activity supported?

Based on the risk rating contained in this report, the proposed activity is recommended. Underground mining activities have lesser impacts on surface water resources when compared to opencast activities. However, due to the need of support services which may be located on the surface, it is necessary to ensure that reasonable mitigation measures are in place.

18.3 Dams with a safety risk

It is emphasized that there are no proposed dams with a safety risk. The dirty water dams have a capacity of less than 50 000m^3 and the dam wall is less than 5m.

18.4 Culvert Crossings

For most culvert designs, where no upstream temporary ponding results in hazards, the 25-year and even the 1:10 year frequency storm may be routed and the 100-year storm shall be used to verify should any structural damages be a possible event.

The stage storage relationship upstream of the culvert crossing is favorable as no infrastructure upstream would be flooded. A smaller culvert section could be considered. 600mm diameter culverts were considered at respective culvert crossings. In instances where the flow exceeds the design capacity for a 600mm diameter pipe, two or more (600mm) rows were considered to accommodate the additional flow.

18.5 Sanitation

A package type waste water treatment plant will be constructed. The plant treatment capacity will be 30m^3/hour. The treated effluent will be recycled in the process.

18.6 Water Treatment Plant

Allowance is made for two water treatment plants with a combined design capacity of 30m^3/h for Booysendal South.

18.7 Water Quality monitoring

The current surface water monitoring programme adapted by BN, BS2 and BS4 is sufficient as it covers the major point source pollution areas. The BN and BS2 monitoring programme will need to be amended as soon as the BCM1/2 surface infrastructure and Valley boxcut facility are defined and construction completed.

The current water monitoring program will be revised to incorporate additional monitoring points associated with the proposed activities.

18.8 Waste management

If not properly collected and transported, Waste may be in contact with rain water and alter the chemical characteristics.

18.9 Surface Subsidence

Surface subsidence is defined as the gradual sinking of landforms to a lower level as a result of earth movements related to mining operations. This is referred to as vertical subsidence (conventional subsidence).

Due to the proposed mining methods of extraction by means of board and pillar, surface subsidence is not anticipated.

19.0 RECOMMENDATIONS:

19.1 General Recommendations

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

- Only environmentally friendly materials must be used during the construction phase to minimize pollution;
- Vegetation stripping must be limited to the minimum width required;
- The topography of all disturbed areas must be rehabilitated, in such a manner that it blends with the surrounding natural area. This will reduce soil erosion and improve natural re-vegetation;
- Storage of Contaminated Water is deemed a water use and the Department of Water and Sanitation must be consulted for an authorisation prior to the construction phase.

19.2 Erosion control

It is recommended that erosion and silt management is considered carefully and monitored regularly during extension of the permanent road onto the eastern side of the valley. Most effective means of erosion and silt management is to minimise disturbance of existing vegetation and topsoils, divert upstream runoff around earthworks areas, disperse silty runoff into vegetated areas,

19.3 Clean and Dirty Water Catchment Areas

Clean water from the external catchment must be diverted away from the dirty water catchments by channels and berms.

Dirty water systems should not spill into any clean water system for any storm event less than the 1 in 50 years storm event.

No activities should take place within the 1 in 100 year flood area, unless authorised in accordance to Section 21 of the National Water Act, 1998 (Act 36 of 1998).

All water conveyances should be designed to operate satisfactorily for flows arising from the 50 year recurrence interval rainfall event of 24 hours duration.

Access to Water storage facilities should be restricted and warning signs must be placed at prominent locations.

19.4 Re-use of water

Contaminated water from the PCD can be pumped for further usage.

19.5 Water Quality Monitoring

Surface water samples must be collected on a monthly basis. A report summarising the findings must be produced monthly. This report is an internal report which is used to keep records of changing water qualities as well as to notify mine management team of the changes in water quality and areas of concerns.

The quarterly report must be produced to summarise the 3 months observations and analysis. This report will be submitted to the authorities in order to indicate compliance or challenges in relation to water quality changes.

The annual report must consist of all the active environmental components.

19.6 Waste Management

Recommended strategies for waste management include:

- Garden waste is not accepted in skips on site;
- Domestic waste shall be disposed of at the municipal landfill site;
- Hazardous waste must be disposed off at the hazardous waste disposal site;
- Implementation of cleaner production programmes is required (General Green house keeping); and

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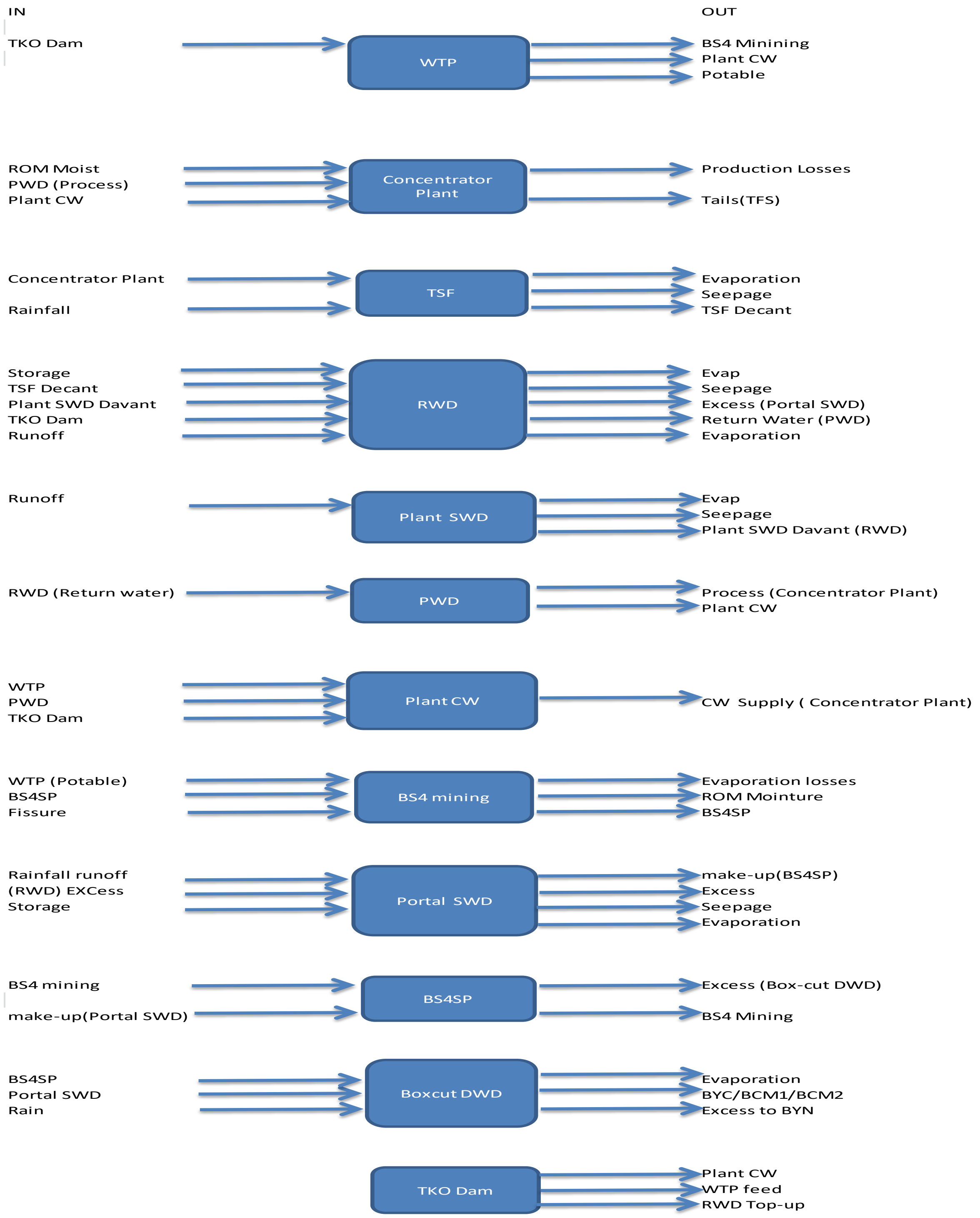
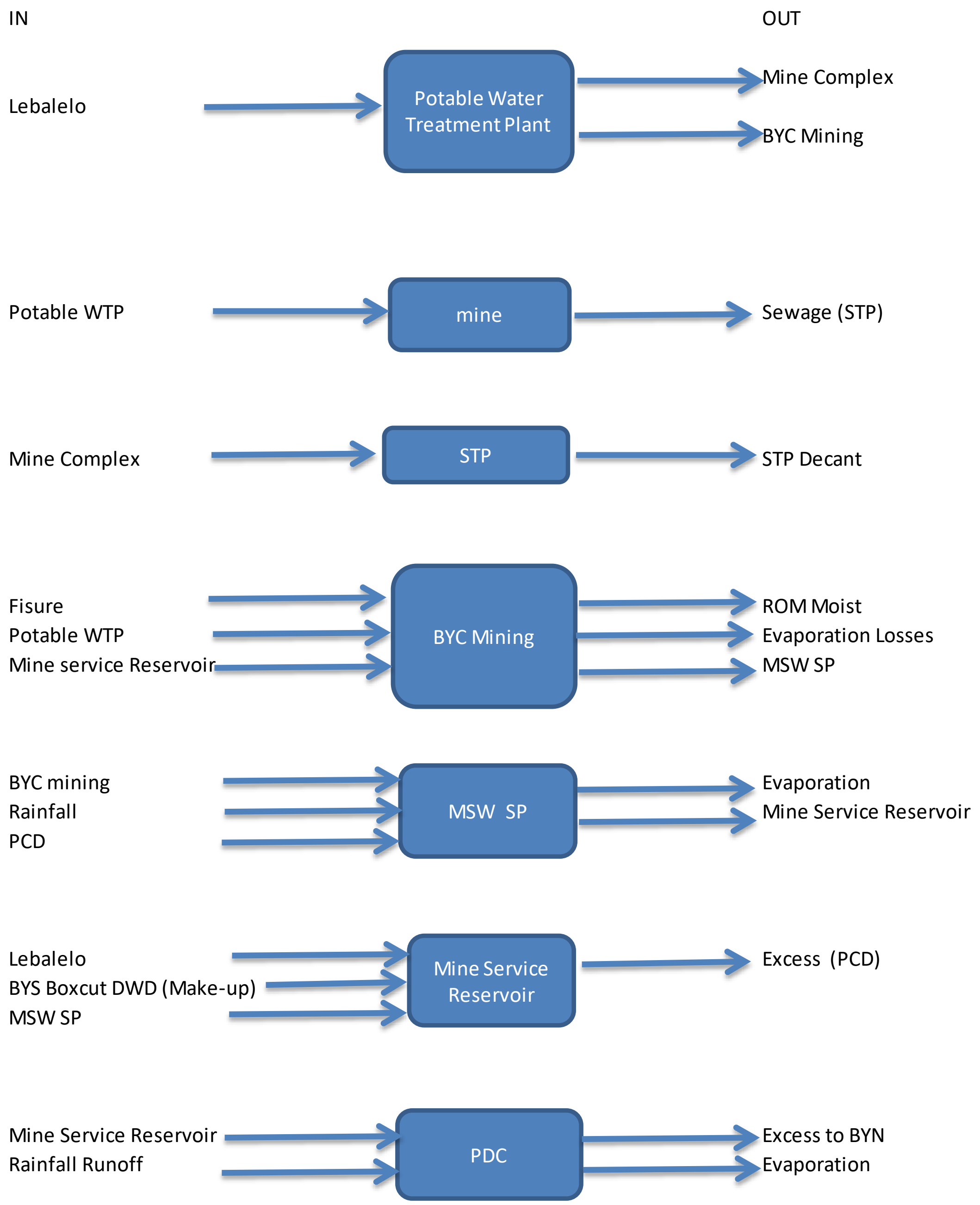
APPENDIX 6 – COMPONENT WATER BALANCE.

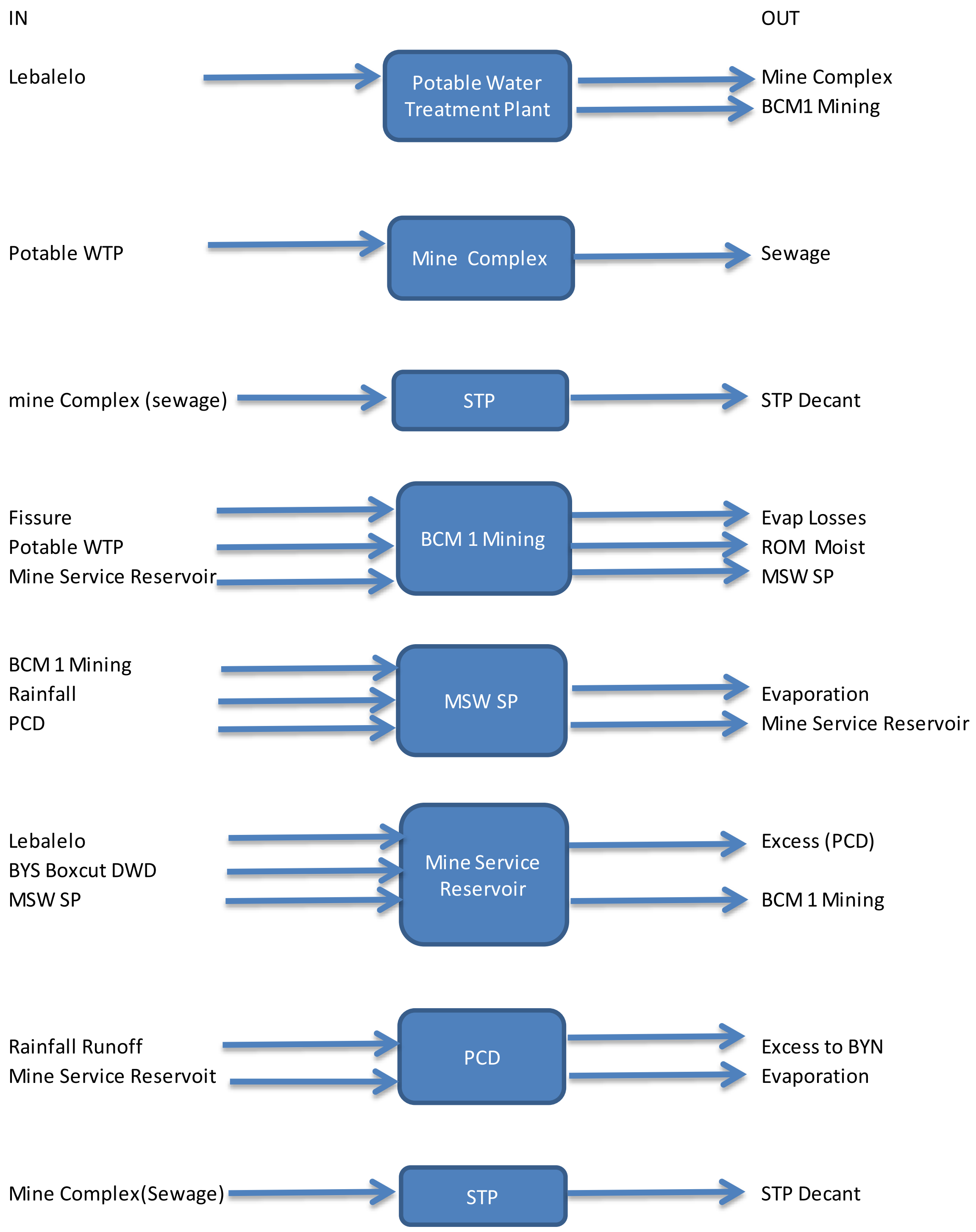
BYS Overall Water Balance flowsheet



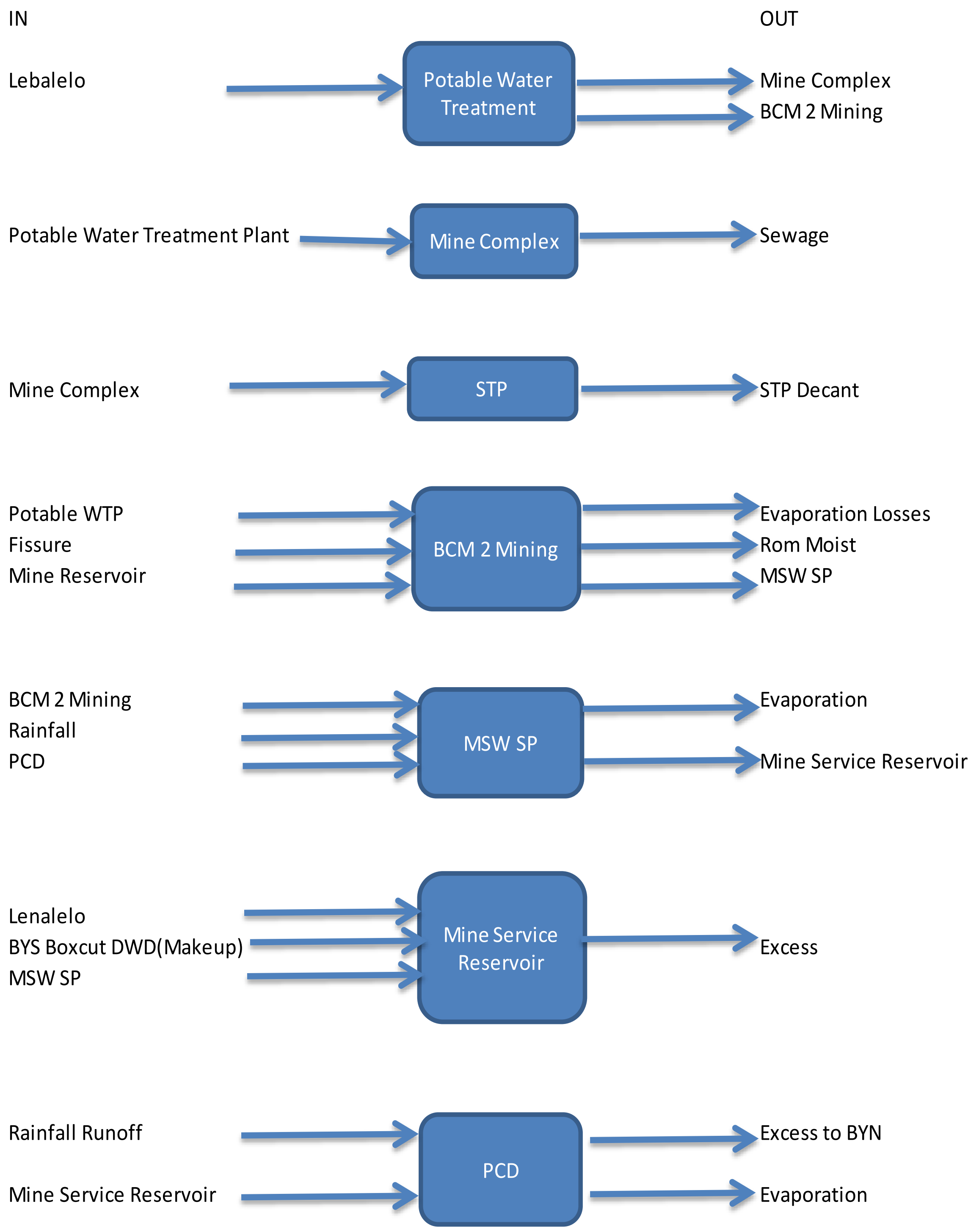
BYC Overall Water Balance Flowsheet

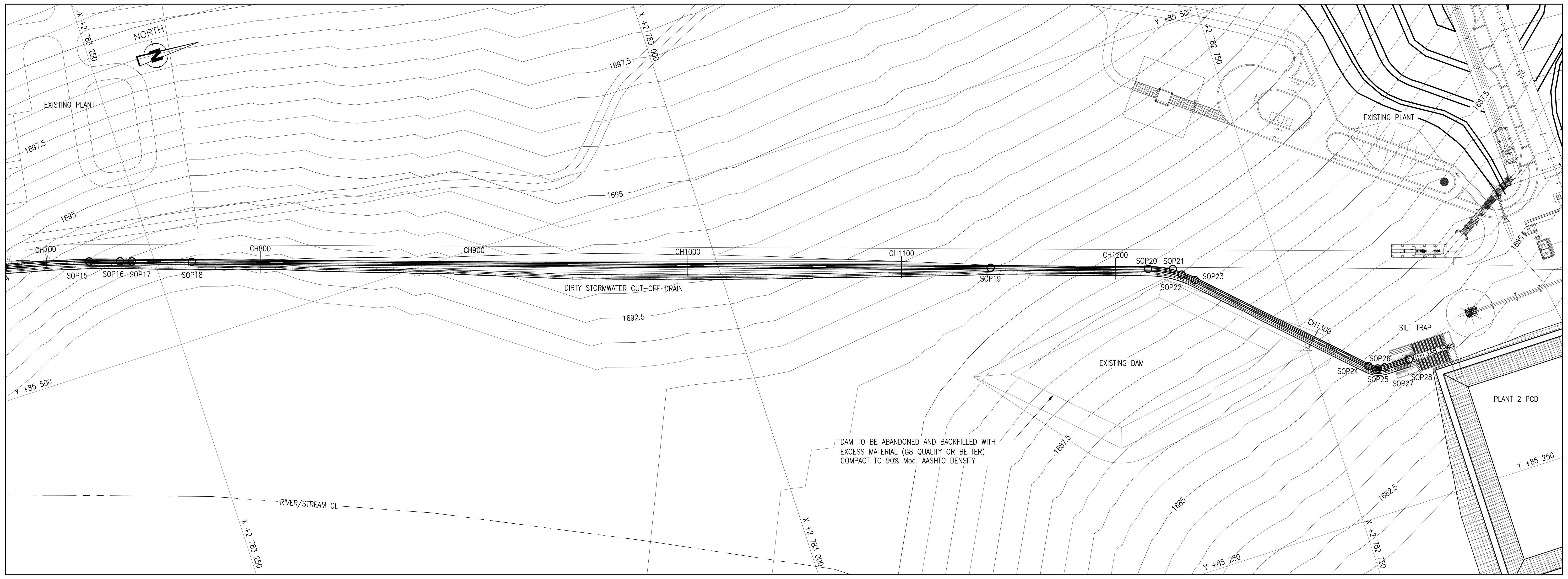


BCM 1 Overall Water Balance flowsheet



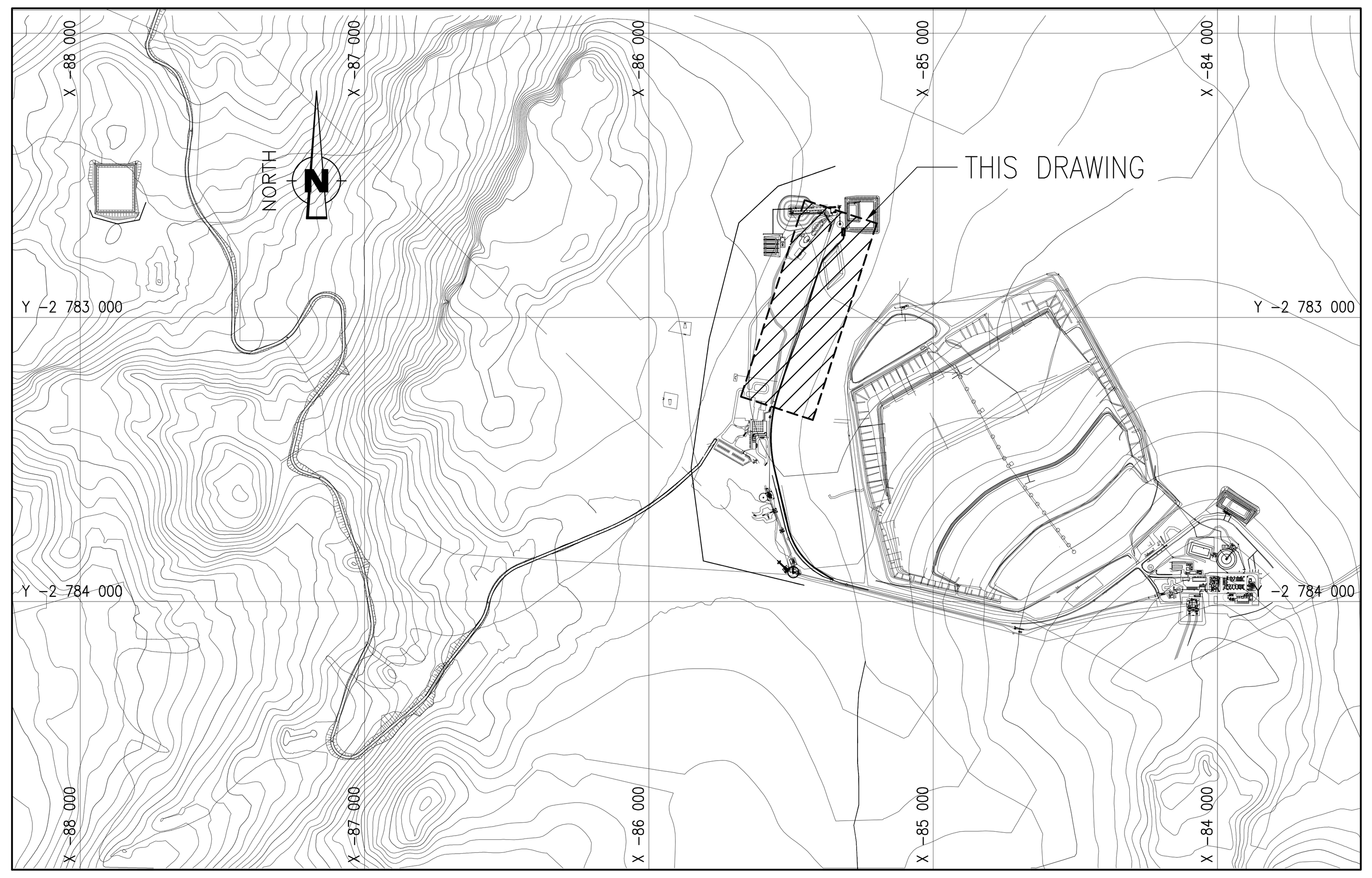
BCM 2 Overall Water Balance flowsheet





DIRTY DRAIN LAYOUT (PART 2)

SCALE 1:1000



KEY PLAN

SCALE 1:15000

COORDINATE LIST WGS84 Lo31			
DIRTY STORMWATER DRAIN SETTING OUT			
POINT	Y-COORD	X-COORD	INVERT
CONST:			
SOP1	85352.203	2783923.449	1709.911
SOP2	85399.708	2783893.832	BC
SOP3	85418.933	2783880.561	1709.400
SOP4	85449.790	2783852.712	1707.751
SOP5	85487.150	2783839.317	PI
SOP6	85493.927	2783787.545	1706.272
SOP7	85510.783	2783739.021	EC
SOP8	85512.741	2783730.708	1704.336
SOP9	85534.374	2783638.896	1701.715
SOP10	85558.137	2783538.047	BC
SOP11	85562.721	2783516.469	1699.471
SOP12	85590.676	2783399.950	PI
SOP13	85567.067	2783357.209	1695.316
SOP14	85560.193	2783317.808	1694.061
SOP15	85550.195	2783279.092	1692.780
SOP16	85545.834	2783265.344	EC
SOP17	85544.072	2783260.056	1692.250
SOP18	85535.220	2783233.482	1691.727
SOP19	85417.122	2782878.983	1690.482
SOP20	85393.828	2782809.058	BC
SOP21	85390.178	2782798.102	PI
SOP22	85386.449	2782794.939	1688.349
SOP23	85382.093	2782789.856	EC
SOP24	85318.606	2782725.107	BC
SOP25	85315.746	2782722.190	PI
SOP26	85316.285	2782721.343	1684.031
SOP27	85315.746	2782718.106	EC
SOP28	85315.746	2782706.213	1683.794

ROAD-CENTRELINE

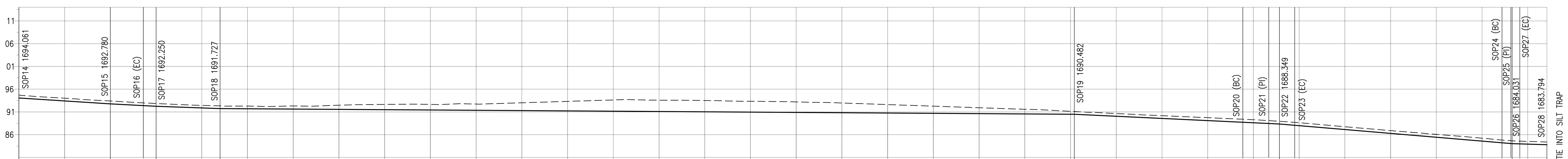
NGL-CENTRELINE

SCALES:

Horizontal 1:1000

Vertical 1:500

Datum : 1681 m

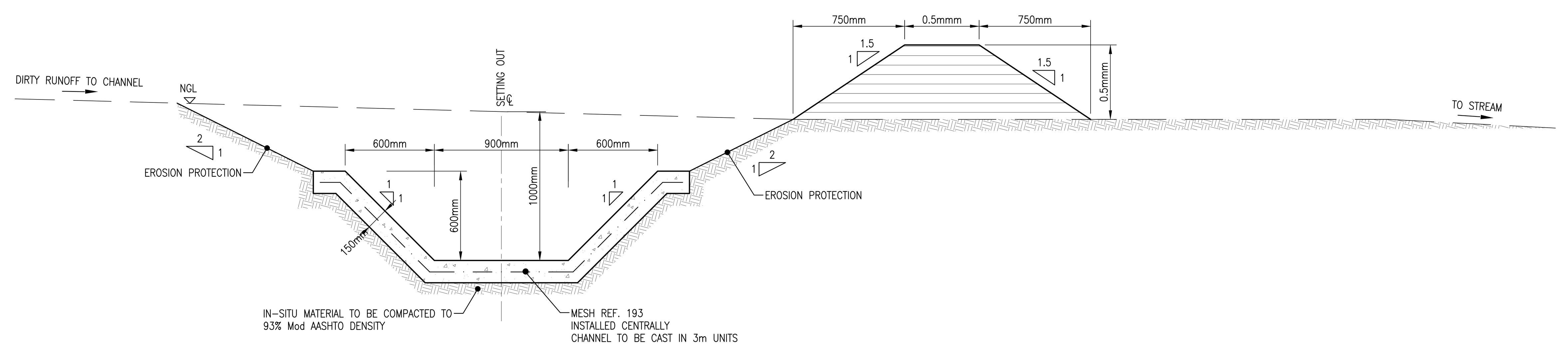


DISTANCE (m)	DRAIN DEPTH	DRAIN INVERT	C/L GROUND LEVEL
680.000	-0.629	1694.061	1694.690
700.000	-0.607	1693.421	1694.028
720.000	-0.629	1692.780	1693.409
734.427	-0.591	1692.398	1692.989
740.000	-0.601	1692.250	1692.851
760.000	-0.562	1691.877	1692.439
768.010	-0.601	1691.727	1692.328
780.000	-0.592	1691.687	1692.279
800.000	-0.700	1691.621	1692.321
820.000	-0.926	1691.554	1692.480
840.000	-1.164	1691.487	1692.651
860.000	-1.237	1691.421	1692.658
880.000	-1.380	1691.354	1692.734
900.000	-1.723	1691.287	1693.010
920.000	-2.101	1691.221	1693.322
940.000	-2.479	1691.154	1693.633
960.000	-2.499	1691.087	1693.586
980.000	-2.495	1691.021	1693.516
1000.000	-2.387	1690.954	1693.341
1020.000	-2.319	1690.888	1693.207
1040.000	-2.144	1690.821	1692.965
1060.000	-1.864	1690.754	1692.618
1080.000	-1.582	1690.688	1692.270
1100.000	-1.302	1690.621	1691.923
1120.000	-1.028	1690.554	1691.582
1140.000	-0.639	1690.488	1691.127
1141.663	-0.600	1690.482	1691.082
1160.000	-0.603	1690.046	1690.649
1180.000	-0.606	1689.570	1690.176
1200.000	-0.649	1689.095	1689.744
1215.365	-0.669	1688.729	1689.398
1220.000	-0.668	1688.619	1689.287
1231.366	-0.600	1688.349	1688.949
1238.064	-0.644	1688.065	1688.709
1240.000	-0.647	1687.983	1688.630
1260.000	-0.615	1687.135	1687.750
1280.000	-0.616	1686.287	1686.903
1300.000	-0.639	1685.439	1686.078
1320.000	-0.640	1684.591	1685.231
1328.746	-0.595	1684.220	1684.815
1333.196	-0.621	1684.031	1684.652
1336.501	-0.599	1683.980	1684.579
1340.000	-0.602	1683.925	1684.527
1348.394	-0.600	1683.794	1684.394

VERTICAL PROFILE

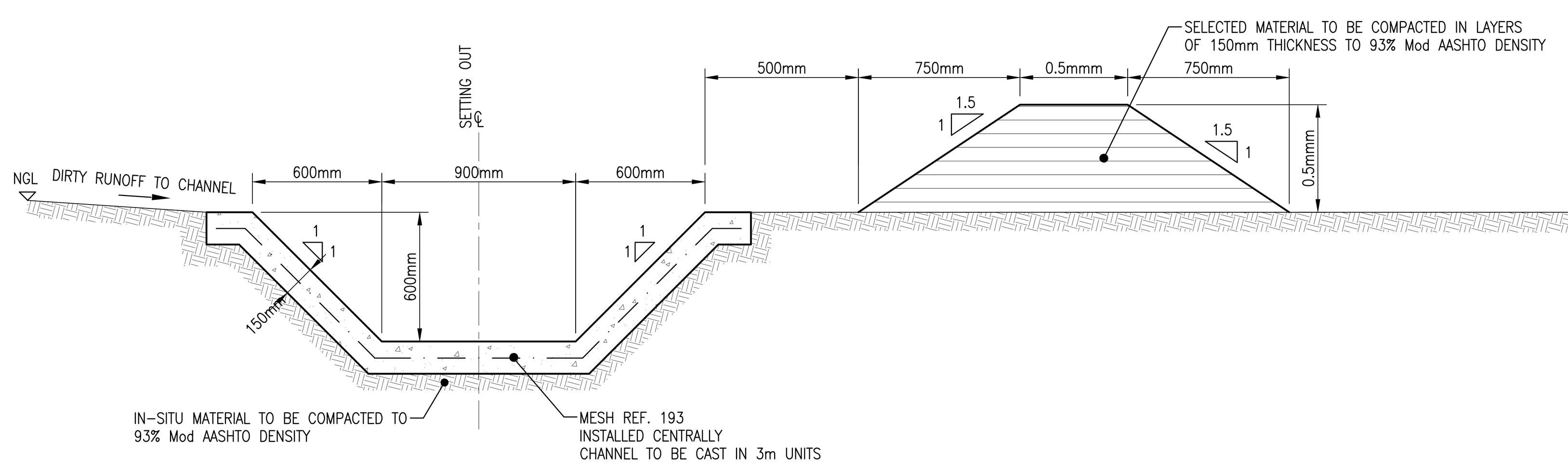
1 IN -31.218	1 IN -37.753	1 IN -53.567	1 IN -300.087	1 IN -42.053	1 IN -23.584	1 IN -64.131
-3.2033%	-2.6488%	-1.8668%	-0.3332%	-2.3780%	-4.2401%	-1.5593%

DIRTY DRAIN LONGITUDINAL SECTION (PART 2)



TYPICAL DETAIL OF NEW DIRTY WATER CUT-OFF DRAIN AND BERM DRAINS EXCEEDING 600mm DEEP.

SCALE 1:20



TYPICAL DETAIL OF NEW DIRTY WATER CUT-OFF DRAIN AND BERM DRAINS NOT EXCEEDING 600mm DEEP.

SCALE 1:20

ISSUED FOR MEASUREMENT

D5	Phase 2 - External Squad Check			Approved	Rejected	Appr. with corrections
	Stage Gate	I	80%			
	Discipline					
	Name	Signature	Date			
Proj. Engineer:						
Proj. Manager:						

PR. ENG. APPROVAL

THIS DRAWING IS NOT TO BE SCALED. ALL DISCREPANCIES ARE TO BE REPORTED TO THE DESIGN ENGINEER. ALL CONSTRUCTION ERRORS OR DEVIATIONS FROM THE DETAILS ARE TO BE RECTIFIED ONLY AFTER CONSULTATION WITH THE DESIGN ENGINEER OR IN HIS ABSENCE THE DESIGN OFFICE HEAD OF DEPARTMENT MUST BE CONSULTED.

NORTHAM
PLATINUM LIMITED

DRAWING NO.	DESCRIPTION
00413-IH-003-06	DIRTY STORMWATER CUT OFF DRAIN CROSS SECTIONS
00413-IH-003-04	DIRTY STORMWATER CUT OFF DRAIN SHEET 1

REFERENCE DRAWINGS

REV.	BY	DATE	REVISIONS
B	TRS	12.07.16	ISSUED FOR SQUAD CHECK
A	TRS	05.07.16	ISSUED FOR INTERNAL SQUAD CHECK

DESIGN REFERENCE | DRAWING NO. | DESCRIPTION

DESIGN | REFERENCE DRAWINGS | CHK. | DATE | S.L. | DATE

CLIENT		
PROJ. MANAGER		
PROF. ENG.		
PROJECT ENG.		
PROCESS ENG.		
DESIGN ENG.		
SECT LEADER		
CHECKED		
DRAWN	TRS	05.07.2016
APPROVAL	SIGNATURE	DATE

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DRA PROJECTS SA (PTY) LTD

TITLE BOOYSENDAL SOUTH - EVEREST INFRASTRUCTURE DIRTY STORMWATER CUT-OFF DRAIN LAYOUT, SECTION AND DETAILS (SHEET 2)

A0	PROJECT DWG NO.	SHEET	REVISION	SCALE
	00413-IH-003-05	OF	B	A/S U.O.S.

TABLE 1.1: CULVERT SCHEDULE FOR NEW CULVERTS

CULVERT ALONG PERMANENT ACCESS ROAD BOOYSENDAL SOUTH TO CENTRAL FROM KM 3.260 TO 6.360

Group	CULVERT AND ROAD ELEMENTS		Unit	3-1	3-2	3-3(a)	3-3(b)	3-4(a)	3-4(b)	4-1	4-2	4-3	4-4	4-5(a)
CULVERT DESCRIPTION	ITEM NUMBER			3-1	3-2	3-3(a)	3-3(b)	3-4(a)	3-4(b)	4-1	4-2	4-3	4-4	4-5(a)
	ROAD KILOMETER DISTANCE		km	3.260	3.470	3.660		3.880		4.120	4.180	4.220	4.340	4.440
	TYPE			PC	PC	PC	ARMCO	PC	ARMCO	PC	PC	PC	PC	PC
	BARRELS / TOTAL UNITS		No.	1	2	2	1	1	1	1	1	1	1	1
	SPAN / DIA		mm	600	900	600	450	900	450	600	600	600	600	600
	HEIGHT		mm											
	PIPE & BEDDING CLASS			75D-A	50D-A	75D-A	Met-B	50D-A	Met-B	75D-A	75D-A	75D-A	75D-A	75D-A
	SKEW ANGLE		deg	90	90	90	90	90	90	90	90	90	90	90
	WINGWALL REFERENCE			P1 , P1	P4 , P4	MH , CP	*	MH , P3	*	P1 , CP	P1 , P1	P1 , P1	P1 , CP	MH , CP
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m	66.45	37.19	10.94		90.50		83.50	81.68	79.38	65.93	52.79
	ROAD LEVEL - ROAD C/L	RM	m	66.35	37.09	10.84		90.40		83.40	81.58	79.28	65.83	52.69
	ROAD LEVEL - RIGHT SHOULDER	RR	m	66.25	36.99	10.74		90.30		83.30	81.48	79.18	65.73	52.59
	ROAD FORMATION WIDTH	F	m	11.40	11.40	11.40		11.40		11.40	11.40	11.40	11.40	11.40
NEW CULVERT DATA	FLOOR SLOPE	S	(%)	0.88	-4.10	-1.78		-1.71		-2.05	-5.27	-8.20	-7.03	-1.37
	INVERT LEVEL LEFT	IL	m	64.35	34.00	8.66	3.70	88.15	83.20	81.70	78.70	76.70	63.30	51.14
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m	64.28	34.36	8.79		88.29		81.87	79.20	77.57	64.04	51.22
	INVERT LEVEL RIGHT	IR	m	64.50	34.70	8.89	7.60	88.41	87.10	82.00	79.60	78.10	64.50	51.30
	FILL HEIGHT LEFT	HL	m	±1,57	±1.60	±1.38		±1.12		±0.85	±1.51	±0.69	±0.83	±0.83
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m	±1.41	±1.74	±1.39		±1.12		±0.87	±1.72	±1.05	±1.13	±0.81
	FILL HEIGHT RIGHT	HR	m	± 1.27	±1.87	±1.39		±1.12		±0.88	±1.91	±1.43	±1.43	±0.78
	LENGTH - LEFT TO ROAD C/L	LL	m	8.45	8.75	7.50		8.00		8.30	9.50	10.60	10.60	6.20
	TOTAL LENGTH TO INLET OR OUTLET	L	m	17.08	17.08	13.50	11.00	14.64	8.50	14.64	17.08	17.08	17.08	11.70
	TOTAL UNITS		No.	(7x2.44m)	(14x2.44m)	(11.1x2.44m)		(6x2.44m)		(6x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(4.8x2.44m)

Group	CULVERT AND ROAD ELEMENTS		Unit	4-5(b)	4-6(a)	4-6(b)	4-7	4-8	4-9	4-10	5-1	5-2	5-3	5-4	5-5	6-1(a)	6-1(b)	6-2
CULVERT DESCRIPTION	ITEM NUMBER			4-5(b)	4-6(a)	4-6(b)	4-7	4-8	4-9	4-10	5-1	5-2	5-3	5-4	5-5	6-1(a)	6-1(b)	6-2
	ROAD KILOMETER DISTANCE		km		4.500		4.600	4.680	4.900	4.980	5.080	5.200	5.320	5.380	5.620	6.120		6.360
	TYPE			ARMCO	PC	ARMCO	PC	PC	PC	PC	PC	PC	PC	PC	PC	PC	ARMCO	PC
	BARRELS / TOTAL UNITS		No.	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
	SPAN / DIA		mm	450	600	450	600	900	900	900	900	1200	600	600	600	900	900	600
	HEIGHT		mm															
	PIPE & BEDDING CLASS			Met-B	75D-A	Met-B	75D-A	50D-A	50D-A	50D-A	50D-A	50D-A	75D-A	75D-A	75D-A	50D-A	Met-B	75D-A
	SKEW ANGLE		deg	90	90	90	90	90	270	270	270	90	90	90	270	270	270	270
	WINGWALL REFERENCE			*	MH CP	*	P1 , CP	P3 , P3	P3 , P3	P3 , P3	CP, P3	P6 , P6	P1 , P1	P1 , CP	P1 , P1	P3 , MH	MH , P3	P1 , P1
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m		45.27		35.32	30.71	8.32	1.51	94.63	85.57	75.92	70.90	45.14	94.97		79.42
	ROAD LEVEL - ROAD C/L	RM	m		45.17		35.22	30.61	8.42	1.61	94.73	85.47	75.82	70.80	45.04	95.07		79.52
	ROAD LEVEL - RIGHT SHOULDER	RR	m		45.07		35.12	30.51	8.52	1.71	94.83	85.37	75.72	70.70	44.94	95.17		79.62
	ROAD FORMATION WIDTH	F	m		11.40		11.40	13.60	13.60	13.60	12.80	13.60	11.40	10.60	13.60	11.40		13.40
NEW CULVERT DATA	FLOOR SLOPE	S	(%)		-1.37		-1.76	-1.76	5.01	2.99	1.17	-9.84	-13.83	2.05	4.10	1.02		7.86
	INVERT LEVEL LEFT	IL	m	45.20	43.40	37.00	33.00	28.60	5.50	0.51	93.00	79.90	71.30	69.00	41.50	92.40	91.40	74.50
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m		43.48		33.17	28.74	5.05	0.31	92.92	81.18	73.00	68.85	41.07	92.31		73.67
	INVERT LEVEL RIGHT	IR	m	50.15	43.60	41.90	33.30	28.90	4.40	0.00	92.80	82.30	74.00	69.30	40.50	92.20	89.00	72.20
	FILL HEIGHT LEFT	HL	m		±1.05		±1.39	±0.88	±2.56	±0.38	±0.78	±2.52	±0.07	±1.51	±3.64	±1,73		±5.53
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m		±1.03		±1.39	±0.88	±2.38	±0.31	±0.82	±2.97	±2.16	±1.29	±3.31	±1.77		±5.19
	FILL HEIGHT RIGHT	HR	m		±1.01		±1.39	±0.92	±2.08	±0.17	±0.83	±3.66	±1.45	±1.09	±2.89	± 1.81		±4.68
	LENGTH - LEFT TO ROAD C/L	LL	m		6.00		9.90	8.00	9.00	6.80	6.50	13.00	12.30	7.40	10.40	8.80		10.60
	TOTAL LENGTH TO INLET OR OUTLET	L	m	8.50	14.64	11.50	17.08	17.08	21.96	17.08	17.08	24.40	19.52	14.64	24.40	19.52	6.50	29.28
	TOTAL UNITS		No.		(6x2.44m)		(7x2.44m)	(7x2.44m)	(9x2.44m)	(7x2.44m)	(7x2.44m)	(20x2.44m)	(8x2.44m)	(6x2.44m)	(10x2.44m)	(8x2.44m)		(12x2.44m)

TABLE 1.2: CULVERT SCHEDULE FOR NEW CULVERTS

CULVERT ALONG PERMANENT ACCESS ROAD BOOYSENDAL SOUTH TO CENTRAL FROM KM 6.460 TO 8.740

Group	CULVERT AND ROAD ELEMENTS		Unit	6-3(a)	6-3(b)	6-4(a)	6-4(b)	6-5	6-6	6-7	6-8	7-1	7-2	7-3	7-4(a)
CULVERT DESCRIPTION	ITEM NUMBER			6-3(a)	6-3(b)	6-4(a)	6-4(b)	6-5	6-6	6-7	6-8	7-1	7-2	7-3	7-4(a)
	ROAD KILOMETER DISTANCE		km	6.460		6.540		6.620	6.700	6.800	6.900	7.040	7.120	7.320	7.580
	TYPE			P C	ARMCO	P C	ARMCO	P C	P C	P C	P C	P C	P C	P C	P C
	BARRELS / TOTAL UNITS		No.	1	1	1	1	1	1	1	1	1	1	1	1
	SPAN / DIA		mm	600	450	600	450	600	600	600	600	600	600	600	600
	HEIGHT		mm												
	PIPE & BEDDING CLASS			75D-A	Met-B	75D-A	Met-B	75D-A	75D-A	75D-A	75D-A	75D-A	75D-A	75D-A	75D-A
	SKEW ANGLE		deg	90	90	270	270	270	270	270	270	270	270	90	90
	WINGWALL REFERENCE			CP, MH	*	CP, MH	*	CP. P1	CP, P1	CP, P1	CP. P1	CP, P1	P1, P1	P1. P1	MH, CP
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m	69.65		61.74		54.20	47.55	40.73	34.40	25.53	22.12	22.61	92.10
	ROAD LEVEL - ROAD C/L	RM	m	69.75		61.84		54.30	47.65	40.83	34.50	25.63	22.22	22.51	92.00
	ROAD LEVEL - RIGHT SHOULDER	RR	m	69.85		61.94		54.40	47.75	40.93	34.60	25.73	22.34	22.41	89.90
	ROAD FORMATION WIDTH	F	m	12.60		12.60		12.60	12.60	12.60	12.60	10.60	13.40	13.50	13.50
NEW CULVERT DATA	FLOOR SLOPE	S	(%)	1.25		1.29		6.66	1.17	1.76	1.76	2.34	1.17	-4.10	-1.37
	INVERT LEVEL LEFT	IL	m	68.75	67.60	60.60	59.80	52.30	46.00	39.00	33.20	24.00	21.00	15.70	88.70
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m	68.67		60.52		51.89	45.93	38.89	33.09	23.85	20.92	16.35	88.84
	INVERT LEVEL RIGHT	IR	m	68.55	64.00	60.40	54.95	51.00	45.80	38.70	32.90	23.60	20.80	17.00	89.00
	FILL HEIGHT LEFT	HL	m	±0.39		±0.63		±2.03	±1.03	±1.28	±0.75	±1.15	±0.61	±5.37	±2.52
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m	±0.42		±0.66		±1.75	±1.06	±1.28	±0.75	±1.12	±0.64	±5.50	±2.50
	FILL HEIGHT RIGHT	HR	m	±0.43		±0.67		±1.39	±1.08	±1.26	±0.73	±1.11	±0.67	±5.72	±0.51
	LENGTH - LEFT TO ROAD C/L	LL	m	6.10		6.00		6.20	6.20	6.20	6.20	6.50	7.20	15.90	10.20
	TOTAL LENGTH TO INLET OR OUTLET	L	m	16.00	7.00	15.50	10.00	19.52	17.08	17.08	17.08	17.08	17.08	31.72	21.96
	TOTAL UNITS		No.	(6.6x2.44m)		(6.4x2.44m)		(8x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(13x2.44m)	(9x2.44m)

Group	CULVERT AND ROAD ELEMENTS		Unit	7-4(b)	7-5	7-6	7-7	8-1(a)	8-1(b)	8-2(a)	8-2(b)	8-3(a)	8-3(b)	8-4(a)	8-4(b)	8-5	8-6	8-7	SERVICE CULVERT 8-8
CULVERT DESCRIPTION	ITEM NUMBER			7-4(b)	7-5	7-6	7-7	8-1(a)	8-1(b)	8-2(a)	8-2(b)	8-3(a)	8-3(b)	8-4(a)	8-4(b)	8-5	8-6	8-7	8-8
	ROAD KILOMETER DISTANCE		km		7.760	7.870	7.940	8.040		8.140		8.240		8.320		8.400	8.500	8.600	8.740
	TYPE			ARMCO	P C	P C	P C	P C	ARMCO	P C	ARMCO	P C	ARMCO	P C	ARMCO	P C	P C	P C	BC
	BARRELS / TOTAL UNITS		No.	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SPAN / DIA		mm	450	900	600	600	600	450	600	600	600	600	600	600	900	600	600	1200
	HEIGHT		mm																1200
	PIPE & BEDDING CLASS			Met-B	50D-A	75D-A	75D-A	75D-A	Met-B	75D-A	Met-B	75D-A	Met-B	75D-A	Met-B	50D-A	75D-A	75D-A	150S
	SKEW ANGLE		deg	90	120	90	90	90		90		90		90		90	90	90	300
	WINGWALL REFERENCE			*	P5, P5	CP. P1	P1, P1	MH, P1	*	MH, P1	*	MH, P1	*	MH, P1	*	P3. P3	P1, P1	P1, P1	REFER TO TP1506.2-W08
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m		75.21	69.67	64.34	52.45		40.27		29.21		21.02		13.88	9.02	1202.15	1188.32
	ROAD LEVEL - ROAD C/L	RM	m		75.29	69.57	64.24	52.35		40.17		29.11		20.92		13.78	8.92	1202.05	1188.23
	ROAD LEVEL - RIGHT SHOULDER	RR	m		75.41	69.47	64.14	52.25		40.07		29.01		20.82		13.68	8.82	1201.95	1188.20
	ROAD FORMATION WIDTH	F	m		15.50	11.60	13.50	11.00		13.50		11.00		11.00		13.60	11.00	11.00	13.40
NEW CULVERT DATA	FLOOR SLOPE	S	(%)		-18.90	-4.68	-13.83	1.11		-1.21		-1.37		-1.02		-14.16	-11.71	-5.46	6.96
	INVERT LEVEL LEFT	IL	m	83.00	62.00	66.50	60.10	51.00	44.00	38.70	33.30	27.50	22.40	19.25	15.00	7.00	5.50	1200.00	1186.52
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m		67.10	66.99	61.58	50.92		38.79		27.60		19.33		9.21	6.72	1200.48	1185.82
	INVERT LEVEL RIGHT	IR	m	87.50	70.30	67.30	62.80	51.15	49.90	38.90	38.00	27.70	26.80	19.40	18.70	10.80	7.50	1200.80	1185.16
	FILL HEIGHT LEFT	HL	m		±5.70	±1.76	±1.33	±0.93		±0.75		±0.87		±0.98		±2.89	±0.99	±0.71	±1.654
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m		±7.20	±1.92	±2.00	±0.77		±0.72		±0.85		±0.93		±3.58	±1.54	±0.91	±1.171
	FILL HEIGHT RIGHT	HR	m		±8.83	±2.10	±2.99	±0.61		±0.71		±0.82		±0.89		±4.61	±2.07	±1.11	±0.603
	LENGTH - LEFT TO ROAD C/L	LL	m		27.00	10.40	10.70	7.00		7.50		7.30		7.50		15.60	10.40	8.70	10.00
	TOTAL LENGTH TO INLET OR OUTLET	L	m	10.00	43.92	17.08	19.52	13.50	12.00	16.50	8.50	14.64	8.50	14.64	7.00	26.84	17.08	14.64	19.52
	TOTAL UNITS		No.		(54x2.44m)	(7x2.44m)	(8x2.44m)	(5.5x2.44m)		(6.8x2.44m)		(6x2.44m)		(6x2.44m)		(11x2.44m)	(7x2.44m)	(6x2.44m)	(16x1.22m)

NOTE:
* REFER TO TP1506.3-W13 FOR DOWN PIPE DETAILS

KEY:
PC - PIPE CULVERT
BC - BOX CULVERT
CP - CATCHPIT INLET
MH - MANHOLE
P - WINGWALL REFERENCE

REFERENCES:
THIS DRAWING MUST BE READ IN CONJUNCTION WITH DRAWINGS:
1. TP1506.3-W01 : CULVERT SCHEDULE
2. TP1506.3-W08 : PRECAST CULVERT CONSTRUCTION INFORMATION
3. TP1506.3-W13 : DOWN PIPE DETAILS FOR SIDE INLETS

NOTES:
1. FOR CULVERT POSITIONS REFER TO GEOMETRIC LAYOUT DRAWINGS
2. ALL LEVELS,SLOPES AND DIMENSIONS TO BE CHECKED AND CONFIRMED ON SITE WITH THE ENGINEER BEFORE CONSTRUCTION COMMENCES.THE ENGINEER TO BE INFORMED OF ANY DISCREPANCIES AS SOON AS POSSIBLE , AFTER THEY HAVE BEEN DISCOVERED.

ISSUED FOR CONSTRUCTION

No.	DATE	REVISION	CONSULT. ENG.
2	23-03-2017	DOWN PIPE DETAILS REVISED AND NOTES AMENDED	G.B. HART
1	13-03-2017	DRAINAGE AMENDED	G.B. HART
0	10-11-2016	ISSUED FOR CONSTRUCTION	G.B. HART

SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD
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DESIGNED BY	N.S.MBUSI
CHECKED BY	L. WESSELS
DRAWN BY	N.S.MBUSI
CHECKED BY	L. WESSELS

CONSULTANT APPROVAL
Name : G.B.HART
Prof. Reg. No. : 740674
Date : 26-08-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

DRA Mining (Pty) Ltd
No 3 Inyanga Close Sunninghill, 2157 P.O.Box 3567, Rivonia 2128
Tel: 0027 11 202 8600 Fax: 0027 11 202 8807 dra@drasa.co.za
NORTHAM BOOYSENDAL DIVISION

APPROVAL
DRA CIVIL PROJECT ENG. Date:
DRA PROJECT MANAGER Date:
CLIENT PROJECT MANAGER Date:

ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
for CEO: DRA Mining (Pty) Ltd
Date:

PROJECT DESCRIPTION
PERMANENT ACCESS ROAD FROM BOOYSENDAL SOUTH MINE TO CENTRAL COMPLEX
DRAWING DESCRIPTION
CULVERT SCHEDULE (SHEET 2 OF 2)
SCALE : AS SHOWN SHEET 2 OF 2

DRA PROJECT NUMBER	JZASM 0413-11-507	
DRAWING LOCATION DATA	START	END
ROUTE	-	-
SECTION	1	1
DRAWING km DISTANCE	1.123 223	9.106 441
DRAWING TYPE	DRAINAGE	
BRIDGE/STRUCTURE No.	N/A	
CONSULTANT DRAWING No. IC	SNA-TP1506.3-W02	VER 2

TABLE 1.1: CULVERT SCHEDULE FOR NEW CULVERTS

CULVERT ALONG PERMANENT ACCESS ROAD BOOYSENDAL SOUTH TO CENTRAL FROM KM 3.260 TO 6.360

CULVERT AND ROAD ELEMENTS				3-1	3-2	3-3(a)	3-3(b)	3-4(a)	3-4(b)	4-1	4-2	4-3	4-4	4-5(a)
CULVERT DESCRIPTION	ITEM NUMBER			3-1	3-2	3-3(a)	3-3(b)	3-4(a)	3-4(b)	4-1	4-2	4-3	4-4	4-5(a)
	ROAD KILOMETER DISTANCE		km	3.260	3.470	3.660		3.880		4.120	4.180	4.220	4.340	4.440
	TYPE			PC	PC	PC	ARMCO	PC	ARMCO	PC	PC	PC	PC	PC
	BARRELS / TOTAL UNITS		No.	1	2	2	1	1	1	1	1	1	1	1
	SPAN / DIA		mm	600	900	600	450	900	450	600	600	600	600	600
	HEIGHT		mm											
	PIPE & BEDDING CLASS			75D-A	50D-A	75D-A	Met-B	50D-A	Met-B	75D-A	75D-A	75D-A	75D-A	75D-A
	SKEW ANGLE		deg	90	90	90	90	90	90	90	90	90	90	90
	WINGWALL REFERENCE			P1 , P1	P4 , P4	MH , CP	*	MH . P3	*	P1 , CP	P1 , P1	P1 , P1	P1 , CP	MH . CP
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m	66.45	37.19	10.94		90.50		83.50	81.68	79.38	65.93	52.79
	ROAD LEVEL - ROAD C/L	RM	m	66.35	37.09	10.84		90.40		83.40	81.58	79.28	65.83	52.69
	ROAD LEVEL - RIGHT SHOULDER	RR	m	66.25	36.99	10.74		90.30		83.30	81.48	79.18	65.73	52.59
	ROAD FORMATION WIDTH	F	m	11.40	11.40	11.40		11.40		11.40	11.40	11.40	11.40	11.40
NEW CULVERT DATA	FLOOR SLOPE	S	(%)	0.88	-4.10	-1.78		-1.71		-2.05	-5.27	-8.20	-7.03	-1.37
	INVERT LEVEL LEFT	IL	m	64.35	34.00	8.66	3.70	88.15	83.20	81.70	78.70	76.70	63.30	51.14
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m	64.28	34.36	8.79		88.29		81.87	79.20	77.57	64.04	51.22
	INVERT LEVEL RIGHT	IR	m	64.50	34.70	8.89	7.60	88.41	87.10	82.00	79.60	78.10	64.50	51.30
	FILL HEIGHT LEFT	HL	m	±1,57	±1.60	±1.38		±1.12		±0.85	±1.51	±0.69	±0.83	±0.83
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m	±1.41	±1.74	±1.39		±1.12		±0.87	±1.72	±1.05	±1.13	±0.81
	FILL HEIGHT RIGHT	HR	m	± 1.27	±1.87	±1.39		±1.12		±0.88	±1.91	±1.43	±1.43	±0.78
	LENGTH - LEFT TO ROAD C/L	LL	m	8.45	8.75	7.50		8.00		8.30	9.50	10.60	10.60	6.20
	TOTAL LENGTH TO INLET OR OUTLET	L	m	17.08	17.08	13.50	11.00	14.64	8.50	14.64	17.08	17.08	17.08	11.70
	TOTAL UNITS		No.	(7x2.44m)	(14x2.44m)	(11.1x2.44m)		(6x2.44m)		(6x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(4.8x2.44m)

CULVERT AND ROAD ELEMENTS				4-5(b)	4-6(a)	4-6(b)	4-7	4-8	4-9	4-10	5-1	5-2	5-3	5-4	5-5	6-1(a)	6-1(b)	6-2
CULVERT DESCRIPTION	ITEM NUMBER			4-5(b)	4-6(a)	4-6(b)	4-7	4-8	4-9	4-10	5-1	5-2	5-3	5-4	5-5	6-1(a)	6-1(b)	6-2
	ROAD KILOMETER DISTANCE		km		4.500		4.600	4.680	4.900	4.980	5.080	5.200	5.320	5.380	5.620	6.120		6.360
	TYPE			ARMCO	PC	ARMCO	PC	PC	PC	PC	PC	PC	PC	PC	PC	PC	ARMCO	PC
	BARRELS / TOTAL UNITS		No.	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
	SPAN / DIA		mm	450	600	450	600	900	900	900	900	1200	600	600	600	900	900	600
	HEIGHT		mm															
	PIPE & BEDDING CLASS			Met-B	75D-A	Met-B	75D-A	50D-A	50D-A	50D-A	50D-A	50D-A	75D-A	75D-A	75D-A	50D-A	Met-B	75D-A
	SKEW ANGLE		deg	90	90	90	90	90	270	270	270	90	90	90	270	270	270	270
	WINGWALL REFERENCE			*	MH CP	*	P1 , CP	P3 . P3	P3 , P3	P3 , P3	CP, P3	P6 , P6	P1 . P1	P1 ,CP	P1, P1	P3 , MH	MH , P3	P1, P1
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m		45.27		35.32	30.71	8.32	1.51	94.63	85.57	75.92	70.90	45.14	94.97		79.42
	ROAD LEVEL - ROAD C/L	RM	m		45.17		35.22	30.61	8.42	1.61	94.73	85.47	75.82	70.80	45.04	95.07		79.52
	ROAD LEVEL - RIGHT SHOULDER	RR	m		45.07		35.12	30.51	8.52	1.71	94.83	85.37	75.72	70.70	44.94	95.17		79.62
	ROAD FORMATION WIDTH	F	m		11.40		11.40	13.60	13.60	13.60	12.80	13.60	11.40	10.60	13.60	11.40		13.40
NEW CULVERT DATA	FLOOR SLOPE	S	(%)		-1.37		-1.76	-1.76	5.01	2.99	1.17	-9.84	-13.83	2.05	4.10	1.02		7.86
	INVERT LEVEL LEFT	IL	m	45.20	43.40	37.00	33.00	28.60	5.50	0.51	93.00	79.90	71.30	69.00	41.50	92.40	91.40	74.50
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m		43.48		33.17	28.74	5.05	0.31	92.92	81.18	73.00	68.85	41.07	92.31		73.67
	INVERT LEVEL RIGHT	IR	m	50.15	43.60	41.90	33.30	28.90	4.40	0.00	92.80	82.30	74.00	69.30	40.50	92.20	89.00	72.20
	FILL HEIGHT LEFT	HL	m		±1.05		±1.39	±0.88	±2.56	±0.38	±0.78	±2.52	±0.07	±1.51	±3.64	±1,73		±5.53
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m		±1.03		±1.39	±0.88	±2.38	±0.31	±0.82	±2.97	±2.16	±1.29	±3.31	±1.77		±5.19
	FILL HEIGHT RIGHT	HR	m		±1.01		±1.39	±0.92	±2.08	±0.17	±0.83	±3.66	±1.45	±1.09	±2.89	± 1.81		±4.68
	LENGTH - LEFT TO ROAD C/L	LL	m		6.00		9.90	8.00	9.00	6.80	6.50	13.00	12.30	7.40	10.40	8.80		10.60
	TOTAL LENGTH TO INLET OR OUTLET	L	m	8.50	14.64	11.50	17.08	17.08	21.96	17.08	17.08	24.40	19.52	14.64	24.40	19.52	6.50	29.28
	TOTAL UNITS		No.		(6x2.44m)		(7x2.44m)	(7x2.44m)	(9x2.44m)	(7x2.44m)	(7x2.44m)	(20x2.44m)	(8x2.44m)	(6x2.44m)	(10x2.44m)	(8x2.44m)		(12x2.44m)

TABLE 1.2: CULVERT SCHEDULE FOR NEW CULVERTS

CULVERT ALONG PERMANENT ACCESS ROAD BOOYSENDAL SOUTH TO CENTRAL FROM KM 6.460 TO 8.740

CULVERT AND ROAD ELEMENTS				6-3(a)	6-3(b)	6-4(a)	6-4(b)	6-5	6-6	6-7	6-8	7-1	7-2	7-3	7-4(a)
CULVERT DESCRIPTION	ITEM NUMBER			6-3(a)	6-3(b)	6-4(a)	6-4(b)	6-5	6-6	6-7	6-8	7-1	7-2	7-3	7-4(a)
	ROAD KILOMETER DISTANCE		km	6.460		6.540		6.620	6.700	6.800	6.900	7.040	7.120	7.320	7.580
	TYPE			P C	ARMCO	P C	ARMCO	P C	P C	P C	P C	P C	P C	P C	P C
	BARRELS / TOTAL UNITS		No.	1	1	1	1	1	1	1	1	1	1	1	1
	SPAN / DIA		mm	600	450	600	450	600	600	600	600	600	600	600	600
	HEIGHT		mm												
	PIPE & BEDDING CLASS			75D-A	Met-B	75D-A	Met-B	75D-A	75D-A	75D-A	75D-A	75D-A	75D-A	75D-A	75D-A
	SKEW ANGLE		deg	90	90	270	270	270	270	270	270	270	270	90	90
	WINGWALL REFERENCE			CP, MH	*	CP, MH	*	CP. P1	CP, P1	CP, P1	CP. P1	CP, P1	P1, P1	P1. P1	MH, CP
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m	69.65		61.74		54.20	47.55	40.73	34.40	25.53	22.12	22.61	92.10
	ROAD LEVEL - ROAD C/L	RM	m	69.75		61.84		54.30	47.65	40.83	34.50	25.63	22.22	22.51	92.00
	ROAD LEVEL - RIGHT SHOULDER	RR	m	69.85		61.94		54.40	47.75	40.93	34.60	25.73	22.34	22.41	89.90
	ROAD FORMATION WIDTH	F	m	12.60		12.60		12.60	12.60	12.60	12.60	10.60	13.40	13.50	13.50
NEW CULVERT DATA	FLOOR SLOPE	S	(%)	1.25		1.29		6.66	1.17	1.76	1.76	2.34	1.17	-4.10	-1.37
	INVERT LEVEL LEFT	IL	m	68.75	67.60	60.60	59.80	52.30	46.00	39.00	33.20	24.00	21.00	15.70	88.70
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m	68.67		60.52		51.89	45.93	38.89	33.09	23.85	20.92	16.35	88.84
	INVERT LEVEL RIGHT	IR	m	68.55	64.00	60.40	54.95	51.00	45.80	38.70	32.90	23.60	20.80	17.00	89.00
	FILL HEIGHT LEFT	HL	m	±0.39		±0.63		±2.03	±1.03	±1.28	±0.75	±1.15	±0.61	±5.37	±2.52
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m	±0.42		±0.66		±1.75	±1.06	±1.28	±0.75	±1.12	±0.64	±5.50	±2.50
	FILL HEIGHT RIGHT	HR	m	±0.43		±0.67		±1.39	±1.08	±1.26	±0.73	±1.11	±0.67	±5.72	±0.51
	LENGTH - LEFT TO ROAD C/L	LL	m	6.10		6.00		6.20	6.20	6.20	6.20	6.50	7.20	15.90	10.20
	TOTAL LENGTH TO INLET OR OUTLET	L	m	16.00	7.00	15.50	10.00	19.52	17.08	17.08	17.08	17.08	17.08	31.72	21.96
	TOTAL UNITS		No.	(6.6x2.44m)		(6.4x2.44m)		(8x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(7x2.44m)	(13x2.44m)	(9x2.44m)

CULVERT AND ROAD ELEMENTS				7-4(b)	7-5	7-6	7-7	8-1(a)	8-1(b)	8-2(a)	8-2(b)	8-3(a)	8-3(b)	8-4(a)	8-4(b)	8-5	8-6	8-7	SERVICE CULVERT 8-8
CULVERT DESCRIPTION	ITEM NUMBER			7-4(b)	7-5	7-6	7-7	8-1(a)	8-1(b)	8-2(a)	8-2(b)	8-3(a)	8-3(b)	8-4(a)	8-4(b)	8-5	8-6	8-7	8-8
	ROAD KILOMETER DISTANCE		km		7.760	7.870	7.940	8.040		8.140		8.240		8.320		8.400	8.500	8.600	8.740
	TYPE			ARMCO	P C	P C	P C	P C	ARMCO	P C	ARMCO	P C	ARMCO	P C	ARMCO	P C	P C	P C	BC
	BARRELS / TOTAL UNITS		No.	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SPAN / DIA		mm	450	900	600	600	600	450	600	600	600	600	600	600	900	600	600	1200
	HEIGHT		mm																1200
	PIPE & BEDDING CLASS			Met-B	50D-A	75D-A	75D-A	75D-A	Met-B	75D-A	Met-B	75D-A	Met-B	75D-A	Met-B	50D-A	75D-A	75D-A	150S
	SKEW ANGLE		deg	90	120	90	90	90		90		90		90		90	90	90	300
	WINGWALL REFERENCE			*	P5, P5	CP. P1	P1, P1	MH, P1	*	MH, P1	*	MH, P1	*	MH, P1	*	P3. P3	P1, P1	P1, P1	REFER TO TP1506.2-W08
ROAD DATA	ROAD LEVEL - LEFT SHOULDER	RL	m		75.21	69.67	64.34	52.45		40.27		29.21		21.02		13.88	9.02	1202.15	1188.32
	ROAD LEVEL - ROAD C/L	RM	m		75.29	69.57	64.24	52.35		40.17		29.11		20.92		13.78	8.92	1202.05	1188.23
	ROAD LEVEL - RIGHT SHOULDER	RR	m		75.41	69.47	64.14	52.25		40.07		29.01		20.82		13.68	8.82	1201.95	1188.20
	ROAD FORMATION WIDTH	F	m		15.50	11.60	13.50	11.00		13.50		11.00		11.00		13.60	11.00	11.00	13.40
NEW CULVERT DATA	FLOOR SLOPE	S	(%)		-18.90	-4.68	-13.83	1.11		-1.21		-1.37		-1.02		-14.16	-11.71	-5.46	6.96
	INVERT LEVEL LEFT	IL	m	83.00	62.00	66.50	60.10	51.00	44.00	38.70	33.30	27.50	22.40	19.25	15.00	7.00	5.50	1200.00	1186.52
	INVERT LEVEL - ROAD C/L (MEDIAN)	IM	m		67.10	66.99	61.58	50.92		38.79		27.60		19.33		9.21	6.72	1200.48	1185.82
	INVERT LEVEL RIGHT	IR	m	87.50	70.30	67.30	62.80	51.15	49.90	38.90	38.00	27.70	26.80	19.40	18.70	10.80	7.50	1200.80	1185.16
	FILL HEIGHT LEFT	HL	m		±5.70	±1.76	±1.33	±0.93		±0.75		±0.87		±0.98		±2.89	±0.99	±0.71	±1.654
	FILL HEIGHT - ROAD C/L (MEDIAN)	HM	m		±7.20	±1.92	±2.00	±0.77		±0.72		±0.85		±0.93		±3.58	±1.54	±0.91	±1.171
	FILL HEIGHT RIGHT	HR	m		±8.83	±2.10	±2.99	±0.61		±0.71		±0.82		±0.89		±4.61	±2.07	±1.11	±0.603
	LENGTH - LEFT TO ROAD C/L	LL	m		27.00	10.40	10.70	7.00		7.50		7.30		7.50		15.60	10.40	8.70	10.00
	TOTAL LENGTH TO INLET OR OUTLET	L	m	10.00	43.92	17.08	19.52	13.50	12.00	16.50	8.50	14.64	8.50	14.64	7.00	26.84	17.08	14.64	19.52
	TOTAL UNITS		No.		(54x2.44m)	(7x2.44m)	(8x2.44m)	(5.5x2.44m)		(6.8x2.44m)		(6x2.44m)		(6x2.44m)		(11x2.44m)	(7x2.44m)	(6x2.44m)	(16x1.22m)

NOTE:
* REFER TO TP1506.3-W13 FOR DOWN PIPE DETAILS

KEY:
PC - PIPE CULVERT
BC - BOX CULVERT
CP - CATCHPIT INLET
MH - MANHOLE
P - WINGWALL REFERENCE

REFERENCES:
THIS DRAWING MUST BE READ IN CONJUNCTION WITH DRAWINGS:
1. TP1506.3-W01 : CULVERT SCHEDULE
2. TP1506.3-W08 : PRECAST CULVERT CONSTRUCTION INFORMATION
3. TP1506.3-W13 : DOWN PIPE DETAILS FOR SIDE INLETS

NOTES:
1. FOR CULVERT POSITIONS REFER TO GEOMETRIC LAYOUT DRAWINGS
2. ALL LEVELS,SLOPES AND DIMENSIONS TO BE CHECKED AND CONFIRMED ON SITE WITH THE ENGINEER BEFORE CONSTRUCTION COMMENCES.THE ENGINEER TO BE INFORMED OF ANY DISCREPANCIES AS SOON AS POSSIBLE , AFTER THEY HAVE BEEN DISCOVERED.

ISSUED FOR CONSTRUCTION

No.	DATE	REVISION	CONSULT. ENG.
2	23-03-2017	DOWN PIPE DETAILS REVISED AND NOTES AMENDED	G.B. HART
1	13-03-2017	DRAINAGE AMENDED	G.B. HART
0	10-11-2016	ISSUED FOR CONSTRUCTION	G.B. HART

SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD
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e-mail - pta@sna.co.za

DESIGNED BY	N.S.MBUSI
CHECKED BY	L. WESSELS
DRAWN BY	N.S.MBUSI
CHECKED BY	L. WESSELS

CONSULTANT APPROVAL
GBHart
Name : G.B.HART
Prof. Reg. No. : 740674
Date : 26-08-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

DRA Mining (Pty) Ltd
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NORTHAM BOOYSENDAL DIVISION

APPROVAL
DRA CIVIL PROJECT ENG. Date:
DRA PROJECT MANAGER Date:
CLIENT PROJECT MANAGER Date:

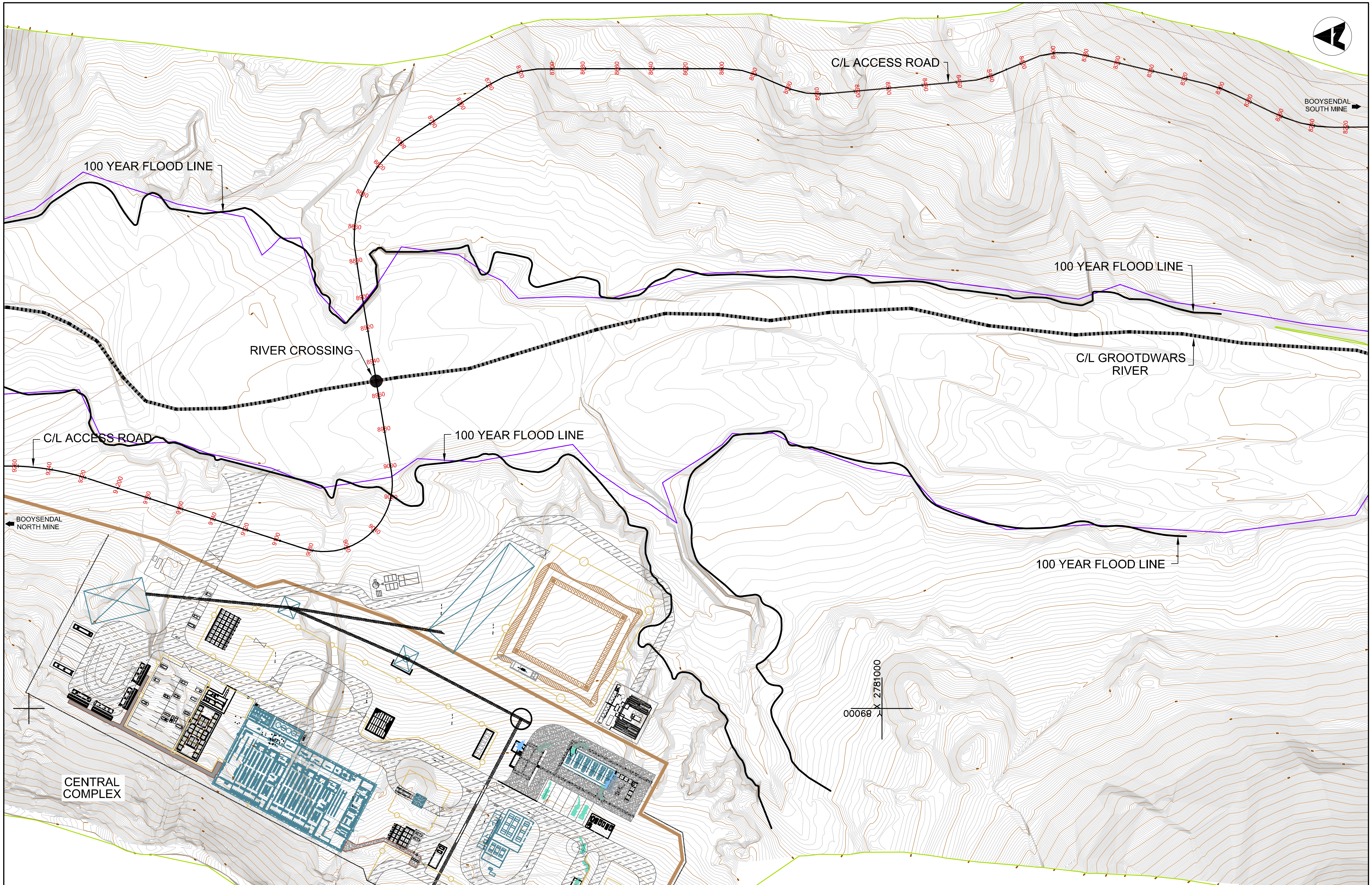
ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
for CEO: DRA Mining (Pty) Ltd
Date:

PROJECT DESCRIPTION
PERMANENT ACCESS ROAD FROM BOOYSENDAL SOUTH MINE TO CENTRAL COMPLEX

DRAWING DESCRIPTION
CULVERT SCHEDULE (SHEET 2 OF 2)

SCALE : AS SHOWN | SHEET 2 OF 2

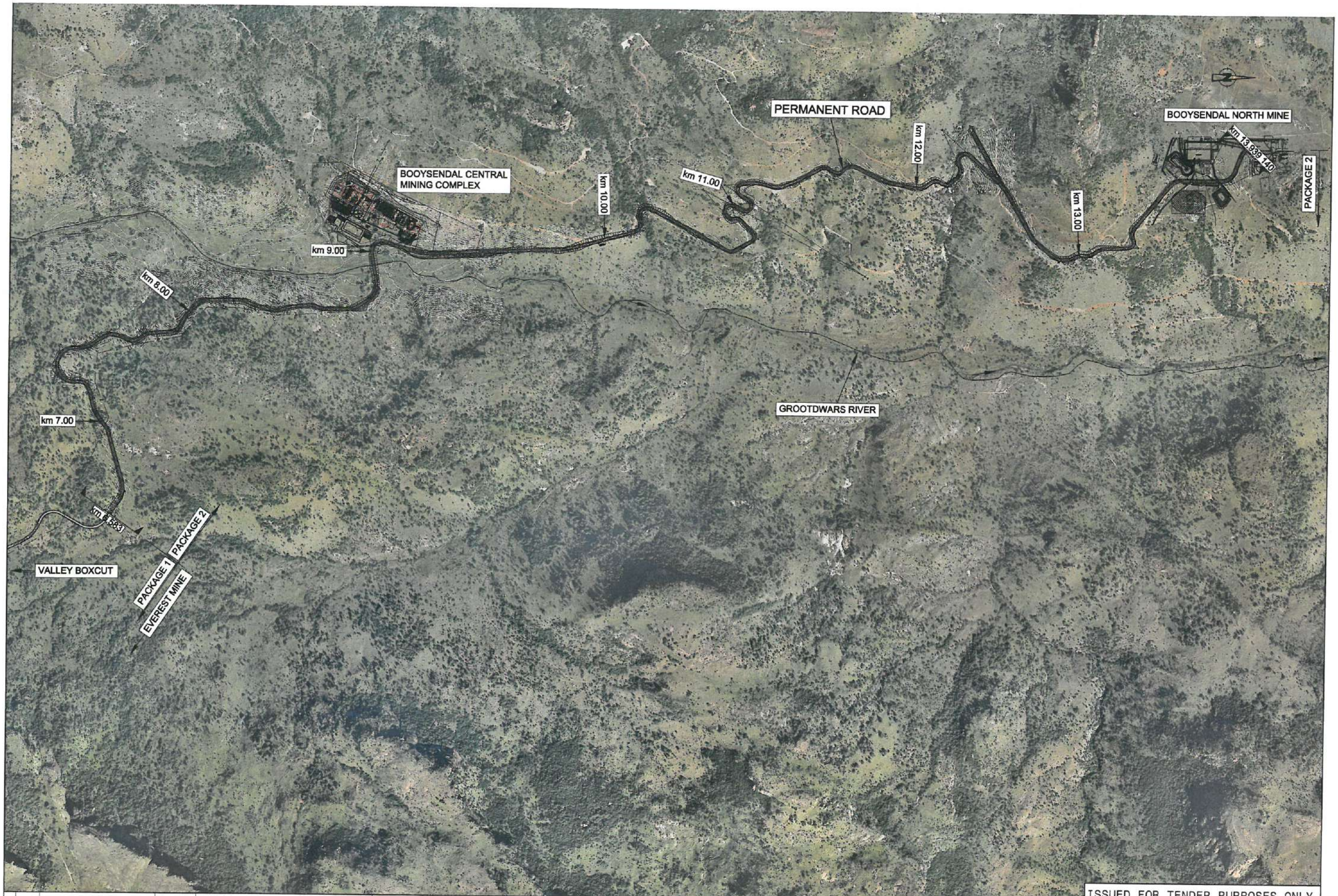
DRA PROJECT NUMBER	JZASM 0413-11-507		
DRAWING LOCATION DATA	START	END	
ROUTE	-	-	
SECTION	1	1	
DRAWING km DISTANCE	1.123 223	9.106 441	
DRAWING TYPE	DRAINAGE		
BRIDGE/STRUCTURE No.	N/A		
CONSULTANT DRAWING No.	IC	SNA-TP1506.3-W02	VER 2



SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD

PERMANENT ACCESS ROAD FROM
BOOYSENDAL SOUTH MINE
TO BOOYSENDAL NORTH MINE

ANNEXURE B : 100-YEAR FLOOD LINE



ISSUED FOR TENDER PURPOSES ONLY

No.	DATE	REVISION	CONSULT. ENG.
C	07-06-2016	DRAINAGE AMENDED FROM km 13.580 TO km 13.939	G.B. HART
B	08-04-2016	ALIGNMENT AMENDED FROM km 9.00 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

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DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	A. van der WALT
CHECKED BY	G. B. HART

CONSULTANT APPROVAL

Name: G B HART
Prof. Reg. No.: 740874
Date: 11-02-2016

THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

DRA Mining (Pty) Ltd

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dra@drasa.co.za

NORTHAM

APPROVAL

DRA CIVIL PROJECT ENG. Date

DRA PROJECT MANAGER Date

CLIENT PROJECT MANAGER Date

ACCEPTANCE

THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING

for CEO: DRA Mining (Pty) Ltd

Date

PROJECT DESCRIPTION

CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

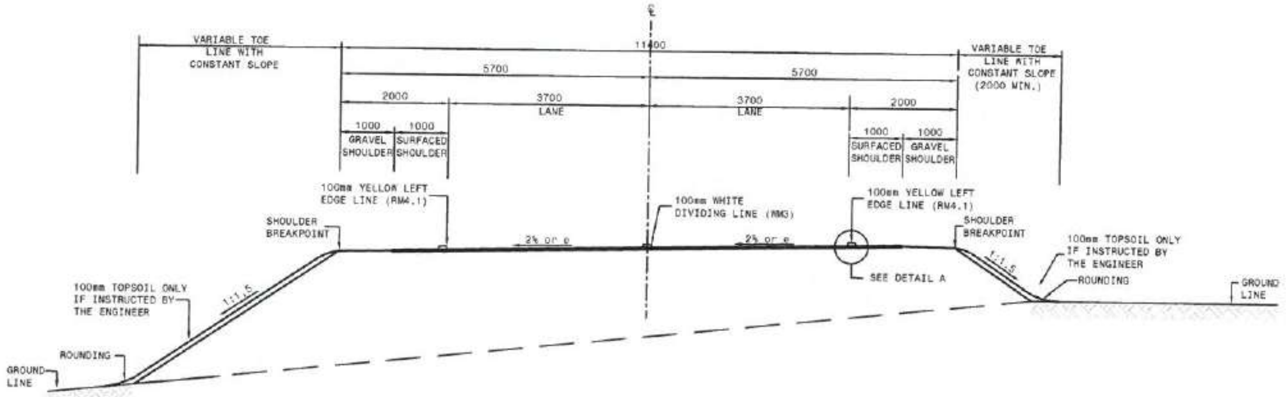
DRAWING DESCRIPTION

GENERAL KEY PLAN

SCALE : 1 : 5000 (A0 SHEET) SHEET 1 OF 1

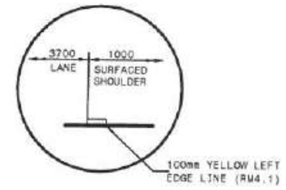
PROJECT NUMBER	JZASM 0413-11-507	
DRAWING LOCATION DATA	START	END
ROUTE	-	-
SECTION	1	1
DRAWING km DISTANCE	6.583	13.939 140
DRAWING TYPE	ROADS - LOCALITY	
BRIDGE/STRUCTURE No.	N/A	
CONSULTANT DRAWING No.	FA SNA-TP1506-A02	VER C

TYPICAL CROSS-SECTION OF BOOYSENDAL NORTH ACCESS ROAD
(SHEET 1 OF 3 SHEETS)



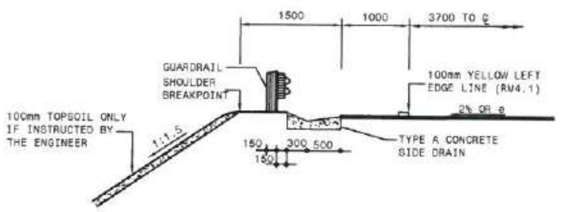
TYPICAL CROSS-SECTION IN FILL CONDITIONS

SCALE: 1:50



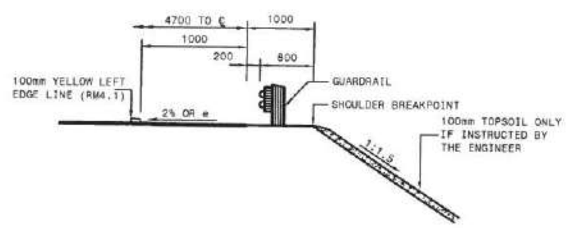
DETAIL A

SCALE: N.T.S.



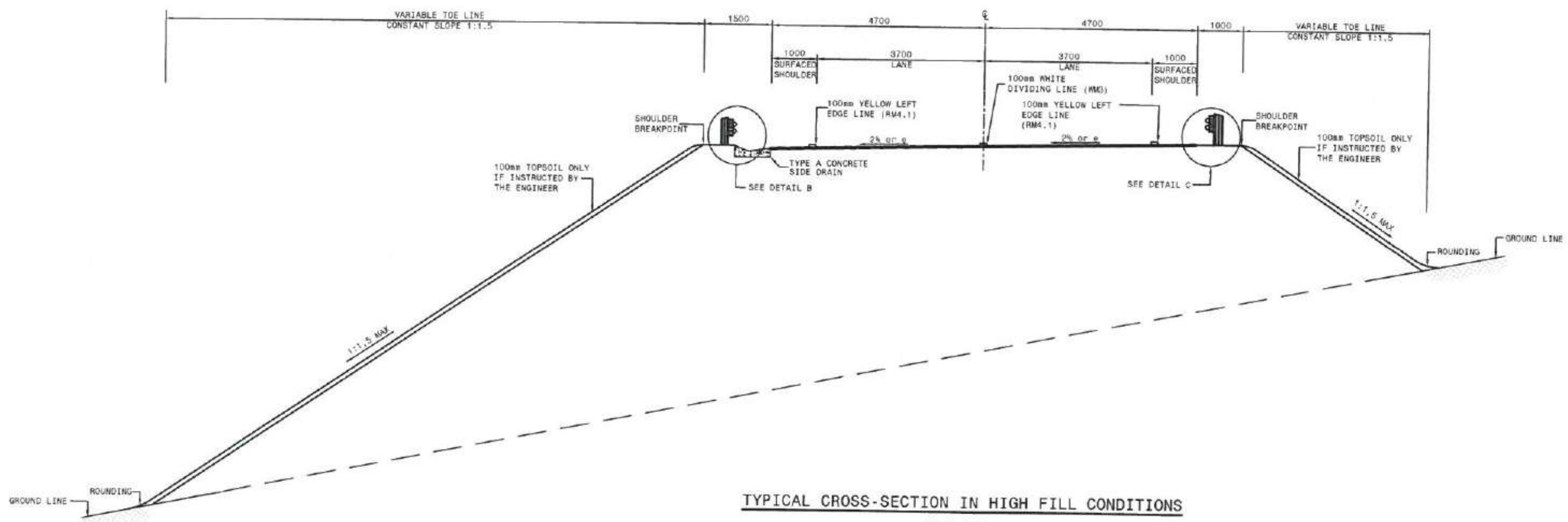
DETAIL B : IN SITU CONCRETE SIDE DRAIN (TYPE A)

SCALE: N.T.S.



DETAIL C : POSITION OF GUARDRAIL WITHOUT SIDE DRAIN

SCALE: N.T.S.



TYPICAL CROSS-SECTION IN HIGH FILL CONDITIONS

SCALE: 1:50

NOTES:

1. TOPSOIL
   (a) WHERE SPECIFIED BY THE ENGINEER, CUT AND FILL SLOPES MUST BE COVERED WITH TOPSOIL.
   (b) IF DIRECTED BY THE ENGINEER, THE THICKNESS OF THE TOPSOIL PLACED ON CUT AND FILL SLOPES MUST BE REDUCED FROM 100mm TO 75mm.
2. ALL POINTS OF INTERSECTION MUST BE ROUNDED TO A MINIMUM WIDTH OF 1.0m MEASURED HORIZONTALLY.
3. CONCRETE SIDE DRAINS MAY ONLY BE CONSTRUCTED AFTER THE SURFACING HAS BEEN COMPLETED.
4. NO TRACES OF CONCRETE MUST BE LEFT ON THE SURFACING AFTER THE CONCRETE SIDE DRAINS HAVE BEEN CONSTRUCTED.
5. CONCRETE EDGES SHALL BE ROUNDED WITH A NOSING TOOL TO THE RADII SHOWN ON THE RELEVANT DRAWINGS.

ISSUED FOR TENDER PURPOSES ONLY

No.	DATE	REVISION	CONSULT. ENG.
B	08-04-2016	ALIGNMENT AMENDED FROM km 9.60 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

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DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	R. VAN RENSBURG
CHECKED BY	G. B. HART

CONSULTANT APPROVAL
Name G B HART
Prof. Reg. No. 746674
Date 11-02-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

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NORTHAM

APPROVAL
Date DRA CIVIL PROJECT ENG.
Date DRA PROJECT MANAGER
Date CLIENT PROJECT MANAGER

ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
Date for CEO: DRA Mining (Pty) Ltd

PROJECT DESCRIPTION
CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

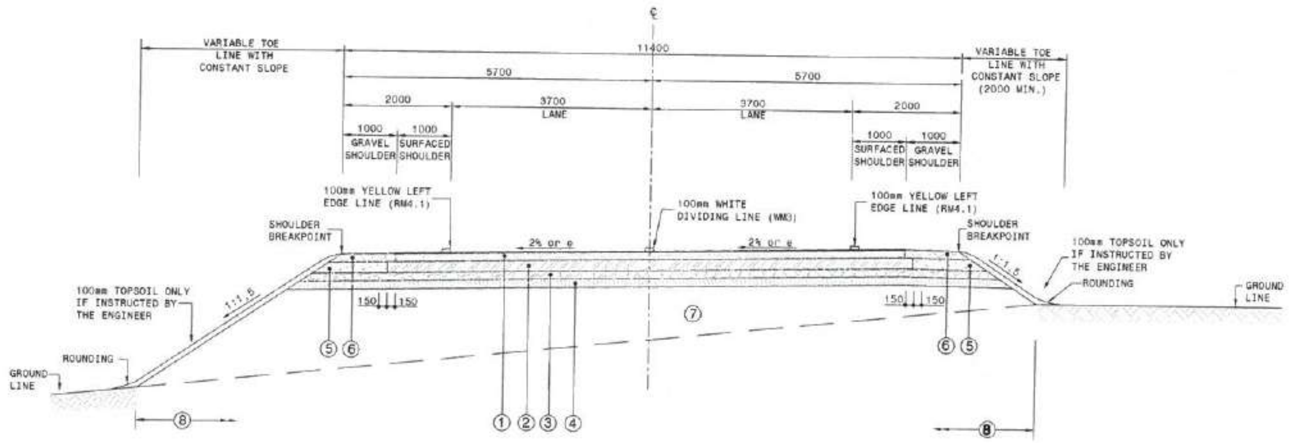
DRAWING DESCRIPTION
TYPICAL CROSS-SECTION OF BOOYSENDAL NORTH ACCESS ROAD (SHEET 1 OF 3 SHEETS)

SCALE : 1 : 50 (A0 SHEET) SHEET 1 OF 3

DRA PROJECT NUMBER	JZASM 0413-11-507	
DRAWING LOCATION DATA	START	END
ROUTE	-	-
SECTION	1	1
DRAWING km DISTANCE	6.583	13.921
DRAWING TYPE	ROADS - X SECTIONS	
BRIDGE/STRUCTURE No.	N/A	
CONSULTANT DRAWING No. FA	SNA-TP1506-B01	VER B

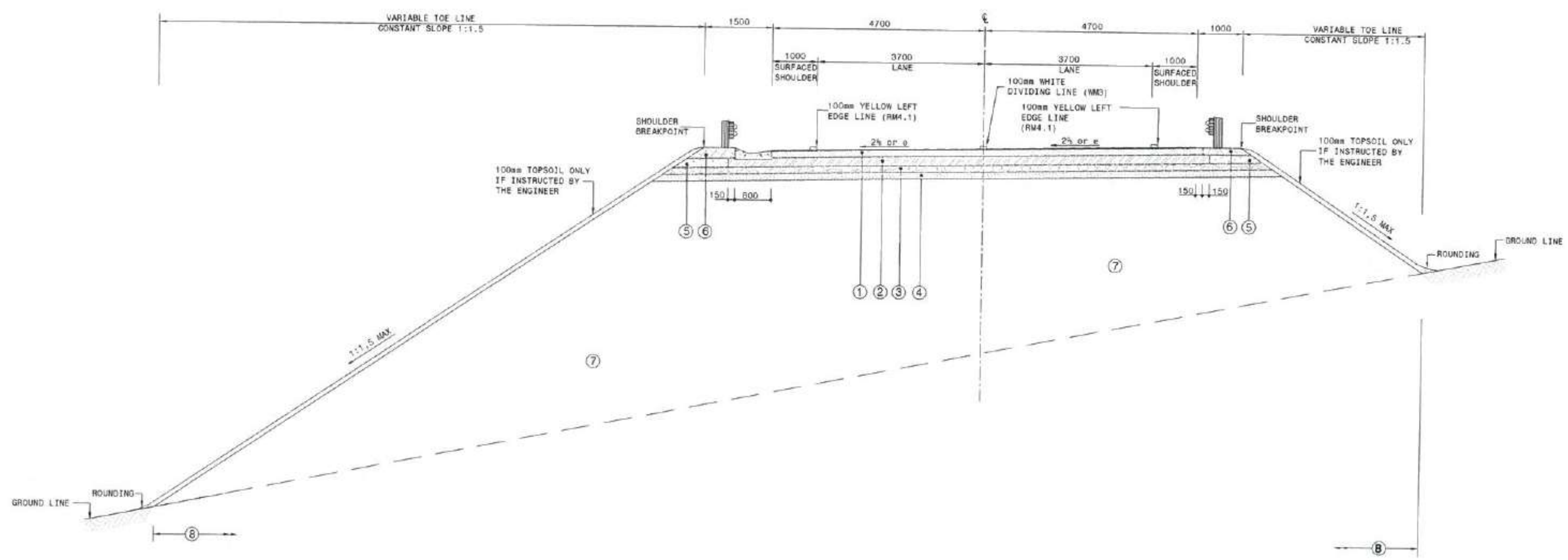
BASIC PAVEMENT DESIGN FOR BOOYSENDAL NORTH ACCESS ROAD

(SHEET 1 OF 3 SHEETS)



BASIC PAVEMENT DESIGN IN SHALLOW FILL CONDITIONS

SCALE: 1:50



BASIC PAVEMENT DESIGN IN HIGH FILL CONDITIONS

SCALE: 1:50

BOOYSENDAL NORTH ACCESS ROAD : MATERIAL REQUIREMENTS							
NEW CONSTRUCTION km 6.583 TO km 13.921							
SURFACING: 40/50mm*4 CONTINUOUSLY GRADED ASPHALT (TRH 8 COARSE - A-E2 BINDER)							
LAYER No	DESCRIPTION	TRH 14 MATERIAL TYPE	SECTION OF SPECIFICATION	COMPACTION (% OF MOD. AASHTO)	P.I. (MAX)	G.M. (MIN)	CBR/UCS AT % OF MOD AASHTO COMPACTION
1	150mm CRUSHED STONE BASE	G1	3600	88%/89% OF APPARENT RELATIVE DENSITY	4	-	-
2	300 TO 350mm*4 STABILIZED GRAVEL SUBBASE	C3	3400 & 3500	96% AVERAGE DENSITY &	NP	1.75	UCS : 2000 @ 100% ITS : 300@ 100% CBR : 45@ 95% (NEAT)
3	150mm NATURAL GRAVEL UPPER SELECTED LAYER	G6	3400	95%	*1	1.2	25 @ 95%
4	150mm NATURAL GRAVEL LOWER SELECTED LAYER (IN SITU OR IMPORTED)	G7	3400	93%	*2	1.2	15 @ 93%
5	300 TO 350mm*4 NATURAL GRAVEL SUBBASE	G5	3400	95%	*1	1.5	45 @ 95%
6	150mm GRAVEL SHOULDER	G5	3400	95%	10 MAX 6 MIN	2.0	45 @ 95%
7	FILL	G9	3300	93%	-	-	3 @ 90%
8	ROADBED PREPARATION	-	3300	*3	-	-	-
9	150mm NOMINAL THICKNESS LEVELING LAYER (UPPER SELECTED LAYER QUALITY)	G6	3400	93%	*1	1.2	25 @ 95%

*1 (3xGM) + 10 OR 14 WHICHEVER IS THE LESSER
*2 (3xGM) + 10 OR 16 WHICHEVER IS THE LESSER
*3 90% MOD. AASHTO COMPACTION OR "n"-PASS ROLLER COMPACTION

*4

	BOOYSENDAL TO CENTRAL	CENTRAL TO VALLEY
SURFACING	40mm	50mm
SUBBASE	300mm	350mm

ISSUED FOR TENDER PURPOSES ONLY

No.	DATE	REVISION	CONSULT. ENG.
C	08-06-2016	MATERIAL REQUIREMENTS AMENDED	G.B. HART
B	08-04-2016	ALIGNMENT AMENDED FROM km 9.00 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

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DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	R. VAN RENSBURG
CHECKED BY	G. B. HART

CONSULTANT APPROVAL
Name G B HART
Prof. Reg. No. 740674
Date 11-02-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING

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NORTHAM

APPROVAL
DRA CIVIL PROJECT ENG. Date
DRA PROJECT MANAGER Date
CLIENT PROJECT MANAGER Date

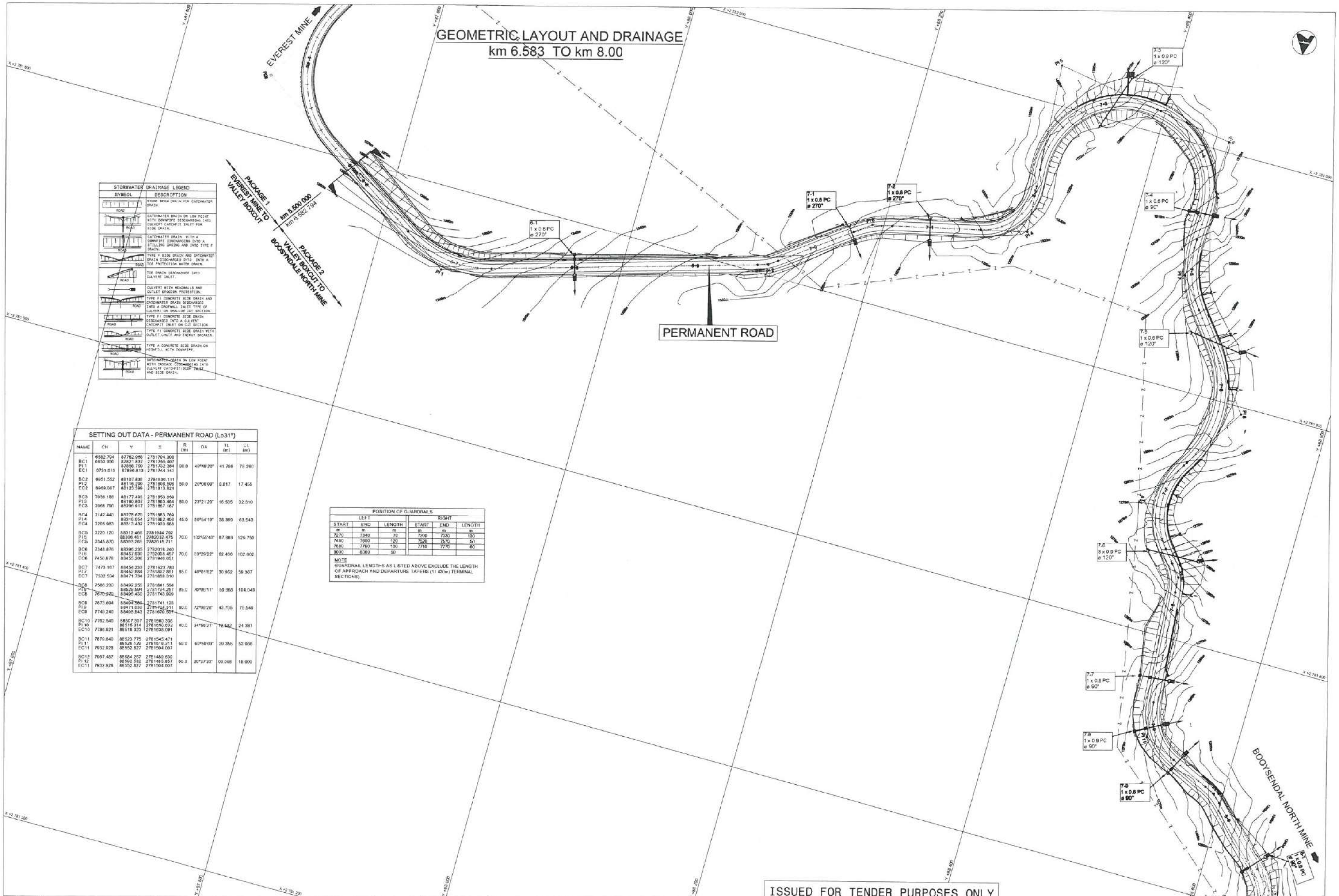
ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
for CEO: DRA Mining (Pty) Ltd Date

PROJECT DESCRIPTION
CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

DRAWING DESCRIPTION
BASIC PAVEMENT DESIGN FOR BOOYSENDAL NORTH ACCESS ROAD (SHEET 1 OF 3 SHEETS)

SCALE : 1 : 50 (A0 SHEET) SHEET 1 OF 3

DRA PROJECT NUMBER	JZASM 0413-11-507		
DRAWING LOCATION DATA	START	END	
ROUTE	-	-	
SECTION	1	1	
DRAWING km DISTANCE	6.583	13.921	
DRAWING TYPE	ROADS - X SECTIONS		
BRIDGE/STRUCTURE No.	N/A		
CONSULTANT DRAWING No.	FA	SNA-TP1506-C01	VER C



STORMWATER DRAINAGE LEGEND

SYMBOL	DESCRIPTION
ROAD	STONE BERM DRAIN FOR CATCHWATER DRAIN.
ROAD	CATCHWATER DRAIN ON LOW POINT WITH DOWNPIPE DISCHARGING INTO CULVERT CATCHPIT INLET FOR SIDE DRAIN.
ROAD	CATCHWATER DRAIN WITH A DOWNPIPE DISCHARGING INTO A STILLING BASING AND INTO TYPE F DRAIN.
ROAD	TYPE F SIDE DRAIN AND CATCHWATER DRAIN DISCHARGES INTO INTO A TOE PROTECTION WATER DRAIN.
ROAD	TOE DRAIN DISCHARGES INTO CULVERT INLET.
	CULVERT WITH HEADWALLS AND OUTLET EROSION PROTECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN AND CATCHWATER DRAIN DISCHARGES INTO A DROPWALL INLET TYPE OF CULVERT ON SHALLOW CUT SECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN DISCHARGES INTO A CULVERT CATCHPIT INLET ON CUT SECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN WITH OUTLET CHUTE AND ENERGY BREAKER.
ROAD	TYPE A CONCRETE SIDE DRAIN ON HIGHFILL WITH DOWNPIPE.
ROAD	CATCHWATER DRAIN ON LOW POINT WITH CASCADE DISCHARGING INTO CULVERT CATCHPIT/DISH INLET AND SIDE DRAIN.

SETTING OUT DATA - PERMANENT ROAD (Lo31°)

NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
-	6582.794	87762.966	2781794.308				
BC1	6653.356	87821.837	2781755.407				
PI 1		87856.709	2781732.364	90.0	40°49'20"	41.798	78.260
EC1	6731.616	87896.813	2781744.141				
BC2	6951.552	88107.838	2781806.111				
PI 2		88116.299	2781808.596	50.0	20°00'00"	8.817	17.455
EC2	6969.007	88125.399	2781813.824				
BC3	7036.186	88177.493	2781853.859				
PI 3		88190.807	2781863.464	80.0	23°21'20"	16.535	32.610
EC3	7068.796	88206.917	2781867.187				
BC4	7142.440	88278.670	2781883.769				
PI 4		88316.054	2781892.408	45.0	80°54'19"	38.369	63.543
EC4	7205.983	88313.432	2781930.688				
BC5	7220.120	88312.466	2781944.792				
PI 5		88306.461	2782032.475	70.0	102°55'40"	87.889	125.750
EC5	7345.870	88393.265	2782018.711				
BC6	7348.876	88396.235	2782018.240				
PI 6		88457.930	2782008.457	70.0	83°29'22"	62.466	102.002
EC6	7450.878	88455.206	2781946.051				
BC7	7473.167	88454.233	2781923.783				
PI 7		88452.884	2781892.881	85.0	40°01'02"	30.952	59.367
EC7	7532.534	88471.734	2781868.310				
BC8	7566.230	88492.255	2781841.584				
PI 8		88528.594	2781794.257	85.0	70°08'11"	59.668	104.049
EC8	7670.929	88496.430	2781743.999				
BC9	7673.694	88494.569	2781741.123				
PI 9		88471.030	2781704.311	60.0	72°08'28"	43.705	75.540
EC9	7749.240	88498.843	2781670.587				
BC10	7762.540	88507.307	2781660.338				
PI 10		88515.314	2781650.632	40.0	34°55'21"	12.582	24.381
EC10	7786.921	88516.323	2781638.091				
BC11	7879.840	88523.775	2781545.471				
PI 11		88526.129	2781516.211	50.0	60°50'03"	29.355	53.088
EC11	7932.928	88552.827	2781504.007				
BC12	7967.487	88584.257	2781489.638				
PI 12		88592.532	2781485.857	50.0	20°37'33"	09.098	18.000
EC11	7932.928	88552.827	2781504.007				

POSITION OF GUARDRAILS

LEFT			RIGHT		
START	END	LENGTH	START	END	LENGTH
m	m	m	m	m	m
7270	7340	70	7200	7330	130
7480	7600	120	7520	7570	50
7680	7780	100	7710	7770	60
8030	8080	50			

NOTE
GUARDRAIL LENGTHS AS LISTED ABOVE EXCLUDE THE LENGTH OF APPROACH AND DEPARTURE TAPERS (11.430m) TERMINAL SECTIONS)

ISSUED FOR TENDER PURPOSES ONLY

No.	DATE	REVISION	CONSULT. ENG.
B	08-04-2016	ALIGNMENT AMENDED FROM km 9.00 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD
P. O. Box 72727
LYNNWOOD RIDGE
0040
SNAVIA BUILDING
285 ALBERTUS STREET
LA MONTAGNE
Tel - 012-842 0000
Fax - 012-803 4429
e-mail - pta@sna.co.za

DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	A van der WALT
CHECKED BY	G. B. HART

CONSULTANT APPROVAL
Name G B HART
Prof. Reg. No. 740074
Date 11-02-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

DRA Mining (Pty) Ltd
No 3 Inyanga Close
Sunninghill
2157
P.O Box 3567,
Rivonia
2128
Tel: 0027 11 202 8600
Fax: 0027 11 202 8807
dra@drasa.co.za
NORTHAM

APPROVAL
Date DRA CIVIL PROJECT ENG.
Date DRA PROJECT MANAGER
Date CLIENT PROJECT MANAGER

ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
for CEO: DRA Mining (Pty) Ltd
Date

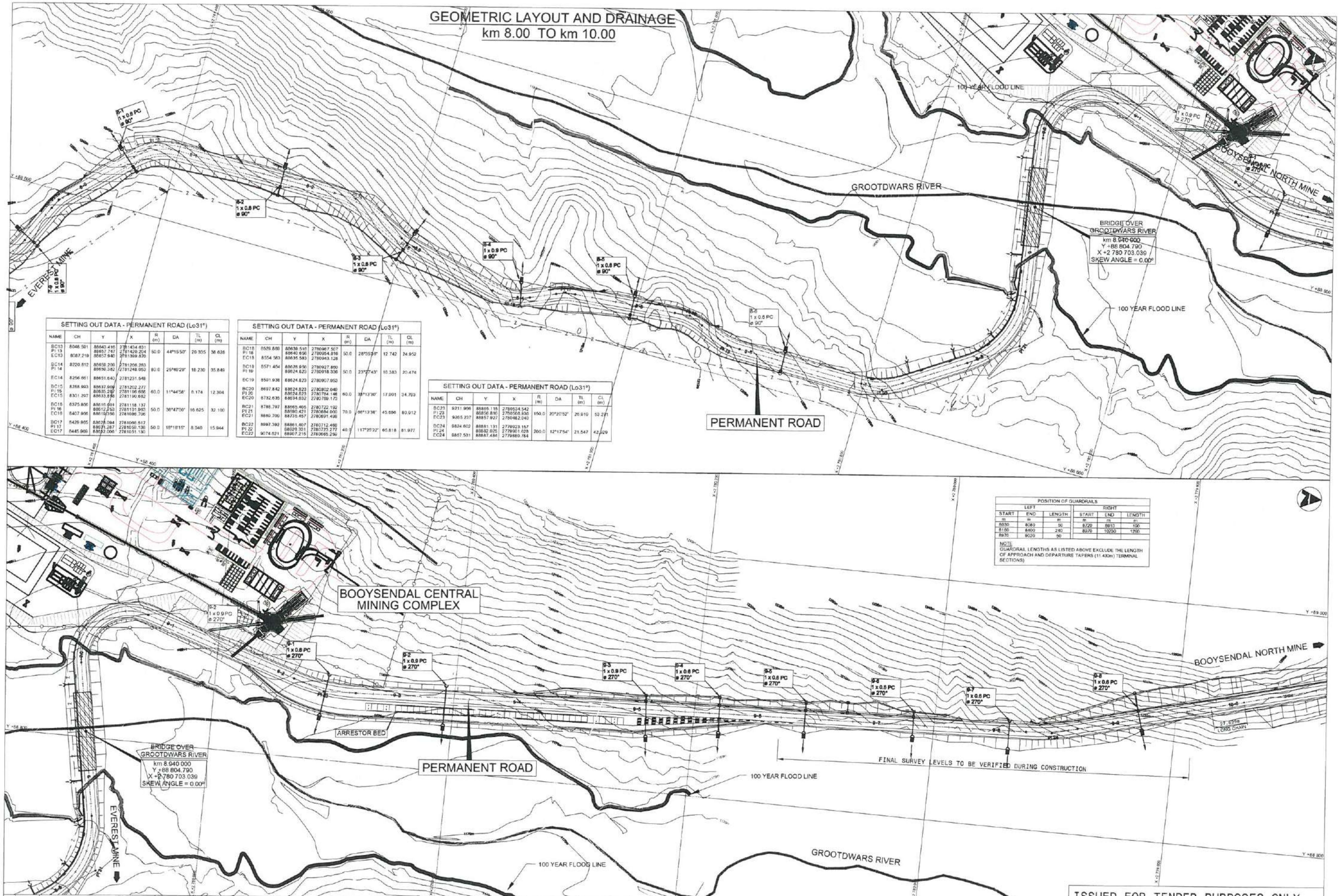
PROJECT DESCRIPTION
CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

DRAWING DESCRIPTION
GEOMETRIC LAYOUT AND DRAINAGE
km 6.583 to km 8.00

SCALE : 1 : 1000 (A0 SHEET)
SHEET 1 OF 4

DRA PROJECT NUMBER	JZASM 0413-11-507	
DRAWING LOCATION DATA	START	END
ROUTE	-	-
SECTION	1	1
DRAWING km DISTANCE	6.583	8.00
DRAWING TYPE	ROADS - LAYOUTS	
BRIDGE/STRUCTURE No.	N/A	
CONSULTANT DRAWING No.	- SNA-TP1506-D01	VER B

GEOMETRIC LAYOUT AND DRAINAGE
km 8.00 TO km 10.00



SETTING OUT DATA - PERMANENT ROAD (Lo31°)

NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC13	8046.591	88643.416	2781434.631				
PI 13		88657.747	2781420.204	50.0	44°15'50"	20.335	38.628
EC13	8087.219	88657.940	2781399.870				
BC14	8220.812	88658.208	2781266.283				
PI 14		88650.382	2781248.053	80.0	25°40'29"	18.230	35.849
EC14	8256.661	88651.640	2781231.548				
BC15	8288.993	88637.909	2781202.277				
PI 15		88635.287	2781196.688	60.0	11°44'58"	6.174	12.304
EC15	8301.297	88633.858	2781190.682				
BC16	8375.866	88616.601	2781118.137				
PI 16		88612.263	2781101.963	50.0	36°47'00"	16.625	32.100
EC16	8407.966	88619.356	2781086.706				
BC17	8429.965	88628.094	2781066.517				
PI 17		88631.287	2781059.138	50.0	18°18'15"	8.040	15.944
EC17	8445.909	88632.006	2781051.130				

SETTING OUT DATA - PERMANENT ROAD (Lo31°)

NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC18	8529.880	88638.516	2780967.507				
PI 18		88640.656	2780954.816	50.0	28°35'36"	12.742	24.952
EC18	8554.583	88635.583	2780943.128				
BC19	8571.464	88628.956	2780927.860				
PI 19		88624.823	2780918.336	50.0	23°27'43"	10.383	20.474
EC19	8591.938	88624.823	2780907.953				
BC20	8697.842	88624.823	2780802.049				
PI 20		88624.823	2780784.148	60.0	33°13'30"	17.901	34.793
EC20	8732.635	88634.632	2780769.173				
BC21	8786.797	88665.405	2780722.192				
PI 21		88690.421	2780684.000	70.0	66°13'38"	45.656	80.912
EC21	8869.709	88735.457	2780691.498				
BC22	8997.392	88861.407	2780712.486				
PI 22		88928.301	2780723.277	40.0	117°25'22"	65.818	81.977
EC22	9074.621	88907.216	2780665.259				

SETTING OUT DATA - PERMANENT ROAD (Lo31°)

NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC23	9211.966	88865.115	2780534.542				
PI 23		88856.810	2780508.836	150.0	20°20'52"	26.919	53.271
EC23	9265.237	88857.927	2780482.040				
BC24	9824.602	88881.131	2779923.157				
PI 24		88882.025	2779901.628	200.0	12°17'54"	21.547	42.929
EC24	9867.531	88887.484	2779880.784				

POSITION OF GUARDRAILS

LEFT			RIGHT		
START	END	LENGTH	START	END	LENGTH
m	m	m	m	m	m
8030	8080	50	8720	8910	190
8160	8400	240	8970	10230	1260
8970	9020	50			

NOTE
GUARDRAIL LENGTHS AS LISTED ABOVE EXCLUDE THE LENGTH OF APPROACH AND DEPARTURE TAPERS (11.430m) TERMINAL SECTIONS)

ISSUED FOR TENDER PURPOSES, ONLY

No.	DATE	REVISION	CONSULT. ENG.
B	08-04-2016	ALIGNMENT AMENDED FROM km 9.00 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

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DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	A. van der WALT
CHECKED BY	G. B. HART

CONSULTANT APPROVAL
Name G.B.HART
Prof. Reg. No. 740874
Date 11-02-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING

DRA Mining (Pty) Ltd
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P.O Box 3567, Rivonia 2128
Tel: 0027 11 202 8600 Fax: 0027 11 202 8807
dra@drasa.co.za
NORTHAM

APPROVAL
DRA CIVIL PROJECT ENG. Date
DRA PROJECT MANAGER Date
CLIENT PROJECT MANAGER Date

ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
for CEO: DRA Mining (Pty) Ltd Date

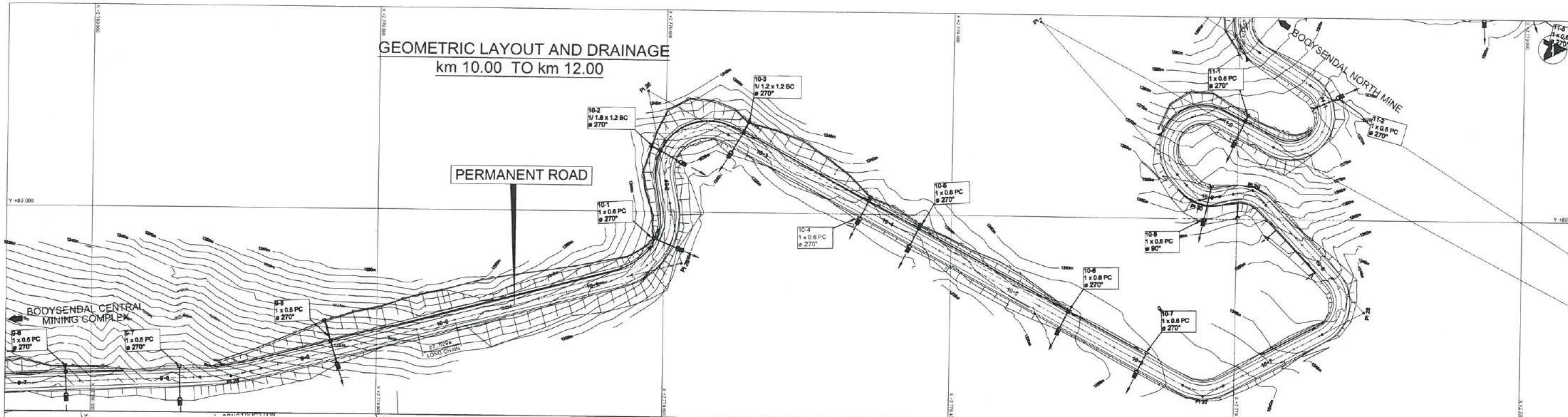
PROJECT DESCRIPTION
CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

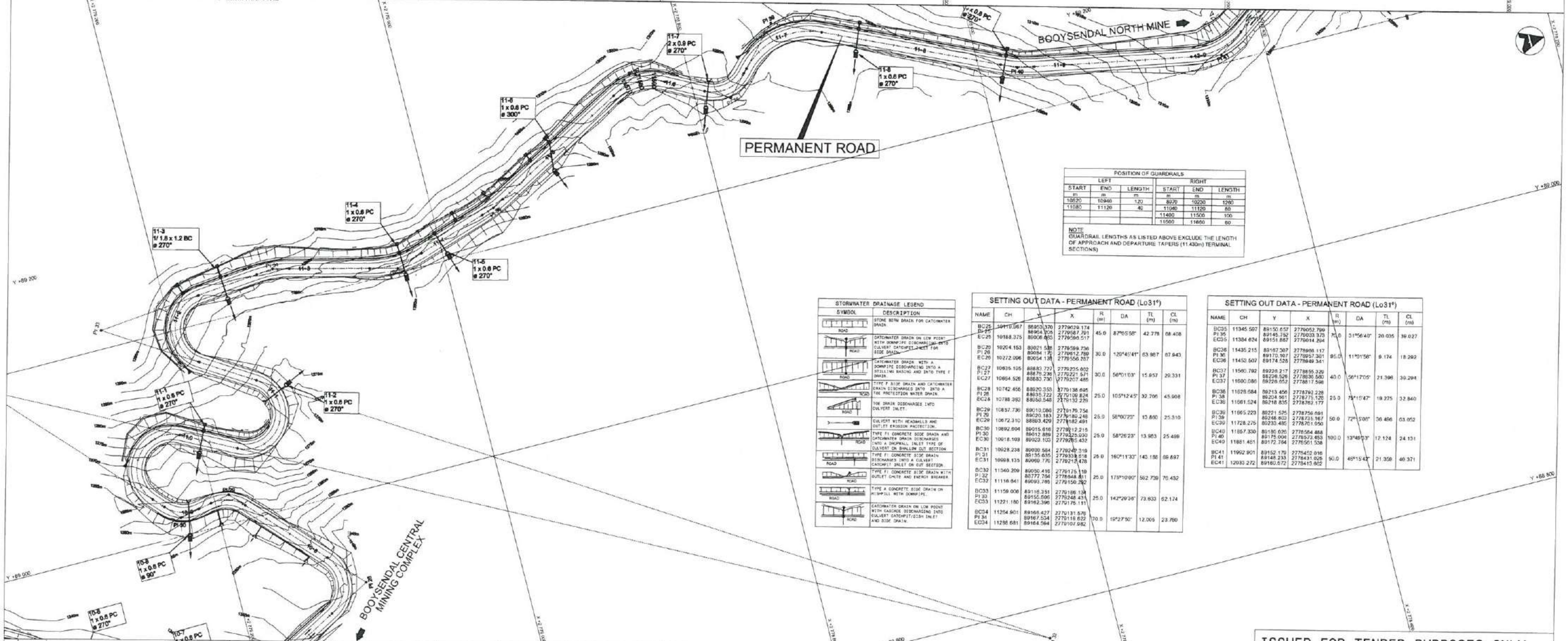
DRAWING DESCRIPTION
GEOMETRIC LAYOUT AND DRAINAGE km 8.00 to km 10.00

SCALE: 1:1000 (A0 SHEET) SHEET 2 OF 4

DRA PROJECT NUMBER	JZASM 0413-11-507		
DRAWING LOCATION DATA	START	END	
ROUTE	-	-	
SECTION	1	1	
DRAWING km DISTANCE	8.00	10.00	
DRAWING TYPE	ROADS - LAYOUTS		
BRIDGE/STRUCTURE No.	N/A		
CONSULTANT DRAWING No.	FA	SNA-TP1506-D02	VER B

GEOMETRIC LAYOUT AND DRAINAGE
km 10.00 TO km 12.00





POSITION OF GUARDRAILS					
LEFT			RIGHT		
START	END	LENGTH	START	END	LENGTH
m	m	m	m	m	m
10520	10640	120	8970	10230	1260
11080	11120	40	11040	11120	80
			11400	11500	100
			11600	11660	60

NOTE
GUARDRAIL LENGTHS AS LISTED ABOVE EXCLUDE THE LENGTH OF APPROACH AND DEPARTURE TAPERS (11.430m) TERMINAL SECTIONS)

STORMWATER DRAINAGE LEGEND	
SYMBOL	DESCRIPTION
ROAD	STONE BERM DRAIN FOR CATCHWATER DRAIN.
ROAD	CATCHWATER DRAIN ON LOW POINT WITH DOWNPIPE DISCHARGING INTO CULVERT CATCHPIT INLET FOR SIDE DRAIN.
ROAD	CATCHWATER DRAIN WITH A DOWNPIPE DISCHARGING INTO A STILLING BASING AND INTO TYPE F DRAIN.
ROAD	TYPE F SIDE DRAIN AND CATCHWATER DRAIN DISCHARGES INTO INTO A TOE PROTECTION WATER DRAIN.
ROAD	TOE DRAIN DISCHARGES INTO CULVERT INLET.
	CULVERT WITH HEADWALLS AND OUTLET EROSION PROTECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN AND CATCHWATER DRAIN DISCHARGES INTO A DROPWALL INLET TYPE OF CULVERT ON SHALLOW CUT SECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN DISCHARGES INTO A CULVERT CATCHPIT INLET ON CUT SECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN WITH OUTLET CHUTE AND ENERGY BREAKER.
ROAD	TYPE A CONCRETE SIDE DRAIN ON HIGHFILL WITH DOWNPIPE.
ROAD	CATCHWATER DRAIN ON LOW POINT WITH CASCADE DISCHARGING INTO CULVERT CATCHPIT/DISH INLET AND SIDE DRAIN.

SETTING OUT DATA - PERMANENT ROAD (Lo31°)

NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC25 PI 25 EC25	10119.967 10188.375	88953.370 88964.205 89008.083	2779629.174 2779587.791 2779580.517	45.0	87°05'58"	42.778	68.408
BC26 PI 26 EC26	10204.153 10272.096	89021.538 89084.170 89054.138	2779599.736 2779612.789 2779556.287	30.0	129°45'41"	63.987	67.943
BC27 PI 27 EC27	10635.195 10664.526	88883.727 88876.238 88883.706	2779235.882 2779221.571 2779207.485	30.0	56°01'03"	15.957	29.331
BC28 PI 28 EC28	10742.456 10788.383	88920.353 88935.722 88958.546	2779138.695 2779109.824 2779132.229	25.0	105°12'45"	32.706	45.908
BC29 PI 29 EC29	10857.736 10872.310	89010.086 89020.183 88883.429	2779179.754 2779189.248 2779182.491	25.0	58°00'23"	13.860	25.310
BC30 PI 30 EC30	10892.604 10918.103	89015.618 89012.889 89023.103	2779212.216 2779225.930 2779265.432	25.0	58°26'23"	13.983	25.499
BC31 PI 31 EC31	10928.238 10998.135	89030.584 89135.635 89060.770	2779247.319 2779339.618 2779212.478	25.0	160°11'33"	143.186	69.897
BC32 PI 32 EC32	11040.209 11116.641	89050.416 88777.784 89093.785	2779175.119 2778648.811 2779150.292	25.0	175°10'00"	592.739	76.432
BC33 PI 33 EC33	11159.006 11221.180	89116.351 89155.806 89162.396	2779186.134 2779248.431 2779175.111	25.0	142°29'38"	73.633	62.174
BC34 PI 34 EC34	11264.901 11288.681	89166.427 89167.534 89164.594	2779131.576 2779119.622 2779107.982	70.0	19°27'50"	12.005	23.780

SETTING OUT DATA - PERMANENT ROAD (Lo31°)

NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC35 PI 35 EC35	11345.597 11384.624	89150.657 89145.752 89151.867	2779052.799 2779033.373 2779014.294	70.0	31°56'40"	20.035	39.027
BC36 PI 36 EC36	11435.215 11453.507	89167.307 89170.107 89174.528	2778966.117 2778957.381 2778949.341	95.0	11°01'56"	9.174	18.292
BC37 PI 37 EC37	11560.792 11600.086	89226.217 89236.526 89226.652	2778855.329 2778836.580 2778817.598	40.0	56°17'05"	21.398	39.294
BC38 PI 38 EC38	11628.684 11661.524	89213.456 89204.961 89218.835	2778792.228 2778775.128 2778762.177	25.0	75°15'47"	19.275	32.840
BC39 PI 39 EC39	11665.223 11728.275	89221.575 89248.603 89233.485	2778759.691 2778735.167 2778701.950	50.0	72°15'06"	36.496	63.052
BC40 PI 40 EC40	11857.330 11881.461	89180.026 89175.004 89172.784	2778584.488 2778573.453 2778561.538	100.0	13°49'33"	12.124	24.131
BC41 PI 41 EC41	11992.901 12033.272	89152.179 89148.233 89160.672	2778452.016 2778431.025 2778413.862	50.0	46°15'42"	21.359	40.371

ISSUED FOR TENDER PURPOSES ONLY

No.	DATE	REVISION	CONSULT. ENG.
B	06-04-2016	ALIGNMENT AMENDED FROM km 9.00 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

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DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	A.van der WALT
CHECKED BY	G. B. HART

CONSULTANT APPROVAL
Name G B HART
Prof. Reg. No. 74002x
Date 11-02-2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

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NORTHAM

APPROVAL
DRA CIVIL PROJECT ENG. Date
DRA PROJECT MANAGER Date
CLIENT PROJECT MANAGER Date

ACCEPTANCE
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for CEO: DRA Mining (Pty) Ltd
Date

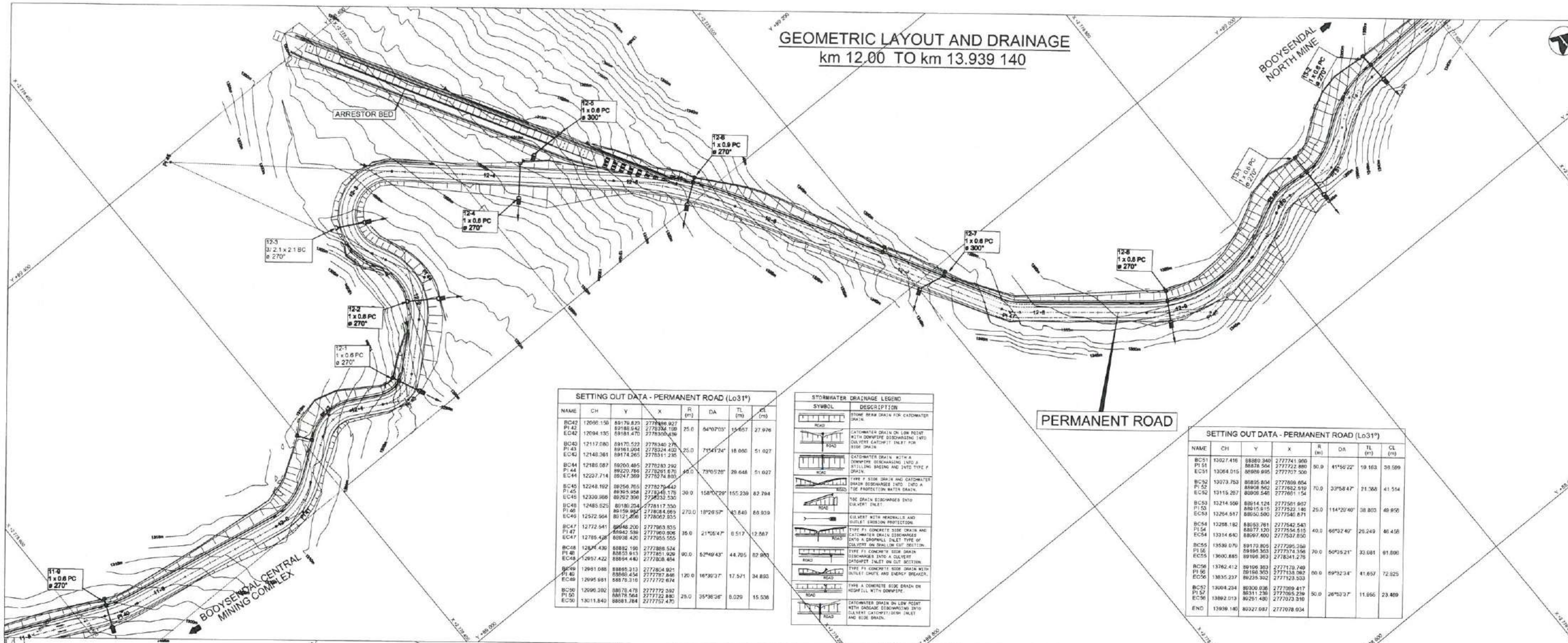
PROJECT DESCRIPTION
CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

DRAWING DESCRIPTION
GEOMETRIC LAYOUT AND DRAINAGE
km 10.00 to km 12.00

SCALE : 1 : 1000 (A0 SHEET)   SHEET 3 OF 4

DRA PROJECT NUMBER	JZASM 0413-11-507		
DRAWING LOCATION DATA	START	END	
ROUTE	-	-	
SECTION	1	1	
DRAWING km DISTANCE	10.00	12.00	
DRAWING TYPE	ROADS - LAYOUTS		
BRIDGE/STRUCTURE No.	N/A		
CONSULTANT DRAWING No.	FA	SNA-TP1506-D03	VER B

GEOMETRIC LAYOUT AND DRAINAGE
km 12.00 TO km 13.939 140



SETTING OUT DATA - PERMANENT ROAD (Lo31°)							
NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC42 PI 42 EC42	12066.158 12094.135	89179.823 89188.942 89181.470	2778386.927 2778374.159 2778360.439	25.0	64°07'03"	15.657	27.976
BC43 PI 43 EC43	12117.080 12148.361	89170.522 89161.904 89174.265	2778340.276 2778324.403 2778311.235	25.0	71°41'24"	18.000	51.027
BC44 PI 44 EC44	12186.087 12237.714	89200.495 89220.786 89247.369	2778283.292 2778261.676 2778274.803	40.0	73°05'28"	29.648	51.027
BC45 PI 45 EC45	12248.192 12330.986	89256.765 89395.958 89292.396	2778279.442 2778349.176 2778232.530	30.0	158°07'29"	155.239	82.794
BC46 PI 46 EC46	12485.625 12572.564	89189.234 89159.982 89121.896	2778117.330 2778084.665 2778062.835	270.0	18°26'57"	43.849	86.939
BC47 PI 47 EC47	12772.541 12785.428	88948.200 88942.539 88936.420	2777963.835 2777960.806 2777955.555	35.0	21°05'47"	6.517	12.887
BC48 PI 48 EC48	12874.439 12957.422	88882.196 88853.913 88864.449	2777888.574 2777851.929 2777808.484	90.0	52°49'43"	44.705	82.983
BC49 PI 49 EC49	12961.088 12995.981	88865.313 88869.454 88876.316	2777804.921 2777787.846 2777772.674	120.0	16°39'37"	17.571	34.893
BC50 PI 50 EC50	12996.302 13011.840	88876.479 88878.564 88881.784	2777772.397 2777722.880 2777757.470	25.0	35°36'36"	8.029	15.536

STORMWATER DRAINAGE LEGEND	
SYMBOL	DESCRIPTION
ROAD	STONE BERM DRAIN FOR CATCHWATER DRAIN.
ROAD	CATCHWATER DRAIN ON LOW POINT WITH DOWNPIPE DISCHARGING INTO CULVERT CATCHPIT INLET FOR SIDE DRAIN.
ROAD	CATCHWATER DRAIN WITH A DOWNPIPE DISCHARGING INTO A STILLING BASING AND INTO TYPE F DRAIN.
ROAD	TYPE F SIDE DRAIN AND CATCHWATER DRAIN DISCHARGES INTO INTO A TOE PROTECTION WATER DRAIN.
ROAD	TOE DRAIN DISCHARGES INTO CULVERT INLET.
	CULVERT WITH HEADWALLS AND OUTLET EROSION PROTECTION.
ROAD	TYPE F1 CONCRETE SIDE DRAIN AND CATCHWATER DRAIN DISCHARGES INTO A DROPWALL INLET TYPE OF CULVERT ON SHALLOW CUT SECTION.
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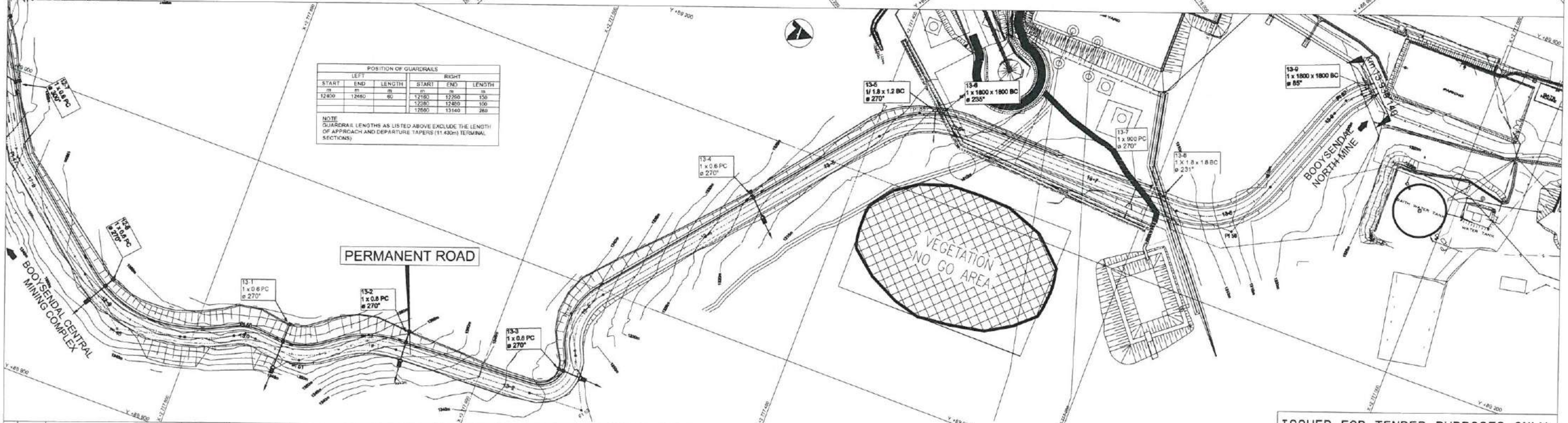
ROAD	CATCHWATER DRAIN ON LOW POINT WITH CASCADE DISCHARGING INTO CULVERT CATCHPIT/DISH INLET AND SIDE DRAIN.

SETTING OUT DATA - PERMANENT ROAD (Lo31°)							
NAME	CH	Y	X	R (m)	DA	TL (m)	CL (m)
BC51 PI 51 EC51	13027.416 13064.015	88880.340 88878.564 88889.895	2777741.980 2777722.880 2777707.500	50.0	41°56'22"	19.163	36.599
BC52 PI 52 EC52	13073.753 13115.267	88895.804 88908.562 88908.548	2777699.654 2777682.519 2777661.154	70.0	33°58'47"	21.388	41.514
BC53 PI 53 EC53	13214.559 13264.517	88914.124 88915.915 88950.500	2777561.967 2777523.146 2777540.871	25.0	114°29'40"	38.803	49.958
BC54 PI 54 EC54	13268.182 13314.640	88053.761 88977.120 88997.400	2777542.543 2777554.515 2777537.850	40.0	66°32'49"	26.249	46.458
BC55 PI 55 EC55	13539.079 13600.885	89170.805 89198.363 89196.363	2777395.358 2777374.356 2778341.276	70.0	50°35'21"	33.081	61.806
BC56 PI 56 EC56	13762.412 13835.237	89196.383 89198.363 89235.392	2777179.749 2777138.092 2777123.533	60.0	69°32'34"	41.657	72.825
BC57 PI 57 EC58	13904.234 13892.013	89300.036 89311.239 89251.480	2777089.417 2777095.239 2777073.310	50.0	26°53'37"	11.956	23.469
END	13939.140	89327.087	2777078.034				



POSITION OF GUARDRAILS					
LEFT			RIGHT		
START	END	LENGTH	START	END	LENGTH
m	m	m	m	m	m
12400	12460	60	12160	12290	130
			12380	12480	100
			12880	13140	260

NOTE
GUARDRAIL LENGTHS AS LISTED ABOVE EXCLUDE THE LENGTH OF APPROACH AND DEPARTURE TAPERS (11.430m) TERMINAL SECTIONS)

ISSUED FOR TENDER PURPOSES ONLY

No.	DATE	REVISION	CONSULT. ENG.
D	07-08-2016	DRAINAGE AMENDED FROM km 13.580 TO km 13.939	G.B. HART
C	11-05-2016	CULVERT 13-5 AND 13-6 AMENDED	G.B. HART
B	08-04-2016	ALIGNMENT AMENDED FROM km 9.00 TO km 10.00	G.B. HART
A	04-04-2016	ISSUED FOR TENDER	G.B. HART

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DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	A.van der WALT
CHECKED BY	G. B. HART

CONSULTANT APPROVAL
Name G.B.HART
Prof. Reg. No. 740074
Date 11-02-2016
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Date DRA PROJECT MANAGER
Date CLIENT PROJECT MANAGER

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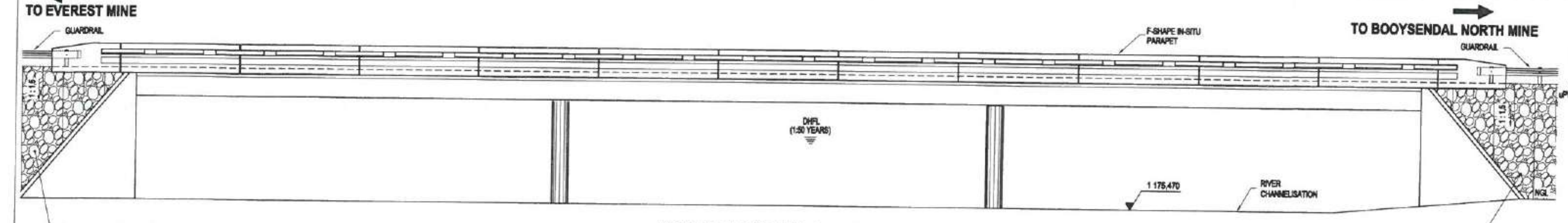
for CEO: DRA Mining (Pty) Ltd
Date

PROJECT DESCRIPTION
CONSTRUCTION OF PERMANENT ACCESS ROAD FROM EVEREST MINE TO BOOYSENDAL NORTH MINE

DRAWING DESCRIPTION
GEOMETRIC LAYOUT AND DRAINAGE
km 12.00 to km 13.939 140

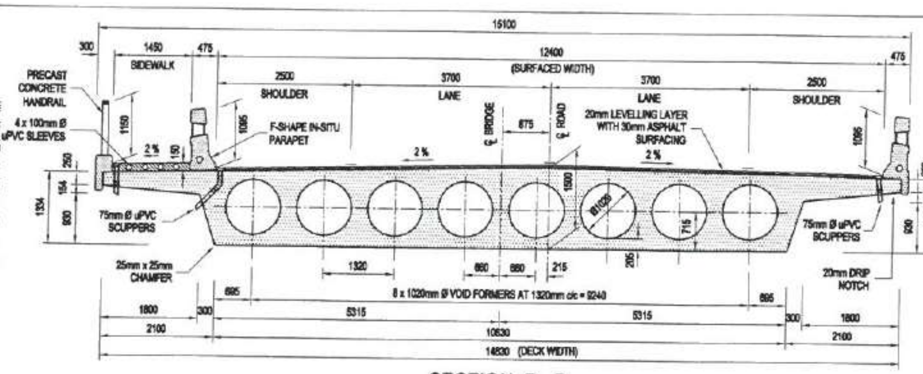
SCALE : 1 : 1000 (A0 SHEET) SHEET 4 OF 4

DRA PROJECT NUMBER	JZASM 0413-11-507		
DRAWING LOCATION DATA	START	END	
ROUTE	-	-	
SECTION	1	1	
DRAWING km DISTANCE	12.00	13.939	
DRAWING TYPE	ROADS - LAYOUTS		
BRIDGE/STRUCTURE No.	N/A		
CONSULTANT DRAWING No.	FA	SNA-TP1506-D04	VER D



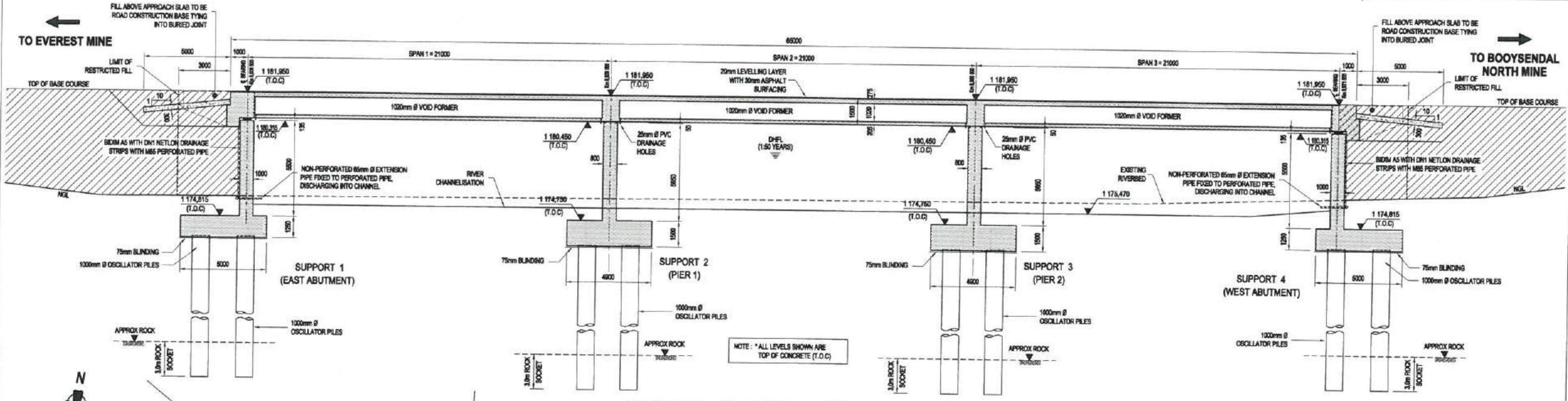
OUTLET ELEVATION OF BRIDGE

SCALE 1 : 100



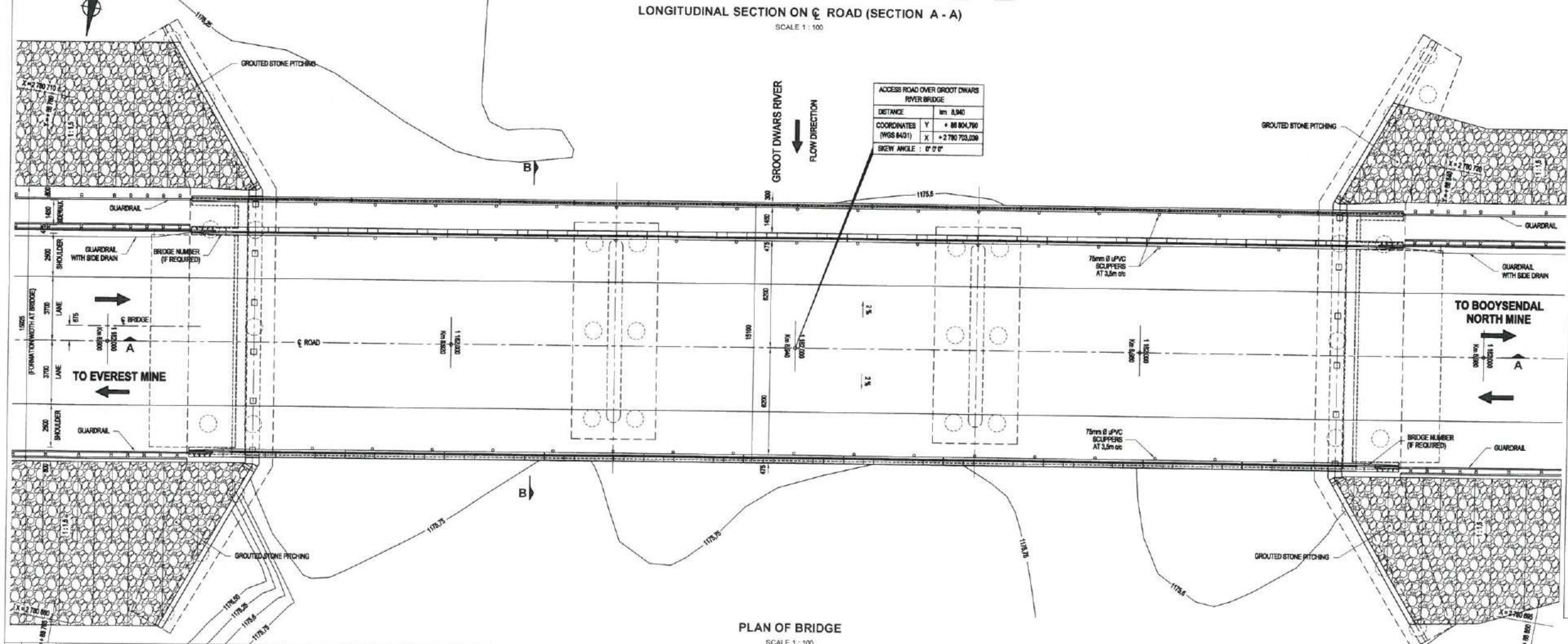
SECTION B - B

SCALE 1 : 50



LONGITUDINAL SECTION ON ℄ ROAD (SECTION A - A)

SCALE 1 : 100



PLAN OF BRIDGE

SCALE 1 : 100

GENERAL NOTES

1.0 DESCRIPTION:

THE SUBSTRUCTURE CONSISTS OF TWO WALL TYPE REINFORCED CONCRETE PIERS AND WALL TYPE ABUTMENTS WITH SPLAYED WINGWALLS. THE PIERS AND ABUTMENTS ARE SUPPORTED ON PILECAPS AND FOUNDED ON 1 000mm dia OSCILLATOR PILES.

THE SUPERSTRUCTURE CONSISTS OF THREE 21,0m SPANS. THE DECK COMPRISES OF AN IN-SITU REINFORCED CONCRETE VOID DECK. (1020mm Ø VOID FORMERS)

THE DECK IS PROVIDED WITH F-SHAPE INSITU CONCRETE PARAPETS AND 1,0m HIGH PRECAST CONCRETE HANDRAILING. 1,45m SIDEWALK FOR PEDESTRIANS IS PROVIDED ON THE SOUTHERN SIDE OF THE BRIDGE.

2.0 DESIGN CRITERIA:

2.1 THIS BRIDGE IS DESIGNED USING THE LIMIT STATE THEORY, IN ACCORDANCE WITH THE REQUIREMENTS OF TMH7, PART 3 (1989)

2.2 LOAD STATEMENT
THIS BRIDGE HAS BEEN DESIGNED FOR SNABC TRAFFIC LOADING IN ACCORDANCE WITH TMH7, PARTS 1 & 2 (AS AMENDED 1988) "CODE OF PRACTICE FOR THE DESIGN OF HIGHWAY BRIDGES AND CULVERTS IN SOUTH AFRICA".
THE F SHAPE PARAPET IS DESIGNED FOR THE LOADING FOR A CLASS I PARAPET
THE PRECAST CONCRETE HANDRAIL IS DESIGNED FOR 1,5kN/m LATERAL LOADING.
THE BELL B30D DUMPTRUCK LOADING IS A SUBSET OF THE SNABC TRAFFIC LOADING.

3.0 STRUCTURAL ANALYSIS AND PARAMETERS:

3.1 THE STRUCTURE HAS BEEN DESIGNED USING ELASTIC ANALYSIS AND THE LIMIT STATE APPROACH IN ACCORDANCE WITH TMH7, PART 3.
DECK ANALYSIS

3.2 DESIGN PARAMETERS.
- 3.2.1 YOUNG'S MODULUS FOR:
  - 3.2.1.1 CONCRETE 30MPa = 28 GPa
  - 3.2.1.2 CONCRETE 40MPa = 31 GPa
  - 3.2.1.3 CONCRETE 50MPa = 34 GPa
  - 3.2.1.4 STEEL REINFORCEMENT = 200 GPa
- 3.2.2 COEFFICIENT OF EXPANSION OF CONCRETE = 12×10^{-6} per degree cent
- 3.2.3 SHRINKAGE FACTOR = 250×10^{-6} / m
- 3.2.4 A LINEAR SOIL PRESSURE DISTRIBUTION IS ASSUMED.
- 3.2.5 DECK DESIGNED AS SEMI-INTEGRAL k* = 6.6

4.0 QUALITY OF MATERIALS:

4.1 CHARACTERISTIC STRENGTH OF MATERIALS

4.1.1 CONCRETE

NORMAL CONCRETE :

MEMBER	CHARACTERISTIC STRENGTH (MPa)	CONCRETE CLASS (MPa/mm)
SCREED	15	15/19
FOUNDATIONS	30	30/19
PILECAPS	30	30/19
APPROACH SLABS	30	30/19

DURABILITY CONCRETE :

ABUTMENTS & WINGWALLS	30	W-30/19
PIER	30	W-30/19
INSITU DECK	30	W-30/19
PARAPETS	40	W-40/19
HANDRAILING	40	W-40/13

4.1.2 STEEL REINFORCEMENT
ALL STEEL REINFORCEMENT MUST CONFORM TO ALL THE REQUIREMENTS OF THE LATEST REVISION OF SANS 920.

4.2 FOUNDATIONS
4.2.1 THE BRIDGE IS FOUNDED BY MEANS OF PILES.

4.3 BEARINGS : ELASTOMERIC BEARING PADS - 350 x 450 x 84mm.

4.4 EXPANSION JOINTS : BURIED TYPE JOINTS.

5.0 LIMITING CRITERIA:

- 5.1 INTERNAL FRICTION ANGLE OF SOIL = 30°
- 5.2 EARTH FILL DENSITY = 20 kN/m³.
- 5.3 REINFORCED CONCRETE DENSITY = 24 kN/m³.
- 5.4 INTEGRAL DESIGN K*VALUE = 6.6

6.0 CONSTRUCTION :

6.1 FORMWORK AND FINISHES TO FORMED (F) AND UNFORMED (U) SURFACES:
- 6.1.1 FOUNDATIONS : F1 U2
- 6.1.2 ABUTMENTS (BURIED) : F1 U2
- 6.1.3 ABUTMENTS (EXPOSED) : F2 U2
- 6.1.4 PIER : F2 U2
- 6.1.5 DECK : F2 U2
- 6.1.6 PARAPETS : F3 U2
- 6.1.7 HANDRAIL : F3 U2
- 6.1.8 ALL EXTERNAL CORNERS TO BE CHAMFERED 25mm x 25mm.

6.2 COVER TO STEEL REINFORCEMENT
- 6.2.1 FOUNDATIONS : BOTTOM = 75mm
  : SIDES & TOP = 60mm
- 6.2.2 PILECAPS : BOTTOM = 75mm
  : SIDES & TOP = 50mm
- 6.2.3 ABUTMENTS & WINGWALLS = 50mm
- 6.2.4 PIER = 50mm
- 6.2.5 DECK = 50mm
- 6.2.6 F-SHAPE PARAPETS = 35mm
- 6.2.7 EDGE BEAM FOR HANDRAIL = 40mm
- 6.2.8 VOID FORMERS = 25mm

7.0 HYDRAULICS :

- 7. 1 MEAN ANNUAL PRECIPITATION = mm
- 7. 2 CATCHMENT AREA = km²
- 7. 3 1:20 YEAR PEAK DISCHARGE (Q20) = m³/s
- 7. 4 DESIGN RETURN PERIOD FLOOD INTERVAL(T) = 1:50 year
- 7. 5 DESIGN PEAK DISCHARGE (DPD) = m³/s
- 7. 6 PEAK DISCHARGE (Q2T) = m³/s
- 7. 7 REGIONAL MAXIMUM FLOOD (RMF) = m³/s
- 7. 8 AVERAGE SLOPE =
- 7. 9 NATURAL DESIGN FLOOD LEVEL (NDFL) = m
- 7. 10 HIGHEST KNOWN FLOOD LEVEL (HKFL) =
- 7. 11 NATURAL DESIGN FLOW DEPTH (NDFD) = m
- 7. 12 NATURAL DESIGN FLOW VELOCITY (Vn) = m/s
- 7. 13 BACKWATER (h) = m
- 7. 14 DESIGN HIGH FLOOD LEVEL (DHFL) = m
- 7. 15 Q2T FLOOD LEVEL = m
- 7. 16 RMF FLOOD LEVEL = m
- 7. 17 DESIGN FLOW VELOCITY (Vn2) = m/s
- 7. 18 REQUIRED MINIMUM FREEBOARD = m
- 7. 19 DESIGN FREEBOARD = m

No.	DATE	REVISION	CONSULT. ENG.
A	16-03-2016	ISSUED FOR INFORMATION ONLY	K.G. MALCOMSON

SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD
REG NO 2005/006128/07
P. O. Box 72727
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SNAVIA BUILDING
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LA MONTAGNE
Tel:- 012-842 0000
Fax:- 012-803 4429
e-mail - pta@sna.co.za

DESIGNED BY	M. CHRISTODOULOU
CHECKED BY	K. G. MALCOMSON
DRAWN BY	M. ASHMAN
CHECKED BY	M. CHRISTODOULOU

CONSULTANT APPROVAL
Name: K.G. MALCOMSON
Prof. Reg. No: 880540
Date: 16/03/2016

THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

DRA Mining (Pty) Ltd
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Fax: 0027 11 202 8807
dra@draas.co.za

NORTHAM

ACCEPTANCE

THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING

for CEO: DRA Mining (Pty) Ltd
Date

PROJECT DESCRIPTION

PERMANENT ROAD FROM
BOOYSENDAL CENTRAL MINING COMPLEX
TO BOOYSENDAL NORTH MINE

RIVER BRIDGE OVER THE GROOT DWARS RIVER AT km 8.940

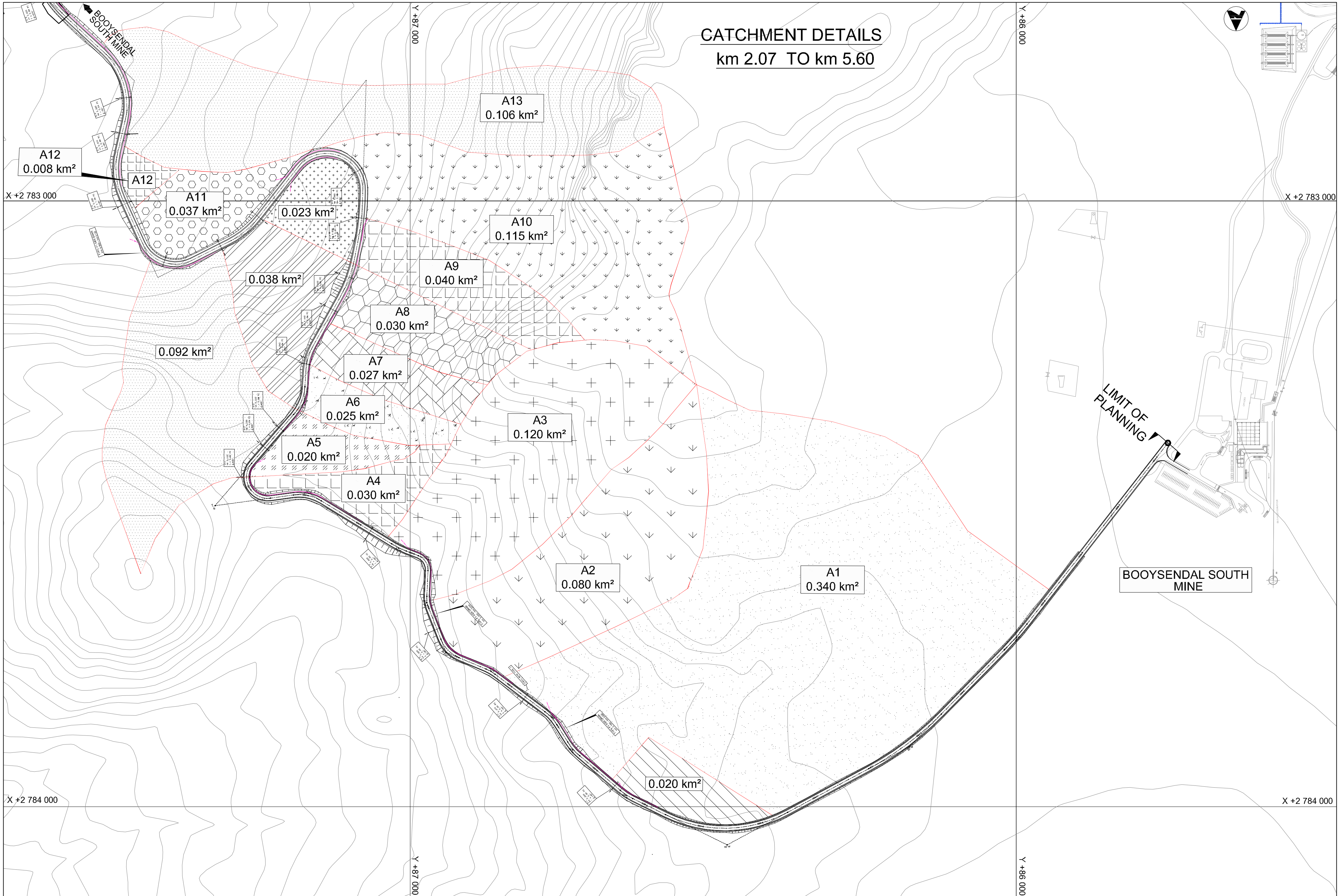
GENERAL ARRANGEMENT

SCALE : 1 : 100 ; 1 : 50

SHEET 1 OF 1

PROJECT NUMBER		
DRAWING LOCATION DATA	START	END
ROUTE	-	-
SECTION	1	1
DRAWING km DISTANCE	8.9081	8.9720
DRAWING TYPE	STRUCTURES - BRIDGES	
BRIDGE/STRUCTURE No.	N/A	
CONSULTANT DRAWING No.	FA	TP1506/B1/02

A



No.	DATE	REVISION	CONSULT. ENG.
A	16-08-2016	ISSUED FOR TENDER	G.B. HART

SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD

REG NO 2005/006128/07

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Fax:- 012-803 4429
e-mail - pta@sna.co.za

DESIGNED BY	R. VAN RENSBURG
CHECKED BY	G. B. HART
DRAWN BY	A. van der WALT
CHECKED BY	G. B. HART

CONSULTANT APPROVAL

Name : G.B.HART
Prof. Reg. No. 1740074
Date :

THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

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ACCEPTANCE

THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING

for CEO DRA Mining (Pty) Ltd
Date:

PROJECT DESCRIPTION

PERMANENT ROAD FROM
BOOYSENDAL SOUTH MINE TO BOOYSENDAL NORTH MINE

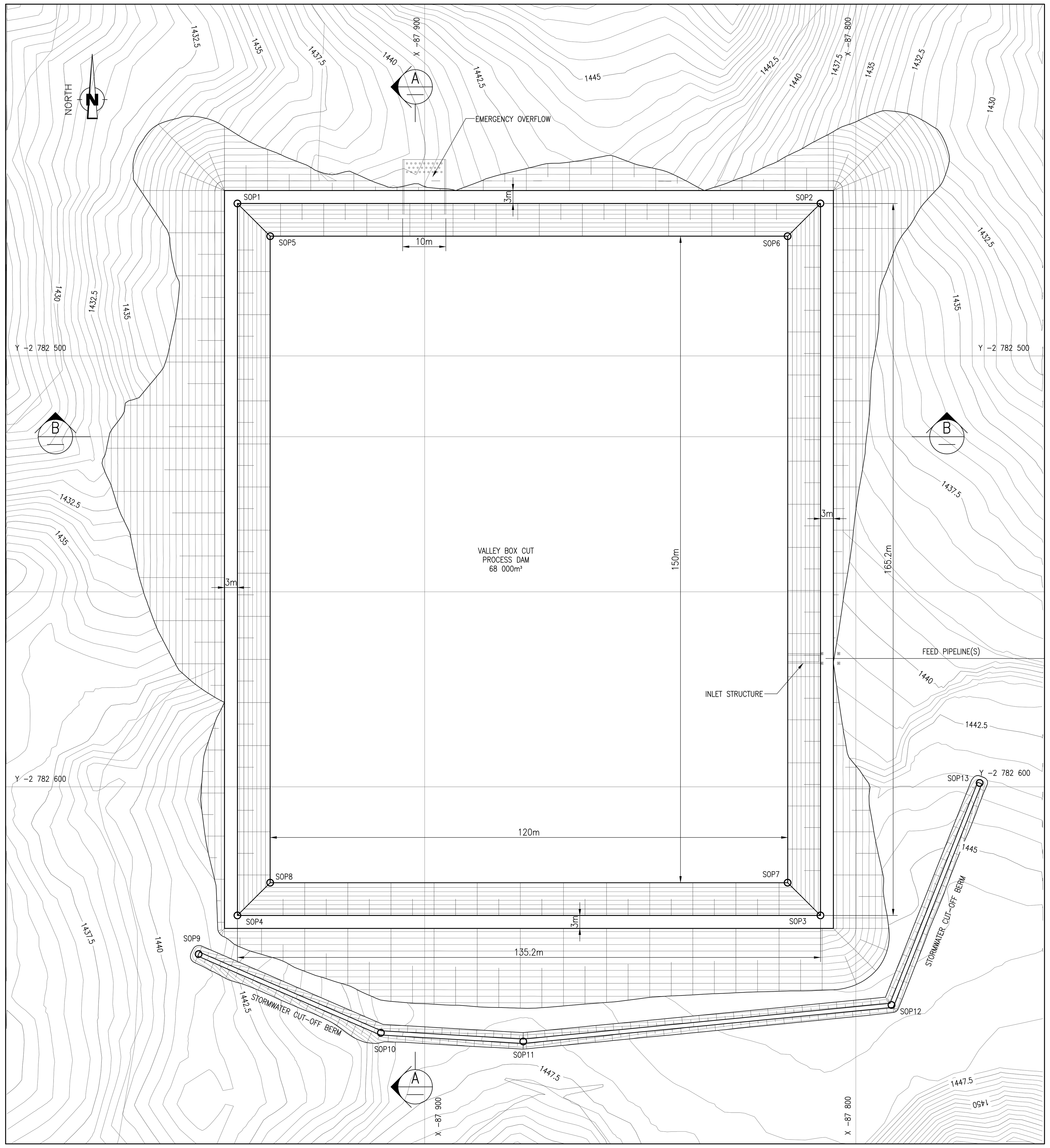
DRAWING DESCRIPTION

CATCHMENT DETAILS
km 2.07 TO 5.60

SCALE : 1 : 2000 (A0 SHEET)   SHEET 1 OF 11

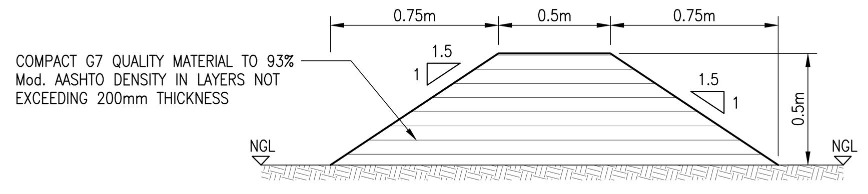
PROJECT NUMBER	-	
DRAWING LOCATION DATA	START	END
ROUTE	-	
SECTION	-	
DRAWING km DISTANCE	-	
DRAWING TYPE	CATCHMENT DETAILS	
BRIDGE/STRUCTURE No.	-	
CONSULTANT DRAWING No.	SNA-TP1506.2 & 3-R01	

COORDINATE LIST			
WGS84 Lo31			
EARTHWORKS SETTING OUT			
POINT	Y-COORD	X-COORD	ELEVATION
PROCESS DAM SETTING OUT			
SOP1	87943.410	2782464.630	1440.750
SOP2	87808.210	2782464.630	1440.750
SOP3	87808.210	2782629.830	1440.750
SOP4	87943.410	2782629.830	1440.750
SOP5	87935.810	2782472.230	1436.950
SOP6	87815.810	2782472.230	1436.950
SOP7	87815.810	2782622.230	1436.950
SOP8	87935.810	2782622.230	1436.950
STORMWATER CUT-OFF BERM SETTING OUT			
SOP9	87952.406	2782638.802	–
SOP10	87910.138	2782657.064	–
SOP11	87877.112	2782659.085	–
SOP12	87791.735	2782650.622	–
SOP13	87771.287	2782599.106	–



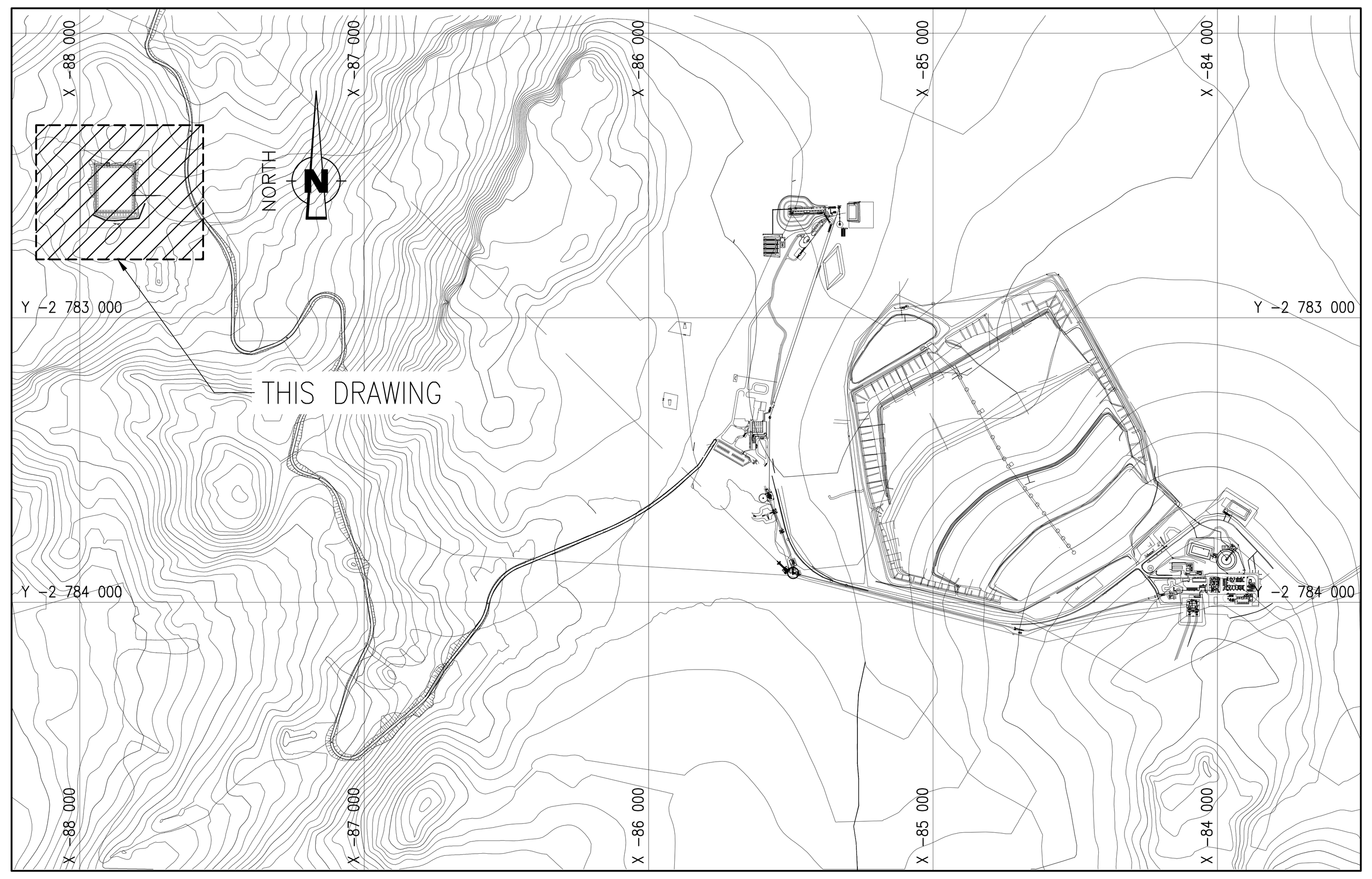
DAM LAYOUT

SCALE 1:500



TYPICAL CLEAN WATER CUT OFF BERM

SCALE 1:20

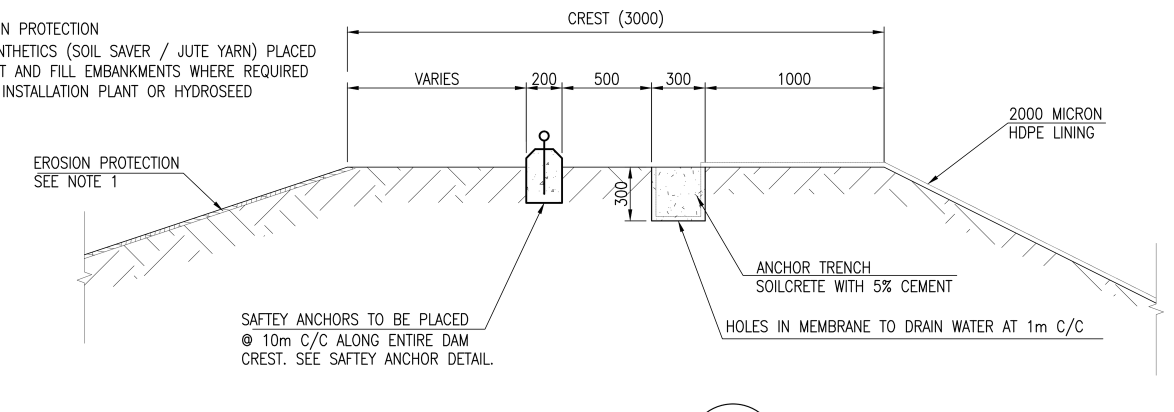


KEY PLAN

SCALE 1:15000

NOTES:

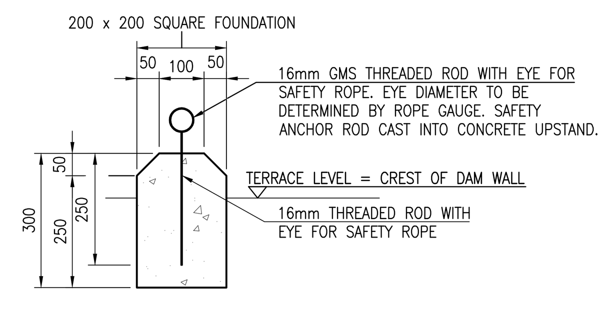
1. EROSION PROTECTION
   GEOSYNTHETICS (SOIL SAVER / JUTE YARN) PLACED ON CUT AND FILL EMBANKMENTS WHERE REQUIRED AFTER INSTALLATION PLANT OR HYDROSEED



TYPICAL DETAIL 1

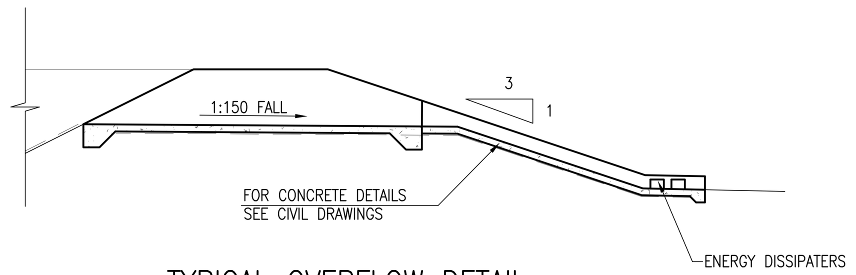
SCALE 1:25

NOTE:
SAFETY ANCHORS TO BE PLACED @ 10m C/C SPACING ALONG ENTIRE DAM CREST, OUTSIDE OF LINING ANCHOR AS SHOWN IN DETAIL 1
SAFETY ROPE, SPECIFICATIONS, SIZE AND INSTALLATION BY OTHERS



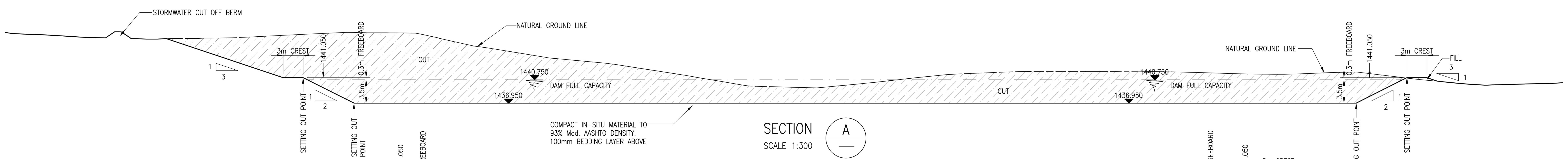
SAFETY ANCHOR DETAIL

SCALE 1:10

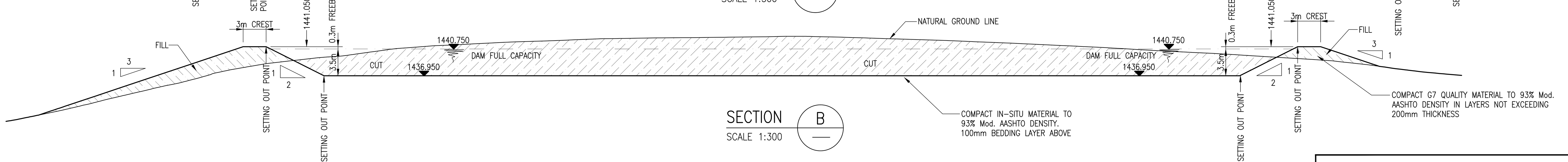


TYPICAL OVERFLOW DETAIL

SCALE 1:100



SECTION A
SCALE 1:300



SECTION B
SCALE 1:300

ISSUED FOR MEASUREMENT

THIS DRAWING IS NOT TO BE SCALED. ALL DISCREPANCIES ARE TO BE REPORTED TO THE DESIGN ENGINEER. ALL CONSTRUCTION ERRORS OR DEVIATIONS FROM THE DETAILS ARE TO BE RECTIFIED ONLY AFTER CONSULTATION WITH THE DESIGN ENGINEER OR IN HIS ABSENCE THE DESIGN OFFICE HEAD OF DEPARTMENT MUST BE CONSULTED.

REV.	BY	DATE	REVISIONS	CHK.	DATE	S.L.	DATE
B	TRS	12.07.16	ISSUED FOR SQUAD CHECK				
A	TRS	05.07.16	ISSUED FOR INTERNAL SQUAD CHECK				

DESIGN	REFERENCE DRAWINGS		REFERENCE DRAWINGS	
DESIGN REFERENCE	DRAWING NO.	DESCRIPTION	DRAWING NO.	DESCRIPTION

APPROVAL	SIGNATURE	DATE
CLIENT		
PROJ. MANAGER		
PROF. ENG.		
PROJECT ENG.		
PROCESS ENG.		
DESIGN ENG.		
SECT LEADER		
CHECKED		
DRAWN	TRS	05.07.2016

D5	Phase 2 – External Squad Check			Approved	Rejected	Appr. with corrections
	Stage Gate	I	80%			
	Discipline					
	Name	Signature	Date			
Proj. Engineer:						
Proj. Manager:						

PR. ENG. APPROVAL

NORTHAM
PLATINUM LIMITED

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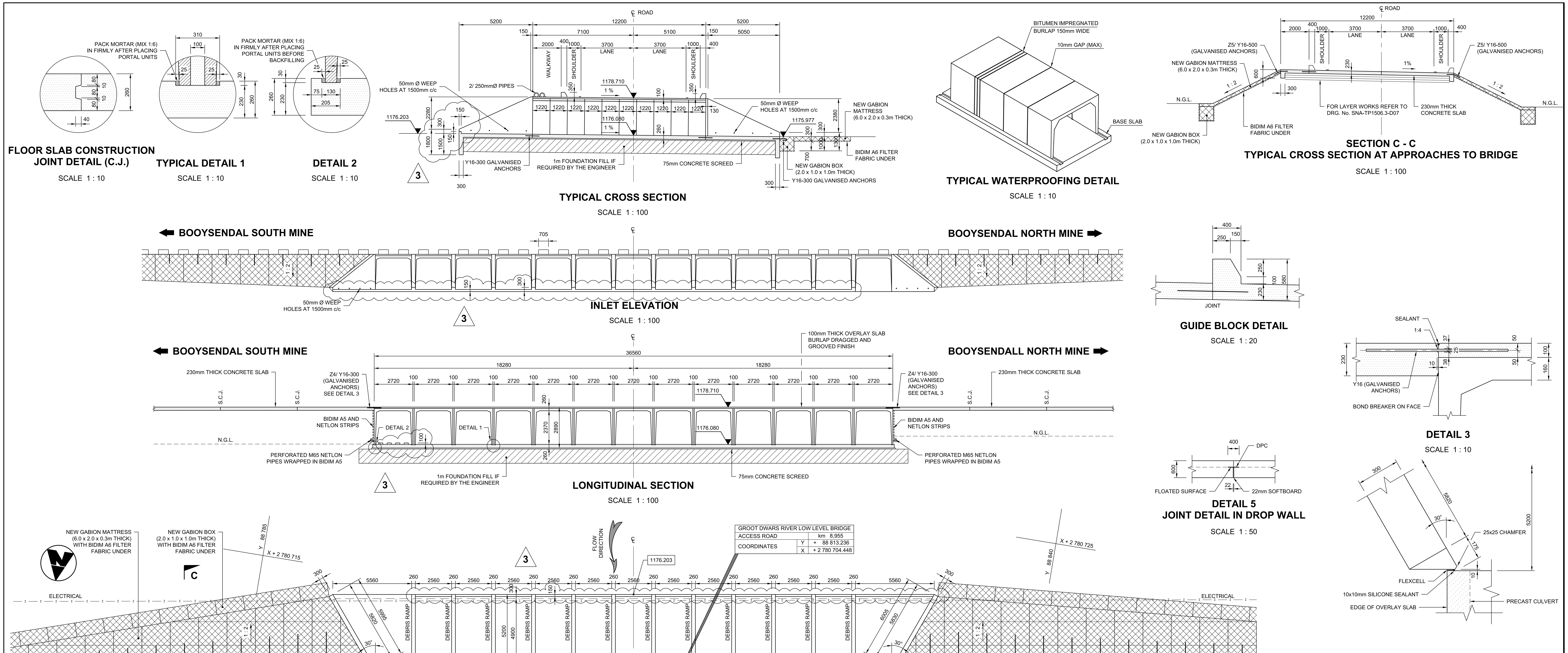
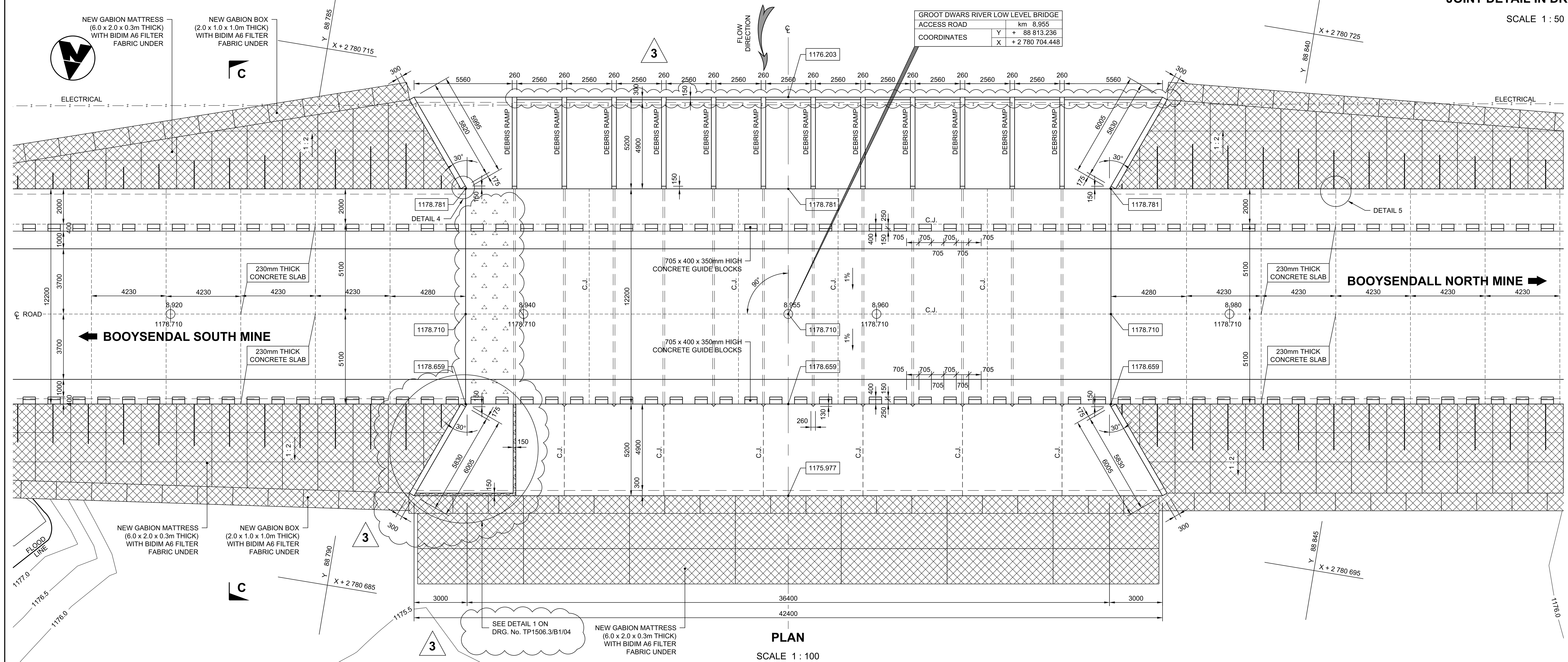
Telephone: +27 11 202 8600
www.DRAglobal.com
DRA PROJECTS SA (PTY) LTD

TITLE BOOYSENDAL SOUTH – EVEREST INFRASTRUCTURE
VALLEY BOX CUT PROCESS DAM
LAYOUT, SECTION AND DETAILS

A0	PROJECT DWG NO.	SHEET	REVISION	SCALE
	00413-IH-003-01	OF	B	A/S U.O.S.





GENERAL NOTES

1. DESCRIPTION
THE PROPOSED CULVERT CONSISTS OF 13/ 2.4m x 2.4m RECTANGULAR PORTAL PRECAST CULVERTS WITH A 260mm CAST INSITU FLOOR SLAB AND A 200mm CAST INSITU TOPPING. THE INLET AND OUTLET CONSISTS OF REINFORCED CONCRETE WINGWALLS SPLAYED AT 30°. THE INLET HAS DEBRIS RAMPS.

2. DESIGN CRITERIA
2.1 THE CULVERT HAS BEEN DESIGNED FOR THE LOADS SPECIFIED IN TMH 7 PARTS 1 AND 2 (AS AMENDED 1988)
LIVE LOAD : NA, NB36 AND NC30.
2.2 THE STRUCTURE HAS BEEN DESIGNED USING ELASTIC ANALYSIS AND THE LIMIT STATE APPROACH IN ACCORDANCE WITH TMH 7, PART 3.

3. STRUCTURAL ANALYSIS AND PARAMETERS
3.1 SOFTWARE PACKAGES USED FOR ANALYSIS AND DESIGN : PROKON
3.2 DENSITIES :
CONCRETE : 2500kg / m³
FILL MATERIAL : 2000kg / m³
3.3 LATERAL EARTH PRESSURE : 6.66 kPa/m
3.4 YOUNG'S MODULUS : CONCRETE (SHORT TERM) - 30MPa : 28GPa
STEEL REINFORCEMENT : 200GPa
3.5 STRESS DISTRIBUTION UNDER BASES : LINEAR

4.1. QUALITY OF MATERIALS
4.1 REINFORCING STEEL (TO SANS 920)
MILD STEEL : 250 MPa
HIGH YIELD STRESS STEEL : 450 MPa
4.2 CONCRETE:

MEMBERS	CLASS (MPa/mm)	CHARACTERISTIC STRENGTH (MPa)
FLOOR SLABS	30/20	30
DECK SLAB	30/20	30
WALLS	30/20	30
WINGWALLS	30/20	30
SCREED	15/20	15

4.3 FOUNDING MATERIAL :
4.4 ALLOWABLE BEARING PRESSURE : 150 kPa ON GROUND FILL

5. LIMITING CRITERIA
5.1 ACTUAL BEARING PRESSURE: 70 kPa
5.2 EARTH PRESSURE BEHIND WALLS:
DENSITY OF FILL: 2000 kg/m³
INTERNAL ANGLE OF FRICTION: 30°

6.0 CONSTRUCTION REQUIREMENTS
6.1 BACKFILLING MUST BE CARRIED OUT SIMULTANEOUSLY ON BOTH SIDES OF THE STRUCTURE AFTER THE DECKS HAVE BEEN CAST AND THE CONCRETE HAS ATTAINED A STRENGTH OF GREATER THAN 2/3 OF THE SPECIFIED 28 DAY CHARACTERISTIC STRENGTH. MAXIMUM LEVEL DIFFERENCE BETWEEN BACKFILL HEIGHT ON OPPOSITE SIDES MUST NOT EXCEED 1.0m.
6.2 FORMWORK AND SURFACE FINISH
(a) CLASS OF SURFACE FINISH SHOWN AS FOLLOWS:
F1 F2 U1 ETC.
(b) ALL EXTERNAL CORNERS TO BE GIVEN A 25mm CHAMFER
6.3 DRAINAGE BEHIND WALLS: NETLON DN1 STRIPS AND PERFORATED M65 NETLON PIPES WRAPPED IN BIDIM A5 AND SHEET OF BIDIM A5
6.4 ALL LEVELS, DIMENSIONS AND CO-ORDINATES TO BE CHECKED AND CONFIRMED ON SITE WITH THE ENGINEER BEFORE CONSTRUCTION COMMENCES. THE ENGINEER TO BE INFORMED OF ANY DISCREPANCIES AS SOON AS POSSIBLE.

No.	DATE	REVISION	CONSULT. ENG.
3	07-06-2017	DETAILS FOR FISH LADDER ADDED	K.G. MALCOMSON
2	13-04-2017	BAR Z5 IN APPROACH SLAB ADDED. DETAIL 5 ADDED. GUIDE BLOCK DETAIL ADDED.	K.G. MALCOMSON
1	24-10-2016	DETAIL 4 AND C.J. DETAIL REVISED. GUIDE BLOCK DIMS ADDED. WATER PROOFING DETAIL ADDED.	K.G. MALCOMSON
0	18-10-2016	ISSUED FOR CONSTRUCTION	K.G. MALCOMSON

SNA CIVIL AND STRUCTURAL ENGINEERS (Pty) LTD
REG NO 2005/006128/07
P. O. Box 72727 LYNNWOOD RIDGE 0040
SNAVIA BUILDING 285 ALBERTUS STREET LA MONTAGNE
Tel:- 012-842 0000
Fax:- 012-803 4429
e-mail - pta@sna.co.za

DESIGNED BY	K. G. MALCOMSON
CHECKED BY	M. CHRISTODOULOU
DRAWN BY	M. ASHMAN
CHECKED BY	K. G. MALCOMSON

CONSULTANT APPROVAL
Name : K.G. MALCOMSON
Prof. Reg. No. : 880542
Date : 18/10/2016
THE ABOVE SIGNATORY CERTIFIES THAT THE DESIGNER AND CHECKER HAVE CONSENTED TO THEIR NAMES BEING INSERTED ON THIS DRAWING AND THAT THEY HAVE SEEN AND APPROVED THE DRAWING.

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P.O.Box 3567, Rivonia 2128
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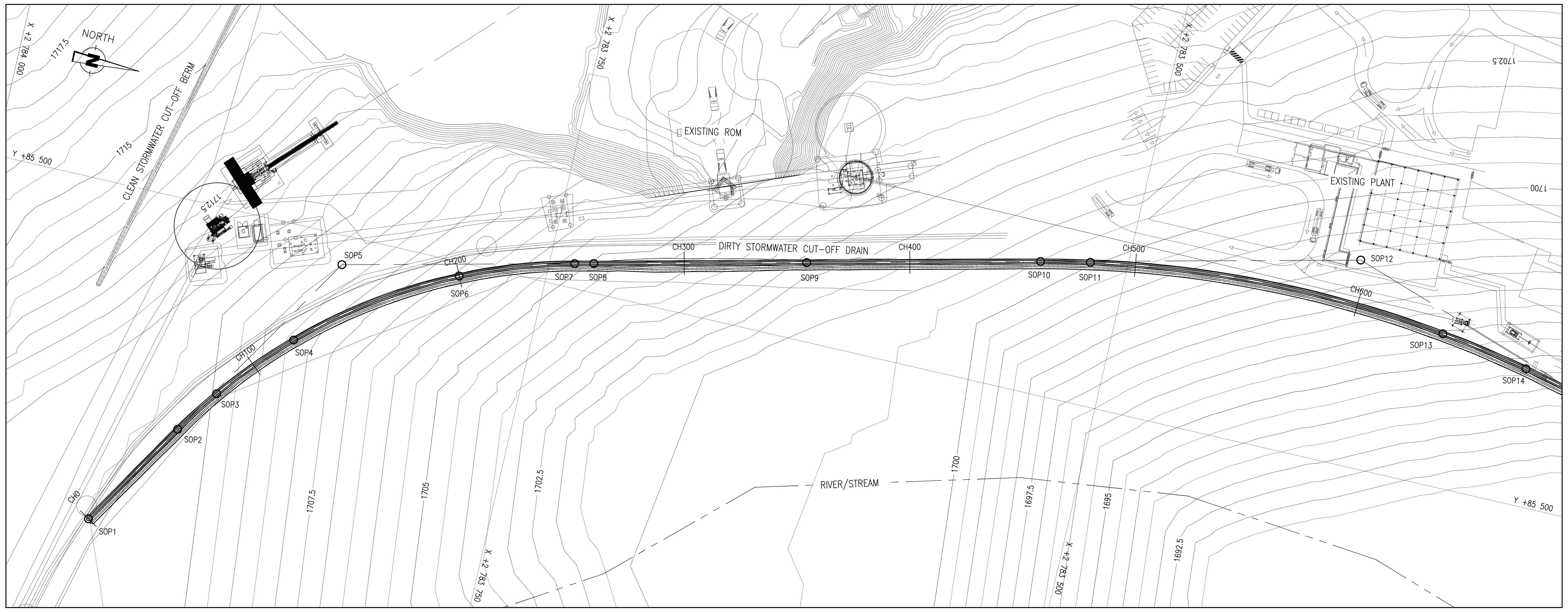
dra@drasa.co.za
NORTHAM BOOYSENDAL DIVISION

ACCEPTANCE
THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
for CEO: DRA Mining (Pty) Ltd
Date:

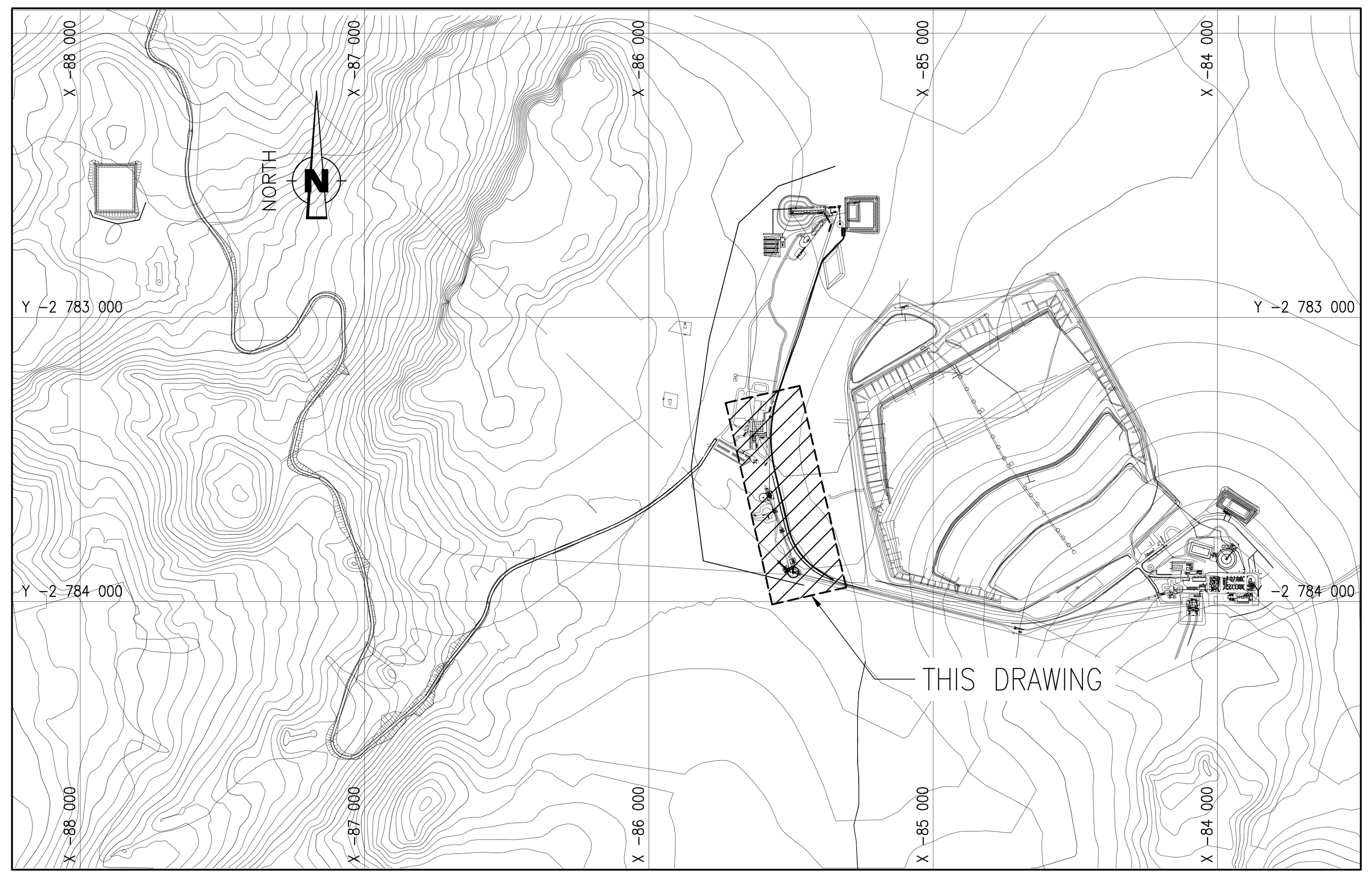
PROJECT DESCRIPTION
PERMANENT ACCESS ROAD FROM BOOYSENDAL SOUTH MINE TO CENTRAL COMPLEX
RIVER BRIDGE OVER THE GROOT DWARS RIVER AT km 8.955
GENERAL ARRANGEMENT
SCALE : 1 : 100 SHEET 1 OF 4

PROJECT NUMBER	SNA-TP1506.3	
DRAWING LOCATION DATA	START	END
ROUTE	-	-
SECTION	1	1
DRAWING km DISTANCE	8.937	8.973
DRAWING TYPE	STRUCTURES - BRIDGES	
BRIDGE/STRUCTURE No.	N/A	
CONSULTANT DRAWING No.	IC TP1506.3/B1/01	3



DIRTY DRAIN LAYOUT (PART 1)

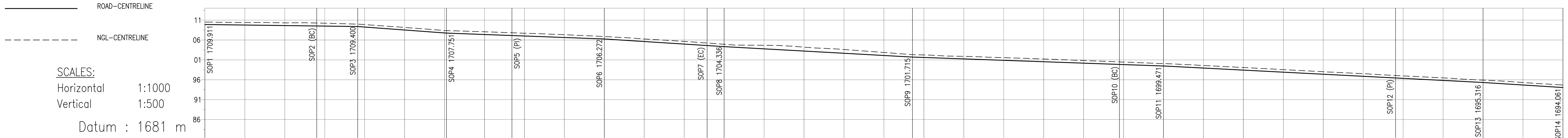
SCALE 1:1000



KEY PLAN

SCALE 1:15000

COORDINATE LIST WGS84 Lo31			
DIRTY STORMWATER DRAIN SETTING OUT			
POINT	Y-COORD	X-COORD	INVERT
CONST:			
SOP1	85352.203	2783923.449	1709.911
SOP2	85399.708	2783893.832	BC
SOP3	85418.933	2783880.561	1709.400
SOP4	85449.790	2783852.712	1707.751
SOP5	85487.150	2783839.317	PI
SOP6	85493.927	2783787.545	1706.272
SOP7	85510.783	2783739.021	EC
SOP8	85512.741	2783730.708	1704.336
SOP9	85534.374	2783638.896	1701.715
SOP10	85558.137	2783538.047	BC
SOP11	85562.721	2783516.469	1699.471
SOP12	85590.676	2783399.950	PI
SOP13	85567.067	2783357.209	1695.316
SOP14	85560.193	2783317.808	1694.061
SOP15	85550.195	2783279.092	1692.780
SOP16	85545.834	2783265.344	EC
SOP17	85544.072	2783260.056	1692.250
SOP18	85535.220	2783233.482	1691.727
SOP19	85417.122	2782878.983	1690.482
SOP20	85393.828	2782809.058	BC
SOP21	85390.178	2782798.102	PI
SOP22	85386.449	2782794.939	1688.349
SOP23	85382.093	2782789.856	EC
SOP24	85318.606	2782725.107	BC
SOP25	85315.746	2782722.190	PI
SOP26	85316.285	2782721.343	1684.031
SOP27	85315.746	2782718.106	EC
SOP28	85315.746	2782706.213	1683.794



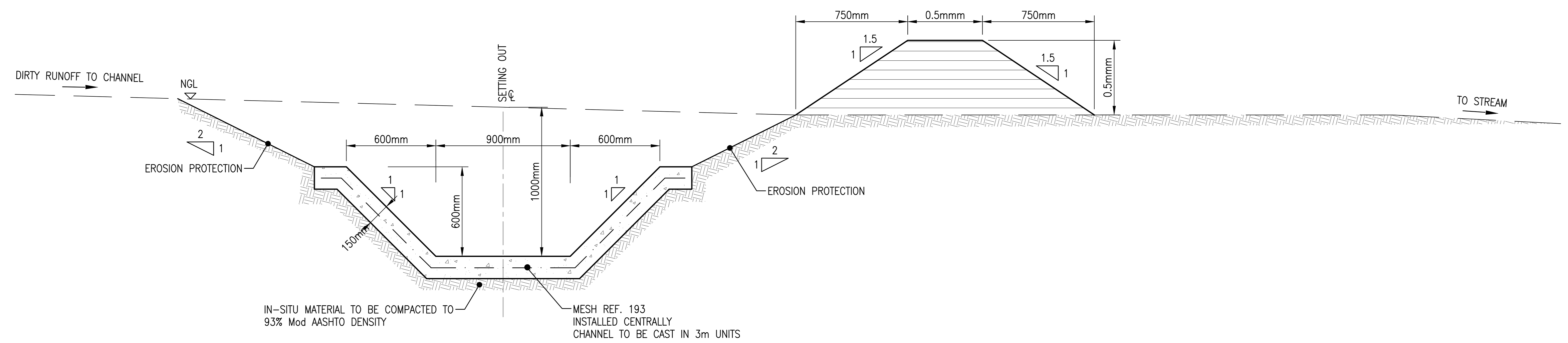
SCALES:
Horizontal 1:1000
Vertical 1:500

Datum : 1681 m

DISTANCE (m)	C/L GROUND LEVEL	DRAIN INVERT	DRAIN DEPTH
0.000	1710.511	1709.911	-0.600
20.000	1710.395	1709.777	-0.618
40.000	1710.318	1709.644	-0.674
55.981	1710.276	1709.537	-0.739
60.000	1710.225	1709.510	-0.715
76.530	1710.000	1709.400	-0.600
80.000	1709.881	1709.271	-0.610
100.000	1709.163	1708.529	-0.634
120.000	1708.390	1707.787	-0.603
120.964	1708.351	1707.751	-0.600
140.000	1708.076	1707.395	-0.681
160.000	1707.711	1707.020	-0.691
180.000	1707.337	1706.646	-0.691
200.000	1706.873	1706.272	-0.601
220.000	1706.272	1705.627	-0.645
240.000	1705.643	1704.982	-0.661
251.460	1705.245	1704.612	-0.633
260.000	1704.938	1704.336	-0.602
280.000	1704.675	1703.781	-0.894
300.000	1704.212	1703.225	-0.987
320.000	1703.612	1702.669	-0.943
340.000	1702.867	1702.113	-0.754
354.326	1702.315	1701.715	-0.600
360.000	1702.242	1701.613	-0.629
380.000	1701.900	1701.256	-0.644
400.000	1701.558	1700.899	-0.659
420.000	1701.227	1700.542	-0.685
440.000	1700.851	1700.185	-0.666
457.937	1700.494	1699.865	-0.629
460.000	1700.454	1699.828	-0.626
480.000	1700.071	1699.471	-0.600
500.000	1699.594	1698.951	-0.643
520.000	1699.079	1698.432	-0.647
540.000	1698.549	1697.913	-0.636
560.000	1698.023	1697.393	-0.630
580.000	1697.531	1696.874	-0.657
600.000	1696.974	1696.355	-0.619
620.000	1696.478	1695.835	-0.643
640.000	1695.917	1695.316	-0.601
660.000	1695.323	1694.689	-0.634
680.000	1694.690	1694.061	-0.629

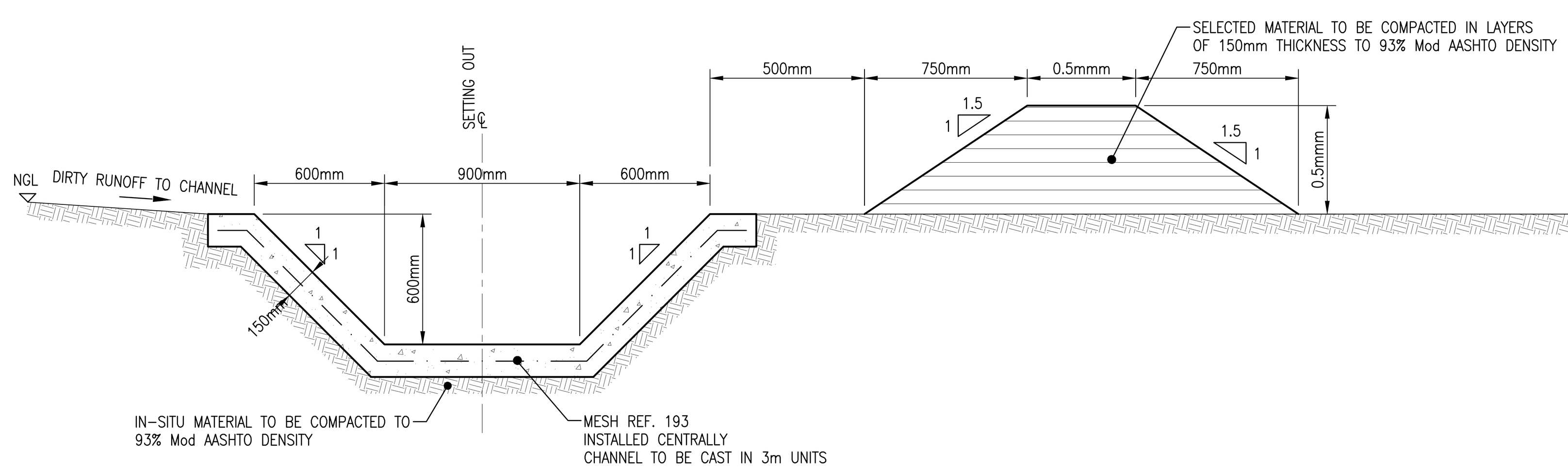
VERTICAL PROFILE:
- 1 IN -149.765 / -0.6677%
- 1 IN -26.943 / -3.7115%
- 1 IN -53.438 / -1.8713%
- 1 IN -31.002 / -3.2256%
- 1 IN -35.980 / -2.7793%
- 1 IN -56.004 / -1.7856%
- 1 IN -38.510 / -2.5967%
- 1 IN -31.878 / -3.1370%

DIRTY DRAIN LONGITUDINAL SECTION (PART 1)



TYPICAL DETAIL OF NEW DIRTY WATER CUT-OFF DRAIN AND BERM DRAINS EXCEEDING 600mm DEEP.

SCALE 1:20



TYPICAL DETAIL OF NEW DIRTY WATER CUT-OFF DRAIN AND BERM DRAINS NOT EXCEEDING 600mm DEEP.

SCALE 1:20

ISSUED FOR MEASUREMENT

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D5	Phase 2 - External Squad Check			Approved	Rejected	Appr. with corrections
	Stage Gate	I	80%			
	Discipline					
	Name	Signature	Date			
Proj. Engineer:						
Proj. Manager:						

PR. ENG. APPROVAL

REFERENCE DRAWINGS:

DRAWING NO.	DESCRIPTION
00413-IH-003-06	DIRTY STORMWATER CUT OFF DRAIN CROSS SECTIONS
00413-IH-003-05	DIRTY STORMWATER CUT OFF DRAIN SHEET 2

REVISIONS:

REV.	BY	DATE	REVISIONS	CHK.	DATE	S.L.	DATE
B	TRS	12.07.16	ISSUED FOR SQUAD CHECK				
A	TRS	05.07.16	ISSUED FOR INTERNAL SQUAD CHECK				

DESIGN REFERENCE | DESIGN

CLIENT		
PROJ. MANAGER		
PROF. ENG.		
PROJECT ENG.		
PROCESS ENG.		
DESIGN ENG.		
SECT LEADER		
CHECKED		
DRAWN	TRS	05.07.2016
APPROVAL	SIGNATURE	DATE

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DRA PROJECTS SA (PTY) LTD

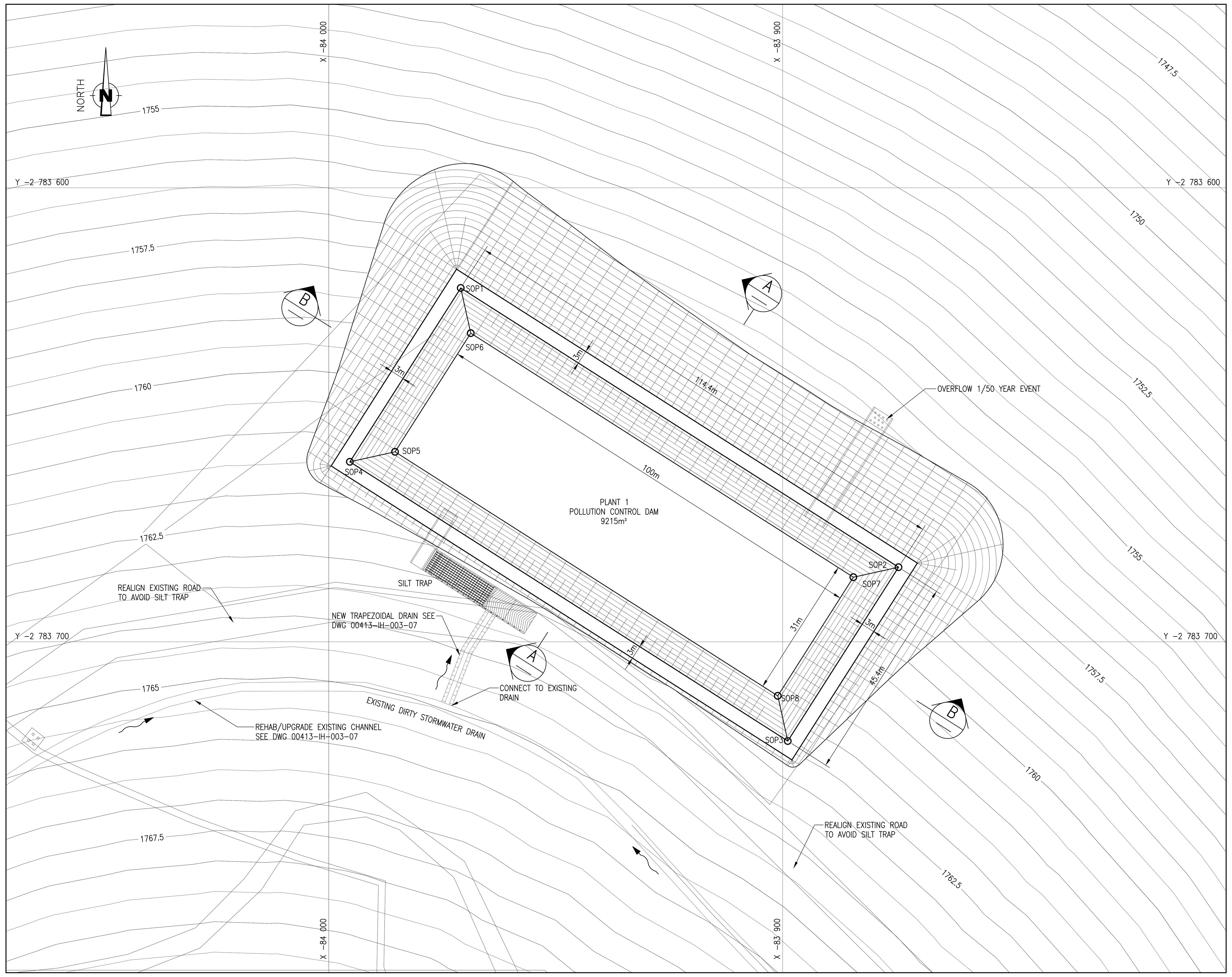
TITLE BOOYSENDAL SOUTH - EVEREST INFRASTRUCTURE
DIRTY STORMWATER CUT-OFF DRAIN
LAYOUT, SECTION AND DETAILS (SHEET 1)

A0	PROJECT DWG NO.	SHEET	REVISION	SCALE
	00413-IH-003-04	OF	B	A/S U.O.S.

COORDINATE LIST

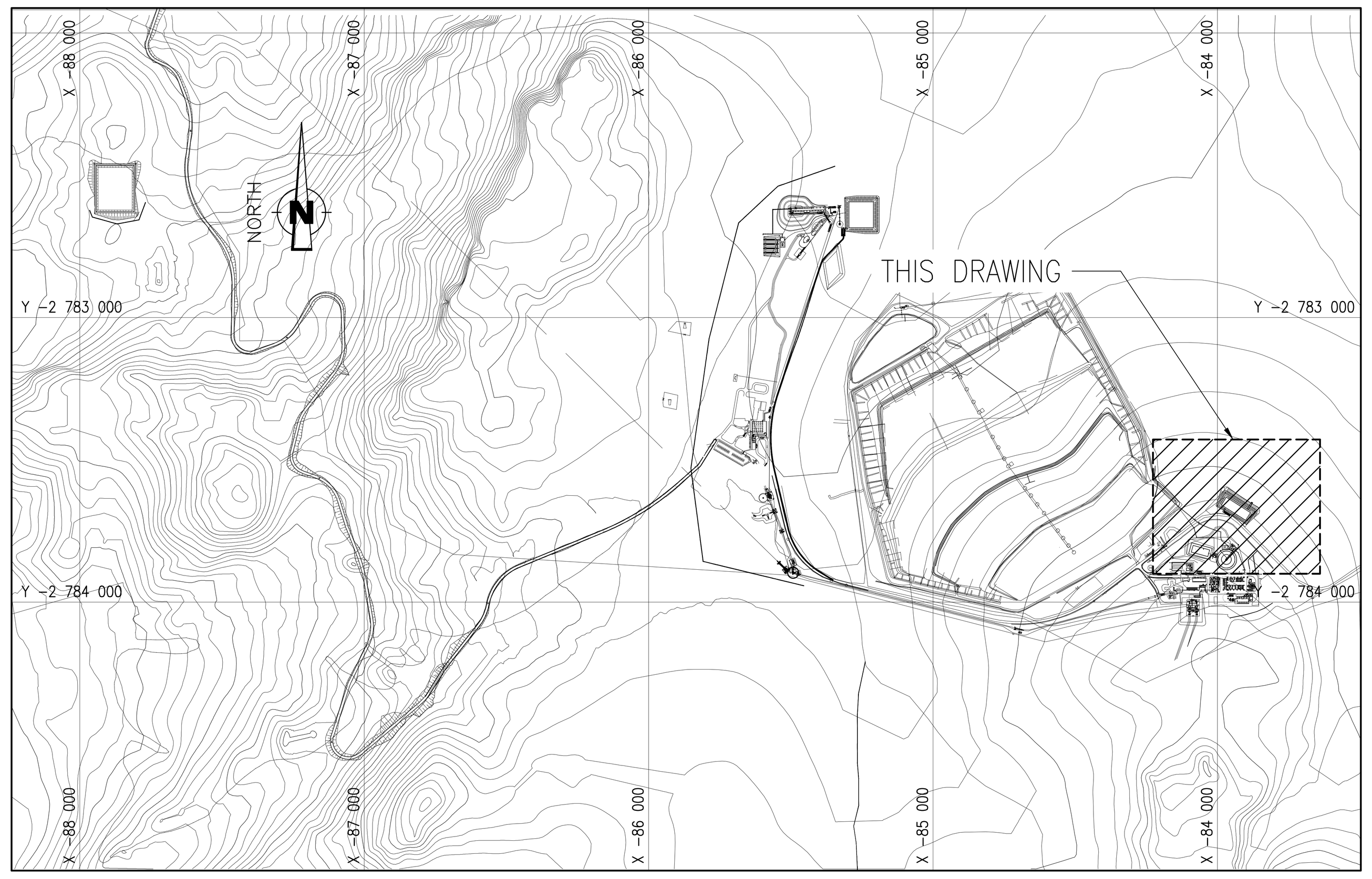
WGS84 Lo31

EARTHWORKS SETTING OUT			
POINT	Y-COORD	X-COORD	ELEVATION
POLLUTION CONTROL DAM			
SOP1	83970.931	2783622.083	1763.300
SOP2	83874.471	2783683.587	1763.300
SOP3	83898.880	2783721.868	1763.300
SOP4	83995.340	2783660.363	1763.300
SOP5	83985.398	2783658.163	1759.700
SOP6	83968.731	2783632.024	1759.700
SOP7	83884.413	2783685.787	1759.700
SOP8	83901.080	2783711.926	1759.700



DAM LAYOUT

SCALE 1:1000

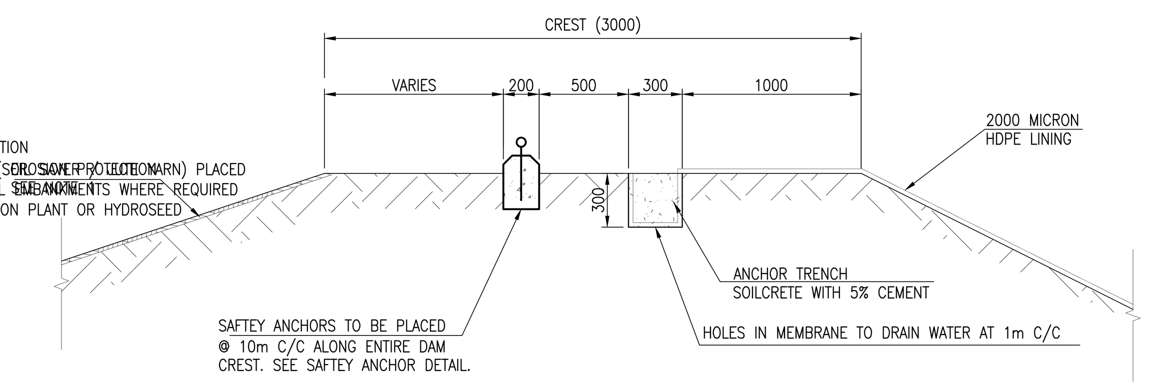


KEY PLAN

SCALE 1:15000

NOTES:

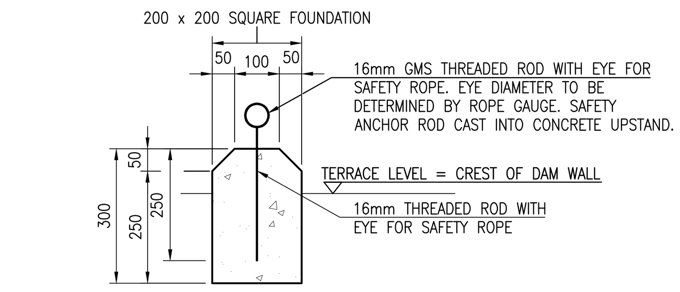
1. EROSION PROTECTION
GEOSYNTHETICS (SOIL SAVER / JUTE YARN) PLACED
ON CUT AND FILL EMBANKMENTS WHERE REQUIRED
AFTER INSTALLATION PLANT OR HYDROSEED



TYPICAL DETAIL 1

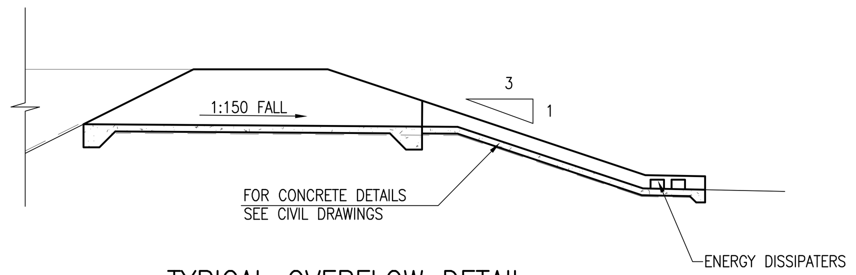
SCALE 1:25

NOTE:
SAFETY ANCHORS TO BE PLACED @ 10m C/C SPACING ALONG ENTIRE DAM CREST, OUTSIDE OF LINING ANCHOR AS SHOWN IN DETAIL 1
SAFETY ROPE, SPECIFICATIONS, SIZE AND INSTALLATION BY OTHERS



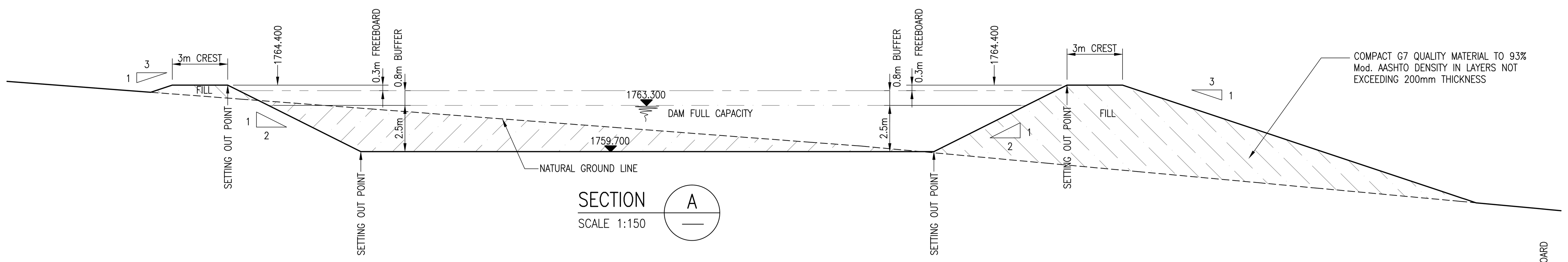
SAFETY ANCHOR DETAIL

SCALE 1:10



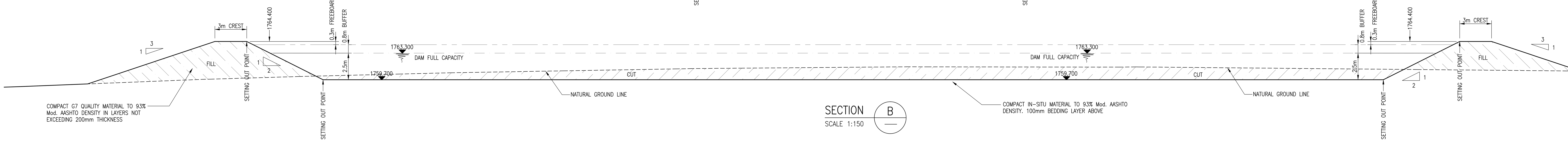
TYPICAL OVERFLOW DETAIL

SCALE 1:100



SECTION A

SCALE 1:150



SECTION B

SCALE 1:150

D5	Phase 2 – External Squad Check			Approved	Rejected	Appr. with corrections
	Stage Gate	I	80%			
	Discipline					
	Name	Signature	Date			
Proj. Engineer:						
Proj. Manager:						

PR. ENG. APPROVAL

ISSUED FOR MEASUREMENT

THIS DRAWING IS NOT TO BE SCALED. ALL DISCREPANCIES ARE TO BE REPORTED TO THE DESIGN ENGINEER. ALL CONSTRUCTION ERRORS OR DEVIATIONS FROM THE DETAILS ARE TO BE RECTIFIED ONLY AFTER CONSULTATION WITH THE DESIGN ENGINEER OR IN HIS ABSENCE THE DESIGN OFFICE HEAD OF DEPARTMENT MUST BE CONSULTED.

DESIGN REFERENCE	DRAWING NO.	DESCRIPTION	DRAWING NO.	DESCRIPTION	REV.	BY	DATE	REVISIONS	CHK.	DATE	S.L.	DATE
					C	TRS	13.07.16	STORMWATER DRAIN DETAIL REMOVED				
					B	TRS	12.07.16	ISSUED FOR SQUAD CHECK				
					A	TRS	05.07.16	ISSUED FOR INTERNAL SQUAD CHECK				
DESIGN	REFERENCE DRAWINGS		REFERENCE DRAWINGS									

CLIENT		
PROJ. MANAGER		
PROF. ENG.		
PROJECT ENG.		
PROCESS ENG.		
DESIGN ENG.		
SECT LEADER		
CHECKED		
DRAWN	TRS	05.07.2016
APPROVAL	SIGNATURE	DATE

NORTHAM
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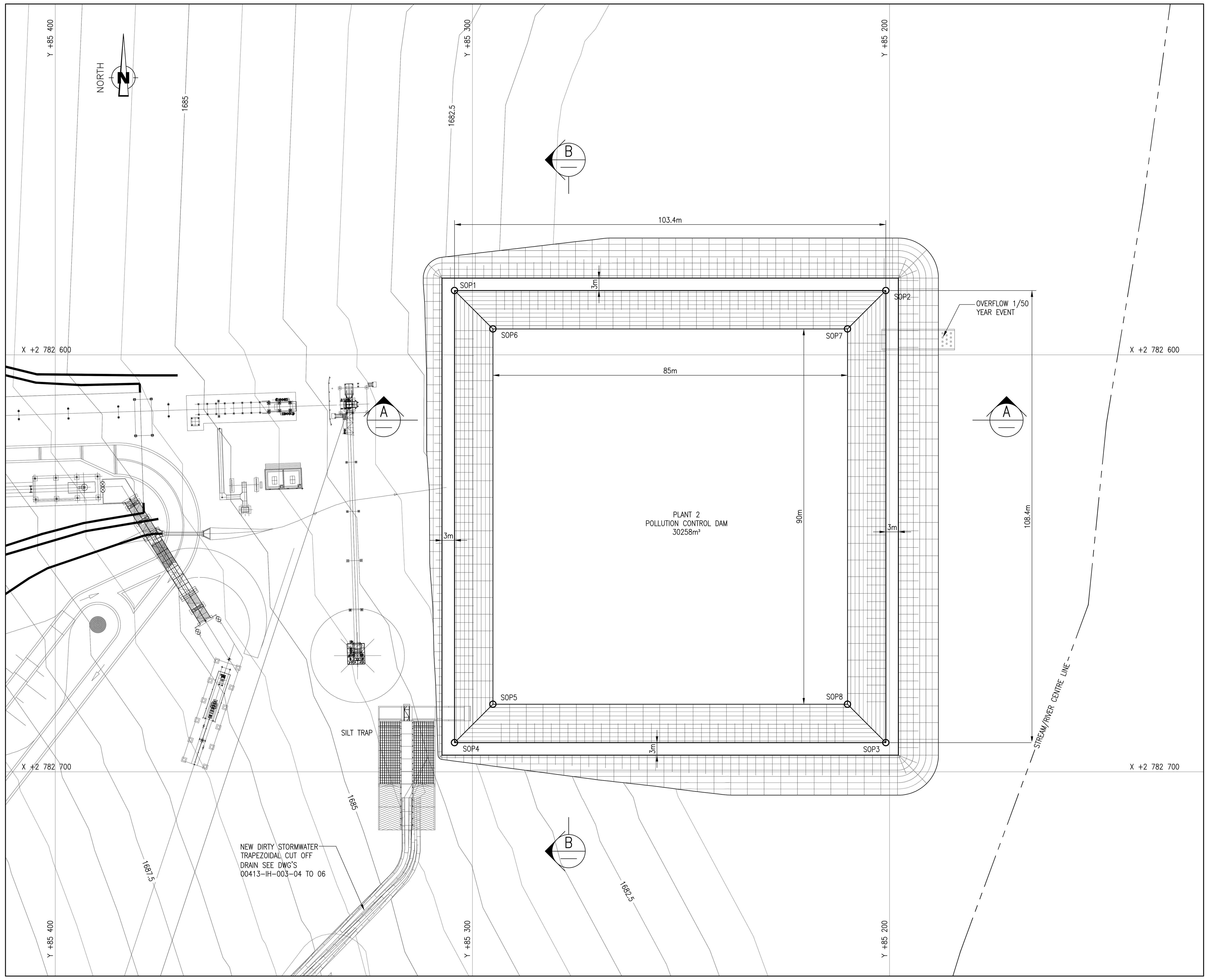
DRA PROJECTS SA (PTY) LTD

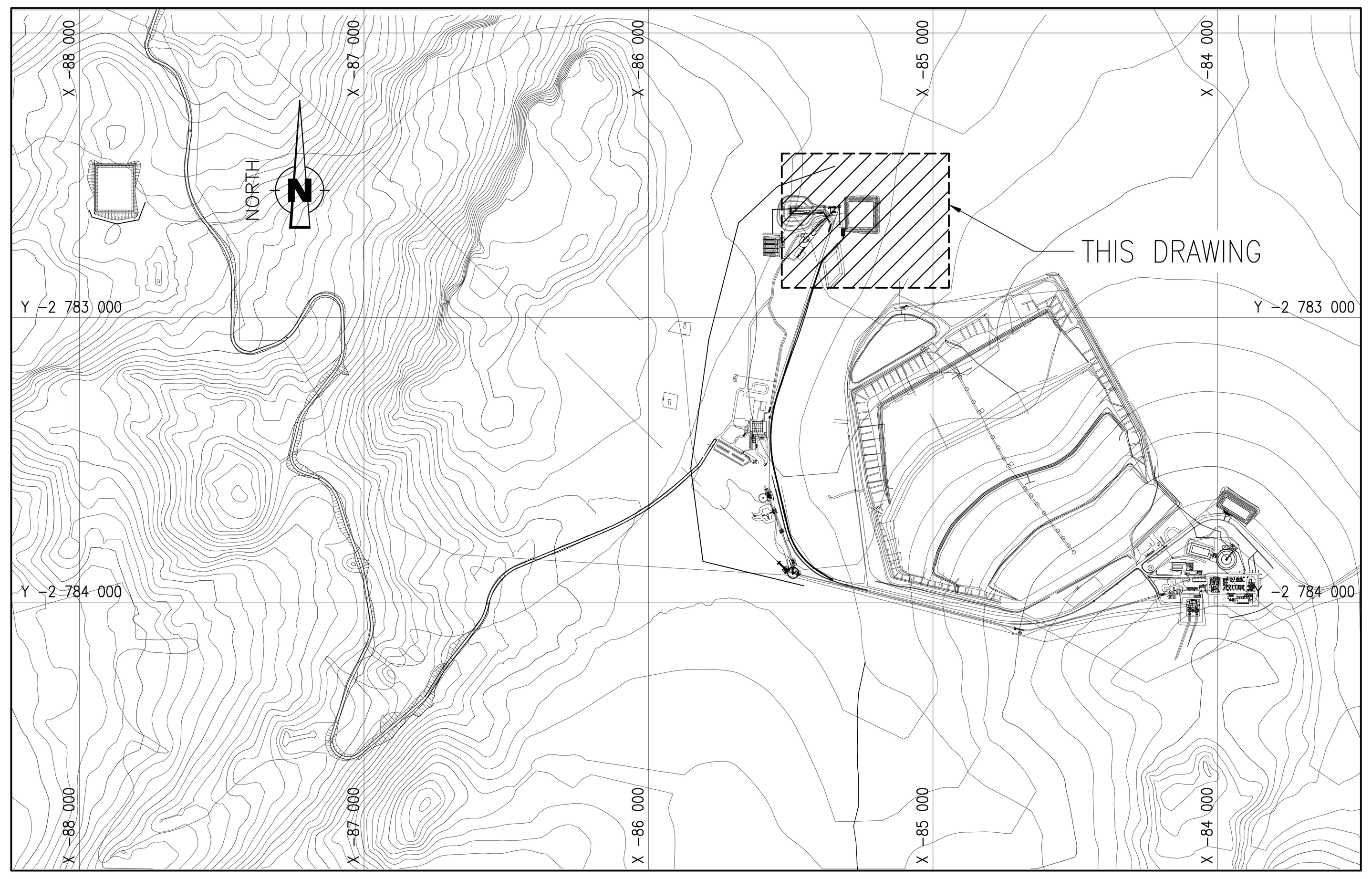
TITLE BOOYSENDAL SOUTH – EVEREST INFRASTRUCTURE
PLANT 1 POLLUTION CONTROL DAM
LAYOUT, SECTION AND DETAILS

A0	PROJECT DWG NO.	SHEET	REVISION	SCALE
	00413-IH-003-02	OF	C	A/S U.O.S.



DAM LAYOUT
SCALE 1:1000

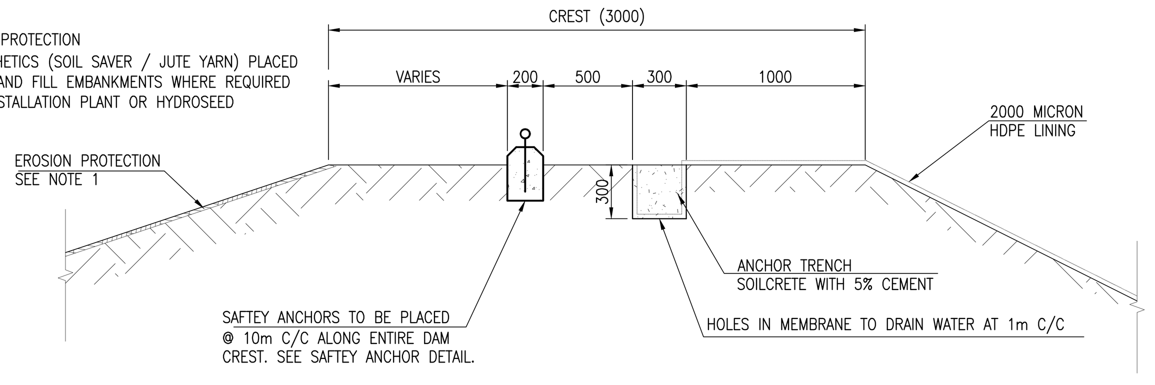
COORDINATE LIST WGS84 Lo31			
PLANT 2 PCD SETTING OUT			
POINT	Y-COORD	X-COORD	ELEVATION
CONST:			
SOP1	85304.293	2782584.593	1684.200
SOP2	85200.893	2782584.593	1684.200
SOP3	85200.893	2782692.993	1684.200
SOP4	85304.293	2782692.993	1684.200
SOP5	85295.093	2782683.793	1679.600
SOP6	85295.093	2782593.793	1679.600
SOP7	85210.093	2782593.793	1679.600
SOP8	85210.093	2782683.793	1679.600



KEY PLAN
SCALE 1:15000

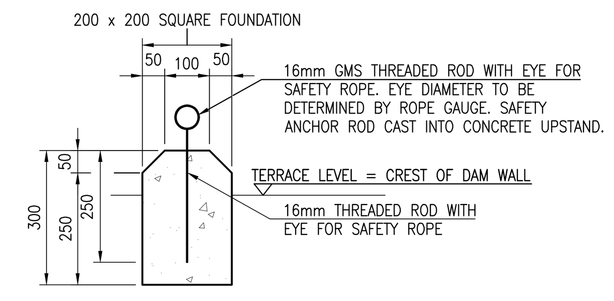
NOTES:

1. EROSION PROTECTION
GEOSYNTHETICS (SOIL SAVER / JUTE YARN) PLACED ON CUT AND FILL EMBANKMENTS WHERE REQUIRED AFTER INSTALLATION PLANT OR HYDROSEED

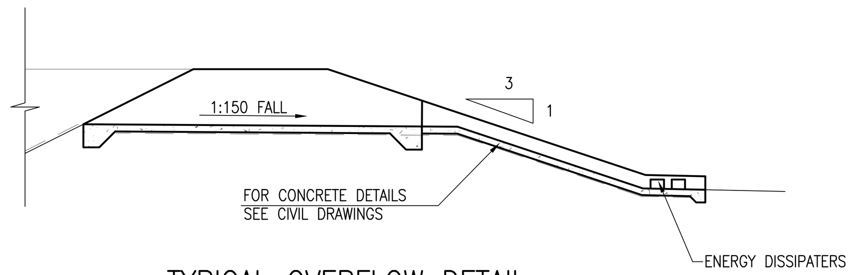


TYPICAL DETAIL 1
SCALE 1:25

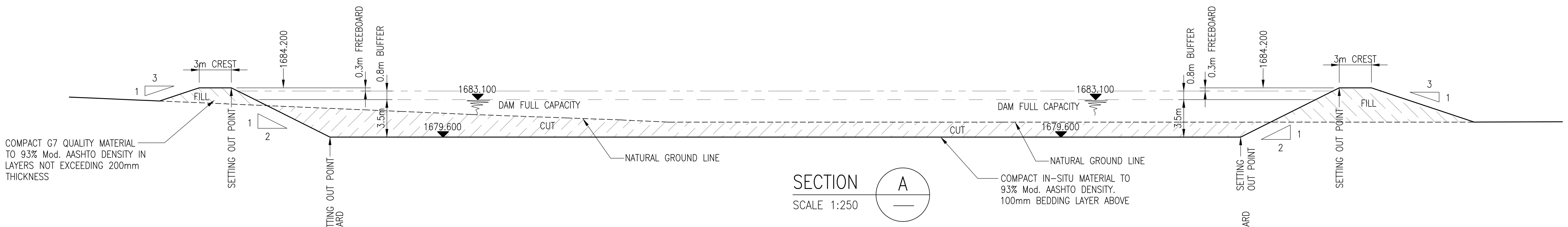
NOTE:
SAFETY ANCHORS TO BE PLACED @ 10m C/C SPACING ALONG ENTIRE DAM CREST, OUTSIDE OF LINING ANCHOR AS SHOWN IN DETAIL 1
SAFETY ROPE, SPECIFICATIONS, SIZE AND INSTALLATION BY OTHERS



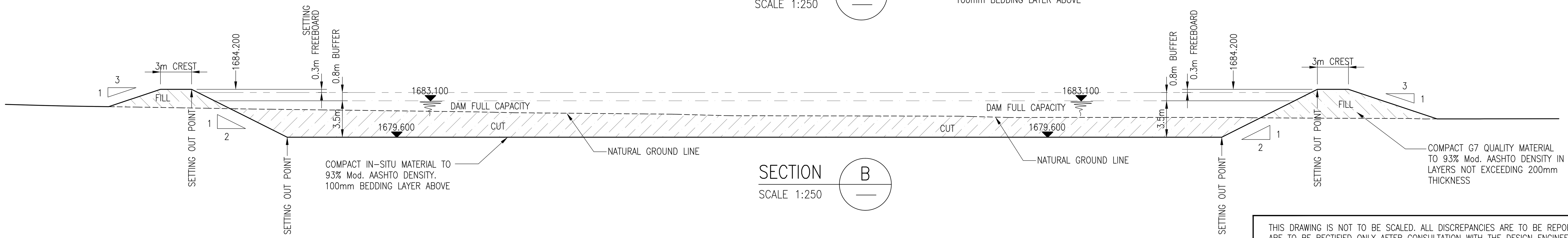
SAFETY ANCHOR DETAIL
SCALE 1:10



TYPICAL OVERFLOW DETAIL
SCALE 1:100



SECTION A
SCALE 1:250



SECTION B
SCALE 1:250

ISSUED FOR MEASUREMENT

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DRAWING NO.	DESCRIPTION
00413-IH-003-06	DIRTY STORMWATER CUT OFF DRAIN CROSS SECTIONS
00413-IH-003-05	DIRTY STORMWATER CUT OFF DRAIN SHEET 2
00413-IH-003-04	DIRTY STORMWATER CUT OFF DRAIN SHEET 1

REFERENCE DRAWINGS

REV.	BY	DATE	REVISIONS
B	TRS	12.07.16	ISSUED FOR SQUAD CHECK
A	TRS	05.07.16	ISSUED FOR INTERNAL SQUAD CHECK

D5 — Phase 2 – External Squad Check; Stage Gate I 80%

Proj. Engineer:
Proj. Manager:
PR. ENG. APPROVAL

CLIENT
PROJ. MANAGER
PROF. ENG.
PROJECT ENG.
PROCESS ENG.
DESIGN ENG.
SECT LEADER
CHECKED
DRAWN TRS 05.07.2016

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TITLE BOOYSENDAL SOUTH – EVEREST INFRASTRUCTURE
PLANT 2 POLLUTION CONTROL DAM
LAYOUT, SECTION AND DETAILS

A0 | PROJECT DWG NO. 00413-IH-003-03 | SHEET OF | REVISION B | SCALE A/S U.O.S.