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Hydrological Assessment for the Samancor Tubatse Ferrochrome PV Plant Development Extension Sites

Report

Version – Final 3

06 May 2024

Royal HaskoningDHV

GCS Project Number: 22-0865

Client Reference: MD6154-RHD-XX-ZZ-CO-Z-0001

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HYDROLOGICAL ASSESSMENT FOR THE SAMANCOR TUBATSE FERROCHROME PV PLANT DEVELOPMENT EXTENSION SITES

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LEGAL NOTICE

DECLARATION OF INDEPENDENCE

GCS (Pty) Ltd was appointed to conduct this specialist surface water study and to act as the independent hydrological specialist. GCS objectively performed the work, even if this results in views and findings that are not favourable. GCS has the expertise in conducting the specialist investigation and does not have a conflict of interest in the undertaking of this study. This report presents the findings of the investigations which include the activities set out in the scope of work.

APPENDIX 6 OF THE EIA REGULATION - CHECKLIST AND REFERENCE FOR THIS REPORT

Table 1 – Requirements from Appendix 6 of GN 326 EIA Regulation 2017

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepares the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Document Issue (Page ii) Appendix D.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Document Issue (Page ii) Appendix D.
(c) Indication of the scope of, and purpose for which, the report was prepared	Section 1.
(cA) Indication of the quality and age of base data used for the specialist report	Sections 1, 2 and 3.
(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 8
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Section 1.4.
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process including equipment and modelling used	Section 2.
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate's structures and infrastructure, inclusive of a site plan identifying alternative	Sections 1, 5 and 6
(g) Identification of any areas to be avoided, including buffers	Section 10.1
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Section 1, 3, 5, 6 and 8
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Sections 2, 5, 6 and 7
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Section 9
(k) Mitigation measures for inclusion in the EMPr	Section 8 and 10.2
(l) Conditions for inclusion in the environmental authorisation	Refer to Section 10.2
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Refer to Section 9
(n) Reasoned opinion - (i) as to whether the proposed activity, activities or portions thereof should be authorised. (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities, or portions thereof should be authorised, and avoidance, management, and mitigation measures should be included in the EMPr, and where applicable, the closure plan	Section 10.3
(o) Description of any consultation process that was undertaken during preparing the specialist report	*None required.*
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto	*None required.*
(q) Any other information requested by the competent authority	*None required.*

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LIST OF ACRONYMS

Acronym	Description
%	Per cent
A	Area
AC	Alternating current
ALOS	Advanced Land Observing Satellite
BESS	Battery Energy Storage Systems
C	Runoff coefficient
CSIR	Council for Scientific and Industrial Research
CSWMP	Conceptual Storm Water Management Plan
DC	Direct current
DFFE	Department of Forestry, Fisheries, and the Environment
DTM	Digital Terrain Model
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
G1	Best Practice Guidelines: Stormwater Management
G3	Best Practice Guidelines: Monitoring
GCS	GCS Water and Environment (Pty) Ltd
GG	Government Gazette
GN	Government Notice
HEC-RAS	Hydrologic Engineering Center's River Analysis System
HRY	#N/A
HSG	Hydrological Soil Group
I	Rainfall intensity
JAXA	Japan Aerospace Exploration Agency
km	Kilometre
km/h	Kilometre per hour
kV	Kilovolt
m	Metres
m3/a	Cubic metres per annum
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	Metres below ground level
MIPI	Midgley and Pitman
mm/a	Millimetres per annum
Mm3/a	Million cubic metres per annum
MW	Megawatt
n	Manning's Roughness Coefficients
NEMA	National Environmental Management Agency
NFEPA	National Freshwater Ecosystem Priority Areas
NMAR	Naturalised Mean Annual Runoff
NWA	National Water Act

PES	Present Ecological State
PV	Photovoltaic
Q	Peak flow
RHDHV	Royal HaskoningDHV
RM	Rational Method
SANLC	South African National Land Cover
SANRAL	South African National Roads Agency SOC Ltd
SCS	Soil Conservation Services
SDF	Standard Design Flood
SWMP	Stormwater Management Plan
USDA	United States Department of Agriculture
WARMS	Water Allocation Registration Management System
WGS84	World Geodetic System 1984
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
WRC	Water Research Commission
WUL	Water Use Licence
WULA	Water Use License Application

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Royal HaskoningDHV (Pty) Ltd (RHDHV) to undertake a hydrological investigation for the proposed expansion of previously authorised sites for an up to 100-Megawatt (MW) photovoltaic (PV) project for the Samancor Tubatse Ferrochrome operation, situated in Steelpoort, Limpopo Province (refer to Figure 1-2), *hereafter referred to as "extension development"*. This report has been prepared to supplement the Environmental Impact Assessment (EIA) and Water Use Authorisation (WUA) process that is being undertaken by Royal HaskoningDHV. The project is situated in quaternary catchment B41J of the Olifants Water Management Area (WMA 2) (DWS, 2016).

1.1 Project background

Samancor Chrome, partnered with TFC Solar (Pty) Ltd, wishes to construct PV plants at their Tubatse FerroChrome operation due to severe power interruptions (colloquially referred to as load-shedding). The site is approximately 120 km south of Polokwane in the Greater Tubatse Local Municipality and the Sekhukhune District Municipality. Previously, five sites have been identified for the PV plants.

Sites 2 to 5 were granted environmental authorisation from the Department of Forestry, Fisheries, and the Environment (DFFE) in April 2022. Site 1 was not deemed viable for the project. Authorised sites 2 to 5 can only achieve a total output of 60 MW. Therefore, extensions to the four sites are required to achieve the 100 MW output by providing the remaining 40 MW. The extensions (areas in white) to the authorised sites are depicted in Figure 1-1.

Each plant will consist of the following infrastructure:

- Solar PV panels that will be able to deliver the required 40 MW output to the Samancor grid;
- Inverters that convert direct current (DC) generated by the PV modules into alternating current (AC) to be exported to the Samancor electrical grid;
- Transformer/s that raises the system AC low voltage to medium voltage. The transformer converts the voltage of the electricity generated by the PV panels to the correct voltage for delivery to the TFC Plant;
- Transformer substation; and
- Instrumentation and Control consisting of hardware and software for remote plant monitoring and operation of the facility.

Associated infrastructure includes:

- Mounting structures for the solar panels in a fixed tilt of rotating tracking configuration;
- Cabling between the structures, to be lain underground where practical;
- New 33kV overhead powerlines between the various sites and the Tubatse East and -West substation buildings;
- Local substation and transformer yard at each PV site;
- Containerized switchgear substation at Tubatse East and -West MV substations for connecting to the Tubatse substation busbars;
- Water provision infrastructure (i.e. pipeline/ s, storage tank/ s, etc.) for PV panel cleaning;
- Battery Energy Storage System (BESS); and
- Internal access roads (typically 5m) roads will be constructed, but existing roads will be used as far as possible), fencing (approximately 3m in height), gates and access control.

The principal aims of a hydrology assessment will be to determine how this development (and its separate elements, e.g., solar PV panels, pylons, and road crossings) will impact the surface water hydrology of the area, compile a stormwater management plan for the solar PV facility.

Figure 1-1: Site Layout

1.2 The objective of this report

The objectives of this study, were as follows:

- Update the study area's hydrological functions and ecological water requirements (EWR).
- Undertake a site walkover assessment to confirm drainage lines and rivers.
- Develop a conceptual hydrological cycle for the sub-catchment associated with the project area, illustrating the sub-catchment hydrological components that may be impacted.
- Update the 1:10, 1:50 and 1:100-year peak flow return periods, to undertake conceptual flood line modelling. The aim is to identify possible exclusion zones:
    - *A steady-state HEC-RAS model will be constructed.*
    - *Available 0.5m DTM data or public 30m DTM (ALOS) data will be used.*
- Update the stormwater conceptual model and evaluate the 1:2, 1:20, 1:50 and 1:100-year stormwater flood volumes and runoff patterns.
- Update the conceptual water balance assessment.
    - Water balance calculations, for the future/existing infrastructure, will be based on the guidelines and methodologies provided in the (DWS, formerly the Department of Water Affairs and Forestry (DWAF) Best Practice Guidelines (BPG) G2: Water balances (DWS, 2006) for use in the mining industry.
- Compile surface water and stormwater monitoring plans to monitor the impact on the receiving environment; and
- Compile a detailed hydrological report with hydrological risks identified.

1.3 Scope of Work

The scope of work completed, was as follows:

1. **Site walkover assessment:**
    a. A walk-over assessment was undertaken, whereby all groundwater-surface water interaction areas and stream conditions of the site were investigated.
2. **Baseline Hydrology Review:**
    a. Hydro-meteorological data collection and analysis.
    b. Catchment delineation and drainage characteristics.
    c. Determination of catchment hydraulic and geometric parameters.
3. **Hydrological Cycle Conceptual Modelling:**

   a. Conceptual model illustrating sub-catchment hydrological components established in the baseline hydrology review.

4. **Peak Flows & Flood Line Modelling:**
   a. Peak flood volume calculation for the 1:10, 1:20, 1:50, and 1:100-year recurring events.
   b. Flood line modelling using HEC-RAS hydraulic software – 1:50 and 1:100-year flood lines were presented.
   c. Analysis of the modelling results.
5. **Conceptual Storm Water Management Plan and Stormwater Monitoring (CSWMP):**
   a. Identification of stormwater sub-catchments (i.e., clean, and dirty areas).
   b. Determination of stormwater flows and volumes (1:20, 1:50 and 1:100-year return periods) was undertaken.
   c. Indications and explanations of the placement of stormwater attenuation infrastructure were offered; and
   d. A stormwater monitoring system plan was drafted, to ensure that the stormwater discharge impact on the environment is managed and controlled.
6. **Conceptual Water Balance (CWB):**
   a. A static process flow diagram (PFD) was developed based on the information provided by Rossway Quarry.
   b. An Excel spreadsheet conceptual water balance model was developed.
7. **Risk assessment:**
   a. A hydrological risk assessment was undertaken, to contextualize the potential hydrological risks associated with this project.
8. **Surface Water Monitoring Plan:**
   a. A surface water monitoring plan was developed.
9. **Reporting:**
   a. This hydrology assessment report, entailing the above-mentioned components was compiled.

1.4 Study relevance to the season in which it was undertaken

This study was undertaken as a once-off study and relies on historical hydrological and climate data for the site, as well as recognised hydrological and water resource databases for South Africa. Data generated during the time of this study is not seasonally bound as average yearly data was applied where required and as scientifically acceptable.

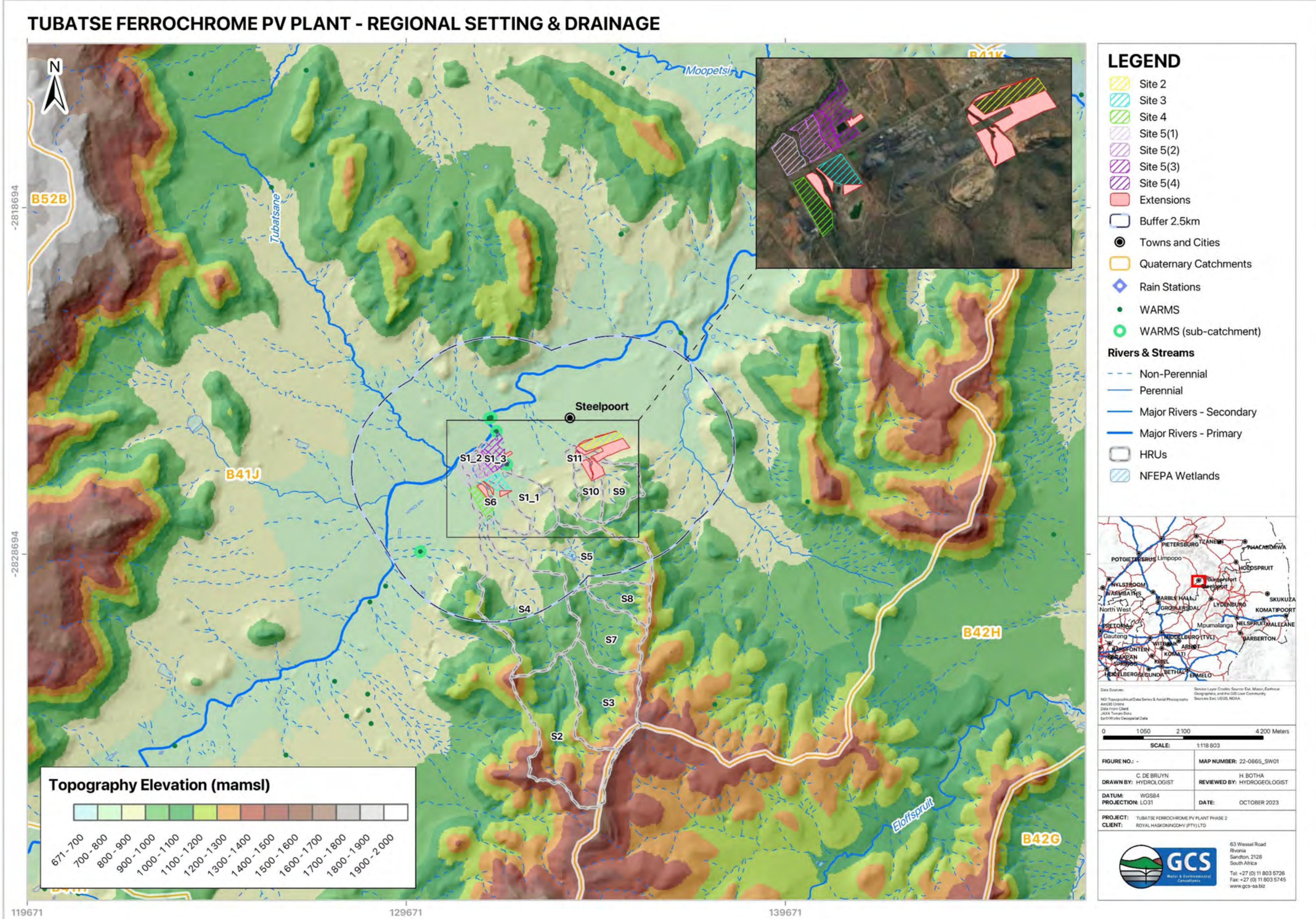


Figure 1-2: Site locality and drainage

2 METHODOLOGY

The methodological approach for the study is described in the sub-sections below.

2.1 Legal considerations

The following regulations published under the NWA apply:

- Government Notice (GN) No. 704, 4 June 1999: Regulations on the use of water for mining and related activities aimed at the protection of water resources (GN704).
- GN No. 1352, 12 November 1999: Regulations requiring that water use be registered.
- GN No. 810 of Government Gazette (GG) No. 33541 dated 17 September 2010: Regulations for the Establishment of a Water Resource Classification System.

The National Environmental Management Act (Act 107 of 1998) (NEMA) stipulates that all relevant factors be considered for proposed developments to ensure that water pollution and environmental degradation are avoided. Section 2 of the Act establishes a set of principles that apply to the activities of all state organs that may significantly affect the environment. These include the following:

- Development must be sustainable.
- Pollution must be avoided or minimized and remedied.
- Waste must be avoided or minimized, reused or recycled.
- Negative impacts must be minimized.

NEMA requires that an environmental authorisation (EA) is obtained for certain listed activities which are triggered by the Project. Appendix 6 of GN 326 EIA Regulation 2014 (summarised in **Table 1** in the executive summary) govern hydrology assessments for EIAs. This hydrology report conforms to Appendix 6 of the EIA Regulations.

The SWMP must be in line with the *Best Practice Guidelines for Water Resource Protection in the South African Mining Industry, G1: Storm Water Management* (DWAF, 2006a). The general objective of a SWMP includes:

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

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

In terms of Section 144 of the National Water Act of 1998 (Act 36 of 1998), a flood line, representing the highest elevation that would probably be reached during a storm with a return interval of 100 years, must be indicated on all plans for the establishment of townships. The term, “establishment of townships” includes the subdivision of stands or farm portions in existing townships/development, if the 100-year flood lines are not already indicated on these plans, or when the land-use category of a particular portion of land is changed.

The National Environmental Management Act (Act 107 of 1998) (NEMA) stipulates that all relevant factors be considered for proposed developments to ensure that water pollution and environmental degradation are avoided. Section 2 of the Act establishes a set of principles that apply to the activities of all organs of the state that may significantly affect the environment. These include the following:

- Development must be sustainable.
- Pollution must be avoided or minimized and remedied.
- Waste must be avoided or minimized, reused, or recycled.
- Negative impacts must be minimized.

The requirements laid down by the National Building Regulations and Building Standards Act (Act 103 of 1977) in terms of development within the 1:50-year flood line area are based only on safety considerations without proper consideration and understanding of the underlying natural streamflow processes. The Town Planning and Townships Ordinance (Ordinance 15 of 1986) also makes provision in Regulation 44(3) for the extension of flood line areas up to 32 m from the centre of a stream in instances where the 1:50-year flood line is less than 62 m wide in total (CSIR, 2005).

2.2 Hydrological assessment

Hydrometeorological data for the study area were obtained from various sources including the South African Water Resources Study WR2012 database (Bailey & Pitman, 2015), South African Atlas of Agrohydrology, and Climatology (Schulze, 1997), and the Daily Rainfall Data Extraction Utility (Lynch, 2004). Moreover, sources such as the Köppen Climate Classification (Kottek, et al., 2006), World Climate Data CMIP6 V2.1 (Eyring, 2016), and Meteoblue (Meteoblue, 2022) were used to refine hydrological data.

These sources provided means of determining the Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) of the study site as well as the design rainfall data. Data was applied to the site water balance calculations, runoff peak flow estimates for flood line modelling and stormwater runoff peak flow estimates for stormwater system sizing (where applicable to this study).

2.2.1 Catchment description and delineation

A 30 m Digital Terrain Model (DTM) data from the Advanced Land Observing Satellite (ALOS) (JAXA, 2022) were used to delineate the area draining to the streams relevant to this study, sub-catchment flow path as well as to derive river geometry characteristics. These characteristics (area, slopes, and hydraulic parameters) are used to parameterize the site hydraulic model for flood line modelling, water balance modelling or stormwater modelling.

2019 South African National Land Cover (SANLC) data (DEA, 2019) was used to characterize the sub-catchment vegetation and derive manning surface roughness (n-values) coefficients.

2.2.2 Design rainfall and peak flow

The Design Rainfall Estimation Software (Smithers & Schulze, 2002) data from the rainfall stations surrounding the study site were used to calculate the 24-hour design rainfall depths for various return periods. Critical storm durations for Rational Methods Alternative 3 were calculated using the Modified Hershfield Equation (Adamson, 1981).

The streams/drainage sections that were modelled applying the three widely used methods were used to calculate 1:10, 1:20, 1:50, and 1:100-year peak flows. These are the Rational Method, Midgley and Pitman (MIPI), and the Standard Design Flood (SDF) methods. A brief description of each of the peak flow methods can be seen in Table 2-1, below.

Methodologies for using the applied peak flow models are explained broadly in the South African Drainage Manual (SANRAL, 2013). Calibration of the runoff coefficients for the drainage areas was guided by the manual, the understanding of the runoff-generating processes as well as land cover attributes. The resulting peak flows calculated using the selected methods were evaluated and conservative values provided inputs into the stormwater management plan.

Peak flows for the major rivers in the study area were further supplemented by available DWS flood line and hydrological data (DWS, 2023)

Table 2-1: Summary of peak flow methods

Rational Method The rational method was developed in the mid-19th century and is one of the most widely used methods for the calculation of peak flows for small catchments (< 15 km^2). The formula indicates that Q = CIA, where I is the rainfall intensity, A is the upstream runoff area and C is the runoff coefficient. Q is the peak flow. There are 3 alternatives to the Rational Method which differ in the methodology used to calculate rainfall intensities. The first alternative (RM1) uses the depth-duration frequency relationships approach, the second uses the modified Hershfield equation and the third alternative uses the Design Rainfall software for South Africa (SANRAL, 2013).
Midgley and Pitman The Midgley and Pitman (MIPI) method is an empirical method that relates peak discharge to catchment size, slope, and distance from the drainage point to the centroid of the catchment (Campbell, 1986). The MIPI method uses 10-unit hydrographs for 10 zones in South Africa. The method does not consider overland flow as a component separate from streamflow but considers only the total longest flow path (Campbell, 1986).
Standard Design Flood Method The Standard Design Flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities (SANRAL, 2013).

2.3 Flood line modelling

A 30 m ALOS digital terrain model (DTM) (JAXA, 2021) was used to derive the hydraulic and river geometry parameters. River/stream cross-sections and flow paths were prepared using RAS Mapper software and provided input into a 1D HEC-RAS (US Army Corps of Engineers, 2016) flood model. Visual assessment of riverbanks from the Google Earth Imagery and land cover types (DEA, 2019) was used to estimate Manning's n coefficients along the river/streamlines. The 1:10, 1:20, 1:50, and 1:100-year flood lines were generated and mapped in Global Mapper and ArcGIS (ESRI, 2018).

2.4 Conceptual stormwater management plan (CSWMP)

The SWMP was designed in conjunction with the provided project description, proposed layouts, and available topographical data. The Rational Method was applied to determine stormwater peak flows (sub-catchments < 15 km^2) within each stormwater sub-catchment, and further considers the U.S. Soil Conservation Service (SCS) hydrological soil types and land impervious percentages.

The conceptual SWMP was designed to consider relevant South African legislation – the National Water Act (1998) (NWA, 1998) and the Council for Scientific and Industrial Research (CSIR) Human Settlement Planning and Design guidelines (CSIR, 2005).

2.5 Hydrological risk assessment

As per GN R326 of the EIA Regulations (2014) (as amended), the significance of potential hydrological impacts will be assessed. Due to the assessment forming part of a larger risk assessment for the study area, the potential impacts and the determination of impact significance will be assessed. The process of assessing the potential impacts of the project includes the following four activities:

1. Identification and assessment of potential impacts.
2. Prediction of the nature, magnitude, extent, and duration of potentially significant impacts.
3. Identification of mitigation measures that could be implemented to reduce the severity or significance of the impacts of the activity; and
4. Evaluation of the significance of the impact after the mitigation measures have been implemented, i.e., the significance of the residual impact.

Per GN R326 of the EIA Regulations (2014) (as amended), the significance of potential impacts will be assessed in terms of the following criteria:

I. Cumulative impacts.
II. Nature of the impact.
III. The extent of the impact.
IV. Probability of the impact occurring.
V. The degree to which the impact can be reversed.
VI. The degree to which the impact may cause irreplaceable loss of resources; and
VII. The degree to which the impact can be mitigated.

Table 2-2 provides a summary of the criteria used to assess the significance of the potential impacts identified. An explanation of these impact criteria is provided in Table 2-3.

Consequence = (Duration + Extent + Irreplaceability of resource) × Severity

The environmental significance of an impact was determined by multiplying the consequence by probability.

Significance = Consequence × Probability

Table 2-2: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts

Criteria	Rating Scales	Notes
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development.
	Negative (-)	
Extent	Footprint (1)	The impact only affects the area in which the proposed activity will occur.
	Site (2)	The impact will affect only the development area.
	Local (3)	The impact affects the development area and adjacent properties.
	Regional (4)	The effect of the impact extends beyond municipal boundaries.
	National (5)	The effect of the impact extends beyond more than 2 regional/ provincial boundaries.
	International (6)	The effect of the impact extends beyond country borders.
Duration	Temporary (1)	The duration of the activity associated with the impact will last 0-6 months.
	Short-term (2)	The duration of the activity associated with the impact will last 6-18 months.
	Medium-term (3)	The duration of the activity associated with the impact will last 18 months - 5 years.
	Long-term (4)	The duration of the activity associated with the impact will last more than 5 years.
Severity	Low (1)	Where the impact affects the environment in such a way that natural, cultural, and social functions and processes are minimally affected.
	Moderate (2)	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way, and valued, important, sensitive, or vulnerable systems or communities are negatively affected.
	High (3)	Where natural, cultural, or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease, and valued, important, sensitive, or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable resources	No (0)	No irreplaceable resources will be impacted.
	Yes (1)	Irreplaceable resources will be impacted.
Consequence	Extremely detrimental (-25 to -33)	A combination of extent, duration, intensity, and the potential for impact on irreplaceable resources.
	Highly detrimental (-19 to -24)	
	Moderately detrimental (-13 to -18)	
	Slightly detrimental (-7 to -12)	
	Negligible (-6 to 0)	
	Slightly beneficial (0 to 6)	
	Moderately beneficial (13 to 18)	
	Highly beneficial (19 to 24)	
	Extremely beneficial (25 to 33)	
Probability (the likelihood of the impact occurring)	Improbable (0)	It is highly unlikely or less than 50% likely that an impact will occur.
	Probable (1)	It is between 50 and 70% certain that the impact will occur.
	Definite (2)	It is more than 75% certain that the impact will occur or the impact will occur.
Significance	Very high - negative (-49 to -66)	A function of Consequence and Probability.
	High - negative (-37 to -48)	
	Moderate - negative (-25 to -36)	
	Low - negative (-13 to -24)	
	Neutral - Very low (0 to -12)	
	Low-positive (0 to 12)	
	Moderate-positive (13 to 24)	
	High-positive (37 to 48)	
	Very high - positive (49 to 66)	

Table 2-3: Explanation of Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact of change on the environment be positive, negative, or neutral?
Extent or Scale	This refers to the spatial scale at which the impact will occur. The extent of the impact is described as footprint (affecting only the footprint of the development), site (limited to the site), and regional (limited to the immediate surroundings and closest towns to the site). The extent of scale refers to the actual physical footprint of the impact, not to the spatial significance. It is acknowledged that some impacts, even though they may be of a small extent, are of very high importance, e.g., impacts on species of very restricted range. To avoid "double counting", specialists have been requested to indicate spatial significance under "intensity" or "impact on irreplaceable resources" but not under "extent" as well.
Duration	The lifespan of the impact is indicated as temporary, short, medium, and long-term.
Severity	This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, alter its functioning, or render it slightly altered?
Impact on irreplaceable resources	This refers to the potential for an environmental resource to be replaced should it be impacted. A resource could be replaced by natural processes (e.g., by natural colonisation from surrounding areas), through artificial means (e.g., by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems, substitutes are often possible (e.g., by constructing new social facilities for those who are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable, e.g., red data species that are restricted to a particular site or habitat to a very limited extent.
Consequence	The consequence of the potential impacts is a summation of the above criteria, namely the extent, duration, intensity, and impact on irreplaceable resources.
Probability of occurrence	The probability of the impact occurring is based on the professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. It is important to distinguish between the probability of the impact occurring and the probability that the activity causing a potential impact will occur. Probability is defined as the probability of the impact occurring, not as the probability of the activities that may result in the impact.
Significance	Impact significance is defined to be a combination of the consequence (as described below) and the probability of the impact occurring. The relationship between consequence and probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact occurring. In simple terms, if the consequence and probability of an impact are high, then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making.
Degree of confidence in predictions	Specialists and the EIR team were required to indicate the degree of confidence (low, medium, or high) that there is in the predictions made for each impact based on the available information and their level of knowledge and expertise. The degree of confidence is not taken into account in the determination of consequence or probability.
Mitigation measures	Mitigation measures are designed to reduce the consequence or probability of an impact or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation.

2.6 Water quality screening and stormwater monitoring plan

The monitoring network is based on the principles of a monitoring network design as described by the DWAF Best Practice Guidelines: G3 Monitoring (DWAF, 2007). The methodological approach that the monitoring plan follows is represented in Figure 2-1, below.

Figure 2-1: Monitoring Process

A surface and stormwater monitoring program that presents water quality constituencies to be analysed, the frequency of sampling, and the locality of sampling points were drafted.

3 SITE OVERVIEW AND HYDROLOGY

As mentioned previously, the site is situated in Quaternary Catchment B41J of the Olifants Water Management Area (DWS, 2016) (WMA 2). Elevations on the proposed sites typically range from 751 to 821 meters above mean sea level (mamsl).

The Steelpoort River valley is steep with slopes of 2.5% in the plain and steep hills with slopes of 23% rising 1,000 m to altitudes of 1700 mamsl on the sides from approximately 700 mamsl along the river. The Steelpoort River has major tributaries of the Tubatsane River which joins it from the north. There are many small non-perennial drainage lines throughout the valley. There are two chrome smelters in the catchment. These are the main centres of development, otherwise, the area is generally undeveloped.

In terms of the greater hydrological area, the site is situated on the south-eastern bank of the Steelpoort River (the closest distance to the river is ±70 m), just downstream of the confluence with the Tubatsane River. Drainage from the proposed development area is via four non-perennial tributaries of the Steelpoort River in a north-west direction as presented in Figure 1-2 (runoff from the site). The Steelpoort River flows into the Olifants River approximately 40km from the site, which drains into Mozambique.

3.1 Sub-catchments / hydrological response units (HRUs)

Thirteen (13) hydrological response units (HRU) describe the natural drainage for the site (using a 1:1 100 stream count and a 50 m DTM fill) – refer to Figure 1-2 and Figure 3-2. The sub-catchment relates well to desktop-delineated drainage lines for the project area. Drainage from the sites is towards the northwest via non-perennial drainage lines that drain towards the perennial Steelpoort River.

3.2 Land cover and slope

The sub-catchments are dominated by forested land and grassland. Refer to Figure 3-1 for a more detailed overview of the land cover present. The land cover was simplified into 4 categories and is summarised in Table 3-1. The Slope % rise for the general area is shown in Figure 3-2. Slope rise % was used to characterise the sub-catchment slope and runoff generation.

Table 3-1: Summary of sub-catchments characteristics

Sub-Catchment	Area (km²)	Longest Drainage Line (km)	Average Slope (%)	Slope (%)				Land Cover			
				<3	3-10	10-30	>30	Thick bush & plantation	Light bush & farmlands	Grasslands	No Vegetation
S1_1	1.516	1.051	3.65%	8%	57%	20%	15%	51%	10%	18%	22%
S1_2	0.093	0.268	3.34%	16%	84%	0%	0%	21%	79%	0%	0%
S1_3	0.222	0.518	4.26%	25%	75%	0%	0%	49%	30%	5%	16%
S2	4.831	3.404	6.96%	0%	3%	25%	73%	45%	0%	55%	0%
S3	3.237	1.408	4.45%	0%	6%	34%	60%	83%	0%	17%	0%
S4	5.176	4.50	3.41%	1%	20%	41%	38%	33%	2%	63%	2%
S5	4.420	3.377	3.34%	1%	19%	42%	38%	75%	0%	22%	3%
S6	1.360	1.824	2.37%	7%	77%	14%	1%	77%	8%	2%	14%
S7	2.533	1.210	3.07%	0%	19%	39%	42%	73%	0%	27%	0%
S8	1.062	1.611	11.68%	0%	9%	44%	47%	86%	0%	14%	0%
S9	1.155	1.550	4.99%	0%	13%	33%	54%	38%	4%	58%	0%
S10	0.90	1.35	4.75%	1%	25%	39%	35%	22%	14%	42%	22%
S11	0.27	0.44	3.83%	6%	78%	15%	1%	23%	57%	3%	17%

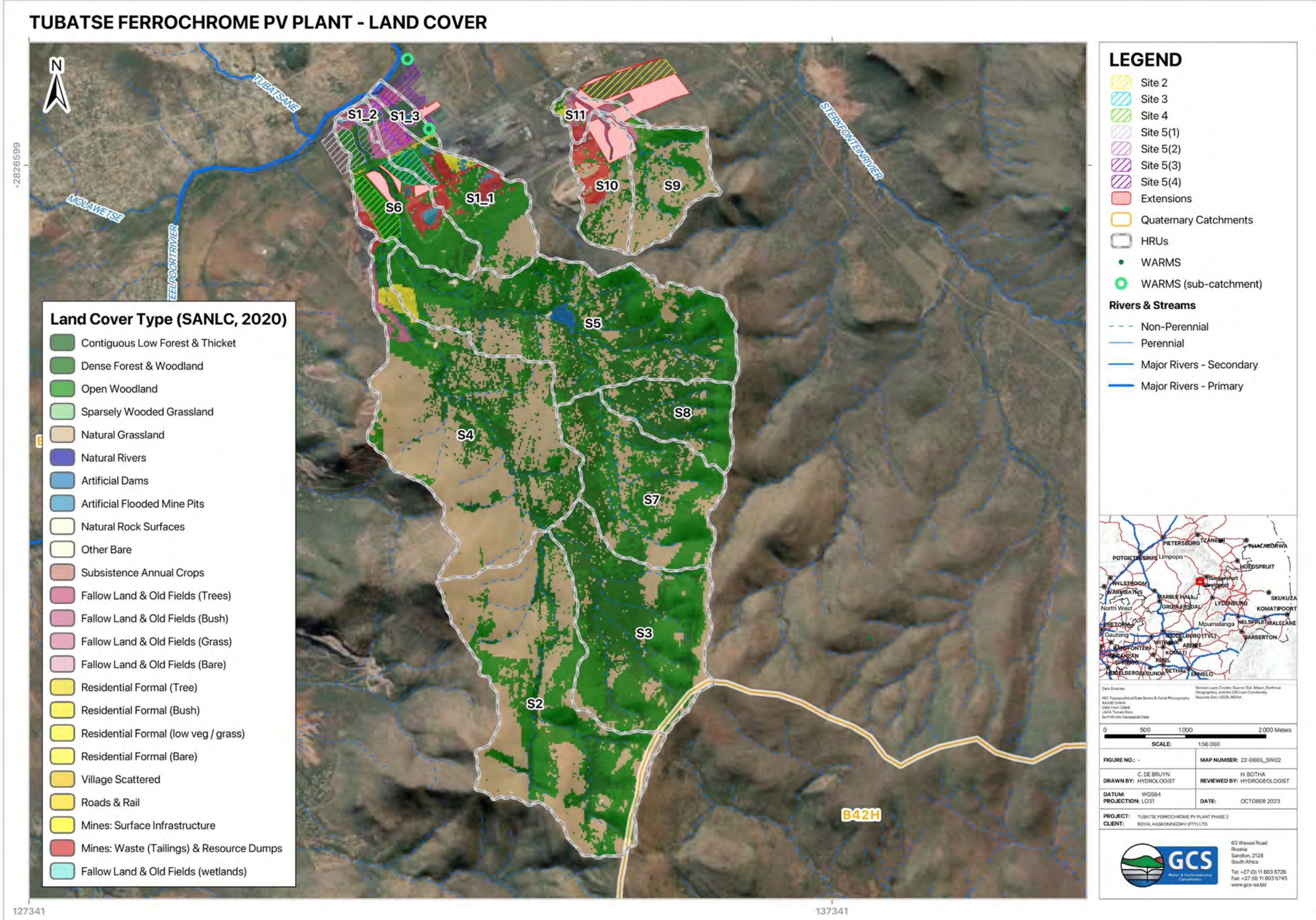


Figure 3-1: Sub-catchment & land cover types

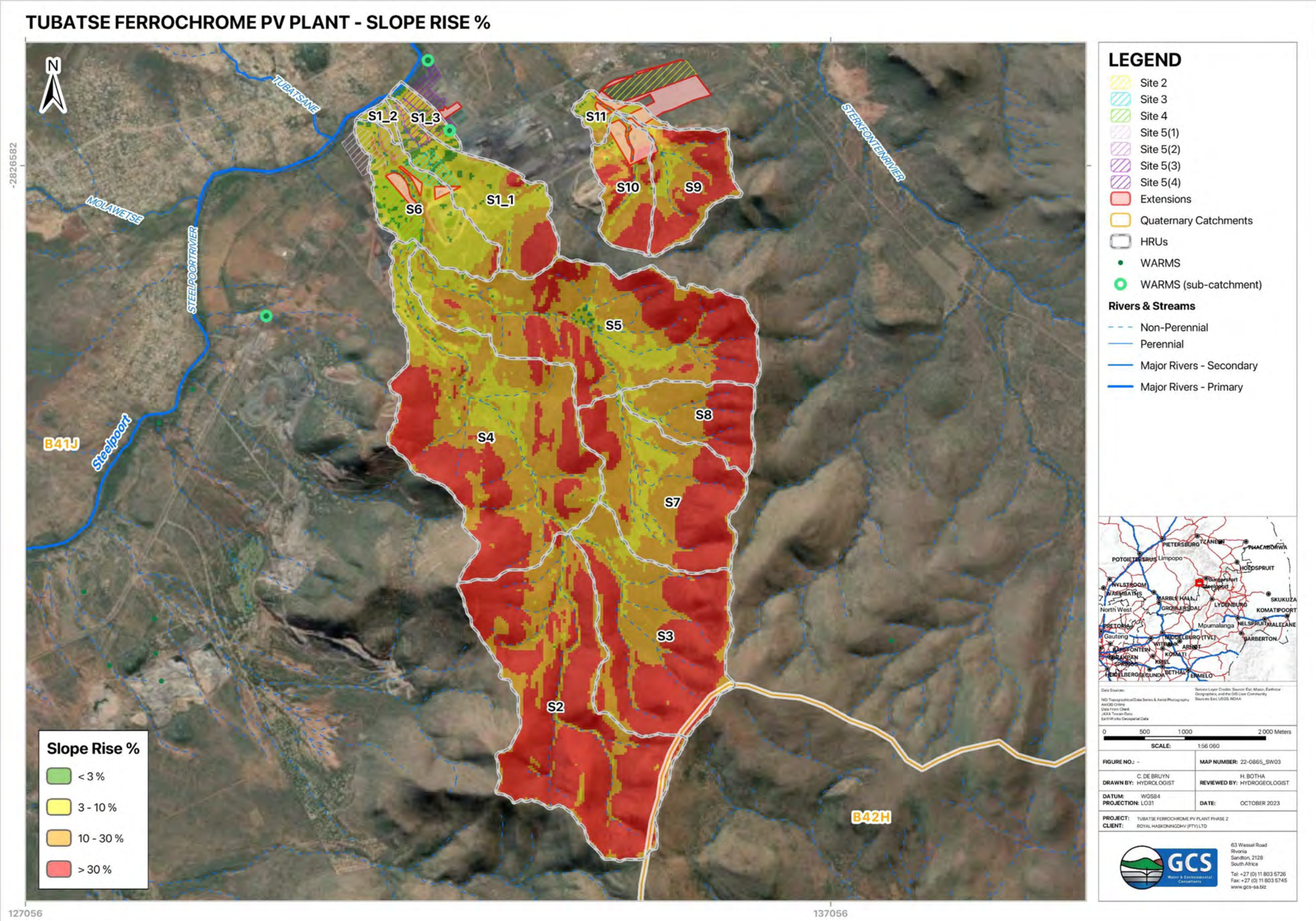


Figure 3-2: Sub-catchments & slope rise %

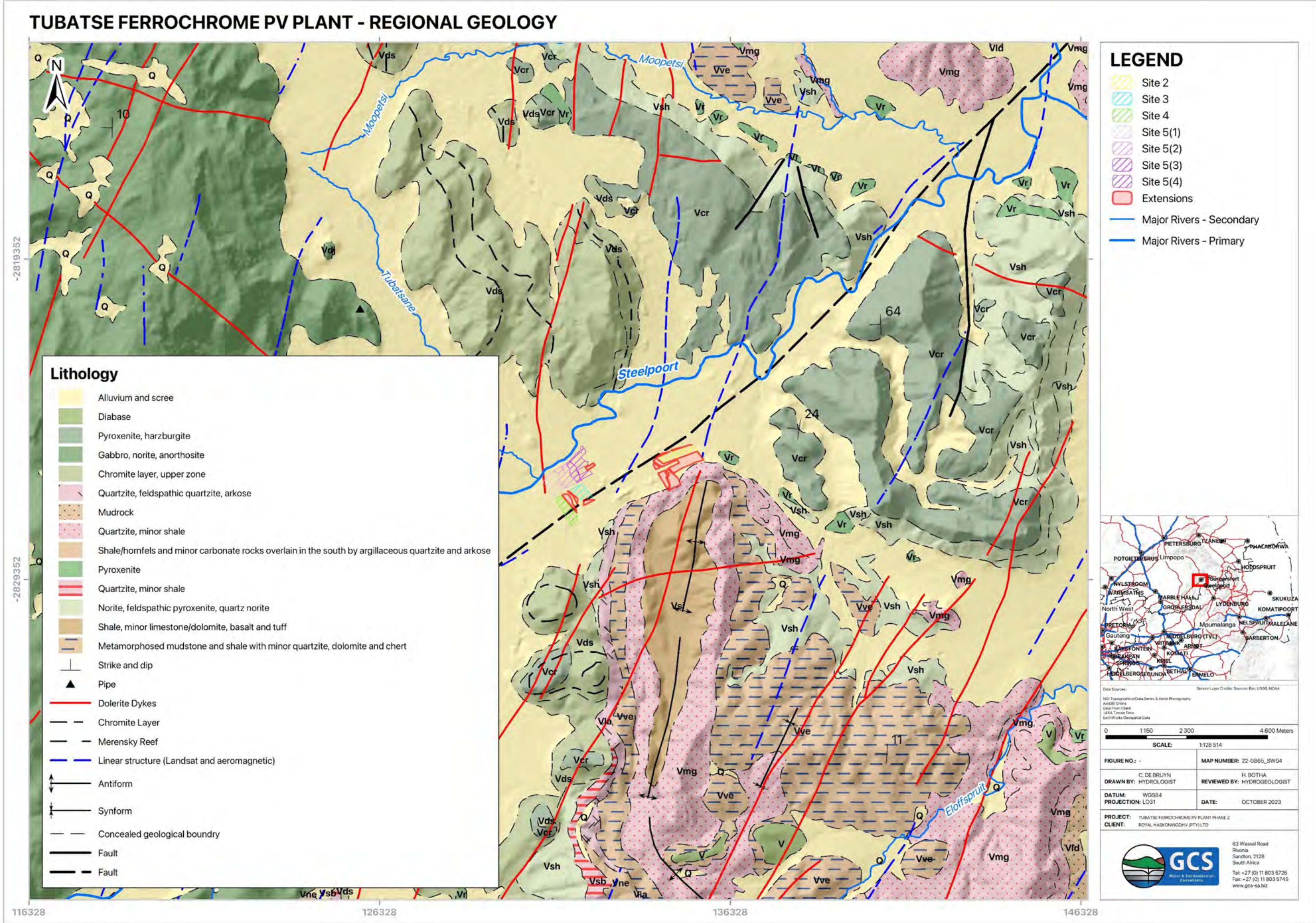


Figure 3-3: Regional geology

3.3 Climate

Climate, amongst other factors, influences soil-water processes and stormwater peak flows. The most influential climatic parameter is rainfall. Rainfall intensity, duration, evaporative demand, and runoff were considered in this study to indicate rainfall partitioning within the project area.

3.3.1 Temperature

The average yearly temperature (refer to Figure 3-4) for the project area ranges from 23 to 37˚C (high) and 3 to 19˚C (low). The study area is situated in a hot semi-arid (steppe) climate (BSh) area with dry winters, as per the Köppen Climate Classification (Kottek, et al., 2006).

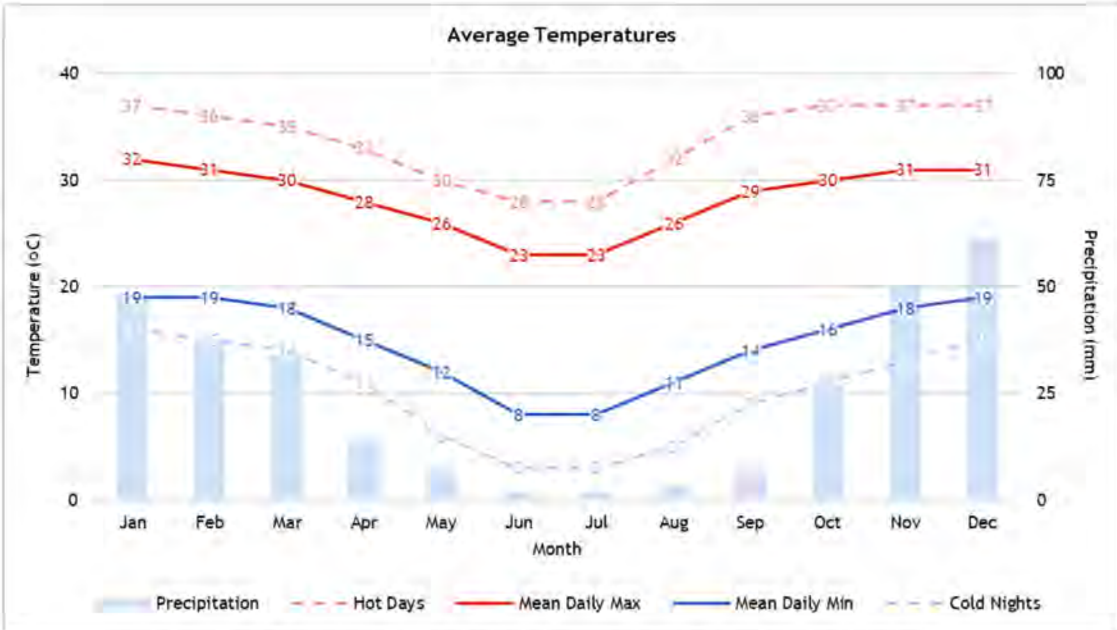


Figure 3-4: Average yearly temperatures (Meteoblue, 2023)

3.3.2 Wind speed and direction

Figure 3-5 shows the wind rose for the project area (Steelpoort used as reference) and presents the number of hours per year the wind blows from the indicated direction. The wind blows predominantly in the NE, ENE, and NNE directions, then more often in N to E directions. Velocities range from 1 km/h to > 19 km/h.

Precipitation intensity during wind will likely cause precipitation intensity changes on slopes perpendicular to the wind direction throughout the year.

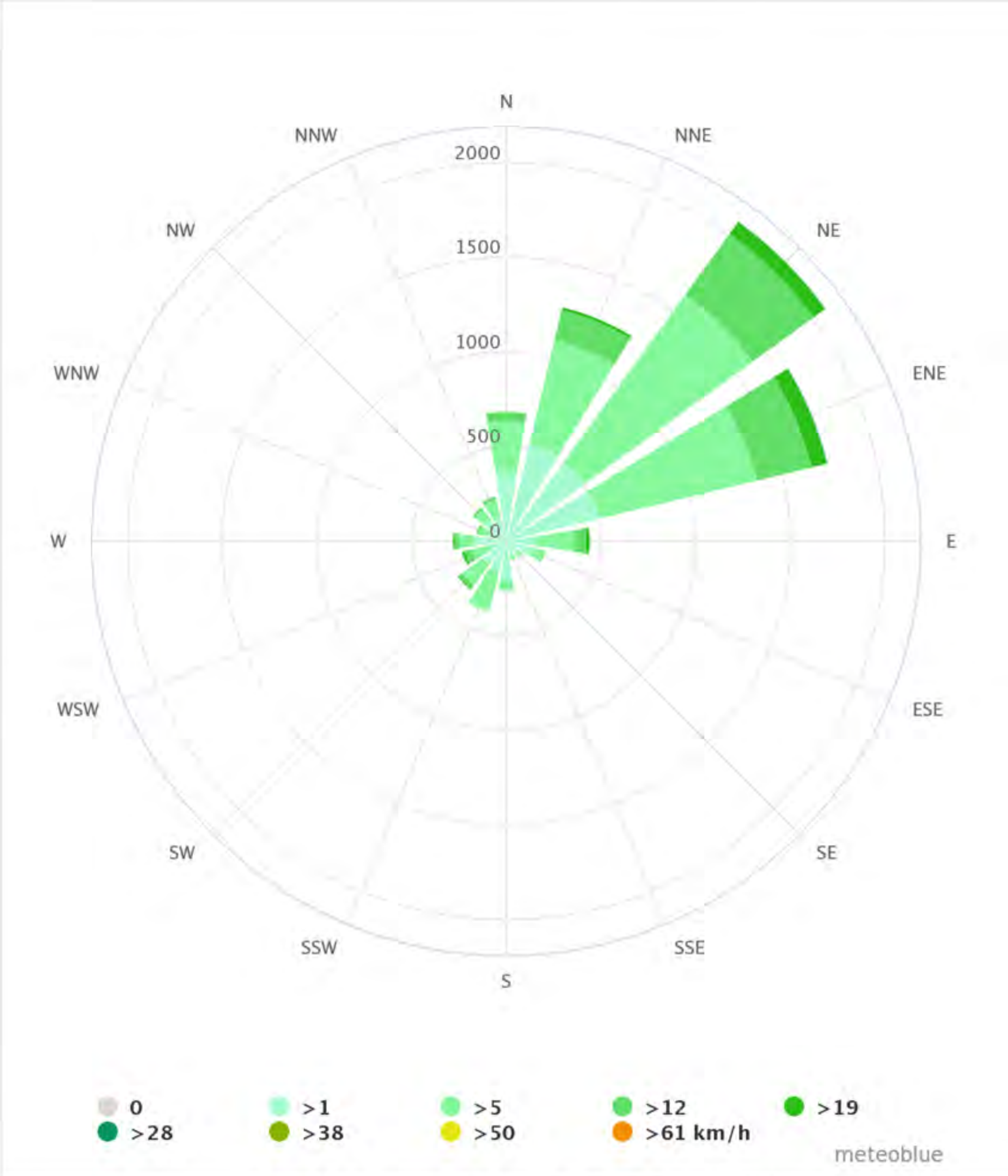


Figure 3-5: Wind rose (Meteoblue, 2023)

3.3.3 Rainfall and evaporation

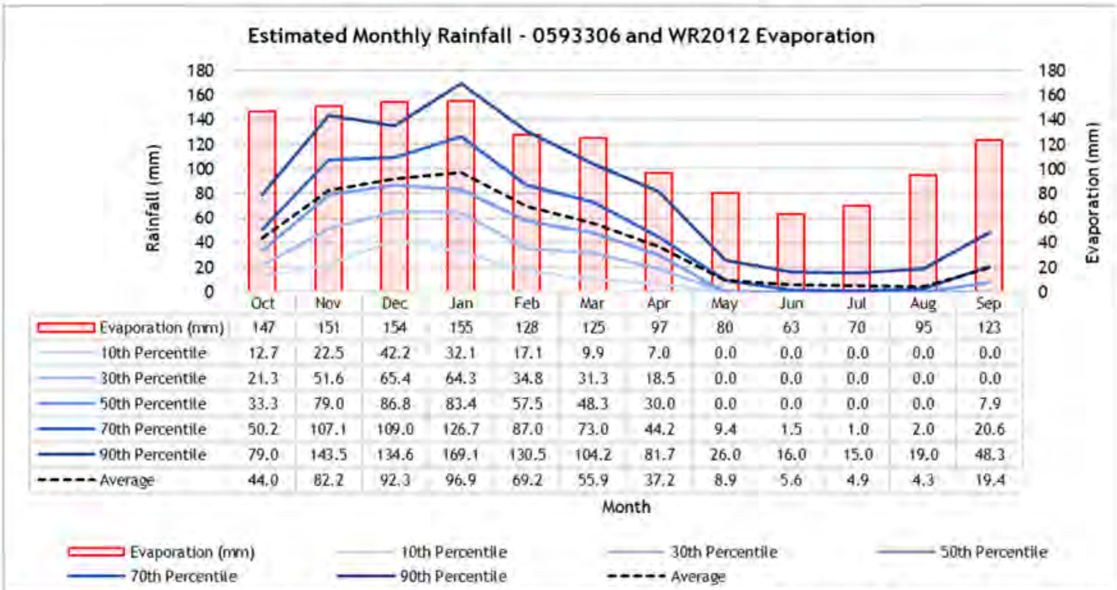
The project area is situated in rainfall zone B4D. The average Mean Annual Precipitation (MAP) for several rainfall stations situated near the site is tabulated in Table 3-2.

Table 3-2: Summary of MAP of closest rainfall stations (Smithers & Schulze, 2002)

Name	Station ID	MAP (mm/a)
Derdegelid (Pol)	**0593306_W**	**582**
Burgersfort (Pol)	0593581_W	550
Ga-Sekhukhuneland	0593015_W	552
De Grootboom	0593586_W	551
Maandagshoek	0593126_W	624
Martenshoop (Pol)	0593419_W	689
Average		**591**

The monthly rainfall data used for the area was obtained from rainfall station 0593306W (Derdegelid), situated 12.6 km from the site. The rainfall record spans from 1929 to 1989, which is a record length of 61 years. Monthly rainfall for the site is likely to be distributed, as shown in Figure 3-6 below.

Available rainfall data suggest a MAP ranging from 287.2 mm/a (30th percentile) to 966.9 mm/a (90th percentile). The average rainfall is in the order of 520.8 mm/a. The project area falls within evaporation zone 4A, of which Mean Annual Evaporation (MAE) ranges from 1 500 to 1 600 mm/a. The MAE far exceeds the MAP for the site, which implies greater evaporative losses when compared to incident rainfall. Monthly evapotranspiration for the site is likely to be distributed, as shown in Figure 3-6 below.

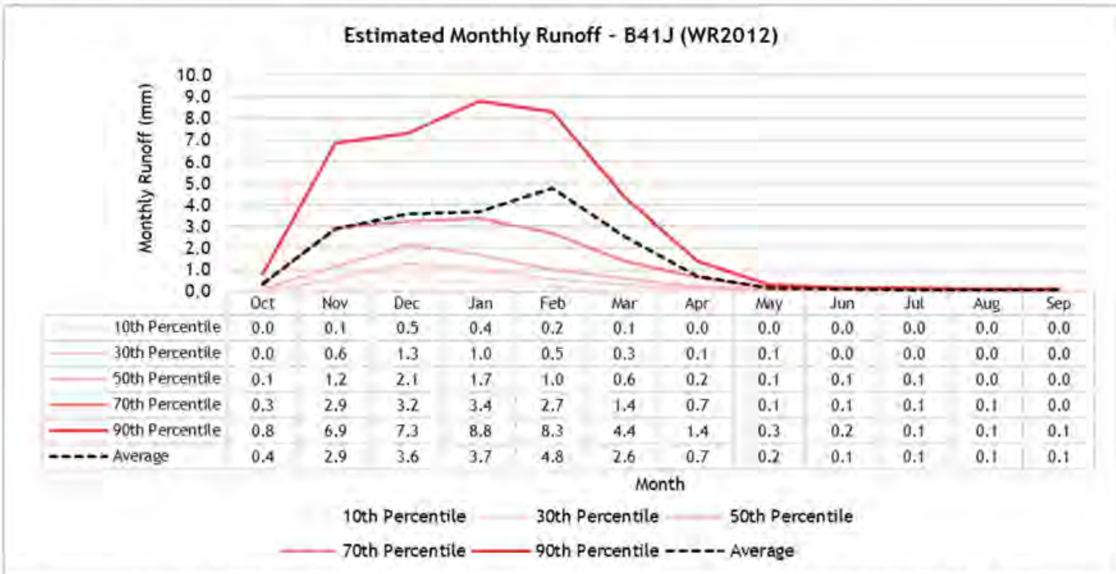


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation (mm)	147	151	154	155	128	125	97	80	63	70	95	123
10th Percentile	12.7	22.5	42.2	32.1	17.1	9.9	7.0	0.0	0.0	0.0	0.0	0.0
30th Percentile	21.3	51.6	65.4	64.3	34.8	31.3	18.5	0.0	0.0	0.0	0.0	0.0
50th Percentile	33.3	79.0	86.8	83.4	57.5	48.3	30.0	0.0	0.0	0.0	0.0	7.9
70th Percentile	50.2	107.1	109.0	126.7	87.0	73.0	44.2	9.4	1.5	1.0	2.0	20.6
90th Percentile	79.0	143.5	134.6	169.1	130.5	104.2	81.7	26.0	16.0	15.0	19.0	48.3
Average	44.0	82.2	92.3	96.9	69.2	55.9	37.2	8.9	5.6	4.9	4.3	19.4

Figure 3-6: Average rainfall for station 0593306W & WR2012 Evaporation

3.3.4 Runoff

As mentioned previously, the site is situated in Quaternary Catchment B41J. The average runoff from natural (unmodified) catchments for quaternary catchment B41J is simulated in WR2012 (WRC, 2015) as being equivalent to 19 mm/a (or 4% of the MAP). This is approximately 13.12 Mm^3/a NMAR average for the surface area.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	0.0	0.1	0.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
30th Percentile	0.0	0.6	1.3	1.0	0.5	0.3	0.1	0.1	0.0	0.0	0.0	0.0
50th Percentile	0.1	1.2	2.1	1.7	1.0	0.6	0.2	0.1	0.1	0.1	0.0	0.0
70th Percentile	0.3	2.9	3.2	3.4	2.7	1.4	0.7	0.1	0.1	0.1	0.1	0.0
90th Percentile	0.8	6.9	7.3	8.8	8.3	4.4	1.4	0.3	0.2	0.1	0.1	0.1
Average	0.4	2.9	3.6	3.7	4.8	2.6	0.7	0.2	0.1	0.1	0.1	0.1

Figure 3-7: Simulated natural (unmodified) average runoff for B41J

3.4 Local geology and soils

According to the 1:250 000 Geological series for the Pilgrim's Rest (Sheet Reference 2430), the sites are located on predominantly surficial deposits, alluvium, and scree of the Quaternary period. The southern sections of the site 2 extensions are located on quartzite containing impersistent shale layers, and interlayered shale, siltstone from the Magaliesberg Formation in the Pretoria Group which forms part of the Transvaal Sequence. Refer to Figure 3-3 for the regional geology map.

Soils in the area are mainly loamy sand and sandy loam from the soil series Mispah, Clovelly and Shortlands. Mispah soils are very shallow and often rocky or gravelly. Clovelly soils are highly fertile, deep agriculture soils with a yellow-brown apedal B horizon. Shortland soils have a red, structured B horizon, and are also highly fertile soils if deep enough.

According to WR2012 soil data for the area, the erodibility of the soil in the area can be considered high (WRC, 2015). The hydrological soil group (HSG) classification for the site ranges from B/C to C, indicating that the soils in the area have a moderately low to moderately high runoff potential when thoroughly wet. These soils tend to have a clay content of 10% to 40% and a sand content of 50 – 90% (USDA, 2009).

3.5 Local hydrogeology & depth to groundwater

The site is situated in an area predominantly underlain by mafic intrusive rocks such as diabase, gabbro, dunite, pyroxenite, norite and anorthosite (King, et al., 1998). The aquifer can be referred to as being primarily intergranular and fractured. Yields of approximately 0-5 to 2.0 l/s (King, et al., 1998) may occur.

Groundwater is typically encountered:

- Shallow alluvium zones associated with the major rivers.
- Basins of weathering occur mostly in igneous rocks; and
- Fractures in transitional zones between weathered and unweathered rocks.

Recharge to the underlying aquifer is estimated to be in the order of 5.1% of the MAP (520.8 mm/a), which falls within quaternary catchments B41J (DWAF, 2006). The aquifer's weathered zones are reported to range from approx. 18-38m thick, with the fractured zone ranging from approx. 83-113 m thick (DWAF, 2006). The combined aquifer thickness is estimated to range from 122-132 m. The aquifers are important contributors to groundwater baseflow to streams and rivers (King, et al., 1998).

According to (Vegter, 1995) and (DWAF, 2006), the groundwater levels within the sub-catchments are expected to range from 17.8 to 18.7 mbgl (meters below ground level). The groundwater table is expected to mimic the topography and be shallower closer to perennial streams (i.e., these are prominent groundwater contributions to baseflow areas or areas where groundwater seepage from the resource into the aquifer units may take place).

3.6 Wetland areas

Based on available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (van Deventer, et al., 2020), wetlands that exist in the surrounding area are channelled and unchanneled valley-bottom wetlands.

In terms of wetland geo-hydrology, baseflow is considered the most important contributor to stream and wetland health. Baseflow (refer to Figure 3-8) is a non-process-related term to signify low amplitude high-frequency flow in a river during dry or fair-weather periods. Baseflow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised that groundwater contributes to the baseflow component of a river or wetland flow.

Available literature (WRC, 2015; DWAF, 2006) suggests groundwater contribution to baseflow is approximately 1.14 mm/a (HUGHES MODEL) for the quaternary catchment B41J. This relates to approximately 0.22% of rainfall.

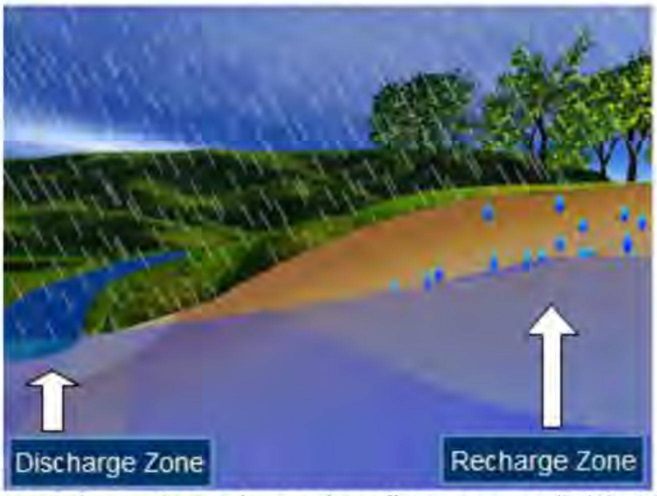


Figure 3-8: Groundwater baseflow concept (DWS, 2011)

3.7 Present ecological state (PES) and ecological importance and sensitivity (EIS)

Table 3-3 provides a summary of the PES and EIS for the quaternary catchment associated with the project area (WRC, 2015).

Table 3-3: Summary of PES and EIS for the Quaternary Catchment

Quat	PES	EIS
B41J	Class C: Moderately Modified	High

The PES for quaternary catchment B41J is classified as Class C: Moderately Modified, and the Ecological Importance and Sensitivity (EIS) as highly sensitive (SANBI, 2011).

3.8 Surface water users within the sub-catchment associated with the site

According to the Water Allocation Registration Management System (WARMS, 2019), there are twenty-seven (27) WARMS water uses within a 2.5 km radius. Nineteen (19) of these are listed as active users, while eight (8) have a registered status of closed. Two of the nineteen active users are surface water users and seventeen (17) are groundwater users. All users are listed as Samancor Tubatse Ferrochrome users. The information is summarised in Table 3-4.

Table 3-4: Summary of WARMS users identified in the study area

ID	Latitude (WGS84)	Longitude (WGS84)	User	Resource Type	Resource	Register Status	Lawfulness Finding	Registered Volume (m³/a)
24007511	-24.73331	30.18628	Tubatse Ferrochrome	Borehole	TWB 1	Active	Lawful	47 194.5
24007511	-24.73022	30.1845	Tubatse Ferrochrome	River/Stream	Steelpoort Catchment Area	Active	Lawful	402 266.5
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	Borehole	Active	Lawful	4 380.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	Lucas Portgiter	Active	Lawful	16 738.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	Lucas Portgiter	Active	Lawful	14 827.2
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	Lucas Portgiter	Active	Lawful	16 262.1
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	TWB 2	Active	Lawful	15 366.5
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	TWB 7	Active	Lawful	78 840.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Dam	Water Dam	Active	Lawful	142 569.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA25	Active	Lawful	15 552.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA20R	Active	Lawful	121 308.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA5	Active	Lawful	29 988.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA7	Active	Lawful	96 468.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA8	Active	Lawful	93 523.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA10	Active	Lawful	29 124.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA34	Active	Lawful	53 244.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	SRK1	Active	Lawful	166 332.0
24007511	-24.741111	30.188722	Tubatse Ferrochrome	Borehole	GA 29	Active	Lawful	157 812.0
24014282	-24.76181	30.16824	SamancorCR Eastern Chrome Mines	Borehole	Borehole	Active	Lawfulness still to be determined	362 487.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	BH GA2	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	BH GA5	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	BH GA6	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	BH GA	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	BH GA8	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	BH GA10	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	SRK14	Closed	Lawful	81 250.0
24099244	-24.730028	30.185	Samancor Limited	Borehole	SRK1	Closed	Lawful	81 250.0

3.9 Overview of the site hydrological cycle

Based on the information attained for the study area (as presented in this section), existing groundwater and surface water users, climate, runoff and estimated baseflow to wetland areas, a sub-catchment-specific hydrological cycle was developed (refer to Figure 3-9).

With regards to the hydrological cycle for the sub-catchment, the following is estimated:

- Average rainfall over the surface of the sub-catchments is in the order of 13.94 Mm^3/a (50% of the total water budget);
- Average runoff accounts for a volume in the order of 0.51 Mm^3/a (1.8% of the total water budget);
- Average evaporation is in the order of 10.83 Mm^3/a (38.8% of the total water budget);
- The average groundwater contribution to baseflow to rivers/wetlands/streams is in the order of 0.03 Mm^3/a (0.1% of the total water budget);
- The average groundwater recharge is in the order of 0.71 Mm^3/a (2.6% of the total water budget); and
- Groundwater and surface water users account collectively for 1.86 Mm^3/a (6.69% of the total water budget).

3.10 Site walkover

A site walkover was conducted on the 4th and 5th of October 2023. The following aspects were inspected:

- Drainage lines were established, as well as vegetation and composition within the riverbeds to aid in flood line modelling of the drainage lines associated with site 2.
- Stormwater systems and structures within the study area were identified and measured to incorporate into the flood line model.
- Photographs were taken for reference.
- Samples were taken from the Steelpoort River. It was established that Samancor also conducts quarterly monitoring, which will supplement the water quality and monitoring plan for the hydrological assessment.

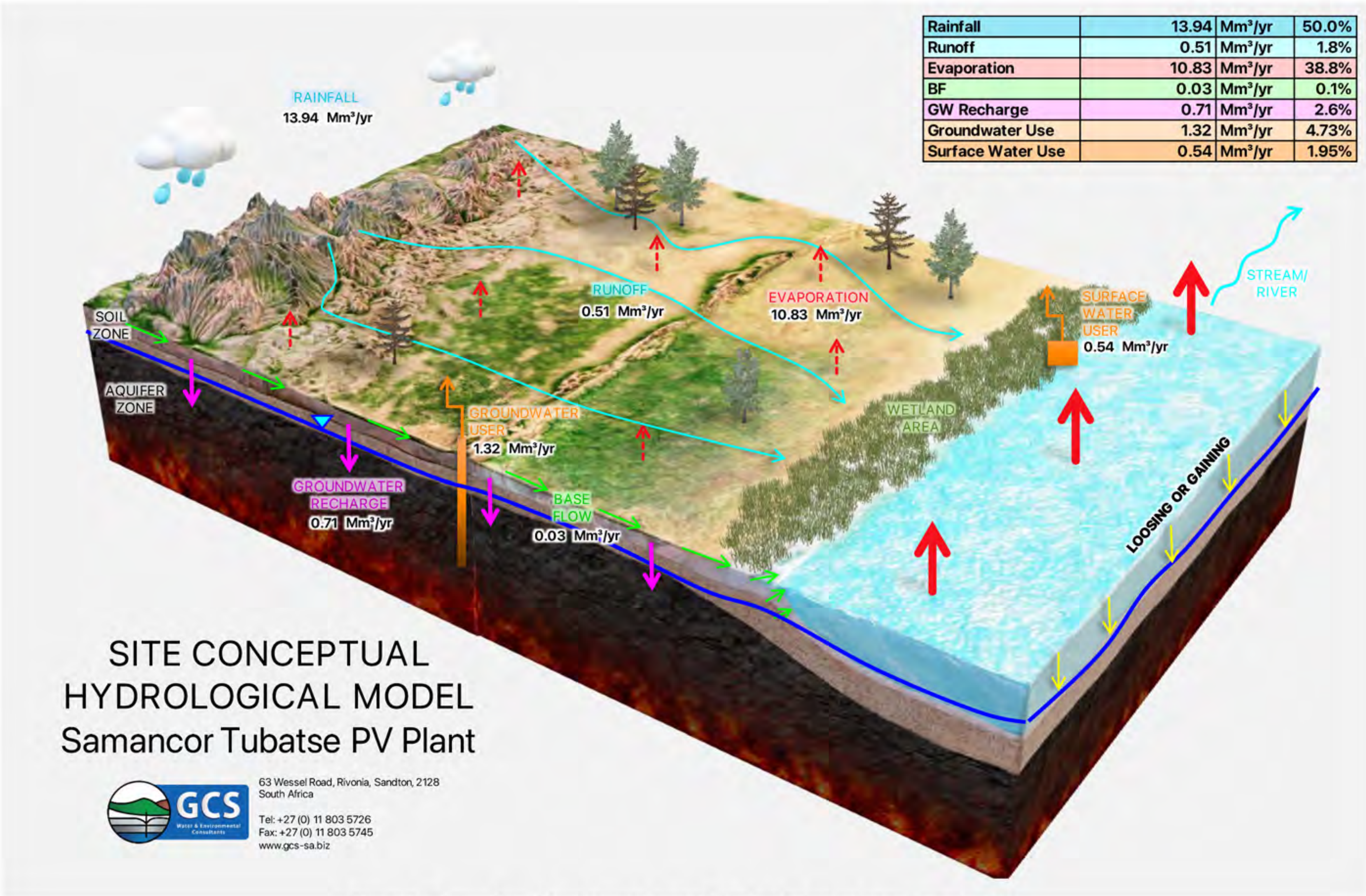


Figure 3-9: Simplified overview of the hydrological cycle at the site

4 WATER QUALITY ASSESSMENT

The following sections supply an overview of the surface water (SW) chemistry for the Steelpoort River close to the sites. The chemistry results are compared against the ideal DWAF (1996) Target Water Quality Ranges (TWQR). These guidelines are used as a means of comparison to give context to the data.

A water quality sample was obtained upstream and downstream of the site in the Steelpoort River. The sample position is indicated in Figure 9-1. The sample point serves as the baseline water quality conditions of the receiving surface water stream and hence should be considered the water quality objectives during the construction and post-construction phases of the project. The samples were submitted to X-Lab Earth Science (SANAS T0775) for analytical screening, and the laboratory certificates are available in **Appendix B.**

The hydrochemistry results are summarised in Table 4-1, and the following is observed:

- Both the upstream and downstream samples have high nitrate levels. These levels are associated with rare instances of methemoglobinemia in infants but no effects in adults. Concentrations in the range of 6 - 10 mg/ℓ are generally well tolerated.
- The turbidity of the upstream sample is slightly high, having a slight chance of adverse aesthetic effects and infectious disease transmission.
- All other constituents analysed are well within the DWAF target water quality ranges for potable water use.

Table 4-1: Summary of surface water hydrochemistry

Constituent	Unit	Steelpoort Upstream	Steelpoort Downstream	DWAF 1996 Domestic Use - TWQR
Chemical				
pH in water at 25°C	pH units	8.4	8.4	6 - 9
Conductivity in mS/m @ 25°C	mS/m	41	42	0 - 70
Total Dissolved Solids at 105°C	mg/ℓ	250	260	0 - 450
Turbidity	NTU	1.2	0.9	0 - 1
Bicarbonate Alkalinity as HCO_3	mg/ℓ	171	153	ns
Bicarbonate as $CaCO_3$	mg/ℓ	140	125	ns
Total Alkalinity as $CaCO_3$	mg/ℓ	140	125	ns
Calcium	mg/ℓ	31	32	0 - 32
Magnesium	mg/ℓ	23	23	0 - 30
Potassium	mg/ℓ	2.1	2.2	0 - 50
Sodium	mg/ℓ	25	25	0 - 100
Chloride	mg/ℓ	36	37	0 - 100
Fluoride	mg/ℓ	0.22	0.25	0 - 1
Nitrate	mg/ℓ	9.2	8.7	0 - 6
Sulphate	mg/ℓ	29	28	0 - 200
Aluminium	mg/ℓ	<0.02	<0.02	0 - 0,15
Iron	mg/ℓ	<0.05	<0.05	<0,1
Manganese	mg/ℓ	<0.01	<0.01	0 - 0,05
Sodium Absorption Ration (SAR)	$(mmol/ℓ)^{0.5}$	0.80	0.80	<6
ns = No Quality Range in Reference Guideline, Red = Above DWAF (1996) Ideal Water Quality Ranges				

5 FLOOD LINE ASSESSMENT

Flood peak flow for the non-perennial stream portion associated with the sub-catchments was estimated with the Rational Method (3), Standard Design Flood (SDF) and Midgley & Pitman (MIPI) Method (refer to **Appendix A**). Table 5-1 provides a summary of the design rainfall data used to calculate peak flows, and time concentrations were calculated based on the sub-catchment size and parameters. The upper limit "U" was used to estimate worst-case peak flows.

Table 5-1: Summary of design rainfall data used for peak flow estimation

Duration	Return Period (years)						
	2	5	10	20	50	100	200
5 min	11.2	15.3	18.4	21.7	26.4	30.3	34.6
10 min	17	23.4	28.1	33.2	40.3	46.3	52.8
15 min	21.8	29.9	36	42.5	51.7	59.4	67.7
30 min	28.4	38.9	46.8	55.3	67.2	77.2	88
45 min	33.1	45.4	54.6	64.4	78.3	90	102.5
1 hr	36.9	50.6	60.9	71.9	87.3	100.3	114.3
1.5 hr	43	59	70.9	83.8	101.8	117	133.3
2 hr	48	65.8	79.1	93.4	113.5	130.4	148.6
4 hr	54.7	75	90.2	106.5	129.4	148.7	169.4
6 hr	59	81	97.4	115	139.7	160.6	183
8 hr	62.3	85.5	102.8	121.4	147.5	169.5	193.2
10 hr	65	89.2	107.3	126.7	153.9	176.8	201.5
12 hr	67.3	92.3	111	131.1	159.3	183.1	208.6
16 hr	71.1	97.5	117.2	138.4	168.2	193.3	220.3
20 hr	74.1	101.7	122.3	144.4	175.4	201.6	229.8
24 hr	76.7	105.3	126.6	149.5	181.6	208.7	237.8
1 day	63.7	87.3	105	124	150.6	173.1	197.3
2 days	73.8	101.3	121.8	143.9	174.8	200.9	228.9
3 days	80.5	110.5	132.9	156.9	190.6	219.1	249.7
4 days	88.7	121.7	146.3	172.8	209.9	241.3	274.9
5 days	95.6	131.2	157.7	186.2	226.2	260	296.3
6 days	101.6	139.4	167.7	198	240.5	276.4	315
7 days	107	146.8	176.6	208.5	253.3	291.1	331.7

5.1 Estimated flood return periods

Calculated peak flows are summarised in Table 5-2. The SDF and Rational Method produced slightly higher flood peaks than the MIPI method (refer to Figure 5-1). The geometric average of the methods was applied to the HEC-RAS model. The flood line assessment is aimed at providing a worst-case inundation scenario to evaluate potential flooding risks. The peak flows presented are for the existing project setting.

Table 5-2: Summary of design peak flows for the delineated sub-catchment (m^3/s)

Catchment	Return Period	S1_1	S1_2	S1_3	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
		Peak flow (m^3/s)												
RM (3)	1:20 yr	0	0	0	93	82	68	73	25	66	52	26	2	8
	1:50 yr	1	0	0	117	104	86	93	32	84	66	33	28	11
	1:100 yr	1	0	0	140	124	102	110	38	100	78	40	34	13
SDF	1:20 yr	0	0	0	46	37	38	38	13	30	18	18	15	7
	1:50 yr	0	0	0	66	54	55	55	19	43	26	27	22	10
	1:100 yr	0	0	0	83	97	70	70	24	54	33	35	29	13
MIPI	1:20 yr	0	0	0	31	24	29	28	11	20	12	13	13	6
	1:50 yr	1	0	0	43	34	41	39	15	28	16	18	16	9
	1:100 yr	1	0	0	54	41	52	49	20	35	21	23	20	11
Geometric Mean	1:20 yr	**0**	**0**	**0**	**51**	**41**	**42**	**43**	**16**	**34**	**22**	**18**	**16**	**7**
	1:50 yr	**0**	**0**	**0**	**69**	**57**	**58**	**58**	**21**	**46**	**30**	**25**	**22**	**10**
	1:100 yr	**1**	**0**	**0**	**86**	**71**	**72**	**72**	**26**	**57**	**38**	**32**	**27**	**12**

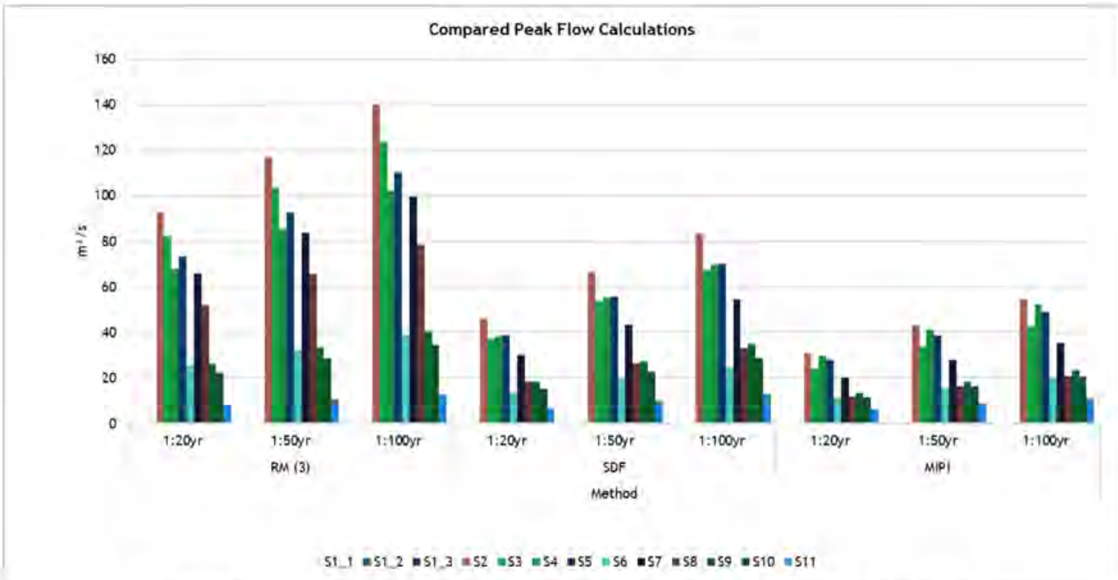


Figure 5-1: Comparison between three design peak flow methods

5.2 Post-development peak flows

Post-development peak flows will be higher due to the changes that will occur to the surface of the sub-catchments (i.e., impervious arrays could lead to a higher concentrated runoff which would potentially increase the peak runoff to the nearest watercourse). Sub-catchments that will be impacted include S1_1-3, S6, S10 and S11. The table summarises the change in peak flow after development.

Table 5-3: Summary of design peak flows for the delineated sub-catchment (m^3/s)

Catchment	S1_1	S1_2	S1_3	S6	S10	S11
Est. Impermeable/Permeability Area Change (%)	30%	60%	50%	30%	17%	26%
1:20Y						
Initial Peak Flow (m^3/s)	0.44	0.09	0.10	25.38	15.72	7.13
Post Development Peak Flow (m^3/s)	0.58	0.15	0.16	33.00	18.39	8.34
1:50Y						
Initial Peak Flow (m^3/s)	0.56	0.12	0.13	32.12	21.71	9.84
Post Development Peak Flow (m^3/s)	0.73	0.19	0.20	41.75	25.40	11.51
1:100Y						
Initial Peak Flow (m^3/s)	0.67	0.14	0.16	38.33	27.16	12.31
Post Development Peak Flow (m^3/s)	0.87	0.22	0.24	49.83	31.78	14.40

5.3 Flood line modelling

5.3.1 Software

HEC-RAS 6.3.1 (September 2022) was used to flood the elevation profile for the 1:50 and 1:100-year flood events. HEC-RAS is a hydraulic programme designed to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

5.3.2 Topography profile data

A high-resolution DTM of 0.9m grid size forms the foundation for the HEC-RAS model and was used to extract elevation data for the river profile together with the river cross-sections. Furthermore, the DTM was used to determine placement positions for the cross-sections along the river profile, such that the watercourse can be accurately modelled to the resolution of the provided topographical data. The positions of the river sections were further refined, by evaluating ortho imagery captured during the drone survey and its correlation to the DTM elevations (i.e., does the actual position of a river/stream correlate to the sub-catchment drainage line generated).

5.3.3 Manning's roughness coefficients

Manning's roughness factor (n) is used to describe the channel and adjacent floodplains' resistance to flow. A Manning factor of 0.06 best represents the frictional characteristics of the riverbanks and 0.05 – 0.035 the channels (river).

5.3.4 Inflow and boundary conditions

Based on the HRUs and the confirmed drainage lines/streams in the project area, six (3) HEC-RAS rivers were defined in the model. Three (3) rivers for site 2 and associated extensions, and three (3) rivers for site 3 to 5. The sites have the same model setup, i.e. two rivers join at a junction, which then forms a tributary to the Steelpoort River. The two upstream rivers consisted of normal depth upstream boundary conditions, with a junction as a downstream boundary. The main tributary consists of a junction as upstream boundary condition, and critical depth downstream boundary condition. The normal depth slope was determined based on the ALOS DTM slope rise for the given sub-catchment drainage lines.

5.3.5 Hydraulic structures

The bridge on the R555 was incorporated into the model for the tributary associated with sites 3 to 5. Measurements for the bridge were determined from the ortho imagery. No hydraulic structures were incorporated for site 2.

5.3.6 Model assumptions

In line with the development of the flood lines, the following assumptions were made:

- The topographic data provided was of sufficient accuracy and coverage to enable conceptual hydraulic modelling at a suitable level of detail.
- The Manning's 'n' values used are considered suitable for use in the flooding events modelled, representing all the channels and floodplains.
- No abstractions or discharges into the stream sections were considered during the modelling.
- Steady-state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate; and
- A mixed flow regime that is tailored to both subcritical and supercritical flows was selected for running the steady-state model.

5.4 Model results

The 1:50-year and 1:100-year flood lines are presented in Figure 5-2 and Figure 5-3. The site 2 expansion areas are somewhat encroached upon by flood waters, especially in the area bordering a nearby quarry. The flood waters are mostly contained within the deep watercourse geometry and do not flow substantially wider than the channel banks. Flood lines associated with sites 3 to 5 indicate that the site 4 expansion is at a greater risk of flooding. This is due to the flood plain topography present and the R555 (and associated bridge) preventing faster flow. A small section of the site 3 expansion will also be affected by flood waters.

5.5 Site-specific sensitivity and buffers

It is recommended to avoid any development within the 1:100-year flood line. Should development continue within the delineated flood lines, flood risk measures should be taken. Measures will be described in the stormwater management plan section.

5.6 Limitations

Steady-state flood modelling was undertaken, which is a conservative approach as it ignores the effect of storage within the system and therefore produces higher flood levels than would be expected to occur. A steady-state model will result in worst-case (conservative) estimates of flooding, and resultant flood levels and floodplain extents would decrease if unsteady state modelling were undertaken using an inflow hydrograph as opposed to continuous peak flow.

Figure 5-2: Simulated flood lines for the tributary flowing adjacent to site 2 and expansion sites

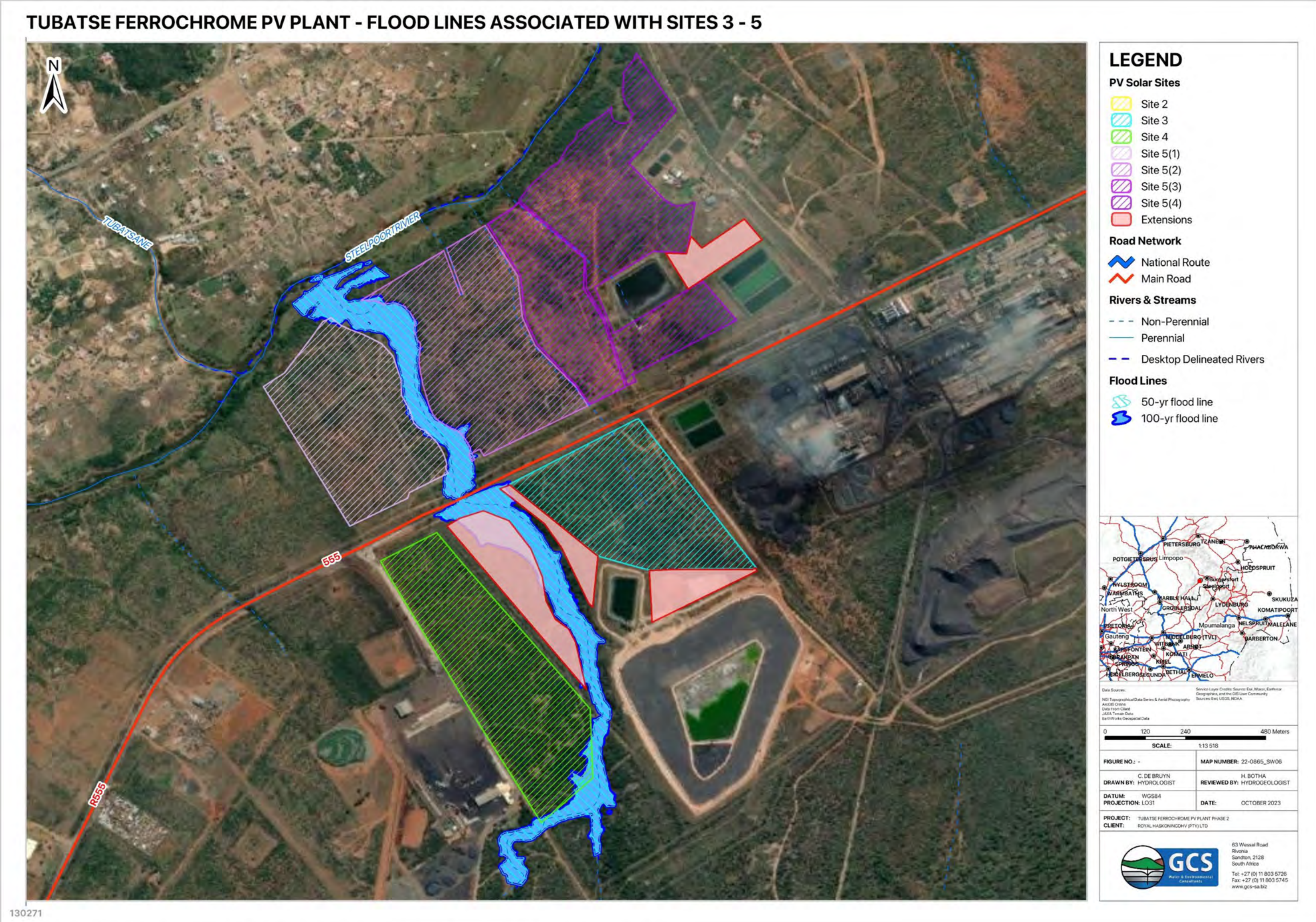


Figure 5-3: Simulated flood lines for the tributary flowing adjacent to sites 3 to 5 and expansion sites

6 CONCEPTUAL STORMWATER MANAGEMENT PLAN

The following section describes the conceptual stormwater management plan (CSWMP) developed and is based on available hydrological data and site layout data. The stormwater management measures must ensure that dirty water from the site is contained or treated before discharge, and to keep clean run-off water from entering the site.

6.1 Aim of a stormwater management plan

Per *Best Practice Guideline - G1: Stormwater Management (2006)* the CSWMP for the site will seek to achieve certain objectives based on a philosophy of protecting the environment from impacts. This is of utmost importance as the sedimentation of drainage streams should be minimised. This can be achieved using the following general guidelines:

- Clean and dirty water should be separated, and it should be ensured that all stormwater structures are designed to keep dirty and clean water separate and can accommodate a defined precipitation event.
- The clean water catchment area should be maximised, and clean water should be routed to a natural watercourse with minimal damage to that watercourse in terms of quantity and frequency of discharge.
- Dirty areas should be minimised, and runoff from these areas should be contained and treated for either reuse or release. Natural watercourses and the environment should be protected from contamination by dirty areas by ensuring that the dirty water cannot enter the clean water system by spillage or seepage.

A CSWMP generally aims to:

- Illustrate likely stormwater sub-catchments (HRUs) and preferential overland runoff flow paths.
- Determine likely dirty and clean water HRUs.
- Provide water containment and diversion systems to prevent the mixing of clean and dirty water and prevent soil erosion and flooding.
- Attenuate stormwater back to the natural environment; and
- Maintain the downstream water quantity and quality requirements.

It should be noted that PV plants are generally considered to be clean areas as they do not introduce any contaminants to the surface which may pollute surface runoff. Therefore, all areas are deemed to be clean.

In addition to the aims, the SWMP has the following criteria:

- Stormwater should be directed in such a way that no water flows in an unruly fashion that may jeopardize the safety of personnel or infrastructure, or such that it is a nuisance.
- Protection of the soils by preventing erosion in also a key requirement.
- Minimise modification of the natural topography of the area and avoid any modification of the natural watercourse as far as possible.

6.2 Existing stormwater infrastructure

All the authorised sites are undeveloped and have no existing stormwater infrastructure. The same applies to the extension sites.

In terms of stormwater infrastructure in the surroundings of the project, the following has been noted:

- Site 2 is located next to a deep non-perennial watercourse that flows under the railway line via a single, rectangular concrete culvert. The extensions of site 2 will border this non-perennial watercourse on all sides.
- Site 3 and 4 and their associated extensions are separated by a non-perennial watercourse and are bordered by roads.
- Sites 3 and 4 are separated from site 5 by the R555. The R555 has various culverts and bridges to allow for drainage from the non-perennial watercourses to the Steelpoort River.

Where possible, the drainage infrastructures of the area will be incorporated into the conceptual stormwater management plan presented in this report.

6.3 Site 2 conceptual stormwater management

6.3.1 Stormwater characterisation

Site 2 is located across the outflow of the catchments S9-11 with water courses running through the site. Therefore, the runoff will mostly flow towards the water course and be channelled via the non-perennial tributary towards the Steelpoort River. Overland runoff or sheet flow will occur from higher elevation to the south, in a general north to north-west direction.

6.3.1.1 Stormwater catchment delineation

Stormwater catchments for the site are indicated in Figure 6-6. Nine (9) sub-catchments characterise the runoff generated upstream from the site that will create overland flow, and eventually flow towards the watercourse. These catchments are overall deemed **clean** in terms of pollutants, carrying only sediment from soil and bare areas such as roads as well as sediment from small-scale surface mining operations.

6.3.1.2 Flow directions in stormwater catchments

- **S2_1-4**
    - These catchments characterise runoff generated for the area east to the non-perennial water course.
    - Runoff generated on these catchments will flow overland in a northern to north-western direction towards the dirt roads and railway north of the site.
- **S2_5**
    - This catchment characterises runoff generated on the area between the two non-perennial streams and upstream of their confluence.
    - Runoff generated in this catchment will flow overland in a north-to-north-western direction towards the confluence.
    - The runoff will be captured by the watercourse.
- **S2_6-9**
    - These catchments characterise runoff generated for the area west of the non-perennial watercourse.
    - Runoff generated on these catchments will flow overland in a general north-to-north-westerly direction and runoff will flow into the watercourse before it flows underneath the road and railway.

6.3.1.3 Impacts of Infrastructure on mean annual runoff

The panel arrays are expected to have some impact on the MAR, but no large or adverse impacts are predicted on the quaternary scale as the panel covers only 0.09% of the quaternary catchment area. And although the panels themselves are considered impermeable; the panel height will be approximately 5m above ground level and will not cause the surface to become impermeable. How runoff from the panels reaches the surface will be altered for the area, but the water will be allowed to run off the panels and infiltrate into the groundwater table below or run to the nearby watercourse.

6.3.1.4 Stormwater flows and volumes

Peak flows for each catchment were calculated using the Rational Method and are summarized in Table 6-1.

Table 6-1: Stormwater catchment peak flows for Site 2

Name	Area (km^2)	Rainfall Intensity				Peak Flow (m^3/s)			
		I_2	I_{10}	I_{50}	I_{100}	Q_2	Q_{10}	Q_{50}	Q_{100}
S2_1	0.217	76.7	126.6	181.6	208.7	1.845	3.045	4.368	5.020
S2_2	0.126	76.7	126.6	181.6	208.7	1.070	1.765	2.532	2.910
S2_3	0.101	76.7	126.6	181.6	208.7	0.863	1.425	2.044	2.349
S2_4	0.336	76.7	126.6	181.6	208.7	2.866	4.731	6.786	7.798
S2_5	0.091	76.7	126.6	181.6	208.7	0.777	1.283	1.840	2.115
S2_6	0.041	76.7	126.6	181.6	208.7	0.353	0.583	0.837	0.961
S2_7	0.070	76.7	126.6	181.6	208.7	0.598	0.987	1.416	1.628
S2_8	0.156	76.7	126.6	181.6	208.7	1.326	2.189	3.140	3.608
S2_9	0.016	76.7	126.6	181.6	208.7	0.135	0.223	0.319	0.367

6.3.2 Stormwater systems placement recommendations

The following stormwater system placement is recommended:

- The placement of **vegetated berms** with an upstream **vegetated channel (trapezoidal)** is recommended between catchments S2_1 and S2_2, as well as catchment S2_3 and S2_4 as illustrated in Figure 6-7 and sizing in Figure 6-1 and Figure 6-2.
    - This will ensure that runoff is routed away from internal access roads and release the runoff back into the environment.
    - **Release points** should be equipped with **riprap pads**, to prevent erosion and dissipate the velocity of runoff.
    - Depending on changes to the existing access road for the nearby quarry, the flow in the channel between S2_1 and S2_2 will have to be routed underneath the road to release runoff into the watercourse. A **culvert** is proposed to route water underneath the road, with a **riprap pad** or **gabion mattress** at the outlet.

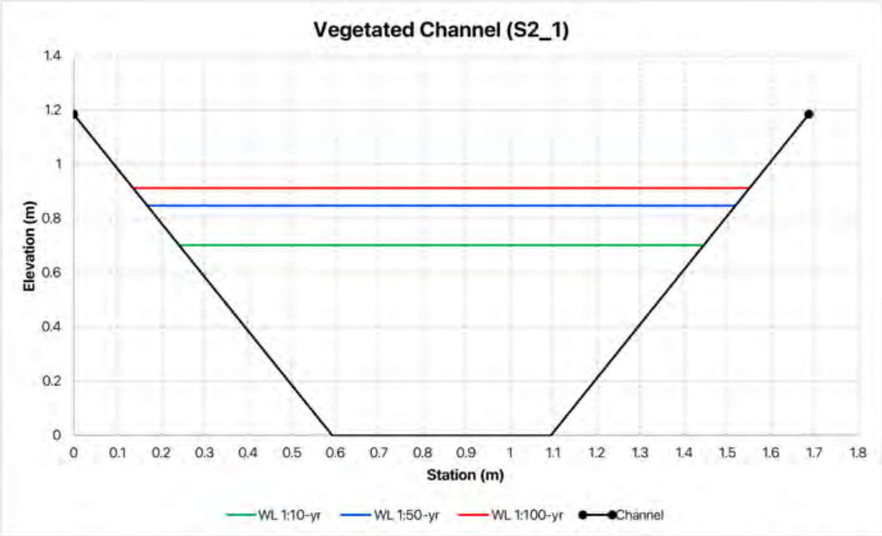


Figure 6-1: Vegetated channel between S2_1 and S2_2

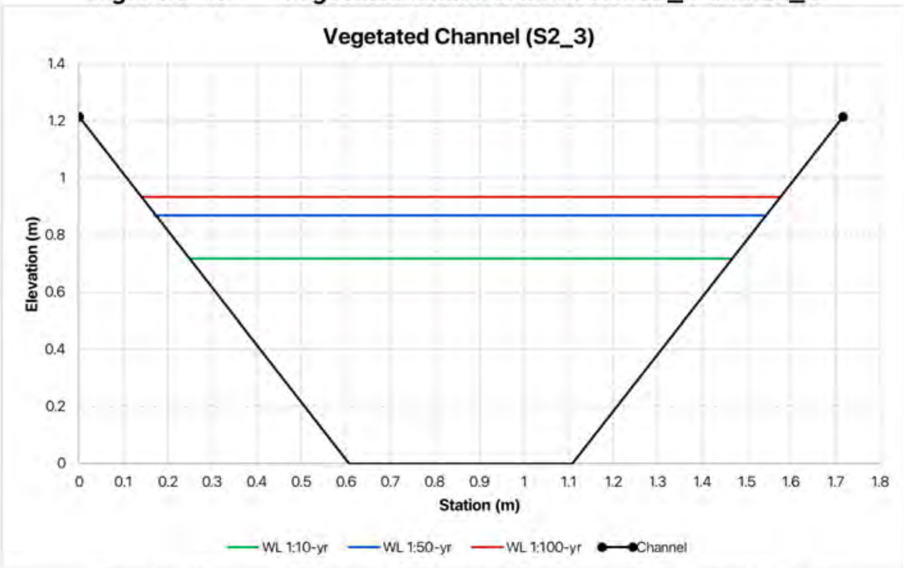


Figure 6-2: Vegetated channel between S2_3 and S2_4

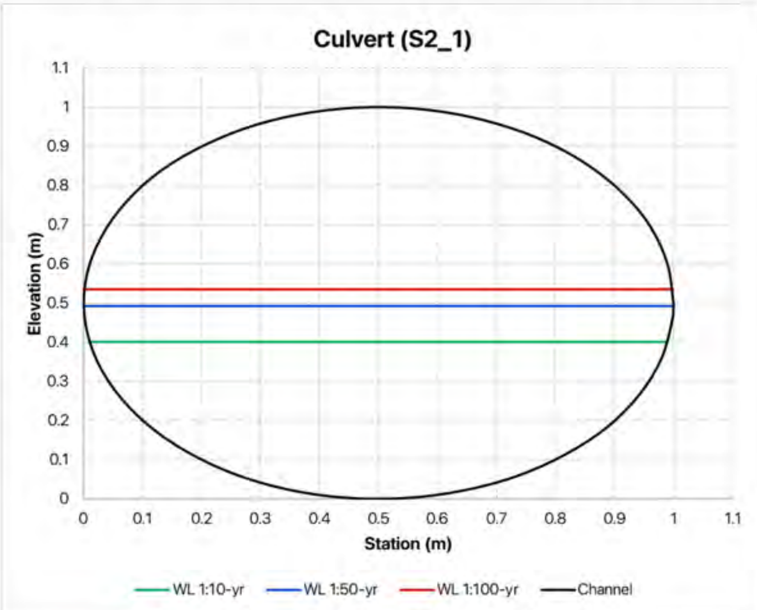


Figure 6-3: Culvert for S2_1 outlet

- Catchment S2_5 is susceptible to flooding near the eastern section. It is suggested that an **earth berm** of approximately **0.5m** be constructed as indicated in Figure 6-6 to ensure access road and panel mounting stability. The berm will ensure that the access road will not flood or create conditions which will disintegrate the integrity of the road. If this measure is implemented, the access road does not have to be moved out of the flood line.
- The engineering layout indicates that overhead powerlines will span the drainage lines from catchment S2_7 to S2_5 and from S2_9 to S2_4. It is not expected that the powerlines should have any adverse effects on the drainage lines. Depending on the distance the pylons are placed from the drainage lines and the associated river banks, care should be taken during construction to ensure that the pylons do not hinder the flow of water in the drainage line and that flow be sufficiently diverted, if necessary, until construction is completed. The base of the pylons should be protected against erosion from a possible flooding event.
- **Diversion berms (vegetated)** are suggested to the west of catchments S2_7-9.
    - This will ensure that runoff generated upstream of the area will be routed along a road to the west of the site and prevent any sediment from this runoff (generated on stockpile areas) from entering the site.
    - Flow routed along these berms and roads will be allowed to run into the watercourse before it flows underneath the railway.
- **Revegetation** of areas underneath and around the panel arrays will greatly reduce the velocities of run-off prevent erosion and reduce sedimentation.
    - It is also recommended that a **gravel erosion control strip** be placed underneath the lowest section of the panel where water will runoff as illustrated in Figure 6-4. This will ensure no erosion (Figure 6-5) of the soil takes place and ensures stability at the base of the panel mounting. This should be in place while vegetation is in the process of establishing.

Figure 6-4: Concept of gravel erosion control strips (McPhillips, 2023)

Figure 6-5: Eroded channel caused by concentrated stormwater flow (DaPonte, et al., 2020)

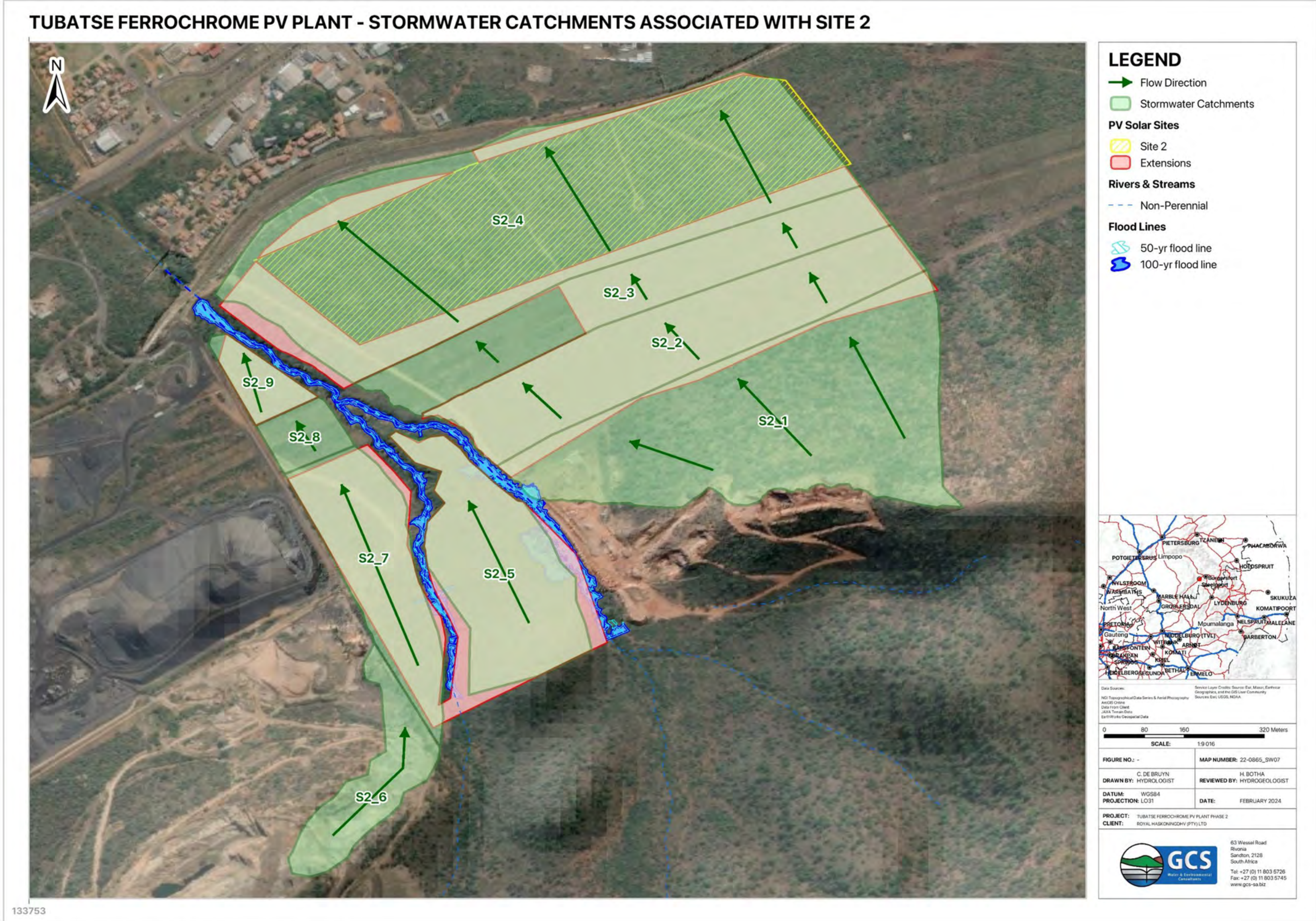


Figure 6-6: Stormwater catchment areas for Site 2

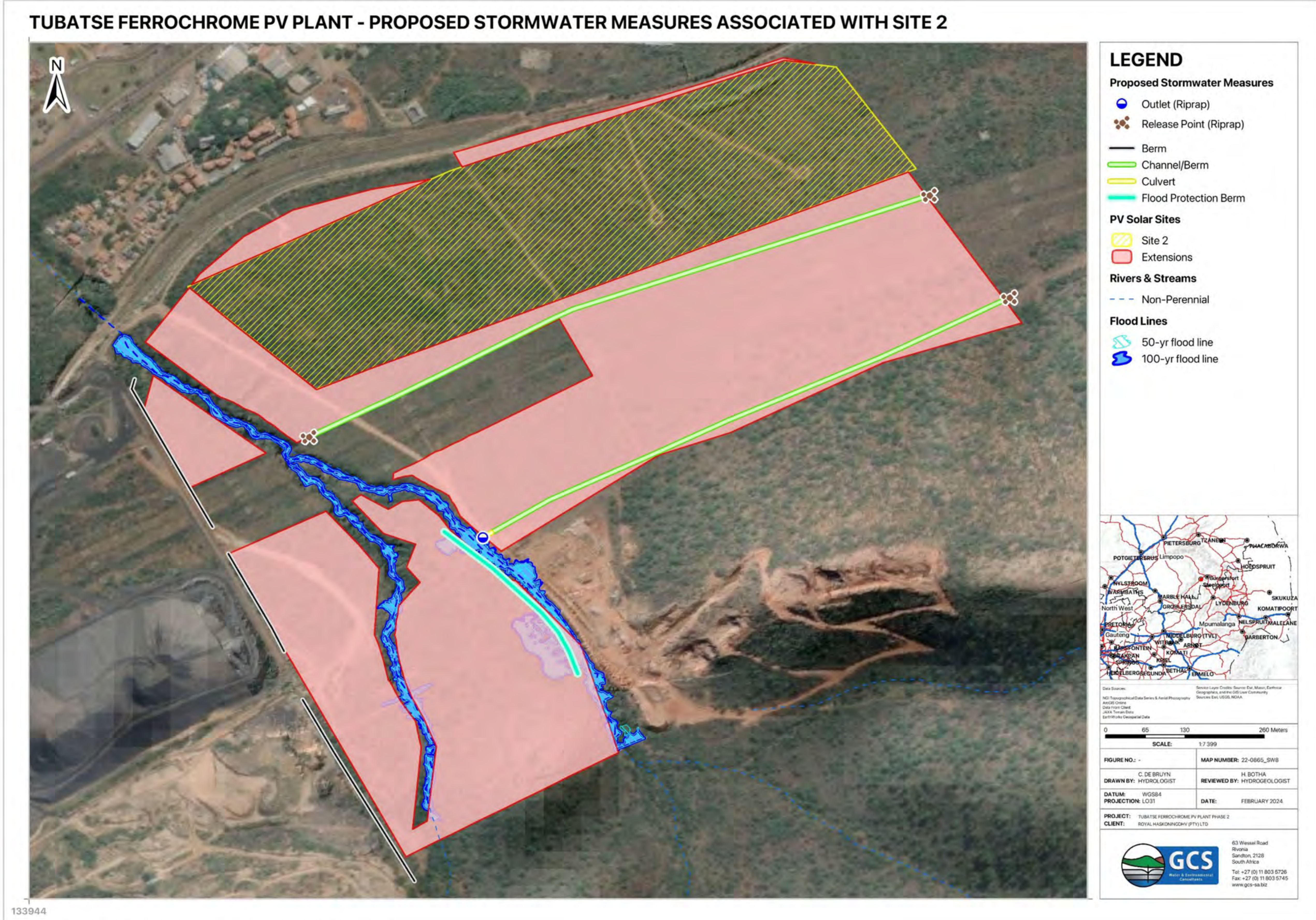


Figure 6-7: Proposed stormwater infrastructure for Site 2

6.4 Site 3 conceptual stormwater management

6.4.1 Stormwater characterisation

Site 3 is located on the watershed between HRUs S1_1 and S6, seeing runoff flow bilaterally off the site. The western section of the site will flow towards the non-perennial watercourse, and the eastern section of the site will flow towards the R555 and be routed by culverts underneath the road. Overland runoff or sheet flow will occur from higher elevation in the south, in a general northwest direction.

6.4.1.1 Stormwater catchment delineation

Stormwater catchments for the site are indicated in Figure 6-10. Five (5) sub-catchments characterise the runoff generated on the site that will create overland flow, and eventually flow towards the watercourse and road stormwater infrastructure. These catchments are overall deemed **clean** in terms of pollutants, carrying only sediment from soil and bare areas such as roads.

6.4.1.2 Flow directions in stormwater catchments

- **S3_1**
  - This catchment characterises runoff generated on the eastern section of the site that will flow towards the R555.
  - Runoff will flow to the northeastern corner of the site and flow through two culverts underneath the R555 downstream to Site 5(3).
- **S3_2**
  - This catchment characterises runoff generated in the area between the two dams present.
  - Runoff generated in this catchment will flow overland into the dam around which site 3 is located and be captured.
- **S3_3-4**
  - These catchments characterise runoff generated on the western section of the site that will flow west towards the non-perennial watercourse.
  - Runoff generated on these catchments will flow overland in a general north-to-north-westerly direction and runoff will flow into the watercourse before it flows towards the bridge on the R555.
- **S3_5**
  - This catchment characterises the runoff generated upstream from the site to the east of the dam, which will flow via roads along the eastern boundary of the site towards the R555.

6.4.1.3 Impacts of Infrastructure on mean annual runoff

The panel arrays are expected to have some impact on the MAR, but no large or adverse impacts are predicted on a quaternary scale as the panel covers only 0.09% of the quaternary catchment area. And although the panels themselves are considered impermeable; the panel height will be approximately 5m above ground level and will not cause the surface to become impermeable. How runoff from the panels reaches the surface will be altered for the area, but the water will be allowed to run off the panels and infiltrate into the groundwater table below or run-off to the nearby watercourse.

6.4.1.4 Stormwater flows and volumes

Peak flows for each catchment were calculated using the Rational Method and are summarized in Table 6-2.

Table 6-2: Stormwater catchment peak flows for Site 3

Name	Area (km^2)	Rainfall Intensity				Peak Flow (m^3/s)			
		I_2	I_{10}	I_{50}	I_{100}	Q_2	Q_{10}	Q_{50}	Q_{100}
S3_1	0.127	76.7	126.6	181.6	208.7	1.081	1.784	2.559	2.940
S3_2	0.024	76.7	126.6	181.6	208.7	0.205	0.338	0.485	0.557
S3_3	0.072	76.7	126.6	181.6	208.7	0.609	1.006	1.443	1.658
S3_4	0.009	76.7	126.6	181.6	208.7	0.079	0.131	0.188	0.216
S3_5	0.509	76.7	126.6	181.6	208.7	4.338	7.160	10.270	11.803

6.4.2 Stormwater systems placement recommendations

The following stormwater system placement is recommended:

- The placement of a **vegetated berm** with an upstream **vegetated channel (trapezoidal)** is recommended along the eastern boundary of the site between catchments S3_1 and S3_5 as illustrated in Figure 6-11 and sizing as displayed in Figure 6-8.
  - This will ensure that runoff is routed away from internal access roads and towards the culverts underneath the R555.
  - Release points should be equipped with **riprap pads**, to prevent erosion and dissipate the velocity of runoff.
  - During the previous study, the culverts were observed to be heavily silted, and it is recommended that they be cleared and maintained that way to ensure efficient performance during storm events. The culverts were less silted at the time the last site visit was conducted, but a sand mound was observed downstream of the culverts which would inhibit flow. The outflow should also be cleared along with any waste present.

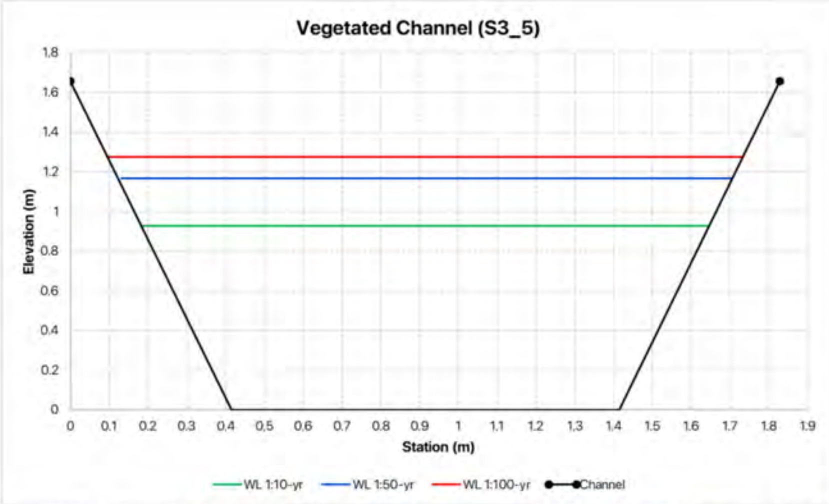


Figure 6-8: Vegetated channel at the eastern boundary of Site 3

Figure 6-9: R555 double barrel culvert system

- A **flood protection berm** of approximately **1m** is suggested at the north-west corner of the site near the R555 as illustrated in Figure 6-11. The simulated flood lines indicated that during a 1:50-year and 1:100-year flood event, the water will likely inundate the southern bank of the road before flowing through. The berm will ensure that the access road will not flood or create conditions which will disintegrate the integrity of the road. If this measure is implemented, the access road does not have to be moved out of the flood line.
- **Revegetation** of areas underneath and around the panel arrays will greatly reduce the velocities of run-off prevent erosion and reduce sedimentation.
    - It is also recommended that a **gravel erosion control strip** be placed underneath the panel arrays as previously discussed.

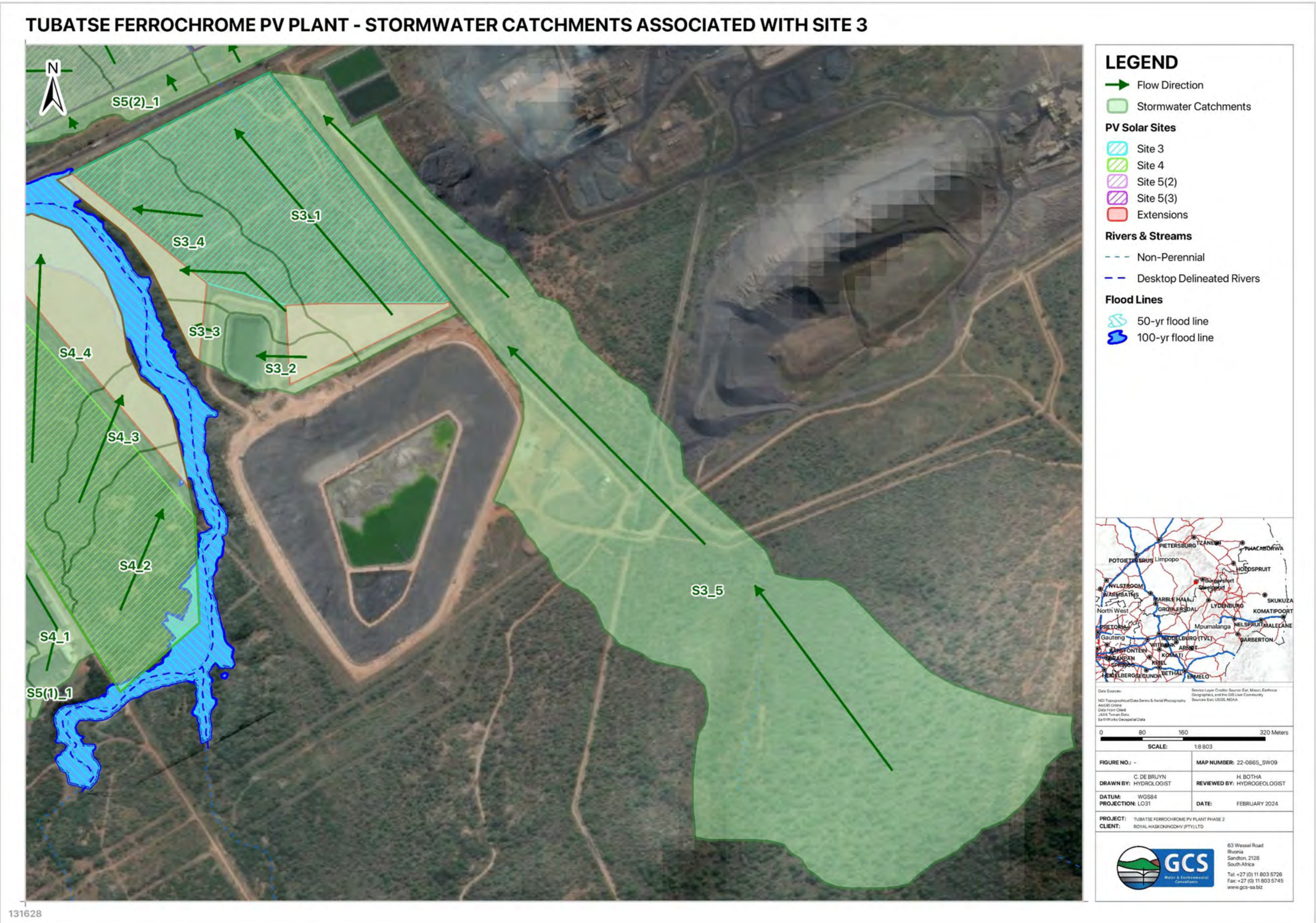


Figure 6-10: Stormwater catchment areas for Site 3

Figure 6-11: Proposed stormwater infrastructure for Site 3

6.5 Site 4 conceptual stormwater management

6.5.1 Stormwater characterisation

Site 4 is located in HRU S6 downstream of the confluence of two non-perennial drainage lines, seeing runoff flow in a general north to northeastern direction off the site towards the non-perennial watercourse.

6.5.1.1 Stormwater catchment delineation

Stormwater catchments for the site are indicated in Figure 6-14. Four (4) sub-catchments characterise the runoff generated on the site and upstream that will create overland flow, and eventually flow towards the watercourse and R555 bridge. These catchments are overall deemed **clean** in terms of pollutants, carrying only sediment from soil and bare areas such as roads.

6.5.1.2 Flow directions in stormwater catchments

- **S4_1**
  - This catchment characterises runoff generated upstream from the site on the adjacent operation to the southwest.
  - Runoff will flow in a north-western direction via dirt roads located along the south-western boundary of the site.
- **S4_2-4**
  - These catchments characterise runoff generated on the site that will flow northeast towards the watercourse via overland flow.

6.5.1.3 Impacts of Infrastructure on mean annual runoff

The panel arrays are expected to have some impact on the MAR, but no large or adverse impacts are predicted on the quaternary scale as the panel covers only 0.09% of the quaternary catchment area. And although the panels themselves are considered impermeable; the panel height will be approximately 5m above ground level and will not cause the surface to become impermeable. How runoff from the panels reaches the surface will be altered for the area, but the water will be allowed to run off the panels and infiltrate into the groundwater table below or run-off to the nearby watercourse.

6.5.1.4 Stormwater flows and volumes

Peak flows for each catchment were calculated using the Rational Method and are summarized in Table 6-3.

Table 6-3: Stormwater catchment peak flows for Site 4

Name	Area (ha)	Rainfall Intensity				Peak Flow (m^3/s)			
		I_2	I_{10}	I_{50}	I_{100}	Q_2	Q_{10}	Q_{50}	Q_{100}
S4_1	0.034	76.7	126.6	181.6	208.7	0.292	0.482	0.691	0.795
S4_2	0.077	76.7	126.6	181.6	208.7	0.653	1.078	1.546	1.776
S4_3	0.038	76.7	126.6	181.6	208.7	0.326	0.538	0.772	0.887
S4_4	0.161	76.7	126.6	181.6	208.7	1.370	2.262	3.245	3.729

6.5.2 Stormwater systems placement recommendations

The following stormwater system placement is recommended:

- The placement of a **vegetated berm** is recommended along the south-western boundary of the site to divert upstream runoff as illustrated in Figure 6-15.
    - This will ensure that runoff is routed away from internal access roads.
- A **flood protection berm** is suggested at the southeastern corner of the site near the confluence of the two non-perennial streams as illustrated in Figure 6-15. The simulated flood lines indicated that during a 1:50-year and 1:100-year flood event, the water level will rise into the site. The berm should reach an elevation of approximately 783 mamsl, this will translate to a berm height ranging from **1.5m** to **2m**. Otherwise, the terrain should be lifted to form a platform for the panels to rise above the water course.
- The site 4 extension area is located within a large section of the inundation zone south of the bridge (Figure 6-12). A more robust approach will be required to protect the panels from flood damage. Something more akin to a **concrete flood wall** (Figure 6-13) is recommended and the structure should be approximately **3.5 to 4m** in height or at an elevation of **779.21 mamsl** and a berm of this size is not viable within the space constraints.
    - The wall should have outlets to ensure that stormwater generated on-site can be released to the water course.
    - An adverse impact could be posed to the bridge and R555 immediately downstream from this area should the end client decide to use this recommendation.
        - The flood protection wall will ultimately alter the flow path and potentially increase the flow velocity of the flood waters. This may cause structural instability of the bridge and flood the R555 for a period of time.

- *An alternative recommendation would be to perhaps raise the panels higher on the mounting structures above the 1:50 or 1:100-year flood water elevation level to protect the panel face from waterlogging and to prevent debris within flood waters to damage the panel components.*
- *Proper insulation of other components should be ensured that may be exposed to flood waters.*

- The engineering layout indicates that overhead powerlines will span the drainage line starting from catchment S4_2 to S3_2. It is not expected that the powerlines should have any adverse effects on the drainage lines. Depending on the distance the pylons are placed from the drainage lines and the associated riverbanks, care should be taken during construction to ensure that the pylons do not hinder the flow of water in the drainage line and that flow be sufficiently diverted, if necessary, until construction is completed. The base of the pylons should be protected against erosion from a possible flooding event.
- **Revegetation** of areas underneath and around the panel arrays will greatly reduce the velocities of run-off prevent erosion and reduce sedimentation.
    - It is also recommended that a gravel erosion control strip be placed underneath the panel arrays as previously discussed.

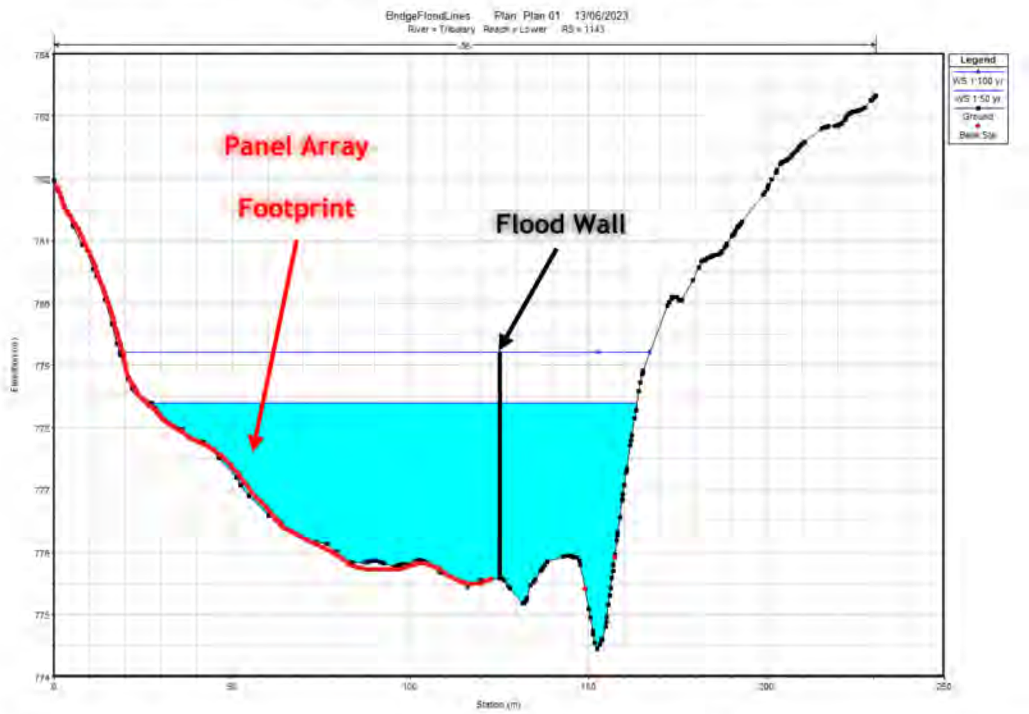


Figure 6-12: Cross section depicting 1:50-yr and 1:100-yr flood line elevations relative to the site (red line) and the placement and height of the recommended flood wall (black line)

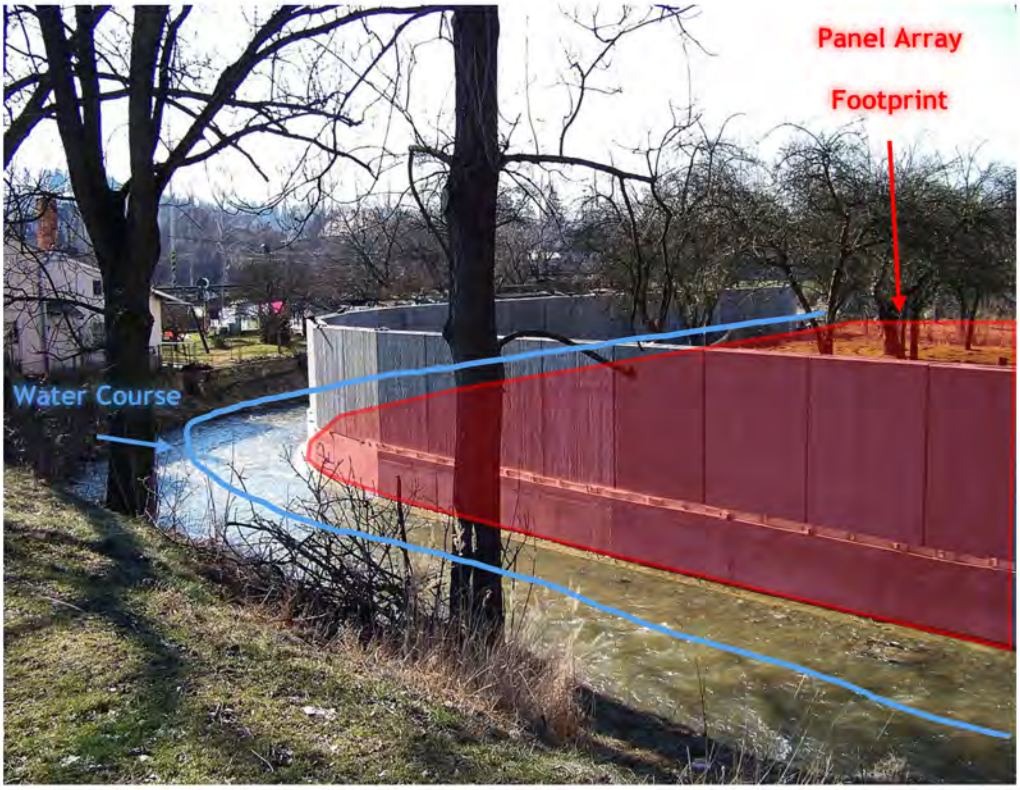


Figure 6-13: Example of a concrete flood wall

Figure 6-14: Stormwater catchment areas for Site 4

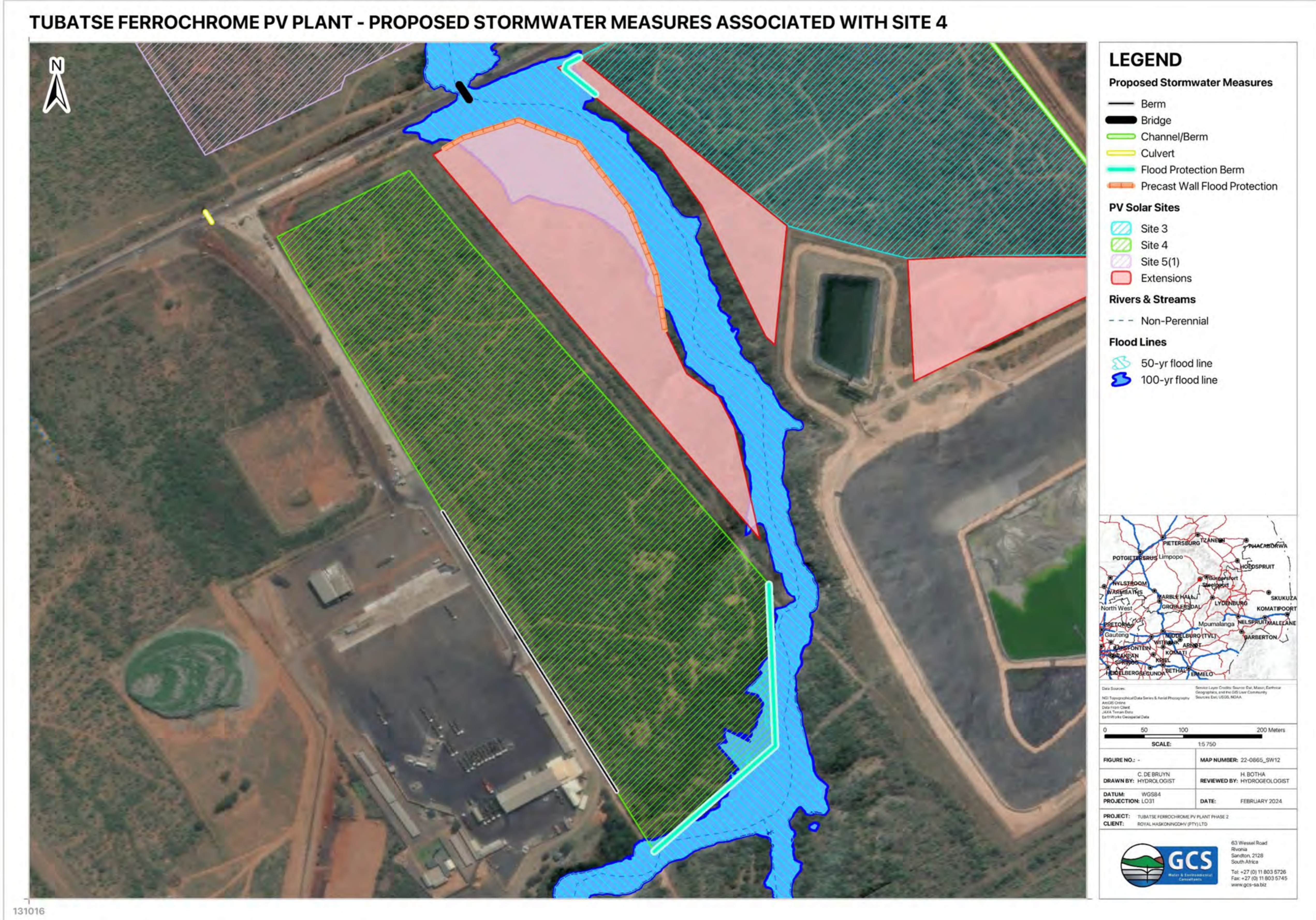


Figure 6-15: Proposed stormwater infrastructure for Site 4

6.6 Site 5 conceptual stormwater management

6.6.1 Stormwater characterisation

Site 5 is located between the R555 and the Steelpoort River, and west of the Tubatse FerroChrome operation. The site will see drainage via the non-perennial water course, and overland runoff will flow in a general north-to-north-west direction.

Within the site boundaries, four drainage lines have been identified:

- Moving from the west side to the east is firstly the watercourse identified in the flood lines. This is a significant feature that comes into the site through a bridge on the R555 road.
- Then there is a minor drainage line that is only visible from 250 m upslope from the Steelpoort River.
- There is then a third drainage line that originates in Site 3 and crosses the R555 via a culvert and flows through Site 5 to the Steelpoort River.
- Finally, there is a drainage line originating at the existing water treatment facility and then running through the site to the Steelpoort River.

None of these drainage lines are perennial, all streams present with defined channels and the proposed conceptual SWMP will have to factor this into the design thereof.

6.6.1.1 Stormwater catchment delineation

Stormwater catchments for the site are indicated in Figure. Twenty-seven (27) sub-catchments characterise the runoff generated on the site and upstream that will create overland flow, and eventually flow towards the various drainage lines and Steelpoort River. These catchments are overall deemed **clean** in terms of pollutants, carrying only sediment from soil and bare areas such as roads.

6.6.1.2 Flow directions in stormwater catchments

- **S5(1)_1-2**
  - This catchment characterises runoff generated upstream from the site south of the R555, that will flow underneath the R555 via a culvert.
  - Runoff will then flow paradelle along the western boundary of Site 5(1) where it will flow into the site before discharging into the Steelpoort River.
- **S5(1)_3-4**
  - These catchments characterise runoff generated upstream and on the site that will flow northwest towards the Steelpoort River.
- **S5(1)_5**

  - This catchment characterises runoff generated on the western section of the site that will contribute overland flow into the watercourse, before discharging into the Steelpoort River.
- **S5(2)_1**
  - This catchment generates runoff upstream from the site north of the R555.
- S5(2)_2
  - This catchment will have runoff flowing into the watercourse to the west.
- **S5(2)_3 & 5**
  - These catchments will generate runoff that will flow overland towards the Steelpoort River.
- **S5(2)_4 & 6**
  - These catchments will have runoff flowing into the drainage line to the east.
- **S5(3)_1**
  - This catchment characterises the area between the R555 and Site 5(3).
  - Runoff generated upstream at Site 3 (S3_1 and S3_5) will flow via the R555 culverts onto the site and into the drainage line to the east.
- **S5(3)_2-3**
  - These catchments will have runoff flow towards the Steelpoort River.
- **S5(4)_1-2**
  - These catchments will generate runoff that will flow into the dam present on site.
- **S5(4)_3-5**
  - These catchments will generate runoff that will flow towards the expansion site between the two dams on site.
- **S5(4)_6-13**
  - These sites will all see runoff flowing towards the Steelpoort River.

6.6.1.3 Impacts of Infrastructure on mean annual runoff

The panel arrays are expected to have some impact on the MAR, but no large or adverse impacts are predicted on the quaternary scale as the panel covers only 0.09% of the quaternary catchment area. And although the panels themselves are considered impermeable; the panel height will be approximately 5m above ground level and will not cause the surface to become impermeable. How runoff from the panels reaches the surface will be altered for the area, but the water will be allowed to run off the panels and infiltrate into the groundwater table below or runoff to the nearby watercourse.

6.6.1.4 Stormwater flows and volumes

Peak flows for each catchment were calculated using the Rational Method and are summarized in Table 6-4.

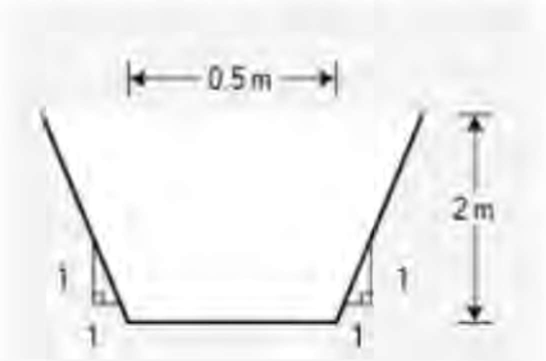
Table 6-4: Stormwater catchment peak flows for Site 5

Name	Area (ha)	Rainfall Intensity				Peak Flow (m^3/s)			
		I_2	I_{10}	I_{50}	I_{100}	Q_2	Q_{10}	Q_{50}	Q_{100}
S5(1)_1	0.180	76.7	126.6	181.6	208.7	1.532	2.529	3.628	4.169
S5(1)_2	0.022	76.7	126.6	181.6	208.7	0.185	0.306	0.439	0.505
S5(1)_3	0.013	76.7	126.6	181.6	208.7	0.112	0.185	0.265	0.305
S5(1)_4	0.108	76.7	126.6	181.6	208.7	0.917	1.514	2.171	2.495
S5(1)_5	0.060	76.7	126.6	181.6	208.7	0.513	0.847	1.215	1.396
S5(2)_1	0.018	76.7	126.6	181.6	208.7	1.532	2.529	3.628	4.169
S5(2)_2	0.075	76.7	126.6	181.6	208.7	0.185	0.306	0.439	0.505
S5(2)_3	0.017	76.7	126.6	181.6	208.7	0.112	0.185	0.265	0.305
S5(2)_4	0.051	76.7	126.6	181.6	208.7	0.917	1.514	2.171	2.495
S5(2)_5	0.036	76.7	126.6	181.6	208.7	0.513	0.847	1.215	1.396
S5(2)_6	0.019	76.7	126.6	181.6	208.7	0.159	0.262	0.376	0.432
S5(3)_1	0.011	76.7	126.6	181.6	208.7	1.532	2.529	3.628	4.169
S5(3)_2	0.055	76.7	126.6	181.6	208.7	0.185	0.306	0.439	0.505
S5(3)_3	0.042	76.7	126.6	181.6	208.7	0.112	0.185	0.265	0.305
S5(4)_1	0.035	76.7	126.6	181.6	208.7	0.513	0.847	1.215	1.396
S5(4)_2	0.021	76.7	126.6	181.6	208.7	0.177	0.293	0.420	0.482
S5(4)_3	0.025	76.7	126.6	181.6	208.7	0.210	0.347	0.498	0.573
S5(4)_4	0.010	76.7	126.6	181.6	208.7	0.081	0.134	0.192	0.221
S5(4)_5	0.019	76.7	126.6	181.6	208.7	0.163	0.269	0.385	0.443
S5(4)_6	0.011	76.7	126.6	181.6	208.7	1.532	2.529	3.628	4.169
S5(4)_7	0.094	76.7	126.6	181.6	208.7	0.185	0.306	0.439	0.505
S5(4)_8	0.015	76.7	126.6	181.6	208.7	0.112	0.185	0.265	0.305
S5(4)_9	0.011	76.7	126.6	181.6	208.7	0.917	1.514	2.171	2.495
S5(4)_10	0.016	76.7	126.6	181.6	208.7	0.513	0.847	1.215	1.396
S5(4)_11	0.010	76.7	126.6	181.6	208.7	0.082	0.135	0.194	0.223
S5(4)_12	0.058	76.7	126.6	181.6	208.7	0.495	0.817	1.172	1.347
S5(4)_13	0.038	76.7	126.6	181.6	208.7	0.320	0.529	0.759	0.872

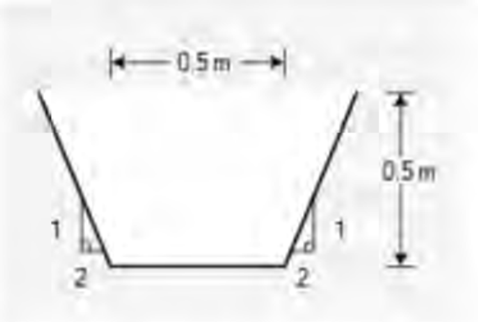
6.6.2 Stormwater systems placement recommendations

The following stormwater system placement is recommended:

- As per the original stormwater management plan conducted for the already authorised sites (GCS, 2023), most of the site will be left to drain freely into the nearest watercourse.
- It was concluded that the third drainage line should be augmented and formalised. The following parameters were recommended:
  - Trapezoidal cross-section, 2 m deep, 0.5 m bottom width, 1:1 side slopes



  - Length of 750 m
  - The slope of 3.8 %
  - For the 1:10-year event, the peak discharge will be 4.7 m^3/s, the maximum velocity will be 6.73 m/s and the maximum depth will be 0.62 m.
  - Due to the high velocity predicted, it is recommended that this channel be lined with concrete with energy-dissipating concrete blocks installed at 3 m intervals along its length.
  - The stormwater will discharge into the Steelpoort River via a suitable design release structure.
  - The release structure will consist of a drop box, a stilling basin and an exit apron lined with rip rap opening out into the river.
  - The drop box and stilling basin are recommended to be constructed of gabions.
- The fourth drainage line has a small catchment and is therefore predicted to receive small flows. This channel should be formalised into a trapezoidal-shaped cross-section, lined with grass. The grass lining is essential to prevent erosion. The channel will be 0.5 m deep, 0.5 m bottom width, with 1:2 side slopes.



- Due to the lower flood risk in the main channel than upstream from the bridge, no flood protection berms are recommended. This will allow runoff to freely drain into the watercourse as per natural conditions.
- **Revegetation** of areas underneath and around the panel arrays will greatly reduce the velocities of run-off prevent erosion and reduce sedimentation.
  - It is also recommended that a gravel erosion control strip be placed underneath the panel arrays as previously discussed.

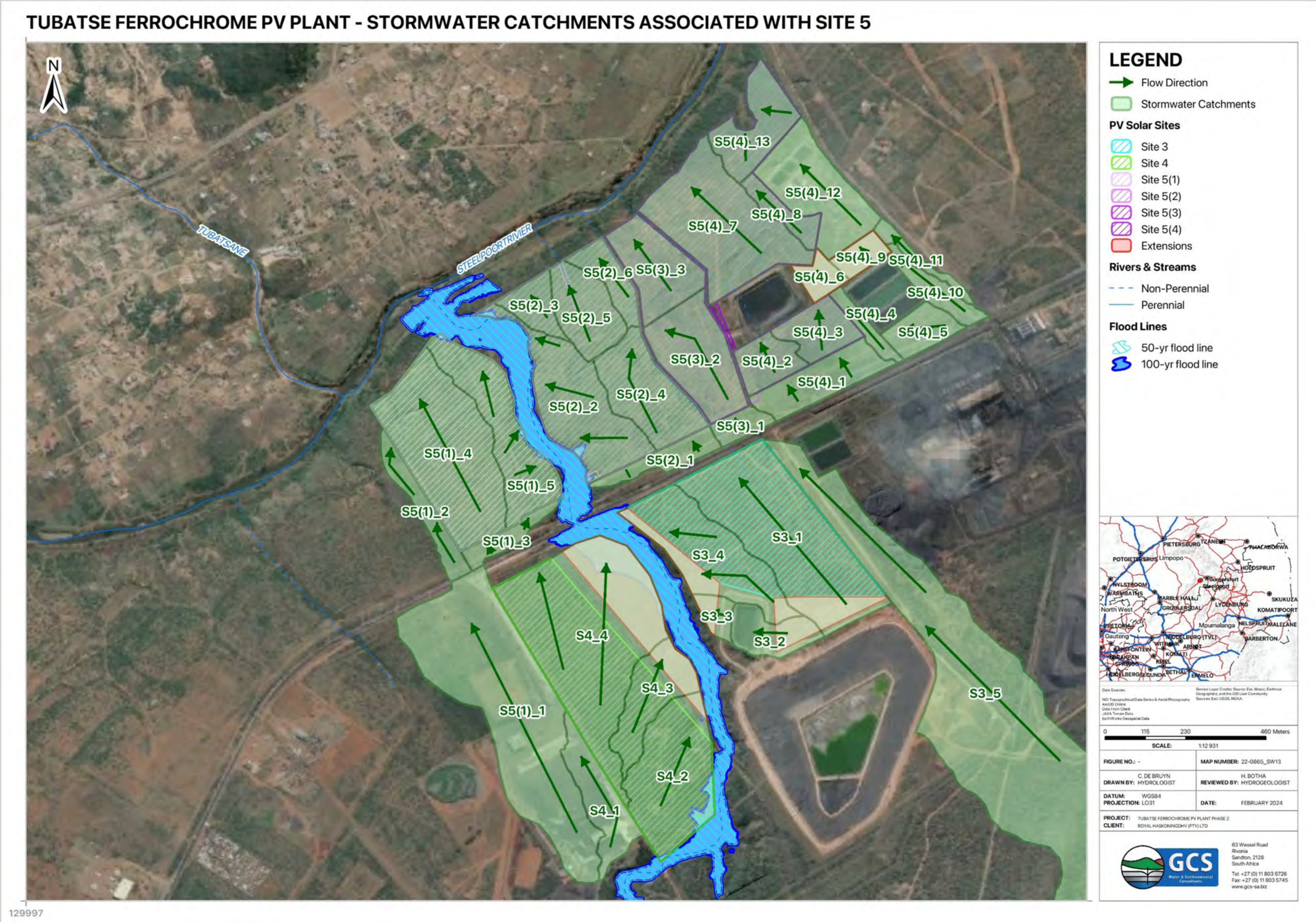


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Figure 6-16: Stormwater catchment areas for Site 5

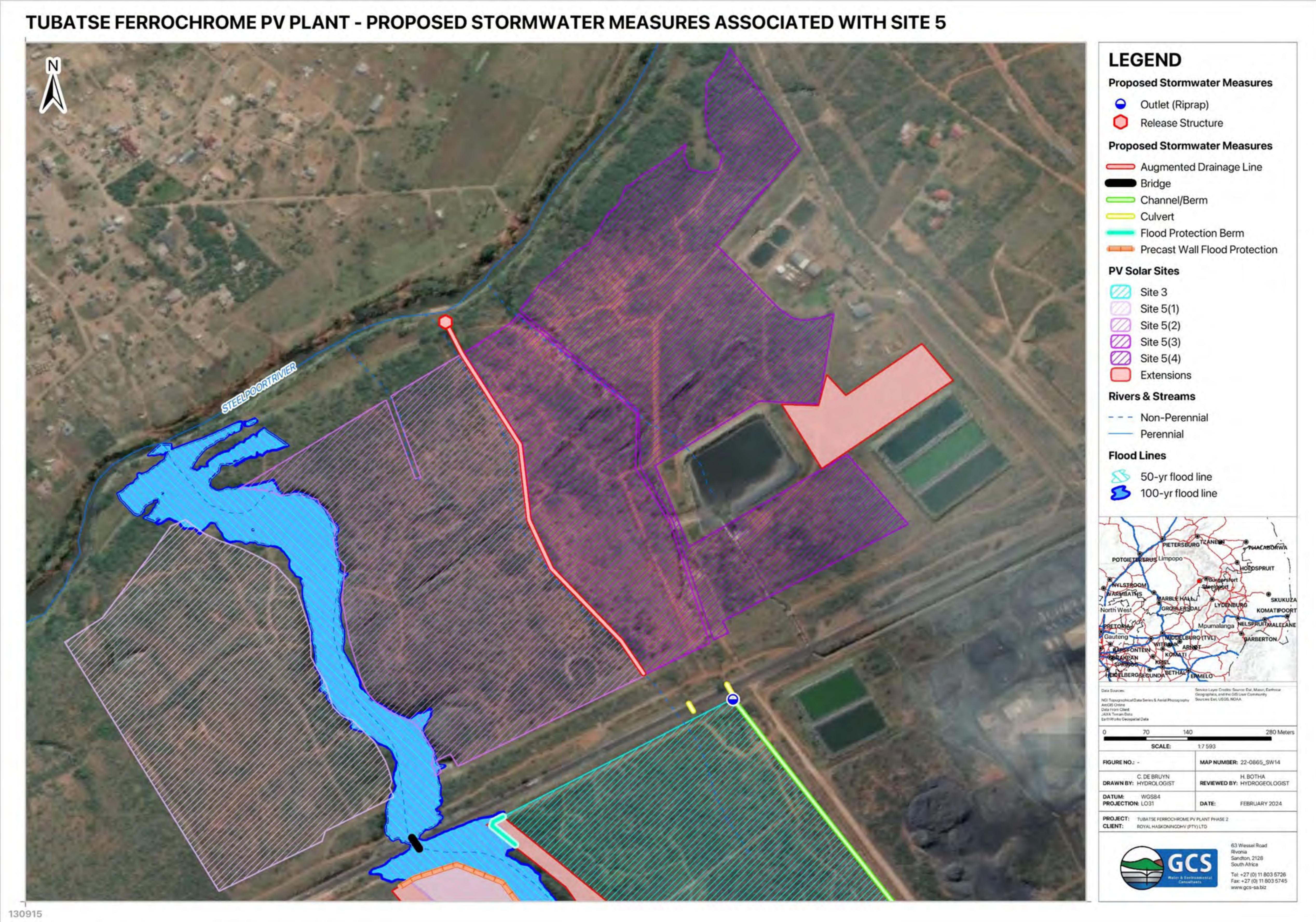

Figure 6-17: Proposed stormwater infrastructure for Site 5

7 CONCEPTUAL WATER BALANCE

As part of this study, a conceptual water balance was developed (operational phase and operational phase). The water balance was developed in MS Excel and further considers the Best Practice Guideline G2: Water and Salt Balances (DWAF, 2006b). The water balance aims to characterise the water distribution system of the site.

As there are no permanent water supply or discharge activities being applied for in the WUL, no water balance is applicable. However, a high-level overview of water consumption activities will be provided in this section.

7.1 Available data

During both the construction and operation phases no permanent water supply by borehole or river abstraction will take place nor will wastewater removal infrastructure be installed on the site.

Construction Phase

- During construction, water will be brought in by tanker.
- Water will be used for construction and dust suppression purposes.
- 2 × 15 000 ℓ (15m^3) tankers will be used for dust suppression.

Operational Phase

- During operation, panels will be cleaned by water brought in by tanker.
- The water will be supplied by the Tubatse FerroChrome Water Plant (treated water).
- The runoff water from washing the panels will discharge to the ground and will either infiltrate, evaporate or run-off into the environment. This is acceptable as it is considered clean water.
- Wash water may need to be demineralised before it can be used on the panels.
- A single cleaning cycle will use approximately 1 200 m^3 wash water.
- The cleaning cycle depends on the type of technology, the pollution at the location as well as the seasonality.
- A typical global approach is to allow for two (2) cleaning cycles per month, i.e. **2 400 m^3 per month**.
- In terms of domestic use, portable toilets with a conservancy tank will be placed on site and will periodically be removed and emptied. There will be no sewage network installed on site.
- Chemical toilets will be provided per 15 people which will be serviced at a minimum of once every week.

7.2 Water process flow diagram

The process flow diagram (PFD) developed for the site is shown in Figure 7-1, below. An average-year PFD is presented.

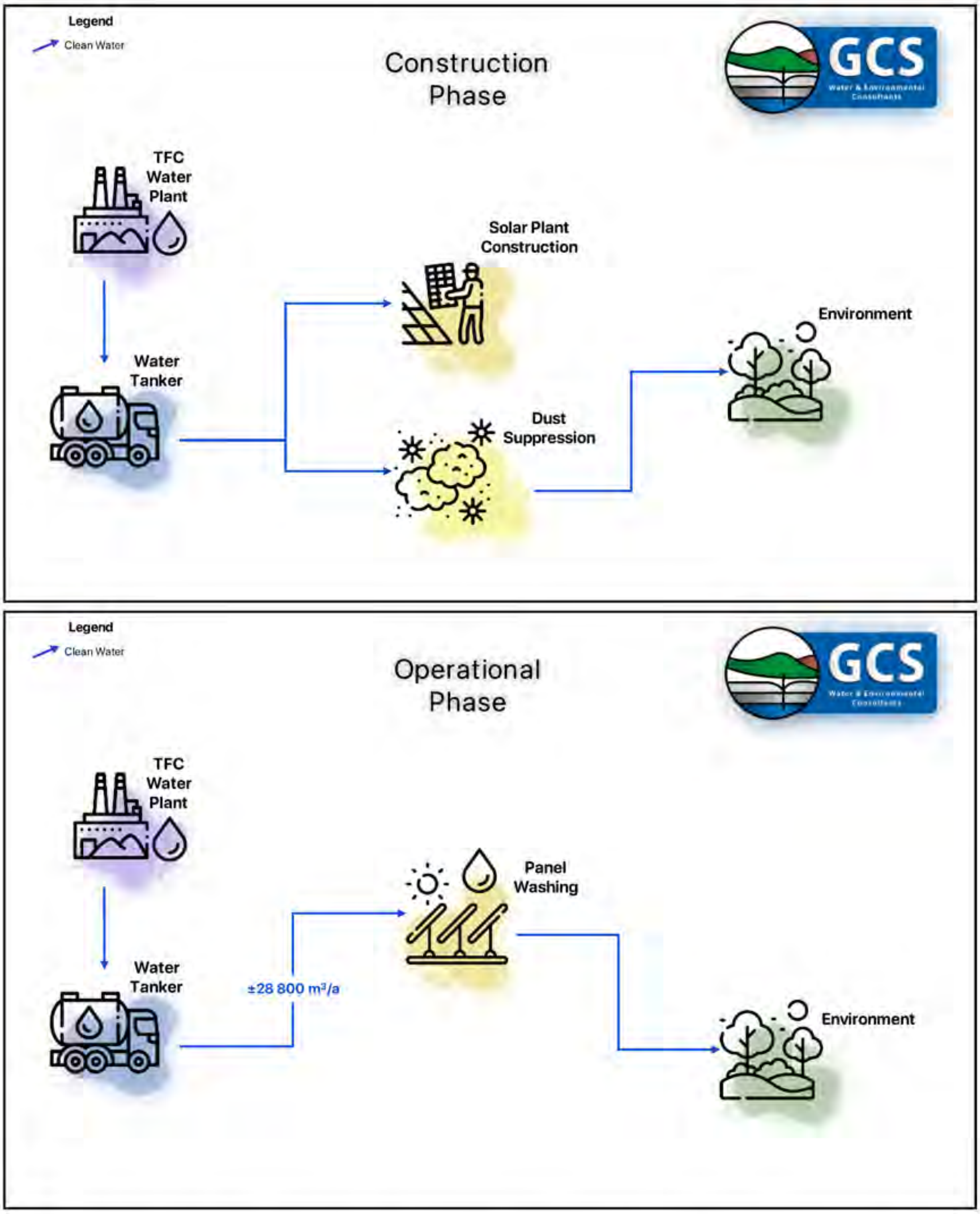

Figure 7-1: Process Flow Diagrams for the construction and operational phase

8 HYDROLOGICAL RISK ASSESSMENT

The anticipated hydrological risk concerning the operational phase of the mine was assessed. The SPR model (DWAF, 2008) was used to evaluate potential pollution sources and primary receptors within the study area.

Risk assessment entails understanding the generation of a hazard, the probability that the hazard will occur, and the consequences if it should occur. The net consequence is established by the following equation:

$$\boldsymbol{Consequence = (Duration + Ectent + Irreplaceability\ of\ resource) \times Severity}$$

The environmental significance of an impact was determined by multiplying the consequence by probability.

$$\boldsymbol{Significance\ =\ Consequence \times Probability}$$

The risk significance rating is summarised in Table 8-1.

Table 8-1: Risk rating scale

Criteria	Rating Scales
Significance	Very high - negative (-49 to -66)
	High - negative (-37 to -48)
	Moderate - negative (-25 to -36)
	Low - negative (-13 to -24)
	Neutral - Very low (0 to -12)
	Low-positive (0 to 12)
	Moderate-positive (13 to 24)
	High-positive (37 to 48)
	Very high - positive (49 to 66)

The potential impacts identified and environmental significance for the construction and operational phases of the project are listed in Table 8-2 to Table 8-3. Mitigation measures are captured in the table, and the net result of the applied mitigation is evaluated in the last column of the table. No closure phase risks were evaluated as the end use of the land is unknown.

The risk assessment focuses on the proposed activities. Risks are further discussed in the sections below.

8.1 Construction phase

The following activities are anticipated during the construction phase of the PV plant area:

- Destruction of topsoil due to site preparation.
- Sedimentation of water courses if rainfall occurs during the construction phase.
- Poor quality seepage from:
  - Building materials and fuel spills from construction vehicles.
  - Temporary waste storing and handling facilities during construction.
- Poor quality runoff from:
  - Construction vehicle oil and fuel spills.
  - Runoff containing sediment from excavation of part of the vadose zone.

8.2 Operational Phase

The possible hydrological impacts for the activities during the operational phase until closure are as follows:

- Poor quality seepage from:
  - Oil and fuel spills from site vehicles.
  - Domestic waste is present on site and sewage spillages from septic tank.
  - Potentially poor-quality dust suppression water composition.
  - Potentially poor-quality wash water from panels.
- Poor quality runoff from:
  - Sedimentation of drainage lines due to exposed soils or unvegetated surface runoff during storm events.

The non-perennial drainage lines and vadose zone soils are the main receptors of potential surface-related pollution at the site. The risk assessment for the construction and operational phase of the project is considered moderate to low, with mostly reversible and manageable impacts.

8.3 Cumulative impacts

As all activities will take place on the same property, there will be cumulative impacts. The operational phase risk table includes cumulative risk about the site, and activities thereon. Considering the sub-catchment conceptual hydrological cycle and the activities associated with the site and surroundings, no impacts are expected in terms of the hydrological cycle. The largest impact will be sedimentation of the river due to construction site runoff. Slight increases in runoff may occur, but water will flow off of the panels and runoff or infiltrate.

Table 8-2: Construction phase hydrological impacts

Component Being Impacted On	Activity Which May Cause the Impact	Activity	Pre- Mitigation							Recommended Mitigation Measures	Post Mitigation							Confidence
			Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance		Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Vadose zone soils and subsequent groundwater table	• Poor quality seepage and runoff from construction vehicles parked on site. • Poor quality or uncontrolled runoff from construction sites.	Net Result of Earthworks and Construction	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Probable (1)	Neutral/ Very low (0 to -12) (-5)	• Ensure service vehicles are parked in designated areas, with drip trays placed under the vehicles. Vehicles are to be pre-inspected for leakages before entering the site. • Keep the site clean of all general and domestic wastes.	Short-term (2)	Site (2)	Low (-1)	No (0)	Negligible (0 to -6) (-4)	Probable (1)	Neutral/ Very low (0 to -12) (-4)	Medium
	Disturbing vadose zone during soil excavations/construction activities	Net Result of Earthworks and Construction	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Definite (2)	Neutral/ Very low (0 to -12) (-10)	• Only excavate areas that apply to the project area. • Backfill the material in the same order it was excavated to reduce contamination of deeper soils with shallow oxidised soils. • Cover excavated soils with a temporary liner to prevent contamination. • Retain as much indigenous vegetation as possible. • Exposed soils are to be protected using a suitable covering or revegetating.	Short-term (2)	Site (2)	Low (-1)	No (0)	Negligible (0 to -6) (-4)	Probable (1)	Neutral/ Very low (0 to -12) (-4)	Medium
Primary surface water Receivers > Rivers and non-perennial streams	Surface water contamination and sedimentation from the following activities: • Erosion and sedimentation of watercourses due to unforeseen circumstances (i.e., bad weather); and • Alteration of natural drainage lines due to cable trenches, powerline and pylon construction and internal access road construction.	Earthworks	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Definite (2)	Neutral/ Very low (0 to -12) (-10)	• Install a temporary cut-off trench to contain poor-quality runoff (if observed). • Cover soil stockpiles with a temporary liner to prevent contamination. • Construct temporary silt traps at drainage points to allow sediment settlement from runoff. • Return the drainage line to the previous geometry after construction and ensure sufficient measures are taken to divert water around the working area.	Short-term (2)	Site (2)	Yes (1)	No (0)	Negligible (0 to -6) (-4)	Definite (2)	Neutral/ Very low (0 to -12) (-8)	Medium
	Water quality impacts due to: • Spillage of fuels and chemicals; and • Construction equipment and vehicles.	Plant on-site during construction	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Probable (1)	Neutral/ Very low (0 to -12) (-5)	• Clean up spillages immediately. • Keep chemicals in bunded areas. • Keep vehicles and equipment clean.	Short-term (2)	Site (2)	Yes (1)	No (0)	Negligible (0 to -6) (-4)	Probable (1)	Neutral/ Very low (0 to -12) (-4)	Medium
	Increased runoff altering flow regimes of receiving watercourses due to: • Vegetation removal; and • Compacting of soil.	Site clearing and preparation	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Definite (2)	Neutral/ Very low (0 to -12) (-10)	• Vegetation clearing is to be limited to what is essential. • Retain as much indigenous vegetation as possible. • Compact the site footprint only and minimise the working area.	Short-term (2)	Site (2)	Yes (1)	No (0)	Negligible (0 to -6) (-4)	Probable (1)	Neutral/ Very low (0 to -12) (-4)	Medium

Table 8-3: Operational phase hydrological risk

Component Being Impacted On	Activity Which May Cause the Impact	Activity	Pre- Mitigation							Recommended Mitigation Measures	Post Mitigation						
			Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance		Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance
Vadose zone soils and subsequent groundwater table	*Development Impacts* There is a potential for some erosion if there are storm events. Hydrocarbon/oil spillages onto soils have the potential to contaminate the soils.	Site activities	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (-13 to -24) (-14)	• Keep the site clean of all general and domestic wastes. • All development footprint areas to remain as small as possible, and vegetation clearing to be limited to what is essential. • Retain as much indigenous vegetation as possible / re-vegetate. • Have fuel/oil spill clean-up kits on site. • Exposed soils are to be protected using a suitable covering or sandbags or berms to control erosion.	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Probable (1)	Neutral/ Negligible (0 to -12) (-7)
Primary Surface Water Receivers – > River and non-perennial streams	Increased runoff due to compacted surfaces from the proposed site onto the surrounding soils may cause higher velocities and frequency of occurrence and sediment transport to the nearby streams.	Runoff	Long-term (4)	Local (3)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-8)	Probable (1)	Negligible (0 to -12) (-8)	Release structures for stormwater runoff from the site must dissipate energy and disperse flow to ensure minimal impact on the receiving environment.	Long-term (4)	Local (3)	No (0)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Improbable (0)	Negligible (0 to -12) (0)
	Potential sedimentation several months after the site has been constructed. It is anticipated that the sediment load will decrease with time to pre-construction levels.	The net result of earthworks and development	Medium Term (3)	Local (3)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (-13 to -24) (-14)	• Release structures for stormwater runoff from the site should incorporate silt traps to allow for the settlement of sediments. • Silt traps are to be regularly cleaned.	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-6)	Probable (1)	Negligible (0 to -12) (-6)
	Water quality impacts due to chemical spills, vehicle pollutants, fuel and oil spillages and leaks.	Site operations	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Probable (1)	Negligible (0 to -12) (-7)	• Implementation of a SWMP to keep clean water away from dirty areas. • Demarcated dirty areas to be limited to roads, parking areas and chemical storage areas. • Spills are to be cleaned up immediately. • Vehicles and equipment are to be regularly maintained and cleaned.	Long-term (4)	Footprint (1)	Yes (1)	Low (-1)	Negligible (0 to -6) (-6)	Probable (1)	Negligible (0 to -12) (-6)
	Erosion due to changes in topography, land use and vegetation removal.	Catchment modification	Long-term (4)	Local (3)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-8)	Probable (1)	Negligible (0 to -12) (-8)	• Design the SWMP to ensure that the velocities of stormwater runoff flow are kept to a minimum • Design release structures to dissipate stream power. • Include erosion protection measures such as rip rap in release structures.	Long-term (4)	Footprint (1)	Yes (1)	Low (-1)	Negligible (0 to -6) (-6)	Probable (1)	Negligible (0 to -12) (-6)

9 STORMWATER MONITORING PLAN

Tubatse FerroChrome already has a surface water monitoring plan in place, but additional stormwater monitoring will have to be conducted. The monitoring programme is divided into two phases:

- Phase 1: Monitoring during any construction activities (temporary monitoring); and
- Phase 2: Monitoring after development is complete (long-term or for a period after the activity).

9.1 Phase 1 monitoring

During any construction activities, water and soil monitoring should focus on active excavation sites and equipment/heavy machinery parking or housing areas. Regular visual inspections of these areas need to be undertaken. Moreover, placement and monitoring of drip trays underneath parked construction vehicles will help to determine which vehicles need to be repaired/taken off-site to prevent contamination while in service.

If visual observations during the construction phase show areas of concern (i.e., where pollution is observed during the construction phase or near wetland units), then it is advised that an additional water quality sample be obtained from the observation point. Mitigation measures should then be formulated based on the scale of impact observed.

9.2 Phase 2 monitoring

From the hydrology assessments undertaken, it is anticipated that the Steelpoort River and non-perennial stream are the receptors of any pollution from the proposed activity (i.e., overland runoff, stormwater discharge etc.). The vadose zone and underlying aquifers are also viewed as receptors of potential pollution (i.e., poor-quality seepage). Phase 2 monitoring should focus on these areas and will entail visual inspections every quarter during the operational phase of the development.

It is proposed that four (4) stormwater monitoring points be established, as illustrated in Figure 9-1 that will monitor stormwater in the days after a storm event.

9.3 Monitoring duration

It is proposed that monitoring of SW1 to SW4 be undertaken during the construction and operational phase of the project after a storm event, specifically after the first storm event of the season, and then before the season ends. The need for further monitoring of the site can be evaluated by the local environmental authorities or DWS representative.

9.4 Monitoring responsibility

It is proposed that the developer be responsible for Phase 1 and Phase 2 monitoring. The proposed monitoring type, frequencies, and constituents to monitor are listed in Table 9-1 below.

Table 9-1: Proposed monitoring points, frequencies, and sample analyses

Site Type	Frequency	Type	Field Measurements	Laboratory Analyses
Non-perennial drainage streams	Monthly during construction Bi-annually for at least 2 years after construction has taken place	Field assessment and laboratory (if required).	None	If field measurements indicate a contaminant trend, it is advised that a sample be submitted for analytical testing. The following should typically be screened: • pH, Conductivity, Total dissolved solids (TDS), and total suspended solids (TSS) • Biological oxygen demand (BOD). • Calcium, Magnesium, Sodium, Potassium, Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Iron, Manganese, Fluoride, Aluminium, Total Alkalinity (TALK), Ammonia, Ammonium.
Hydraulic monitoring (channels and culverts)	Monthly Visual	Field visual assessment	Flow (if possible)	None

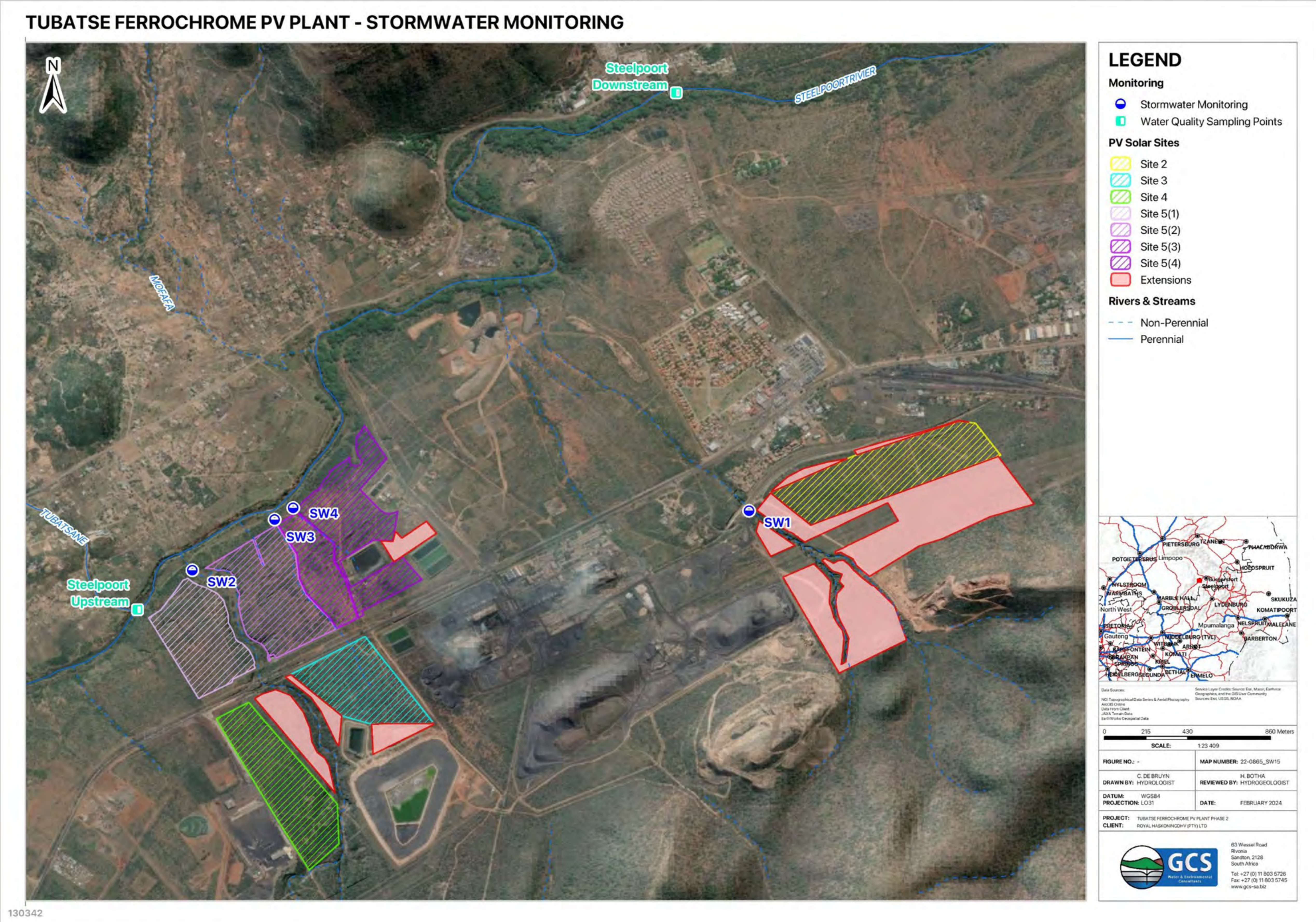

Figure 9-1: Proposed stormwater monitoring

10 CONCLUSION

Based on the investigation undertaken, the following conclusions are made:

- The site is situated in the B41J quaternary catchment of the Olifants Water Management Area (DWS, 2016)
    - The site's mean annual precipitation (MAP) is in the order of 520.8 mm/a.
    - Natural runoff was recorded as approximately 19 mm/a, which represents approximately 4% of the MAP.
    - Evaporation is reported as 1 500 to 1 600 mm/a.
- The site is on the southeastern bank of the Steelpoort River (the closest distance to the river is ±70 m), just downstream of the confluence with the Tubatsane River. Drainage from the proposed development area is via four non-perennial tributaries of the Steelpoort River in a north-west direction. Thirteen (13) hydrological response units (HRU) describe the natural drainage for the site (using a 1:1 100 stream count and a 50 m DTM fill). The sub-catchments relate well to desktop-delineated drainage lines for the project area.
- Two surface water quality samples were obtained up and downstream of the site. The sample points serve as the baseline water quality conditions of the receiving surface water stream and hence should be considered the water quality objectives during the construction and post-construction phases of the project. The water quality of the Steelpoort River shows elevated nitrate levels. These levels are associated with rare instances of methemoglobinemia in infants but no effects in adults.
- The flood lines are produced to suggest that some infrastructure at the site is situated inside probable zones of inundation. Hence, measures need to be taken to minimise flooding risk as mentioned in Section 6 (SWMP). The site specifically at risk is site 4 as the panels will be placed in the 1:50-yr and 1:100-yr flood line.
- The hydrological risk was evaluated (refer to Section 8), and the hydrological risk of the proposed activities is considered low to marginal. Mitigation measures were proposed to circumvent potential impacts.
- A high-level conceptual water balance was successfully developed although no permanent water supply to the area will be present. Water will be provided by TFC and brought in by tanker.

10.1 Identification of any areas that should be avoided

It would normally be recommended that the 1:100-year flood line be used as an avoidance area for any future development at the site. However, due to space constraints within the sites and the number of panels needed to generate the desired 100MW, some panel arrays will have to be placed within the inundation zones. With this, the internal access roads on the perimeter of the panel arrays will also be located within some inundation zones. It is our opinion that this should be allowed if the mitigation measures in Section 8 and recommendations within the SWMP (Section 6) be adhered to or viable alternatives are proposed during the detailed design phase. The mitigation measures will not prevent the flow of flood waters within the drainage line, but merely divert it around the site, allowing the drainage system to function as it normally would and ensuring flood waters are allowed to flow to the downstream Steelpoort River system.

10.2 Recommendations for EMPr and WUL

Stormwater management should focus on the following during the construction and pre-construction phases:

- **Assess the site constraints and any site-specific concerns, including:**
  - Specific vegetation that may need to be identified and/or isolated from the site disturbance.
  - The type of construction must consider landform. Avoid slab-on-ground construction on steep sites.
  - Up-slope drainage catchments that may need to be diverted around the work site.
  - Workspace limitations must require site-specific sediment control measures and/or the extensive use of skips or bins for material storage and waste management.
  - Expected rainfall intensity during the period of disturbance (wet season vs dry season).
  - If cable trenches are to cross drainage lines (such as at site 2), the work should preferably be conducted in winter months (dry season), to avoid runoff posing a construction risk. The drainage line must also be restored to its former shape after construction is completed.

- **Stabilise the site entry/exiting points:**
    - A stabilised site access must be established and, if possible, limited to one point only. The access allows for construction vehicles to enter the work area while preventing the unnecessary tracking of sediment onto the nearby environment from multiple locations. A stabilised entry/exit point normally consists of a stabilised rock pad.
- **Prevent erosion & manage stockpiles:**
    - Suitable material storage areas must be located up-slope of the main sediment barrier (e.g., sediment fence).
    - Stockpiles kept on site for more than two weeks will require an impervious cover (e.g., builder's plastic or geofabric) to protect against raindrop impact. Stockpiles of sandy material located behind a sediment fence will only need a protective cover if the stockpiles are likely to be exposed to strong winds.
    - On steep sites and sites with limited available space, erodible materials may need to be stored in commercial-sized bins or mini-skips before use.
- The stormwater management plan recommendations as laid out in Section 6 should be implemented as far as possible for the operational phase of the project.
    - *It should be emphasised that the conceptual stormwater plan is intended for informational and planning purposes only. It is not a detailed engineering design and should not be used for construction or regulatory compliance purposes. The accuracy and effectiveness of the plan may be limited by assumptions, data availability, and site-specific conditions.*
    - *The recommendations made in this report should be taken into account during the detailed design phase and water use authorisation process and should consult a qualified professional engineer or stormwater management specialist to finalise the SWMP.*
    - *The stormwater measures mentioned in this report are recommendations and are not strict requirements if an option is not deemed viable by the end client or department.*
- From a health and safety standpoint, it is recommended that a flood awareness initiative be undertaken amongst staff that will be working with and on the solar PV sites. Personnel should be aware of the risks involved with flood waters and should evacuate inundation-risk areas.

10.3 Reasoned opinion on whether the activity should be authorised

This assessment cannot find any grounds to not authorise the WUL and Environmental Authorisation. This is grounded on the assumption that the proposed mitigation (Section 8), monitoring (Section 9) and stormwater management recommendations (Section 6) are implemented.

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APPENDIX A: PEAK FLOW CALCULATIONS

RATIONAL METHOD 3							
Description of catchment	59						
River detail	Tributary						
Calculated by	Chané de Bruyn			Date	Thursday, 29 February 2024		
Physical characteristics							
Size of catchment (A)	1.155	km^2		Rainfall region		B4D	
Longest watercourse (L)	1.55	km		Area distribution factors			
Average slope (S_{av})	0.0499	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall (MAR)	520.80	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	0.27	0.01	0.00	Lawns			
Flat areas (3 - 10%)	13.10	0.06	0.79	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	33.09	0.12	3.97	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	53.54	0.22	11.78	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	16.54	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	0	0.03	0.00	Houses	0	0.5	0
Permeable	80	0.06	4.80	Flats	0	0.6	0
Semi-permeable	20	0.12	2.40	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	7.20	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	37.77	0.03	1.13	City centre	0	0.8	0
Light bush & farm-lands	3.90	0.07	0.27	Suburban	0	0.65	0
Grasslands	58.33	0.17	9.92	Streets	0	0.75	0
No vegatation	0.00	0.26	0.00	Max flood	0	1	0
Total	100	0.53	11.32	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$			Use Defined watercourse			
0.973 hours	0.295	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.351	0.351	0.351	0.351	0.351	0.351	
Adjusted for dolomitic areas, C_{1D}	0.351	0.351	0.351	0.351	0.351	0.351	
Adj factor for initial saturation, F_t	0.75	0.8	0.85	0.9	0.95	1	
Adjusted run - off coefficient, C_{1T}	0.2629616	0.280492374	0.298023147	0.316	0.333	0.351	
Combined run - off coefficient, C_T	0.2629616	0.280492374	0.298023147	0.316	0.333	0.351	
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	36.49	50.04	60.22	71.09	86.33	99.18	
Point Intensity (mm/h), P_{iT}	123.78	169.74	204.28	241.15	292.84	336.47	
Area reduction factor (%),ARF_T	1.063	1.063	1.063	1.063	1.063	1.063	
Average intensity (mm/hour),I_T	131.531	180.369	217.068	256.252	311.179	357.533	
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	11.097	16.232	20.755	25.943	33.254	40.22	0.00

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment	S9						
River detail	Tributary						
Calculated by	Chané de Bruyn			Date	Thursday, 29 February 2024		
Physical characteristics							
Size of catchment (A)	1.155	km^2		Days of thunder per year (R)	20	days	
Longest watercourse (L)	1.55	km		Time of concentration, t	17.687	minutes	
Average slope (S_{av})	0.0499	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$	0.2948	
SDF Basin	4						
2-year return period rainfall (M)	58	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP	520.8	mm	
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	15.2	25.7	33.6	41.5	51.9	59.8	67.7
Area reduction factor (%),ARF_T	1.063	1.063	1.063	1.063	1.063	1.063	1.063
Average intensity (mm/hour),I_T	54.8	92.5	121.0	149.5	187.2	215.7	244.2
Run-off coefficient							
Calibration factors C_2 (%)	10		C_{100} (%)		50		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.100	0.244	0.320	0.382	0.452	0.500	0.543
Peak flow (m3/s)	1.76	7.25	12.41	18.30	27.14	34.60	42.53

Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD															
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
S9	1.155	520.8	0.0499	1.55	1.16	0.67	0.91	1.26	1.6	0.1439	9.73	13.22	18.30	23.24

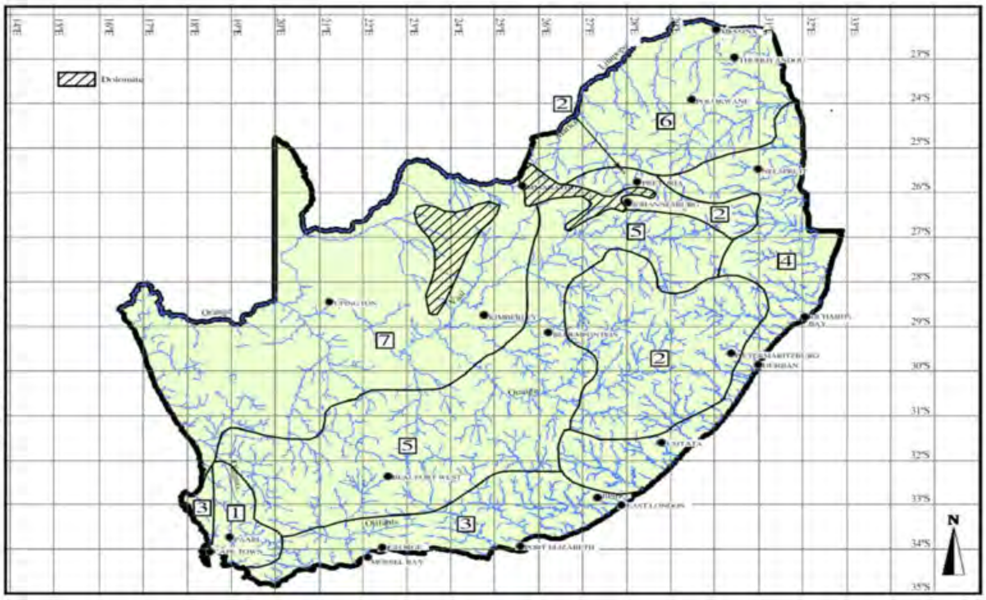


Figure 3.35: Homogeneous flood regions in South Africa

RATIONAL METHOD 3							
Description of catchment	S10						
River detail	Tributary						
Calculated by	Chané de Bruyn			Date	Thursday, 29 February 2024		
Physical characteristics							
Size of catchment (A)	0.9	km^2		Rainfall region	B4D		
Longest watercourse (L)	1.35	km		**Area distribution factors**			
Average slope (S_{av})	0.0475	m/m		Rural (α)	Urban (B)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall (MAR)	520.80	mm					
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	1.21	0.01	0.01	**Lawns**			
Flat areas (3 - 10%)	24.72	0.06	1.48	Sandy, flat<2%	0	0.08	0
Hilly (10 - 30%)	38.59	0.12	4.63	Sandy, steep>7%	0	0.16	0
Steep Areas (>30%)	35.49	0.22	7.81	Heavy s, flat<2%	0	0.15	0
Total	100.00	0.41	13.93	Heavy s, steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0	0.03	0.00	Houses	0	0.5	0
Permeable	80	0.06	4.80	Flats	0	0.6	0
Semi-permeable	20	0.12	2.40	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	7.20	Heavy industry	0	0.7	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	22.34	0.03	0.67	City centre	0	0.8	0
Light bush & farm-lands	13.81	0.07	0.97	Suburban	0	0.65	0
Grasslands	42.23	0.17	7.18	Streets	0	0.75	0
No vegatation	21.62	0.26	5.62	Max flood	0	1	0
Total	100	0.53	14.44	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$			Use Defined watercourse			
0.923 hours	0.270	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.356	0.356	0.356	0.356	0.356	0.356	
Adjusted for dolomitic areas, C_{1D}	0.356	0.356	0.356	0.356	0.356	0.356	
Adj factor for initial saturation, F_t	0.75	0.8	0.85	0.9	0.95	1	
Adjusted run - off coefficient, C_{1T}	0.26677209	0.284556896	0.302341702	0.320	0.338	0.356	
Combined run - off coefficient, C_T	0.26677209	0.284556896	0.302341702	0.320	0.338	0.356	
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	35.72	48.99	58.95	69.58	84.52	97.11	
Point intensity (mm/h), P_{iT}	132.26	181.38	218.25	257.60	312.90	359.53	
Area reduction factor (%), ARF_T	1.071	1.071	1.071	1.071	1.071	1.071	
Average intensity (mm/hour), I_T	141.661	194.269	233.763	275.910	335.137	385.092	
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	9.448	13.820	17.669	22.082	28.312	34.24	0.00

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		S10					
River detail	Tributary						
Calculated by	Chané de Bruyn			Date		Thursday, 29 February 2024	
Physical characteristics							
Size of catchment (A)	0.9	km²		Days of thunder per year (R)		20	days
Longest watercourse (L)	1.35	km		Time of concentration, t		16.207	minutes
Average slope (S_{av})	0.0475	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		0.2701
SDF Basin	4						
2-year return period rainfall (M)	58	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		520.8	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	14.7	24.8	32.4	40.0	50.1	57.7	65.3
Area reduction factor (%), ARF_T	1.071	1.071	1.071	1.071	1.071	1.071	1.071
Average intensity (mm/hour), I_T	58.2	98.2	128.4	158.6	198.6	228.8	259.1
Run-off coefficient							
Calibration factors C_2 (%)	10		C_{100} (%)		50		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.100	0.244	0.320	0.382	0.452	0.500	0.543
Peak flow (m3/s)	1.45	5.99	10.26	15.13	22.44	28.60	35.16

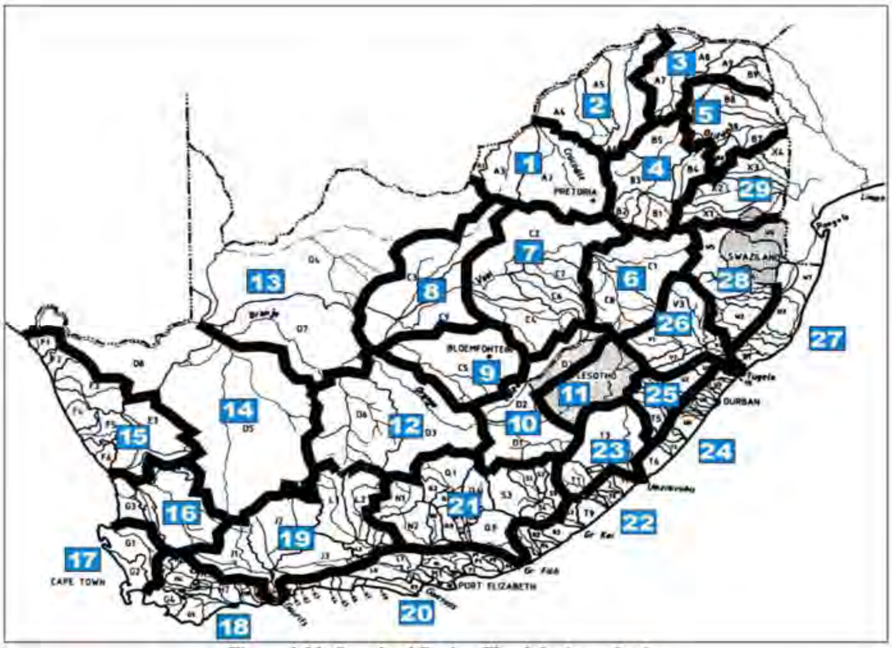
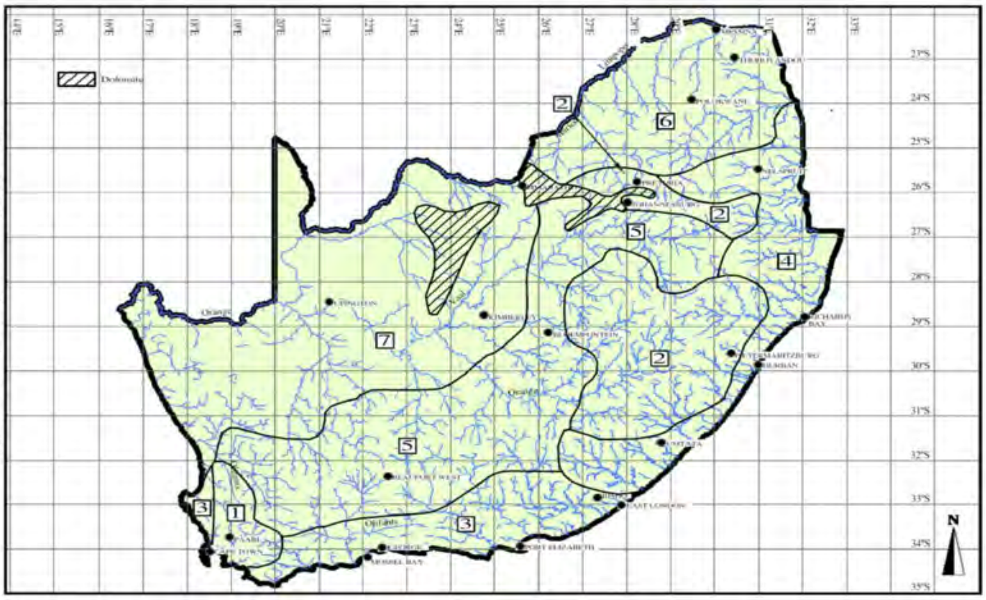


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD															
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows				
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
S10	0.9	520.8	0.0475	1.35	0.91	0.67	0.91	1.26	1.6	0.1604	8.56	11.63	16.10	20.45

Figure 3.35: Homogeneous flood regions in South Africa



RATIONAL METHOD 3							
Description of catchment	S11						
River detail	Tributary						
Calculated by	Chané de Bruyn			Date	Thursday, 29 February 2024		
Physical characteristics							
Size of catchment (A)	0.27	km²		Rainfall region		B4D	
Longest watercourse (L)	0.44	km		Area distribution factors			
Average slope (S_{av})	0.0383	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall (MAR)	520.80	mm					
	Rural			URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	5.54	0.01	0.06	Lawns			
Flat areas (3 - 10%)	78.13	0.06	4.69	Sandy, flat<2%	0	0.08	0
Hilly (10 - 30%)	14.87	0.12	1.78	Sandy, steep>7%	0	0.16	0
Steep Areas (>30%)	1.46	0.22	0.32	Heavy s, flat<2%	0	0.15	0
Total	100.00	0.41	6.85	Heavy s, steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	0	0.03	0.00	Houses	0	0.5	0
Permeable	80	0.06	4.80	Flats	0	0.6	0
Semi-permeable	20	0.12	2.40	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	7.20	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	23.28	0.03	0.70	City centre	0	0.8	0
Light bush & farm-lands	56.80	0.07	3.98	Suburban	0	0.65	0
Grasslands	2.83	0.17	0.48	Streets	0	0.75	0
No vegetation	17.09	0.26	4.44	Max flood	0	1	0
Total	100	0.53	9.60	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87\, L^2}{1000\, S_{AV}}\right]^{0.385}$			Use Defined watercourse			
0.575 hours	0.124	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_T	0.236	0.236	0.236	0.236	0.236	0.236	
Adjusted for dolomitic areas, C_{TD}	0.236	0.236	0.236	0.236	0.236	0.236	
Adj factor for initial saturation, F_T	0.75	0.8	0.85	0.9	0.95	1	
Adjusted run - off coefficient, C_{FT}	0.177354898	0.189178558	0.201002218	0.213	0.225	0.236	
Combined run - off coefficient, C_T	0.177354898	0.189178558	0.201002218	0.213	0.225	0.236	
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	29.81	40.84	49.13	58.02	70.52	81.03	
Point intensity (mm/h), P_{iT}	240.80	329.98	396.95	468.77	569.74	654.64	
Area reduction factor (%), ARF_T	1.098	1.098	1.098	1.098	1.098	1.098	
Average intensity (mm/hour), I_T	264.520	362.483	436.045	514.931	625.850	719.111	
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	3.519	5.143	6.573	8.219	10.545	12.75	0.00

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		S11					
River detail	Tributary						
Calculated by	Chané de Bruyn			Date	Thursday, 29 February 2024		
Physical characteristics							
Size of catchment (A)	0.27	km²		Days of thunder per year (R)	20	days	
Longest watercourse (L)	0.44	km		Time of concentration, t	7.427	minutes	
Average slope (S_{av})	0.0383	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$	0.1238	
SDF Basin	4						
2-year return period rainfall (M)	58	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP	520.8	mm	
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	9.9	16.6	21.8	26.9	33.6	38.8	43.9
Area reduction factor (%),ARF_T	1.098	1.098	1.098	1.098	1.098	1.098	1.098
Average intensity (mm/hour),I_T	87.5	147.6	193.1	238.5	298.6	344.1	389.6
Run-off coefficient							
Calibration factors C_2 (%)	10		C_{100} (%)		50		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.100	0.244	0.320	0.382	0.452	0.500	0.543
Peak flow (m3/s)	0.66	2.70	4.63	6.83	10.12	12.90	15.86

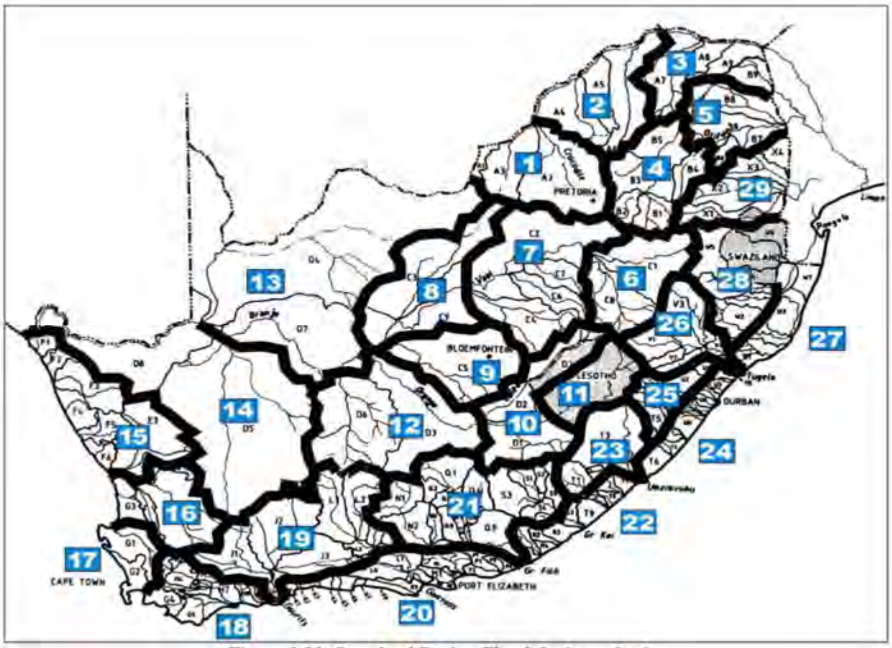
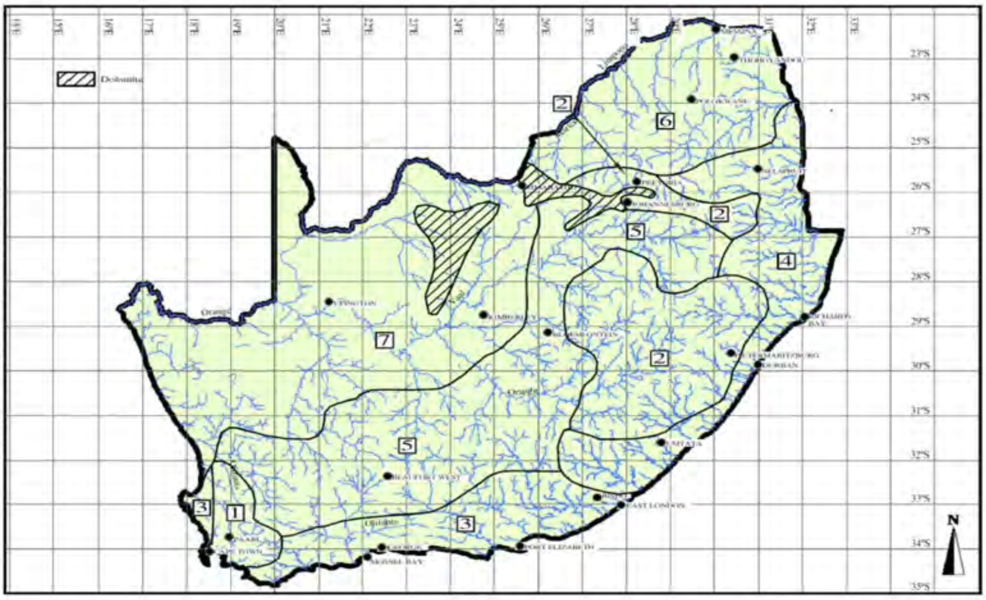


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
S11	0.27	520.8	0.0383	0.44	0.39	0.67	0.91	1.26	1.6	0.3111	4.75	6.45	8.93	11.34

Figure 3.35: Homogeneous flood regions in South Africa



APPENDIX B: LABORATORY CERTIFICATES

X-LAB EARTH

TEST REPORT

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Henri Botha	Laboratory	X-Lab Earth Science
Client	GCS - GROUNDWATER CONSULTING SERVICES (PTY) LTD	Address	2 Samantha Street, Strydompark, Randburg, 2169
Address	63 Wessel Road Rivonia Sandton	Telephone	+27 (0)11 590 3000
Telephone		Laboratory Manager	Mrs Tasneem Tagari
Facsimile		Lab Reference	JBX23-16499
Email	hendrikb@gcs-sa.biz	Report Number	0000066726
		Date Received	13/10/2023 16:20
Order Number	22-0865	Date Started	16/10/2023 16:33
Samples	2	Date Reported	19/10/2023 15:36
Sample matrix	WATER		

The document is issued in accordance with SANAS's accreditation requirements.
Accredited for compliance with ISO/IEC 17025. SANAS accredited laboratory T0775.

Samples received at ambient temp good condition.

Tasneem Tagari

General Manager/Technical Signatory

www.xlab.earth

LAB-QLT-REP-001

X-LAB EARTH

JBX23-16499

Report number 0000066726

Client reference 22-0865

TEST REPORT

Parameter	Units	LOR	Sample Number: JBX23-16499.001 Sample Name: Upstream	Sample Number: JBX23-16499.002 Sample Name: Downstream
Calculation of Anion-Cation Balance				
Anion-Cation Balance	%	-100	0.04	4.20
Sum of Anion Milliequivalents	meq/l	-	4.57	4.27
Sum of Cation Milliequivalents	meq/l	-	4.58	4.65
Turbidity Method: ME-AN-086				
Turbidity *	NTU	0.4	1.2	0.9
Alkalinity on waters by titration Method: ME-AN-081				
Total Alkalinity as CaCO3	mg/l	12	140	125
Bicarbonate Alkalinity as CaCO3	mg/l	12	140	125
Bicarbonate Alkalinity as HCO3	mg/l	12	171	153
Bicarbonate as CaCO3	mg/l	12	140	125
Carbonate Alkalinity as CaCO3	mg/l	12	<12	<12
Carbonate Alkalinity as CO3	mg/l	12	<12	<12
Conductivity on waters Method: ME-AN-007				
Conductivity in mS/m @ 25ºC	mS/m	2	41	42

Total Dissolved Solids (TDS) in water at 105 deg Method: ME-AN-011

10/10/23 Page 2 of 5

X-LAB EARTH

JBX23-16499

Report number 0000066726

Client reference 22-0865

TEST REPORT

Parameter	Units	LOR	Sample Number: JBX23-16499.001 Sample Name: Upstream	Sample Number: JBX23-16499.002 Sample Name: Downstream

Total Dissolved Solids (TDS) in water at 105 deg Method: ME-AN-011 (continued)

TDS (0.7µm) @ 105ºC	mg/l	21	250	260

Total Suspended Solids Method: ME-AN-069

TSS (0.7µm) @ 105ºC	mg/l	21	<21	<21

ICP-OES Metals on waters (Dissolved) Method: ME-AN-027

Aluminium	mg/l	0.02	<0.02	<0.02
Calcium	mg/l	0.5	31	32
Iron	mg/l	0.05	<0.05	<0.05
Magnesium	mg/l	0.01	23	23
Manganese	mg/l	0.01	<0.01	<0.01
Potassium	mg/l	0.2	2.1	2.2
Sodium	mg/l	0.5	25	25

Anions on Waters by Ion Chromatography Method: ME-AN-019

Chloride	mg/l	0.05	36	37
Fluoride	mg/l	0.05	0.22	0.25
Nitrate	mg/l	0.1	9.2	8.7
Sulphate	mg/l	0.05	29	28

10/10/23 Page 3 of 5

X-LAB EARTH

JBX23-16499

Report number 0000066726

Client reference 22-0865

TEST REPORT

Parameter	Units	LOR	Sample Number: JBX23-16499.001 Sample Name: Upstream	Sample Number: JBX23-16499.002 Sample Name: Downstream
pH in water Method: ME-AN-016				
pH in water at 25ºC	-	1	8.4	8.4
Sodium Adsorption Ratio by calculation				
Sodium Adsorption Ratio (SAR) *	-	-	0.8	0.8

JBX23-16499

Report number 0000066726

Client reference

22-0865

METHOD SUMMARY

Calculation of Anion-Cation	Calculation of the cation/anion balance
ME-AN-007	The conductivity of an aliquot of aqueous sample is measured electrometrically using a standard cell connected to a calibrated meter with automated temperature correction. This method is based on APHA 2510.
ME-AN-016	The pH of an aliquot of aqueous sample is measured electrometrically using an electrode connected to a calibrated meter with automated temperature correction. This method is based on APHA 4500-H B.
ME-AN-011	Total dissolved solids (TDS) is determined gravimetrically on a filtered aliquot of aqueous sample by evaporating the sample to dryness in a pre-weighed container at 105 deg C. The method is based on APHA 2540 C.
ME-AN-009	Total suspended solids (TSS) is determined gravimetrically by filtering an aliquot of well-shaken aqueous sample through a pre-weighed filter which is then dried at 105 deg C. The method is based on APHA 2540 D.
ME-AN-008	Turbidity is measured on an aliquot of aqueous sample using a calibrated turbidity meter. The method is based on APHA 2130.
ME-AN-001	An aliquot of aqueous sample is titrated first to pH 8.3 and then to 4.3 using standardised acid. The volumes of acid titrated are used to calculate total alkalinity and/or alkaline species. The method is based on EPA 310.2 and APHA 2320 B.
ME-AN-014	Inorganic anions (Br, Cl, F, NO3, NO2, SO4) are determined on aqueous samples by ion chromatography. The method is based on EPA 300.1 and APHA 4110 B.
ME-AN-027	Dissolved metals are determined on a filtered and acidified (to 1% HNO3) portion of aqueous sample by inductively coupled plasma optical emission spectrometry (ICP-OES). The method is based on EPA 200.7 and APHA 3120.

FOOTNOTES

IS Insufficient sample for analysis.
LNR Sample listed, but not received.
^ Performed by outside laboratory.
LOR Limit of Reporting

\- The sample was not analysed for this analyte
* *Results marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this laboratory / certification body / inspection body".*

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Unless otherwise indicated, samples were received in containers fit for purpose.

LAB-QLT-REP-001

10/19/23 Page 5 of 5

APPENDIX C: DISCLAIMER AND DECLARATIONN OF INDEPENDENCE

The opinions expressed in this report have been based on site /project information supplied to GCS (Pty) Ltd (GCS) by Royal HaskoningDHV (Pty) Ltd and is based on public domain data, field data and data supplied to GCS by the client. GCS has acted and undertaken this assessment objectively and independently.

GCS has exercised all due care in reviewing the supplied information. Whilst GCS has compared key supplied data with expected values, the accuracy of the results and conclusions are entirely reliant on the accuracy and completeness of the supplied data. GCS does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report, apply to the site conditions, and features as they existed at the time of GCS's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this report, about which GCS had no prior knowledge nor had the opportunity to evaluate.

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Hydrological Assessment for the Samancor Tubatse Ferrochrome PV Plant Development Extension Sites

SPECIALIST INFORMATION

Specialist Company Name:	GCS Environmental SA			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	2	Percentage Procurement Recognition	
Specialist name:	Hendrik Botha			
Specialist Qualifications:	[redacted]			
Professional affiliation/registration:	[redacted]			
Physical address:	[redacted]			
Postal address:				
Postal code:	[redacted]	Cell:		
Telephone:	[redacted]	Fax:		
E-mail:	[redacted]			

Specialist Company Name:	[redacted]			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	2	Percentage Procurement Recognition	
Specialist name:	Chané de Bruyn			
Specialist Qualifications:	[redacted]			
Professional affiliation/registration:				
Physical address:	[redacted]			
Postal address:				
Postal code:	[redacted]	Cell:		
Telephone:	[redacted]	Fax:		
E-mail:	[redacted]			

DECLARATION BY THE SPECIALIST

I, Hendrik Botha, declare that –

- I act as the independent specialist in this application.
- I will perform the work relating to the application objectively, even if this results in views and findings that are not favourable 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 specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations and all other applicable legislation.
- 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 concerning 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 the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

____

Signature of the Specialist

GCS

Name of Company:

06 May 2024

Date

DECLARATION BY THE SPECIALIST

I, Chané de Bruyn, declare that –

- I act as the independent specialist in this application.
- I will perform the work relating to the application objectively, even if this results in views and findings that are not favourable 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 specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations, and all other applicable legislation.
- 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 concerning 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 the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

GCS

Name of Company:

06 May 2024

Date

CV OF SPECIALIST TEAM

GCS Water & Environmental Consultants

Hendrik Botha

Technical Director

LinkedIn:

CORE SKILLS

- Project management
- Analytical and numerical groundwater modelling
- Geochemical assessments and geochemical modelling
- Hydropedology, hydrological assessments & yield assessments
- Hydrology, floodline modelling & storm water management
- Groundwater vulnerability, impact, and risk assessments
- Technical report writing
- GIS and mapping

DETAILS

Qualifications

- BSc Chemistry and Geology (Environmental Sciences) (2012)
- BSc Hons Hydrology (Environmental Sciences) (2013)
- MSc Geohydrology and Hydrology (Environmental Sciences) (2014-2016)

Membership

- Groundwater Division of GSSA
- Groundwater Association of KwaZulu Natal Member
- International Mine Water Association (IMWA)

Languages

- Afrikaans – Speak, read, write.
- English – Speak, read, write.

Projects undertaken in

- South Africa
- Nigeria
- Namibia
- Liberia
- Malawi

PROFILE

Hendrik (Henri) Botha is currently the Technical Director at GCS Water and Environment. He holds an MSc in Environmental Science in Geohydrology & Geochemistry, and a BSc Hons. Degree in Hydrology. He is registered as a SACNASP Professional Natural Scientist in the Earth Science Field. Groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry together with GIS, and analytical and numerical modelling skills, are some of his sought-after expertise. General and applied logical knowledge are his key elements in problem-solving.

Professional Affiliations:

SACNASP Professional Natural Scientis[redacted]

Areas of Expertise:

- Project Management of water and environmental projects for mining, industrial and agriculture sectors.
- Integrated Water Investigations
- Waste classification and Impact Assessments
- Aquifer vulnerability assessments
- Geochemical sampling, data interpretation and modelling
- Groundwater impact and risk assessments
- Numerical and Conceptual Visual Modelling (Visual Modflow, ModflowFLEX, Voxler, RockWorks, Surfer and Excel)
- Hydropedology (Hydrological Soil Types) & Soils Assessments
- Floodline Modelling (HEC-RAS)
- Conceptual Stormwater Management Assessments
- Surface Water Yield Assessments
- Water and Salt Balances

Page 1 of 8

SCAN ME
PROJECT RECORD

Chané de Bruyn
Hydrologist

LinkedIn Profile:

CORE SKILLS

- Hydrological Assessment
- Groundwater impact and risk assessment
- Hydrological and flood line modelling
- Stormwater Management
- GIS and Mapping
- Data Analyses
- Computer literacy
- Report writing

DETAILS

Qualifications

- B.Sc. Environmental Sciences with Geology and Botany
- B.Sc. (Hons) Environmental Sciences with Hydrology and Geohydrology
- M.Sc. Environmental Sciences with Hydrology and Geohydrology

Membership

Languages

- Afrikaans
- English

Projects undertaken in

- South Africa
- Botswana

PROFILE

Chané de Bruyn is a Junior Hydrologist at GCS (Pty) Ltd. She is detail oriented with a strong work ethic. With problem-solving skills, she is keen to apply knowledge gained during education to real world situations. Focused on surface water, she is knowledgeable about both surface and groundwater, with an interest in hydropedology.

Professional Affiliations:

Areas of Expertise:

- (Geo)hydrological modelling including:
  - MODFLOW
  - EPA SWMM
  - HEC-RAS
  - HEC-HMS
  - PHREEQC
  - Aquiworx
  - Tripol
  - Surfer
- Geographic Information Systems:
  - ArcGIS
  - Global Mapper
  - QGIS
- Data collection and analyses:
  - Database management systems such as Microsoft Access and SQLite
  - Web-based databases such as NGA and GRIP
- Coding:
  - Basic statistical coding and machine learning using Python and R
- Surveying:
  - Geohydrological/Hydrological
  - Geological
  - Botanical
  - Soil
  - Geophysical