Stormwater, Wastewater and Erosion Management Plan for Doornhoek PV

Doornhoek PV - SWMP, Klerksdorp, South Africa

SRK Consulting (South Africa) (Pty) Ltd. ▪ 585738 ▪ March 2023

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Doornhoek PV – SWMP Klerksdorp South Africa

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File Name:
585738_Doornhoek (Pty) Ltd - SWMP_Report(Final)_Rev3_31_03_2023

Suggested Citation:
SRK Consulting (South Africa) (Pty) Ltd. 2022. Stormwater, Wastewater and Erosion Management Plan for Doornhoek. Prepared for Doornhoek PV (Pty) Ltd South Africa . Project number: 585738. Issued March 2023 .

Cover Image(s):
Picture of the Doornhoek 1 site taken by T.Netshitangani during site visit.

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Executive Summary

Doornhoek PV (Pty) Ltd (The Applicant) propose developing a commercial solar Photo-Voltaic (PV) facility and associated infrastructure (known as the Doornhoek PV Facility, comprising of authorised projects known as Doornhoek 1 PV and Doornhoek 2 PV) on a site located approximately 11 km north of Klerksdorp in the North-West Province of South Africa.

This report documents the Stormwater, Wastewater and Erosion Management Plan (referred to as the SWMP) required for the proposed development. The SWMP aims to facilitate the protection of surface water resources and covers the total proposed project development area.

The proposed facility has no identifiable surface water resources. All the stormwater impacts that exist can be managed in a practical and cost-effective manner. The moderate to low rainfall and low gradients of the area suggest that the detailed design should not vary significantly from the management concepts presented in the report.

The site is situated on a ridge which forms the watershed between quaternary catchments C24G and C24H. As such, there are no upstream catchments draining towards the site that require management, only runoff from within the site boundaries is to be managed. A drainage network that free drains where possible and collects runoff where roads intersect sub-catchments in drains along the roads has been designed (at conceptual level) and then discharges the rainfall back into the natural environment via suitably designed mitre drains. The conceptual designs should be developed to detailed design, and the final plans should incorporate any environmental specifications during construction and operation of the facility.

SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK 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 SRK'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 SRK had no prior knowledge nor had the opportunity to evaluate.

1 Introduction

SRK Consulting (South Africa) (Pty) Ltd was approached by Doornhoek PV (Pty) Ltd (the Applicant) to develop a Stormwater, Wastewater and Erosion Management Plan (referred to as the SWMP) for the proposed new development of a commercial solar Photo-Voltaic (PV) facility, known as the Doornhoek PV facility. The proposed site is located approximately 11 km north of Klerksdorp in the North-West Province of South Africa.

1.1 Objectives and Scope of Report

1.1.1 Objectives

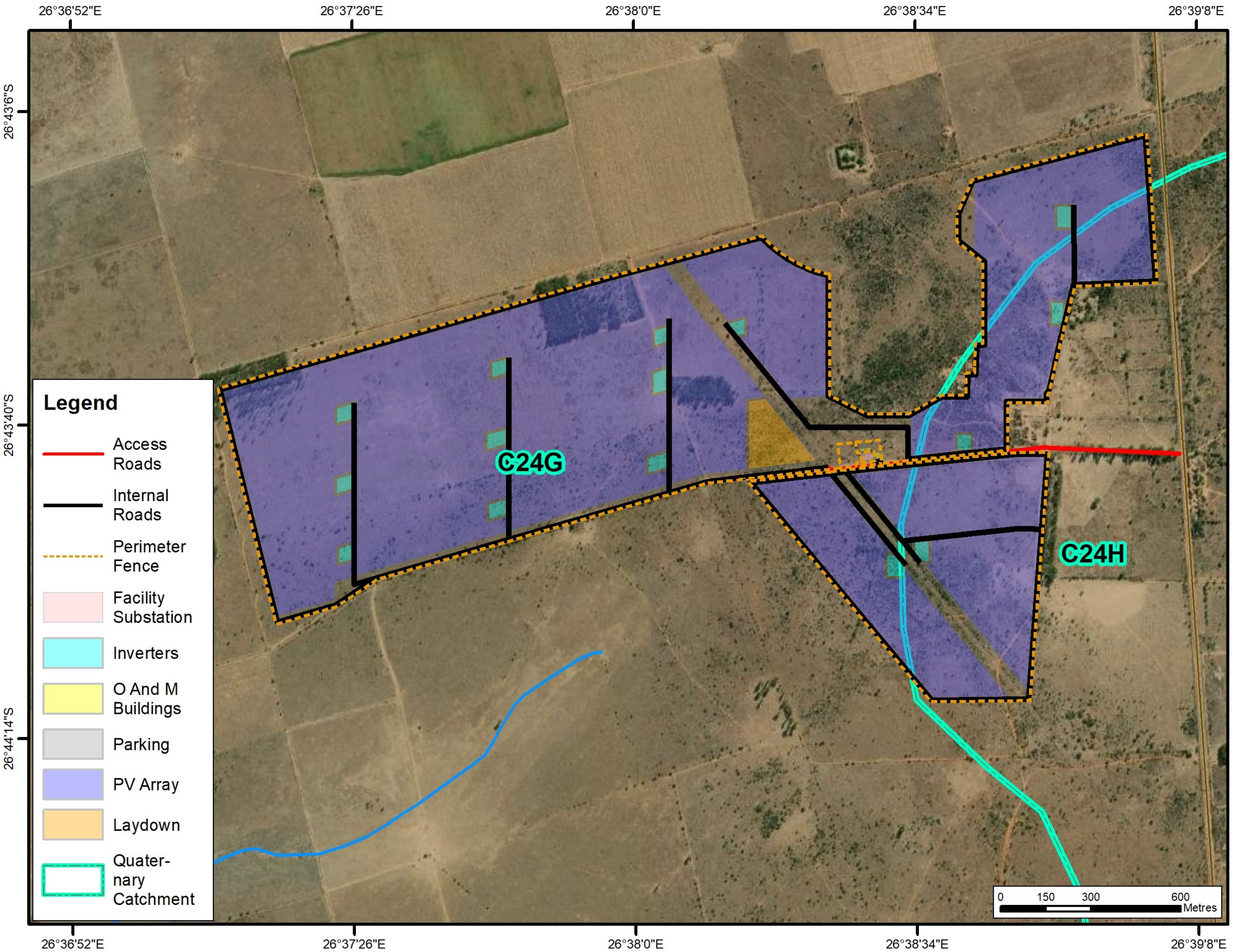
The objective of this report is to prepare a SWMP that strives to protect surface water resources, manages erosion risks and to comply with the relevant regulations and guidelines (listed in Section 2.2) for the construction and operation phases of the Doornhoek facility.

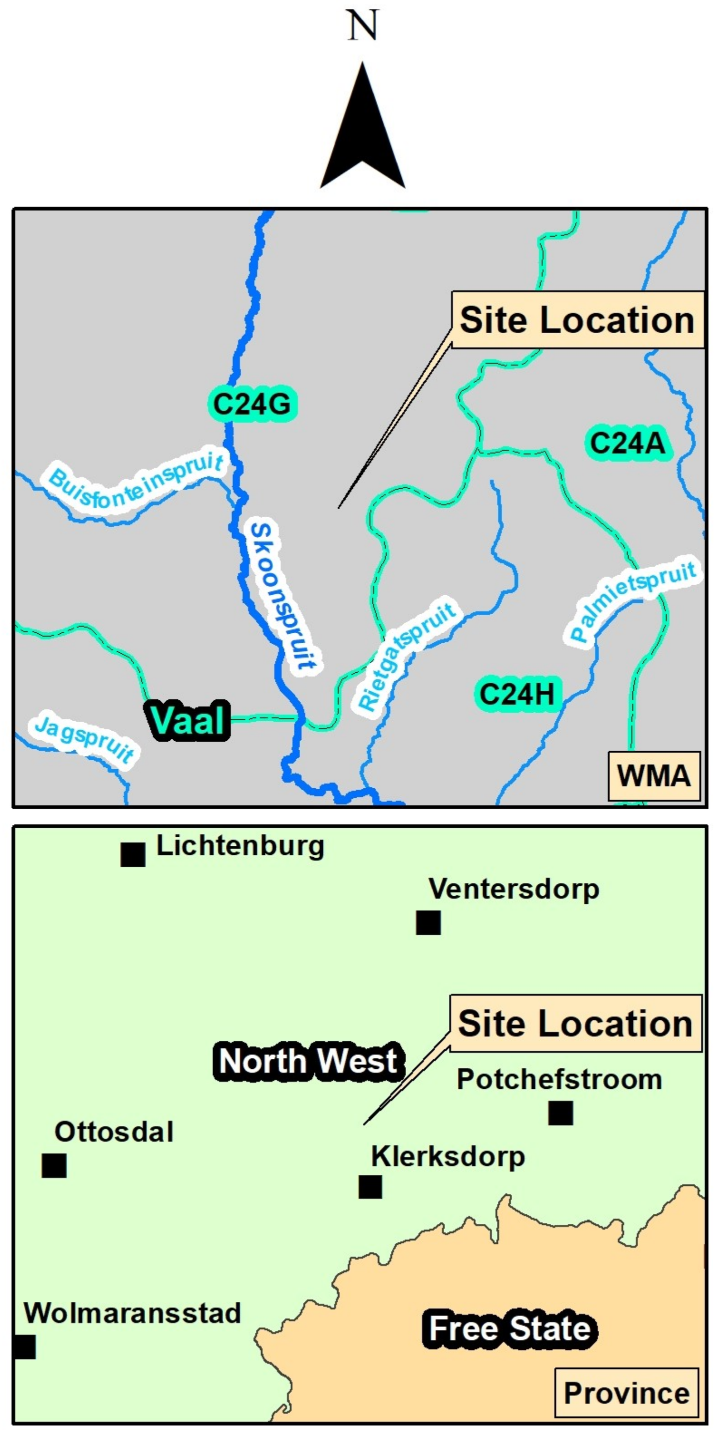
1.1.2 Scope

This report covers the following scope:

- Delineation of the catchments draining through the development area;
- Delineation of the sub-catchments within the development area;
- Determination of the type of catchment (clean or dirty area);
- Calculations of peak stormwater discharges from each catchment; and
- Recommendations for stormwater management and erosion protection during the design, construction, and operation phases of the proposed project.

The SWMP is a conceptual study at this stage, and a detailed survey and SWMP study will need to be undertaken during the design of the required infrastructure.





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DOORNHOEK PV FACILITY SWMP

SITE LAYOUT AND LOCALITY

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2 Supporting Information

This section summarises all the available information and assumptions upon which the derivation of the SWMP is based. This is done to highlight how the plan was developed: by matching regulations and guidelines to the specific needs of the project in the local natural conditions on site. The available information is therefore key to understanding the SWMP.

2.1 Site and Project Information

The project description was provided by the Applicant and the site information has been informed by a site visit undertaken on 4 April 2022.

The revised site layout and survey data (in the form of a digital elevation model) was supplied to SRK on 8th March 2023.

2.1.1 Project Information

The following information provided is relevant to stormwater management:

- Fixed-tilt or tracking solar PV panels;
- Operation and Maintenance (O&M) buildings, inclusive of permanent laydown area, toilet facilities connected to a conservancy tank for wastewater collection, workshop, warehouses and a chemical storage area;
- An electrical substation including transformers containing oil;
- On-site inverters and inverter transformers (containing oil) located between the panels to step up the power;
- Cabling between the project's components, to be laid underground where practical or attached to the PV substructures;
- Fencing around the development area;
- Access roads (up to 8 m wide):
  - Existing roads will be used as access roads where possible; and
  - Existing roads will be extended to create access to the facility where necessary.
- During construction, a temporary laydown area will be used;
- Small quantities of fuel and other motor oils will be stored on site and transferred into vehicles. These will be bunded.
- General waste will only be stored temporarily and taken off site regularly for disposal to landfill.

2.1.2 Site Visit

The site was visited by T.Netshitangani from SRK Consulting on 4th April 2022. The site terrain is gradual (very "flat" land with low angle slopes in colloquial terms). No erosion was observed in either vegetated areas, cleared areas or near roads.

The soils on the site were assessed visually and judged to have moderate permeability for the purposes of a stormwater management plan. The soils were not lab tested and the judgement erred on the conservative side so that no drains would be undersized. No natural or artificial drainage channels were observed on the site or noted on any maps. The vegetation is composed mainly of medium grass cover with light bush and farmlands on the site. A photograph from the site is shown in Figure 2-1.

Figure 2-1: Photographs of the proposed Doornhoek PV Facility site

2.2 Legislation and guidelines

SWMPs are generally required to support the Environmental Management Programme (EMPr) and Water Use License Applications. The following was taken into account in compiling the SWMP:

- Best Practice Guideline for Stormwater Management (Department Water Affairs and Forestry, 2006);
- Regulation 704 of the National Water Act (Department of Water Affairs and Forestry, 4 June 1999).

Municipal regulations/bylaws, which may introduce specific standards for each municipality, but still adhere to the overall principles of the regulations and guidelines above, should be considered during detailed design (if relevant).

2.3 Natural conditions

2.3.1 Climate

The development lies in an arid to semi-arid climatic region with a mean annual precipitation of 600 mm per year.

2.3.2 Design Rainfall

The rainfall analysis was based on the “Design Rainfall Estimation in South Africa” (DRE) program developed by JC Smithers and RE Schulze (Smithers & Schulze, 2002). The program implements procedures from the Water Research Commission (WRC) project entitled “Rainfall Statistics for Design Flood Estimation in South Africa” (WRC Project K5/1060).

The rainfall data is interpolated for a point within the site from nearby rainfall stations (Smithers and Schulze - Design Rainfall in South Africa). The rainfall station closest to the development area is Doornfontein (0436248_W), which is approximately 12.7 km from the site. Table 2-1 indicates the relevant design rainfall for the site.

Table 2-1: Design Rainfall (mm) Data Interpolated for the site centroid.

Design Rainfall Data (mm) interpolated from the six closest stations							
Mean annual rainfall	592	mm	Latitude	26	degrees	44	minutes
Altitude	1395	mamsl	Longitude	26	degrees	38	minutes
Storm duration	**Return Period (Years)**						
	2	**5**	**10**	**20**	**50**	**100**	**200**
5 minutes	9.2	12.5	14.8	17.1	20.1	22.4	24.8
15 minutes	17.3	23.5	27.8	32	37.6	41.9	46.4
1 hour	27.7	37.7	44.5	51.3	60.3	67.2	74.3
1.5 hour	31.8	43.2	51.1	58.9	69.2	77.2	85.3
2 hours	35	47.7	56.3	64.9	76.3	85.1	94.1
8 hours	47.6	64.8	76.6	88.3	103.8	115.8	128
24 hours	60.8	82.8	97.8	112.7	132.4	147.7	163.3
5 day	80.9	110.1	130.1	150	176.2	196.6	217.4

2.4 Potential Stormwater, Wastewater and Erosion Impacts

An overall analysis of the available data and the development plans reveals the following related to potential impacts:

- The facility presents a very low risk to adversely impacting surface water resources because:
  - Apart from minor bush clearing and trampling, and limited vegetation clearance and topsoil scraping to construct the Doornhoek PV Facility and associated infrastructure, the development will leave the natural vegetation, soil conditions and topography largely undisturbed;
  - The roads have been well placed, as they lie completely outside of the natural water flowpaths;
  - No natural or artificial drainage channels were observed on the site or noted on any of the maps;
  - Sewage and landfill waste will be disposed of off site;
  - Rainfall in the area is moderate to low, and no steep slopes exist to generate high flow velocities.
- Some potential impacts do exist, including:
  - Possible contamination of stormwater by:
    - Sediment that is collected in runoff due to the ground disturbance;
    - Oil leaks from the transformers;
    - Oil and lubricants in wash down water from the workshop; and
    - Overflow of wastewater from the conservancy tanks.
  - Potential erosion: Where any stormwater drain concentrated discharges onto the natural land surface; and
  - Potential usually exists in such developments to impede and disrupt flow and to cause damage to infrastructure and exacerbate erosion if infrastructure is placed within areas that are inundated in floods. However, this site has no watercourses within its boundaries and there is no anticipation of infrastructure being inundated by floods.

3 Project Specific Objectives

The project specific objectives were developed based on the site specific characteristics, regulations and guidelines mentioned in Section 2.2, and are as follows:

- Dirty water should not spill into clean water systems more than once in a 50-year return period;
- Collect and treat any dirty water before discharge;
- Do not impede surface or subsurface water flows unless unavoidable;
- Minimize the potential for erosion in large storm events >1:50-year flood events;
- Include a monitoring and inspection system for spills, leaks and erosion and commit to remediating where needed;
- Review and improve the SWMP regularly;
- Do not build infrastructure, in particular infrastructure containing potential pollutants, within 300 m of natural drainage lines.

4 Hydrology Study

The first step in the SWMP development is an analysis of the development area and the proposed facility. The analysis found that the proposed facility is likely to have an intrinsically low impact on the surface water resources (see Section 2.4).

4.1 Delineation of catchments

In order to delineate the catchments, a Digital Terrain Model (DTM) was created in order to use GIS techniques to determine these delineations and characterisation of the various catchments. 20 metre and 5 metre contours (where available) were sourced from ngi.gov.za and compared to elevation data on Google Earth.

The catchments draining from the site were delineated. The outlet of the catchment was taken as the closest likely discharge point or closest mapped water course.

The catchments are as shown in Figure 4-1 below. Catchment A, will drain in a southerly direction while Catchments B,C and D will drain in a westerly direction from the site towards tributaries of Hartsrivier. Consequently, the stormwater from the site could drain south-westerly towards the Hartsrivier.

4.2 Catchment Parameters

The slope of a catchment is a very important characteristic in the determination of flood peaks. Steep slopes cause faster runoff and shorten the critical duration of flood inducing storms, thus leading to higher rainfall intensities in the runoff formulae. On steep slopes, the vegetation is generally less dense, soil layers are shallower, and there are fewer depressions, all of which cause water to run off more rapidly. The result is that infiltration is reduced, and flood peaks are consequently elevated. For flat catchments such as those encountered on this site, the opposite holds true.

Land use is another critical characteristic as it alters the vegetation present and the degree of soil compaction. Compacted soil is less permeable, and vegetation can slow down stormflows over the land surface. Lastly, the soil type can also be important with some soils allowing quicker infiltration of water. These contribute to the estimation of volume of water stored, infiltrated and ultimately resulting in runoff for each catchment.

The development area is characterised by flat slopes and moderately permeable soils/rock. The average slope and other critical parameters for the catchments under consideration are presented in Table 4-1.

Table 4-1: Conceptual Catchment Characteristics

Catchment	Catchment Slope (%)	Catchment Area (km^2)	Permeability (Visual assessment, not lab tested)	Flow type	Vegetation
Catchment A	1.9	10.5	Permeable to Semi-Permeable	Channel Flow	Grasslands, Light Bush and farm-lands
Catchment B	1.1	33.1	Permeable to Semi-Permeable	Channel Flow	Grasslands, Light Bush and farm-lands
Catchment C	1.7	4.9	Permeable to Semi-Permeable	Channel Flow	Grasslands, Light Bush and farm-lands

Catchment	Catchment Slope (%)	Catchment Area (km^2)	Permeability (Visual assessment, not lab tested)	Flow type	Vegetation
Catchment D	2.3	5.9	Permeable to Semi-Permeable	Channel Flow	Grasslands, Light Bush and farm-lands

4.3 Storm Peaks

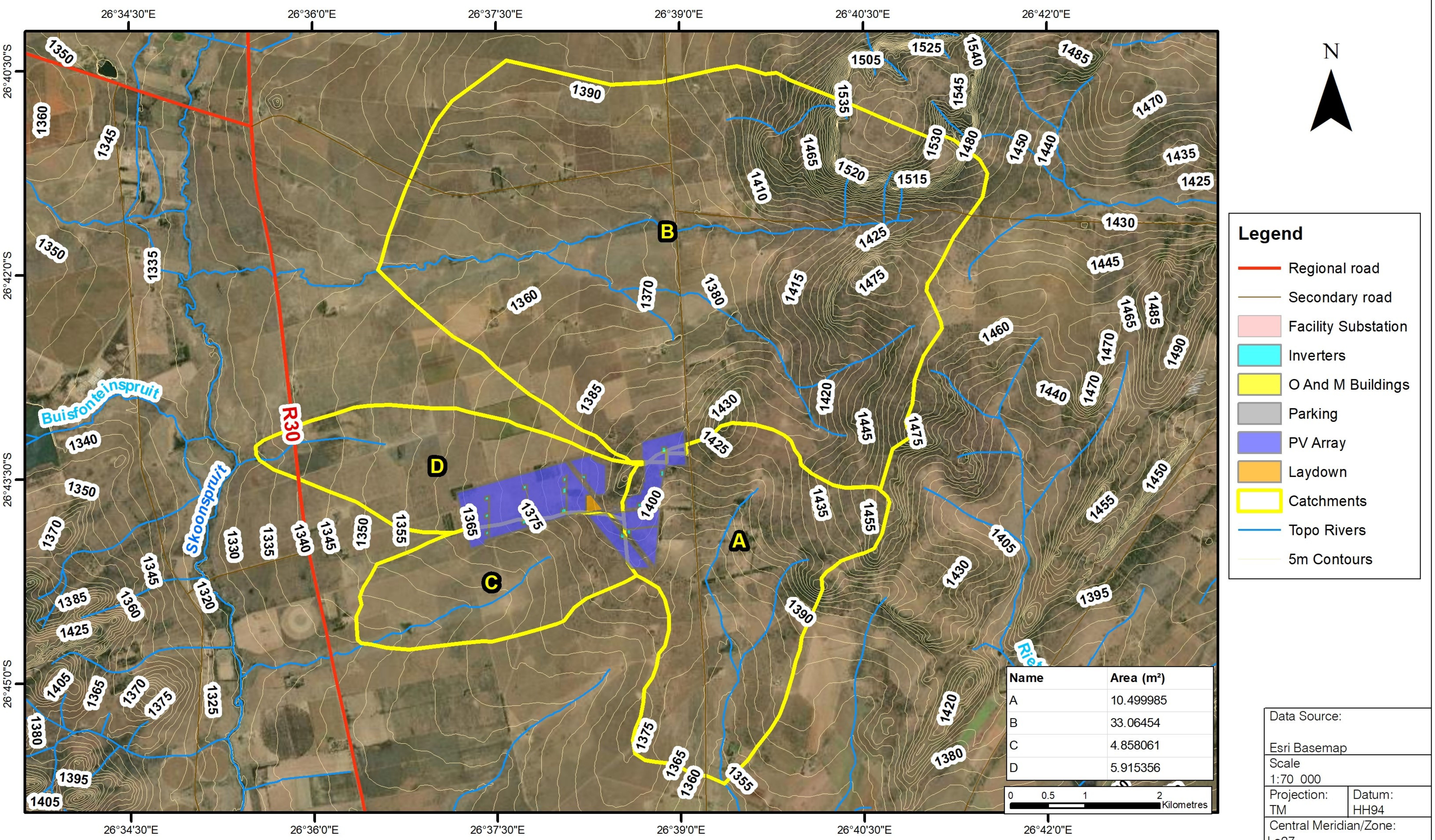
The hydrological and hydraulic parameters of all the catchments contributing towards the study area were calculated and the overland peak flow rates were determined in the study area. The Rational Method model was used to estimate peak flow rates based on the catchment parameters and rainfall intensity.

Storm peaks were calculated for the catchments shown in Figure 4-1. The peaks are relevant to both pre-development and post-development scenarios, because the vegetation, topography and soil conditions will largely remain the same, except where the main buildings (O&M building, stores, etc.) and roads are placed, and this accounts for a negligible proportion of the development area from a surface area viewpoint.

Note that wash water was not considered in the storm peaks, because solar panel washing is unlikely to be done in the rainy season, and volumes will be negligible in comparison to storm volumes. The implications of the storm peaks calculated, and their impact on the SWMP, are discussed in Section 5.

Table 4-2: Peak Flows for Conceptual Catchments in cubic metres per second

Catchment	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
Catchment A	14.1	20.4	25.6	31.2	38.8	45.5
Catchment B	30.0	43.7	54.8	66.9	83.0	97.4
Catchment C	7.4	10.7	13.4	16.4	20.3	23.9
Catchment D	8.4	12.2	15.4	18.7	23.3	27.3



Name	Area (m²)
A	10.499985
B	33.06454
C	4.858061
D	5.915356

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CONCEPTUAL STORMWATER CATCHMENTS FOR PROPOSED DEVELOPMENT

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5 Conceptual Design Review

5.1 Stormwater Management Plan

In the previous section, the hydrology of the broader region of the site was considered. The site is located on a watershed and the sub-catchments draining away from the site were analysed.

In this section, the runoff within the site footprint is assessed and a drainage network to manage the runoff is proposed. Note that due to the site being located on a ridge, there are no upstream sub-catchments draining towards the site the require diversion.

5.1.1 Topography

The topography of the site was assessed from the digital elevation model (DEM) received from the Applicant on 8th March 2023.

The site lies over a ridge that marks the watershed between quaternary catchments C24G and C24H. C24G is drained by the Skoonspruit located 4 km west of the site, flowing in a southerly direction into the Klerksdorp Dam, afterwhich it flows into the Vaal River 20 km downstream. C24H is drained by the Reitgatspruit which has its headwaters 2 km east of the site. The Rietgatspruit confluences with the Skoonspruit downstream of the Klerksdorp Dam.

It follows that the western portion of the site drains in a south-westerly direction to a minor tributary of the Skoonspruit, and the eastern side of the site drains towards the east. A small koppie lies in the centre of the site, with its crest at 1 415 mamsl sloping down to 1 400 mamsl, at which elevation the exclusion zone ends and the solar panels are located. The koppie has slightly steeper slopes of approximately 4 %.

To the west, the site slopes from a maximum elevation of 1 400 mamsl at the base of the koppie to a minimum of 1 362 mamsl at the south-western corner. This is a fall of 38 m over a length of approximately 2 155 m, with a flat slope of 1.64 %.

To the east, the site has a maximum elevation of 1 400 mamsl and a minimum elevation of 1 384 mamsl at the south-eastern corner. This is a decrease in height of 16 m over approximately 1 380 m, resulting in a flat slope of 1.3 %.

5.1.2 Sub-catchment Delineation and Characterisation

The development area is divided into clean and dirty areas as follows:

- Dirty areas:
  - The workshop where oils and lubricants may be stored and used;
  - A chemical storage area will be constructed for the operational phase of the project, which will include proper containment and bunding for all chemicals stored on site;
  - The medium-voltage transformers (at the inverter stations) placed around the development area, as these will contain oil;
  - Transformers at the substation, as these will contain oil;
  - Temporary area during construction for storage of fuel;
  - The conservancy tanks, as this will contain sewage; and
  - Vehicle wash bay that has a hardstanding surface on which vehicles are washed, generating dirty water which drains to a sump.

- Clean areas are deemed to be all areas on the site outside of those stated above as dirty areas.

It follows that the majority of the site is clean and runoff from the site surface may be discharged into the receiving environment via appropriately designed dissipation structures, with adequate erosion control.

The site was delineated into sub-catchments based on the topography, site layout (land use) and the road infrastructure. The sub-catchments can be seen in Figure 5.2. The sub-catchments were characterised as follows:

- The areas of the sub-catchments were measured from the DEM. The total area is approximately 290 ha.
- The longest flow path for each sub-catchment was determined from the topography.
- The positioning of the longest flow path was used to determine the slop of each sub-catchment.
- All sub-catchments with the PV panels on them have short grass vegetating their surfaces. It is specified in this SWMP that the vegetation be allowed to re-establish between the panel posts over the entire surface to encourage infiltration and minimise erosion of the soil. It is assumed that grass will be short when it grows back. PV panel sub-catchments were assigned a roughness factor of 0.30.
- These sub-catchments are assumed to have 5 % of their surface taken up by road infrastructure, which is assumed to be impervious with a roughness factor of 0.02 for compacted earth.
- The koppie will remain undisturbed as no development is planned in that area. Its sub-catchments were assigned a roughness factor of 0.05 based on the vegetation being made up of light brush with trees and shrubs. As there is no development, the entire sub-catchment was assumed to be pervious.
- The laydown area is assumed to be completely impervious, compacted earth with a roughness factor of 0.02.
- All sub-catchments are assumed to have an infiltration rate of 13 mm/hr which is typical of undeveloped veld.

An SCS Type 3 rain event representing the 1 in 10 year 24 hour duration storm event, with a rainfall depth of 97.9 mm was applied to all sub-catchments (see Figure 5-1). The maximum rainfall intensity is 200 mm. The peak discharges from the sub-catchments range from 0.8 to 1.85 m^3/s. These are high values which is anticipated due to the size of the PV panel areas which are 760 m wide by 500 m across, creating a significant area. The sub-catchment parameters are summarised in Table 5-1.

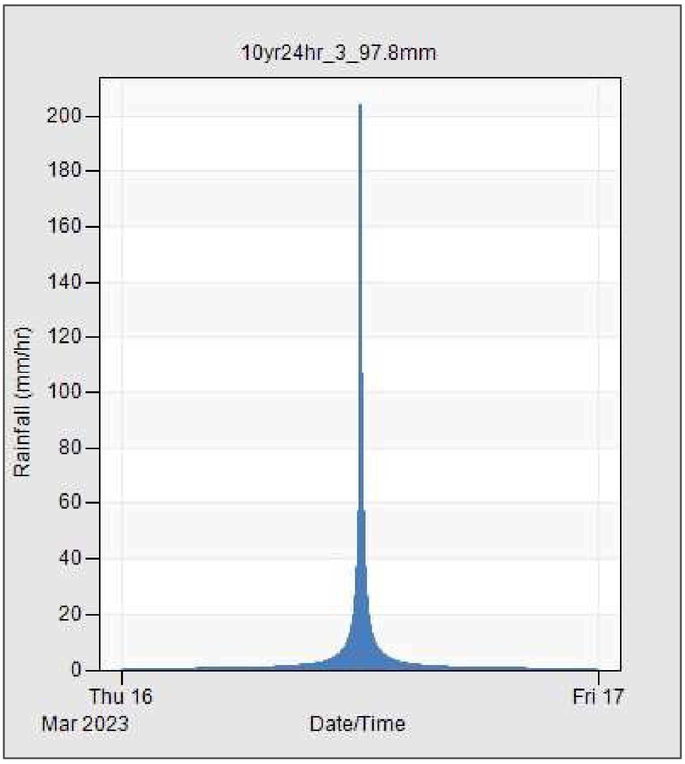
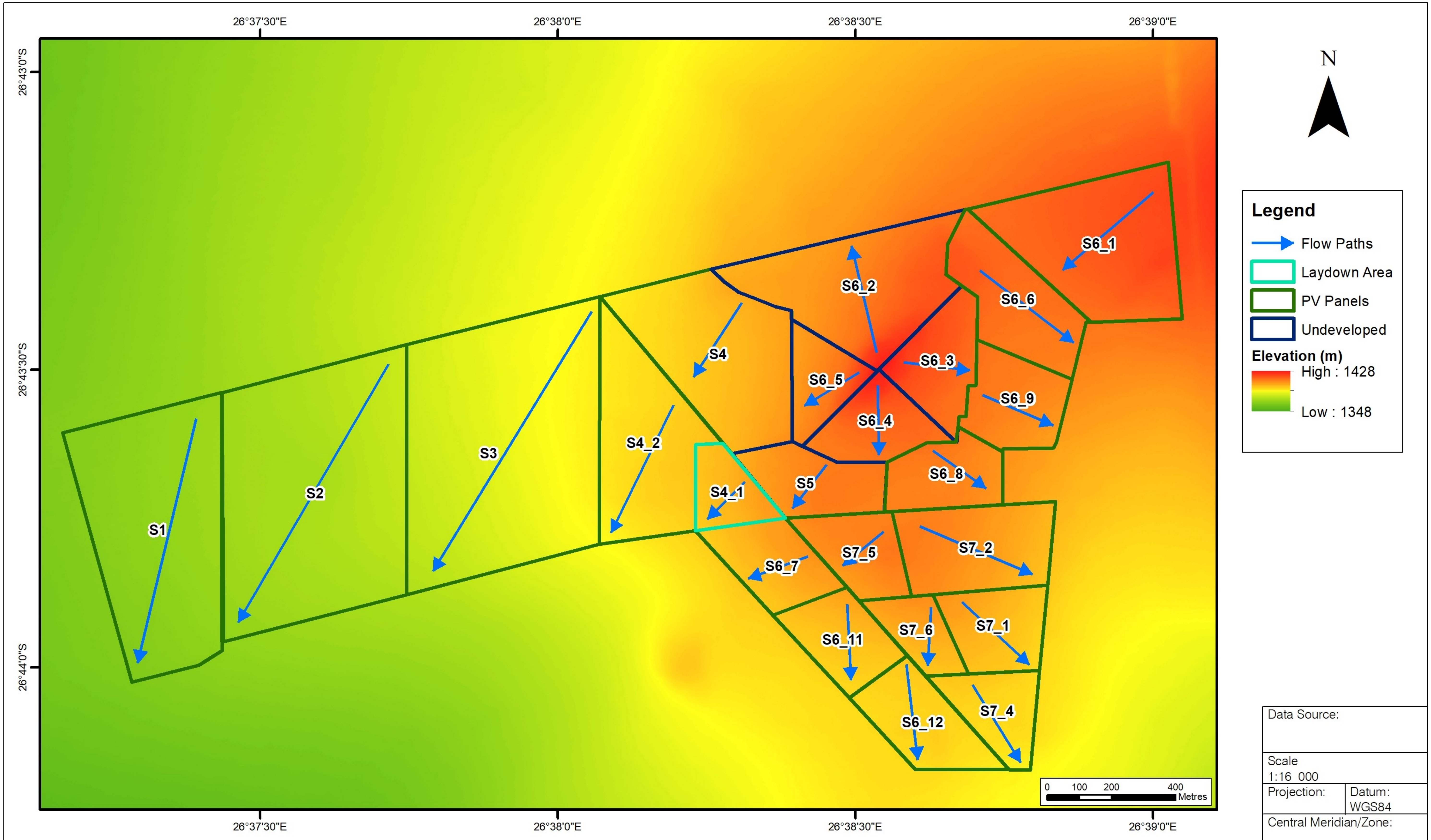


Figure 5-1: SCS Type 3 Design Storm (1 in 10 year recurrence interval, 24 hour duration)

5.1.3 Sub-catchment Flows

The sub-catchments to the west of the site are extremely large at an average of 500 m wide by 750 m long. The large contributing catchment area results in large volumes of runoff, ranging from 24 000 m^3 to 35 000 m^3 for the 1 in 10 year event. The nature of the flow is overland and the runoff from these western catchments in intercepted by the roads.

The sub-catchments to the east of the site are smaller than the western side, but still have significant volumes and discharges ranging from 9 390 m^3 to 15 580 m^3 and 3.55 m^3/s to 5.21 m^3/s respectively. Similarly, these are overland flows – water moving as a sheet across the surface over the natural topography.



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DOORNHOEK PV FACILITY SWMP

SITE SUB-CATCHMENTS

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Table 5-1: Sub-catchment Parameters

Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Runoff Volume (ML)	Runoff Coefficient
S1	28.704	369	777	0.591	5	0.02	0.03	24.46	0.871
S2	39.739	439	905	0.918	5	0.02	0.03	33.91	0.872
S3	41.430	451	919	1.321	5	0.02	0.03	35.44	0.875
S4	18.255	683	267	1.592	5	0.02	0.03	20.06	0.906
S4_1	4.253	272	157	2.76	100	0.02	N/A	4.16	0.999
S4_2	15.627	360	433	1.129	5	0.02	0.03	33.46	0.947
S5	6.831	411	166	1.269	5	0.02	0.03	11.32	0.936
S6_1	18.466	527	351	1.078	5	0.02	0.03	15.92	0.882
S6_11	6.372	270	236	2.727	5	0.02	0.03	9.06	0.926
S6_12	7.628	255	299	0.64	5	0.02	0.03	6.57	0.881
S6_2	17.508	516	339	3.952	0	N/A	0.05	15.00	0.876
S6_3	7.045	375	188	4.152	0	N/A	0.05	6.05	0.878
S6_4	6.301	291	217	4.991	0	N/A	0.05	5.41	0.878
S6_5	4.992	268	186	5.94	0	N/A	0.05	4.29	0.879
S6_6	10.274	299	344	1.296	5	0.02	0.03	8.86	0.882
S6_7	6.681	369	181	3.651	5	0.02	0.03	10.98	0.936
S6_8	6.430	339	190	2.111	5	0.02	0.03	5.57	0.885
S6_9	7.242	331	219	2.206	5	0.02	0.03	12.32	0.938
S7_1	6.694	248	270	1.991	5	0.02	0.03	5.79	0.884
S7_2	10.965	316	348	1.991	5	0.02	0.03	9.47	0.883
S7_4	5.731	208	275	1.991	5	0.02	0.03	4.95	0.884
S7_5	6.000	384	156	1.991	5	0.02	0.03	5.20	0.886
S7_6	4.095	226	182	1.991	5	0.02	0.03	3.54	0.885

Sub-catchment S4_1 is the Laydown Area.

Sub-catchments S6_2, S6_3, S6_4 and S6_5 is the undeveloped koppie area.

All sub-catchments had a 1 in 10 year return interval event, 24 hour duration, SCS Type 3 storm applied to them in PCSWMM hydraulic modelling software.

5.1.1 Drainage Design Approach

Low Impact Design (LID) is the principle of developing a greenfields site such that the post-development state has minimal hydrological variance from the pre-development state. Hydrological impacts that typically result from anthropogenic activity include higher frequencies of runoff exceeding infiltration due to decreased permeability, higher peak discharges and velocities from sub-catchments due to topographical modification and decreased permeability, and erosion or sediment deposition resulting from concentration of overland flow into one-directional flow. Minimising these impacts can be achieved by maintaining the gross infiltration rate of the sub-catchment and maintaining permeability, keeping the catchment slopes as close to those of the natural, unmodified topography and dissipating runoff rather than concentrating it. This is also know as 'interception at source' – meaning the immediate infiltration of rainfall into the sub-catchment where it is incident on the surface or minimising it's flow path prior to infiltration.

The benefits of LID, aside from mitigating hydrological impacts resulting from development, include eliminating the need for hard infrastructure such as large drainage channels and energy dissipation structure that are required for the conventional management of runoff and reintegrate surface water into the environment seamlessly as either overland flow or ground water. One of the limitations of LID is that it is assumed that the soil, neighbouring properties, and receiving watercourse are able to receive the runoff from the site. The other limitation is that while LID is effective for frequent, smaller events, there will be flooding and limited accessibility for larger, less frequent events.

LID is deemed to be appropriate for the site because it is currently undeveloped as are its surrounds, and all runoff from the site will be clean. The proposed drainage systems make use of the following principles to achieve LID objectives:

- As far as possible, sub-catchments will be allowed to free-drain into the surrounding environment;
- Where the sub-catchments drain towards the road and flow becomes concentrated, the flow length of the channel will be kept to a minimum; and
- Dissipation of the concentrated flow back into the environment will be achieved by use of multiple outlets to distribute the volumes as far as possible.

The effectiveness of the approach rests on the following assumptions:

- The natural topography will not be modified by terracing;
- The pre-development infiltration of the sub-catchments will be preserved by re-establishing indigenous vegetation over the area of the PV channels, and by ripping soil that becomes compacted during the construction period e.g. by trafficking; and
- The establishment of impervious surfaces will be limited to the roads and the laydown area.

5.1.2 Drainage Layout

The layout is divided into two networks, one draining the western side of the ridge and the other, the eastern. The proposed drainage network is shown inFigure 5-4.

Where the outer boundaries of the site border on undeveloped land, the sub-catchments have been allowed to free-drain as overland flow. This includes the koppie, the sub-catchments to the east of the koppie and the south-western area.

Where the sub-catchment drain towards a road, the road will collect and serve as a channel for the outflow hydrograph. Flow along the road will be managed by using the road as a channel, and regularly releasing the flow into the downslope environment by diverting it via mitre drains.

The drainage design of the road will be as follows in order to facilitate this methodology:

- The natural upslope of the sub-catchment will intersect the road. The enables overland sheet flow to continue over the surface of the road.
- The upslope side of the road will have a triangular drain running along it. This drain will contain and channel flows from smaller, more frequent events to the mitre drains.
- The road surface will then be cambered to drain away from the upslope of the sub-catchment. This camber will direct the sheet flow to the downslope side of the road and directly into the veld.
- In the event of larger events such as the 1 in 10 year event, the road surface will act as a drainage channel in conjunction with the triangular drain. This means that during large storm events the roads will be inundated. The Applicant has indicated that accessibility to the site is not required during these storm events.

Refer to Figure 5-5 for the geometry of the road profile.

Mitre drains divert flow away from the road and into the environment. An illustration of a mitre drain is shown in Figure 5-3. The mitre drains will be trapezoidal in section and will be positioned at regular intervals along the roads running along the southern and eastern perimeters of the site, as shown in Figure 5-4. The mitre drains will widen and daylight to natural ground level to release the water and will require the necessary erosion protection at their termination to prevent scour.

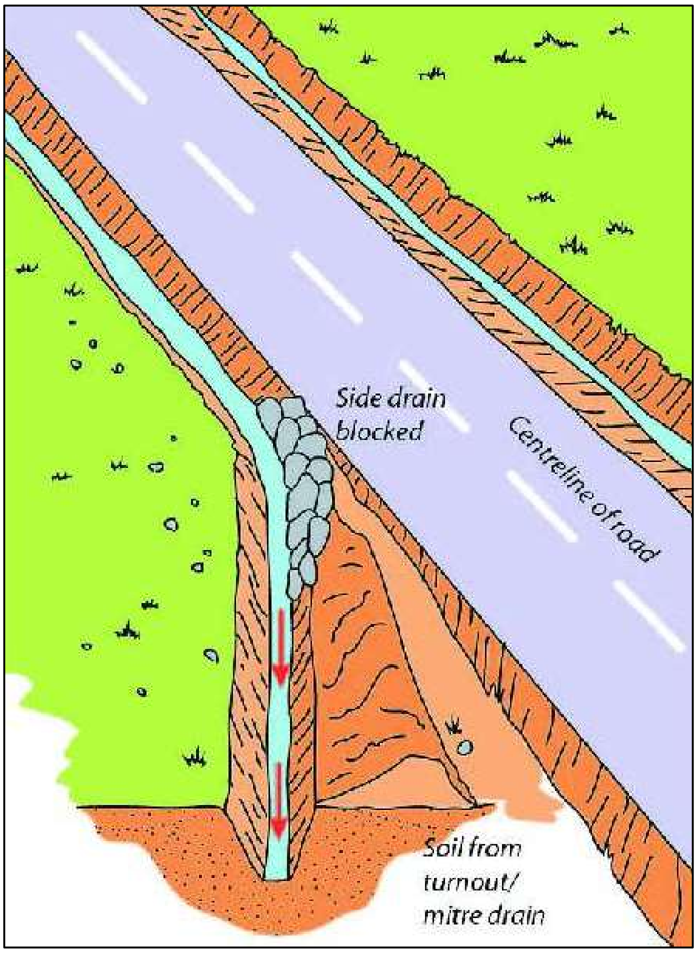


Figure 5-3: Illustration of mitre drain (Engineering in Transport, Lovelace and Loughlin, 2014)

5.1.3 Drainage Channels: Sizing and Lining

The roads have been sized to be 8 m wide including a triangular side drain with side slopes of 1V:3H. The triangular drain is 0.5 m deep from the road surface. Refer to Figure 5-5.

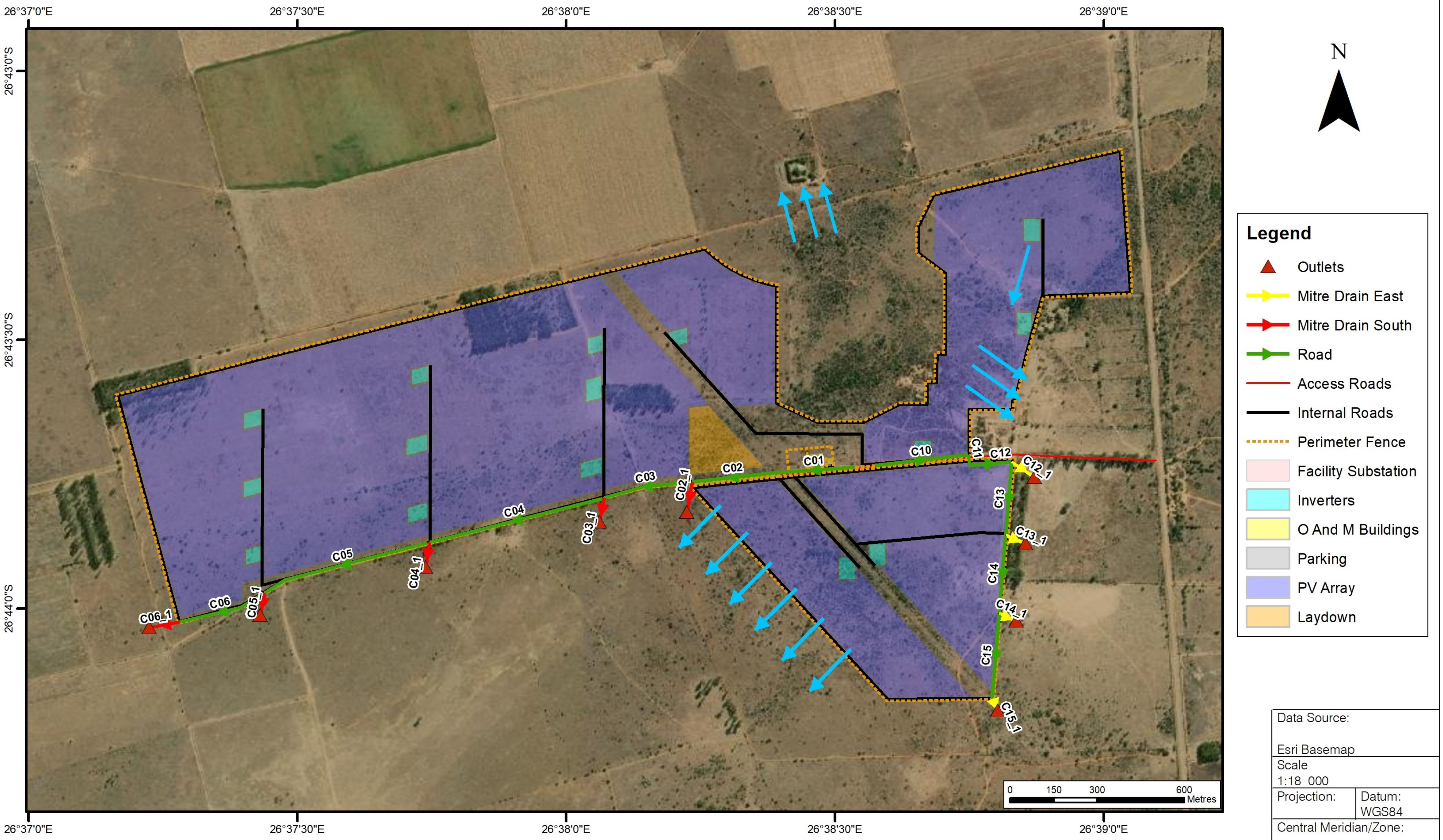
The maximum road length is approximately 500 m and the peak discharge experienced on the southern road is 1.85 m^3/s and on the eastern road it's 0.8 m^3/s.

The southern road experiences much higher velocities (2.0 – 3.0 m/s) than the eastern road. Therefore, the triangular drain on the southern road shall require riprap lining to resist scour, whereas on the eastern road, stabilised, compacted earth will be sufficient (to resist scour resulting from velocities of less than 1.86 m/s).

The road surfaces will be subjected to inundation and therefore will be susceptible to scour if not treated with a stabiliser (cement, polymer or bitumen).

The mitre drains experience significant velocities, ranging from 1.8 to 2.96 m/s and will thus require rip rap lining. Water will be required to be diverted over the road from the triangular drain to the metre drain via a concrete drift (refer to Figures 5.6 and 5.7 respectively).

The roads and mitre drains have been sized to not have a water depth of more than 80 % of the channel depth for the 1 in 10 year event.



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Scale 1:18 000	
Projection:	Datum: WGS84
Central Meridian/Zone:	
Date: 27/03/2023	Compiled by: LEKT
Project No. 585738	Fig No.

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DOORNHOEK PV FACILITY SWMP

DRAINAGE CHANNELS

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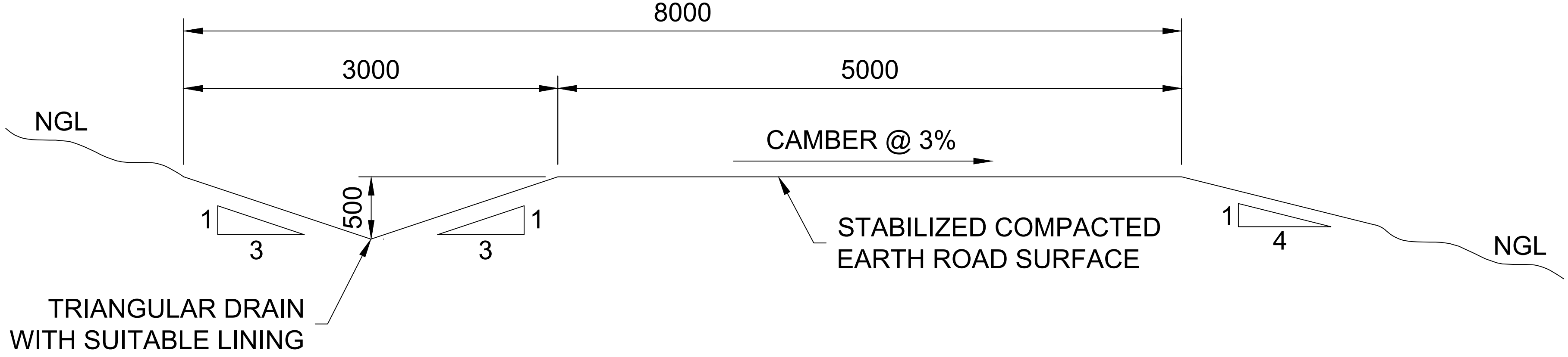
Revision: A Date: 03/04/2023



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DOORNHOEK PV FACILITY SWMP

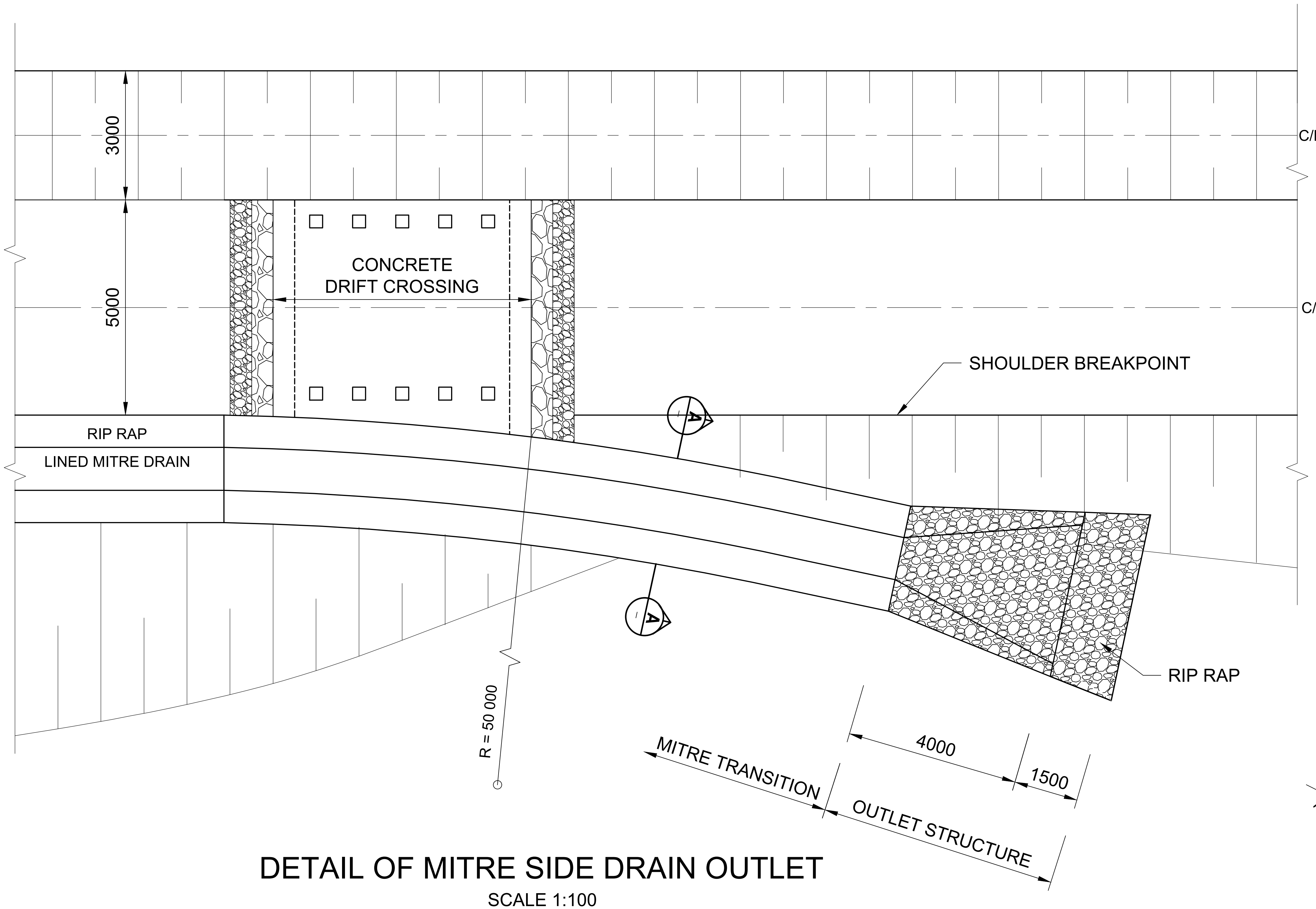
TYPICAL ROAD CROSS SECTION

Date:	Compiled by:
03/04/2023	PRJU
Project No.	Fig No.
585738	5-5

Table 5-2: Channel parameters

Name	Road	Length (m)	Roughness	Slope (%)	Max. |Flow| (m^3/s)	Max. |Velocity| (m/s)	Max/Full Depth	Contributing Area (ha)
C01	South	251	0.025	1.15	4.037	1.410	0.74	13.13
C02	South	252	0.025	3.24	5.612	2.950	0.67	17.39
C02_1	South	10	0.035	2.20	5.532	2.320	0.62	17.39
C03	South	275	0.025	2.55	8.849	2.920	0.79	38.87
C03_1	South	10	0.035	3.05	8.812	2.960	0.72	38.87
C04	South	553	0.025	2.22	8.063	2.670	0.79	41.43
C04_1	South	10	0.035	2.25	7.878	2.560	0.73	41.43
C05	South	534	0.025	1.05	7.069	2.060	0.82	39.74
C05_1	South	10	0.035	1.76	6.897	2.260	0.73	39.74
C06	South	269	0.025	1.29	4.899	1.860	0.75	28.70
C06_1	South	10	0.035	1.03	4.842	1.820	0.67	28.70
C10	East	289	0.025	1.10	2.499	1.220	0.66	6.43
C11	East	37	0.025	1.66	2.412	1.500	0.62	6.43
C12	East	129	0.025	2.53	2.465	1.860	0.61	6.43
C12_1	East	10	0.035	2.56	2.360	2.180	0.62	6.43
C13	East	248	0.025	1.03	3.465	1.560	0.71	10.97
C13_1	East	10	0.035	3.85	3.377	2.780	0.66	10.97
C14	East	267	0.025	1.16	2.304	1.440	0.64	6.69
C14_1	East	10	0.035	2.18	2.177	2.010	0.62	6.69
C15	East	291	0.025	1.32	1.986	1.380	0.62	5.73
C15_1	East	10	0.035	1.63	1.821	1.780	0.60	5.73

Highlighted rows are mitre drains



DETAIL OF MITRE SIDE DRAIN OUTLET

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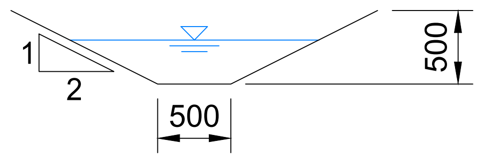

SECTION A-A

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Date: 05/04/2023	Compiled by: PRJU
Project No. 585738	Fig No. 5-7

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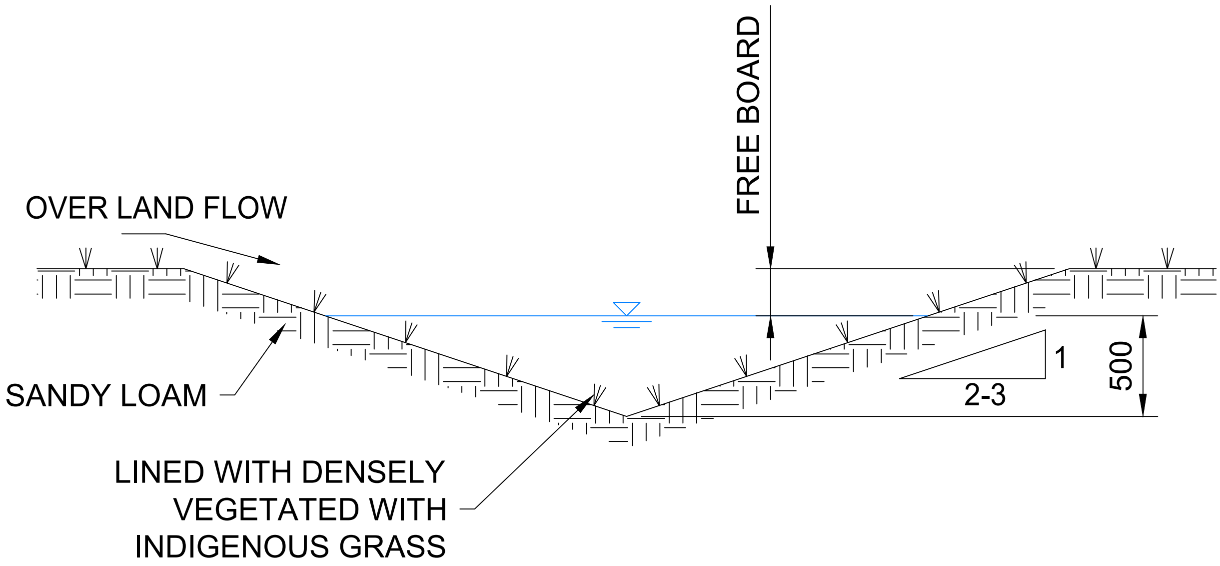
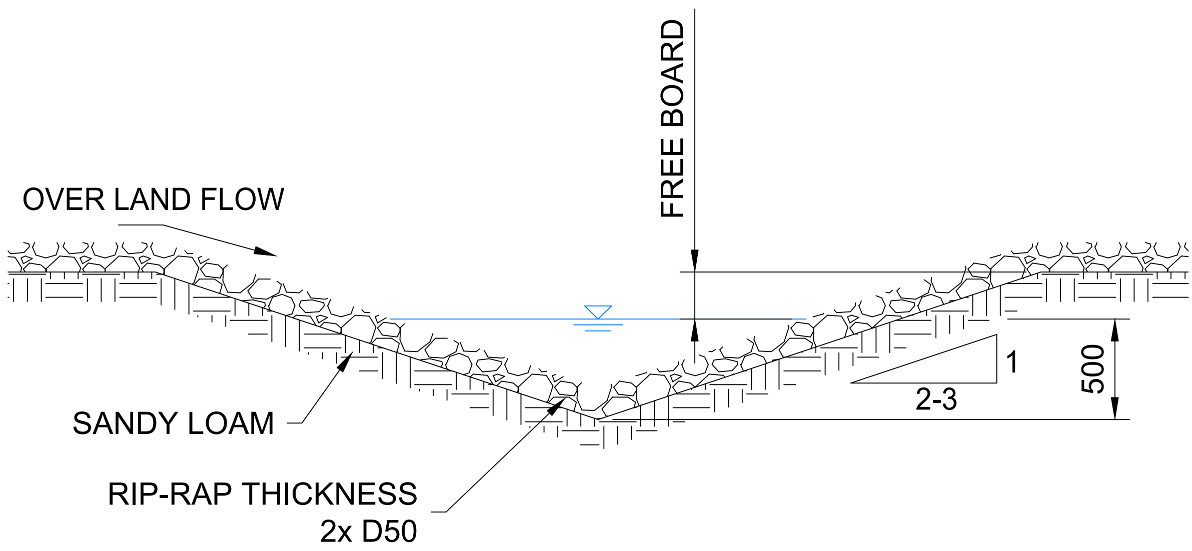
DOORNHOEK PV FACILITY SWMP

SIDE DRAIN OUTLET DETAIL



VELOCITY < 0.3 m/s @ 1:10 YEAR STORM PEAK

TYPICAL DETAIL
VEGETATED LINED V-DRAIN CROSS SECTION
SCALE 1:50



VELOCITY > 0.3 m/s @ 1:10 YEAR STORM PEAK

TYPICAL DETAIL
RIP-RAP LINED V-DRAIN CROSS SECTION
SCALE 1:50

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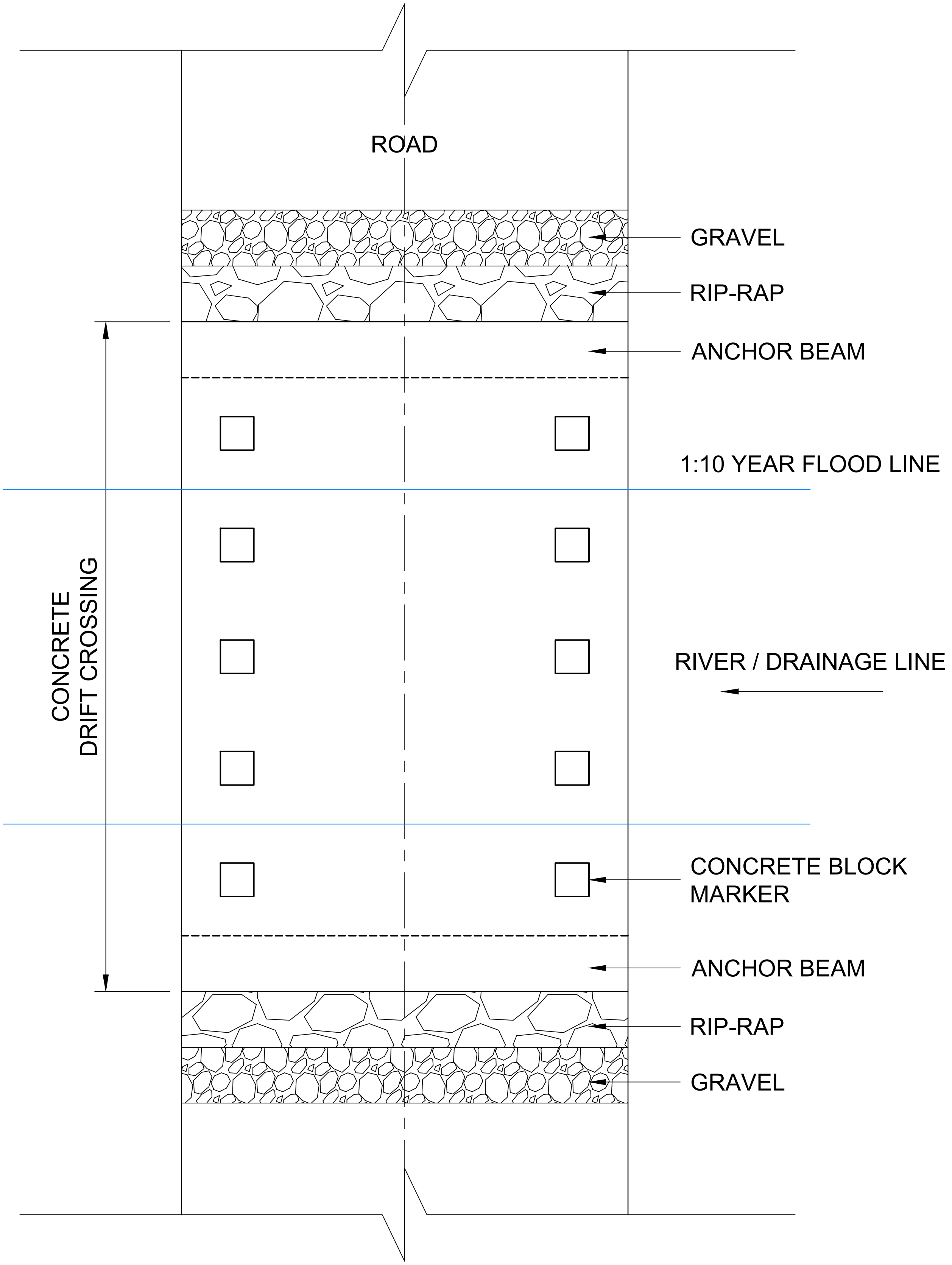
DOORNHOEK PV FACILITY SWMP
TYPICAL CONCEPTUAL DESIGNS
OF STORMWATER INFRASTRUCTURE

Data Source:	
Scale AS SHOWN	
Date: 03/04/2023	Compiled by: PRJU
Project No. 585738	Fig No. 5-7a



TYPICAL PLAN OF DRIFT CROSSING

SCALE 1:50

DOORNHOEK PV FACILITY SWMP

TYPICAL CONCEPTUAL DESIGNS
OF STORMWATER INFRASTRUCTURE

Data Source:	
Scale AS SHOWN	
Date: 03/04/2023	Compiled by: PRJU
Project No. 585738	Fig No. 5-7b

5.2 Waste and wastewater management

Waste will be disposed of at a registered landfill site and domestic wastewater at a licensed wastewater treatment plant (i.e. waste will be treated off site), hence, the SWMP only focuses on temporary storage on site.

Domestic waste should be stored out of the rain and wind, collected (and disposed of) regularly as is currently proposed for the development.

The conceptual design of the wastewater (sewage) conservancy tank was not within the scope of this report, however, the current conceptual plan was evaluated in terms of the risks that this may pose to surface water. Poor management of the tank is the main risk, because the system could fail if the tank is not emptied regularly resulting in overflows. Consequently, a float switch controlled alert system is recommended.

Oil and lubricants in the workshop, and oil from the transformers must be bunded (See Section 5.4 for bunding requirements) as per legal requirements and hence, this was recommended without any alternatives.

5.3 Erosion and sediment transport

In general, the main erosion risks on a solar facility are channel outlets and stockpiles. However, based on the site visit, erosion on roads is excluded as a risk as this is unlikely as long as the roads have no significant camber.

No road crossings exist and thus no opportunities for erosion and sediment transport currently exist.

In the case of stockpiles, temporary stockpiles should have diversion berms or silt fences. One permanent stockpile is planned for the topsoil that is to be used in decommissioning of the facility. This stockpile will be placed within the perimeter fence of the facility. The stockpile, if possible, should have gentle slopes of 1 in 5 or less to encourage revegetation and limit erosion. The stockpile should be bunded until it revegetates. The gentler slopes will necessitate a stockpile with a larger surface area. This is considered the lower impact option as it limits erosion even though it disturbs more surface area.

Material excavated during construction of the panel foundations may be significant (cumulative volume). If that is the case, the material should be removed from site responsibly (e.g. use as cover material on a landfill site).

5.4 Bunding

Requirements for bunding of areas housing potential contaminants are specified in detail in the National Norms and Standards for the Storage of Waste (Notice 926 of 29 November 2013, Department of Environmental Affairs, National Environmental Management: Waste Act 2008, Act No.29 of 2008). The specification, which will apply to the development area, reads as follows: "*bunds having a capacity which can contain at least 110% of the maximum contents of the waste storage facility. Where more than one container or tank is stored, the bund must be capable of storing at least 110% of the largest tank or 25% of the total storage capacity, whichever is greater (in the case of drums the tray or bund size must be at least 25% of total storage capacity)*."

Bunded areas should be sized and sealed to ensure spilled contaminants cannot leak out of the bunded areas.

5.5 Monitoring and management

Monitoring and management are key to the success of a SWMP. The following are therefore included as a key aspect of SWMP:

- Frequent inspections until the success of the design and any unexpected problems are resolved / confirmed and maintenance frequency is determined;
- Review of the plan after a few years to improve, where possible, its practicality, cost-effectiveness or efficacy;
- Alerts that do not rely on a full-time environmental manager on site (which may not be feasible) including:
  - Automatic alert systems for the wastewater conservancy tank (e.g. a float driven switch alert system);
  - Brief, annual refresher training on stormwater protection that should not take more than fifteen minutes for each staff member; and
  - Well placed signs that remind staff members of reporting of incident / issues, as soon as possible and reduce the likelihood that forgetfulness or confusion will prevent reporting.

6 Stormwater, Wastewater and Erosion Management Plan

The SWMP, including wastewater management, is summarised in Table 6-1 and Figure 6-1.

Table 6-1: Construction and Operations / Maintenance SWMP

General principle	Specific outcomes	When	Ref No.	Focus area	Action	Responsible party
Separate clean - and dirty water to ensure clean water remains uncontaminated	Temporary containments and diversion (designed for a 1 in 5-year event)	During contractors site establishment	1	• Stockpiles; • Laydown areas; • Workshops; and • Any other area likely to generate sediment during a storm event or contain contaminants that can be disbursed.	Clean water diversions or bunds: Construct stormwater drains or bunds to divert clean runoff around dirty areas. The diversion should be sized for 1 in 5-year event. Typical design will be an excavated earth channel or berms. For the permanent topsoil stockpile, berms and channels to remain in place until stockpile revegetates.	Construction contractor's onsite environmental officer/representative
	Permanent containments and diversions (designed for a 1 in 50-year event)	Constructed prior to operation	2	• The workshop and chemical stores; • Transformers, inverters and substations (if not bunded); and • Wastewater conservancy tank.	Clean water diversions or bunds: Construct stormwater drains or bunds to divert clean runoff around the workshop, chemical stores, transformers, inverters, substations and wastewater conservancy tank. The diversion should be designed for a 1 in 50-year event.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
Collect and, where required, treat dirty water or runoff from any dirty areas.	Dirty water should not have the potential to spill into clean water systems more than once every fifty years (where influenced by stormwater)	Before stockpiles are deposited	3	Stockpiles	Construct silt fences or berms: to prevent the sediment transport into rivers. All stockpiles to be removed after construction phase ends except permanent topsoil stockpile for decommissioning. Berms to remain around topsoil stockpile until it revegetates.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Throughout construction	4	Waste	Dispose of landfill, oils and other contaminants offsite	
		During site establishment	5	Sewage	Supply chemical toilets	
		Constructed prior to operation	6	Workshop	Workshop collection drain with oil and grease trap: Construct a small concrete drain collecting all water, potentially containing oils and lubricants, from workshop floor and directing it through an oil and grease trap before discharge (or removing to offsite facility). Floor to be sloped such that all water will collect in drains.	
		Inspect every 3 months for first 2 years and then revise	7	Workshop	The oil and grease traps are to be inspected and, when necessary, cleaned and waste taken to a registered offsite facility	Workshop manager and assurance by environmental manager
		As required when the tank is full	8	Transformers	Dispose of any spent oil, removed from transformers during maintenance, to a registered offsite facility	
		As required when the tank is full	9	The sewage conservancy tank	Regularly collect sewage in the conservancy tank and disposed of at a licensed municipal sewage treatment plant.	
	Bund any hazardous substance or pollutant storage areas (including any oils), as per regulations	Throughout construction	10	General	Construct temporary bunds for any chemicals such as oils or fuel stored on sited during construction. Bunds must contain at least 100% of the volume of the container. If all containers are stored together the bund must store at least 110% of the largest container or 25% of the total storage capacity, whichever is greater. Suitability of the material of bund must be investigated whenever a new substance is added to the bund	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Constructed prior to operation	11	Transformers	All transformers will be bunded with bund capacity of at least 110% of the maximum volume of oil in the transformer. Transformers and bund will be protected from rainfall by small covers or roof or housed in containers, as applicable.	
			12	The sewage conservancy tank	The sewage conservancy tank will be a closed tank with an automatic alert system.	
		During operation: as and when containers are purchased	13	Workshop	Small trays for workshop chemicals: Bund any containers with oils and lubricants by placing them in plastic trays that is at least 100% of the volume of the container. If all containers are stored together the bund needs to store at least 110% of the largest container or 25% of the total storage capacity, whichever is greater. Suitability of the bund must be investigated whenever a new substance is added to the bund.	Workshop manager and assurance by environmental manager
Do not impede surface and	Minimise dirty areas such that surface and subsurface	Constructed prior to operation	14	The workshop, transformers, wastewater conservancy tank	Place diversion channels directly upstream of dirty areas such that dirty area catchments are minimised in footprint	Included in detailed designs of design engineer and carried out by

General principle	Specific outcomes	When	Ref No.	Focus area	Action	Responsible party
subsurface flow along drainage lines	movement of water along the drainage lines is not impeded	Throughout construction	15	• Laydown areas; and • Stockpiles	Minimise laydown areas and stockpiles. The permanent topsoil stockpile is excluded from this as it will be the natural topsoil from the area and gentler slopes are recommended which will necessitate a larger area.	contractor appointed for construction
	Ensure any engineered clean stormwater drainage directs water to the closest naturally receiving drainage line		16	All drains	Ensure that any temporary stormwater drains or diversion berms direct water towards the drainage line to which it would naturally flow	
		Constructed prior to operation	17	The workshop, transformers, wastewater conservancy tank	Drains to follow natural topography, Ensure outlets drain towards the natural drainage line that would originally have received flow from that area	
Control, monitor and manage erosion	Prevent erosion in general	Constructed prior to operation	18	All areas	Only remove vegetation where required for the installation of solar panels as to not disturb the natural topography	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		During operation	19		No stockpiles if possible except for the permanent topsoil stockpile.	Environmental manager
	Minimize erosion in large storm event of 1 in 50- years or greater	Constructed prior to operation	20	All drains	Drains sloped and sized such that velocities do no exceed 1 m/s	Included in detailed designs of design engineer and carried out by contractor appointed for construction
			21	Road crossings	Line all major drifts on road crossings with material sufficient to prevent erosion during high flow (e.g. gravel or concrete). If concrete is used, place a section of riprap (larger rocks) underlain by gravel and with gravel on either side to facilitate a smooth flow transition. Detailed modelling and design of road crossings such that erosion is controlled to be a feature of the detailed design.	
	Dissipate stormwater at all drainage outlets to velocities unlikely to cause erosion in natural soils for a 1 in 50-year storm event		22	All drains	Dissipaters: At drain outlets widen the channel and use riprap (can be sourced from spoil during construction) or reno mattresses to dissipate stormwater flows	
			23	Road crossings	Dissipation at road crossings: Detailed modelling and design of road crossings including riprap (can potentially be sourced from spoil during construction) or reno-mattresses.	
	Prevent erosion in general	Throughout construction	24	All	Maintain natural topography and vegetation: Do not disturb the natural topography or vegetation where possible	Construction contractors onsite environmental officer/representative
	Minimize erosion in large storm event of 1 in 5-years or greater		25	All drains	Engineer low velocity temporary drains: Drains sloped and sized such that velocities do no exceed 1 m/s in a 1 in 5-year event	
		Early in construction	26	Road crossings	Engineered temporary drifts: Build roads and road crossings before other infrastructure.	
	Ensure that any chronic erosion is detected and rehabilitated within 6 months	Every 3 months for the first 2 years and annually thereafter	27	• PV cell blocks; • Drains; • Outlet of all Drains; and • All-natural drainage lines that cross the access road.	Inspect all focus areas for erosion. If erosion is found, remediate and redesign the drainage in the area. If erosion is found in a natural drainage line, conduct an assessment and determine the cause. Develop a plan to prevent future erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
	Ensure that any acute erosion due to large storm events is detected within 2 weeks.	Install prior to operation	28	Main office	Install a rain gauge that can measure greater than 150 mm.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		After a rain event of greater than 150 mm in one day (a 10 year - 24-hour rain event) or when staff notice flood damage.	29	All-natural drainage lines that run through the site	Inspect and remediate acute erosion: Inspect all focus areas for erosion. If erosion is found remediate and redesign the drainage in the area. If erosion is found in a natural drainage line conduct and assessment and determine the cause and develop a plan to prevent future erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
		Design and development prior to operation	30	All	Set up rain data system: Build or buy a basic rain program, preferably electronic, that allows site staff to enter rain data from the rain gauge. Ideally the system should let the environmental manager and site manager when a rainfall event in excess of 150 mm.	
		Daily	31	Main office	Record rain data: Read and record rain gauge daily;	Onsite staff member tasked by the Environmental manager

General principle	Specific outcomes	When	Ref No.	Focus area	Action	Responsible party
		Update annually in case of staff change	32		Signs at main office to aid problem reporting: Ensure that a sign providing the following is posed in the reception area, the control room, on each transformer and in the workshop: The name, telephone number and email address of the environmental manager. The sign should state: "If you notice any leaks or spills or erosion anywhere on the property please contact the Environmental Manager by one of these methods..."	Environmental manager
	Training	Annually	33	All	Training: Provide a short briefing to all construction staff on the dynamics of erosion and leaks that covers at least: • How to identify erosion; • How to identify a leak, including car leaks; • Where to find contact details of the environmental officer/representative in case of leaks or erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
	Ensure that any erosion is detected and rehabilitated	After rain events	34		Inspect the site for erosion after rain events. If erosion is found, remediate and redesign the drainage in the area. If erosion is found in a natural drainage line, conduct an assessment to determine the cause and develop a plan to prevent future erosion.	Contractors environmental officer/representative
		During site establishment	35		Install a rain gauge that can measure greater than 150 mm. This rain gauge will also be used during operation.	
Monitor and manage stormwater system	Include a monitoring system for spills and leaks such that they are detected as soon as possible.	Once every 2 weeks during Construction	36	All	Leak inspection: regularly check for leaks and for any breaches or evidence of spills or any other problems not in adherence to this SWMP. All cars should also be checked for oil leaks and any leaks found should be stopped immediately, the cause of the leak identified, the problem remediated such that no further leaks occur, and any contaminated soil or water assessed and remediated.	Contractors environmental officer/representative
	Include a monitoring system for spills and leaks such that they are detected as soon as possible.	Every 3 months for the first 2 years and annually thereafter (Operation)	37		Leak inspection: regularly check for leaks and for any breaches or evidence of spills or any other problems that would indicate that it is not in adherence to this plan. All cars should also be checked for oil leaks during the inspection. Any leaks found should be stopped immediately, the cause of the leak sought, the problem remediated such that no further leaks occur, and any contaminated soil or water assessed and remediated.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
		Continuous	38		Data capture, training and signs: see 32, 33, 34, 35, 36, & 37	Environmental manager and staff in general
		Construct prior to operation	39	The sewage conservancy tank	Sewage conservancy tank alert system: Install a float switch-controlled alarm that will alert the control room when the conservancy tank has less than 2 weeks of capacity remaining.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
			40	Transformers	Signs at transformers: Post a sign on transformers stating "If you notice any leaks or spills or erosion anywhere on the property please contact reception via one of the following methods ……and report it"	
General	Do not build infrastructure within near to watercourses	Detailed design	41	All	Ensure no infrastructure except roads, solar panels and solar panel supports are built within 300 m of a water course. In particular, ensure no dirty areas, that may contain pollutants, are within 300 m of the water course	Design engineer or engineer appointed by the design engineer
	Do not build infrastructure containing potential pollutants in any of the natural drainage lines.		42		Ensure that final infrastructure plans do not propose any potentially polluting infrastructure, such as transformers, workshops or conservancy tanks in the natural drainage lines (currently none are proposed)	
	Review and improve stormwater management plan regularly.	Once every 5 years	43		Review and improve the stormwater plan	Environmental manager or engineer appointed by the environmental manager
	Review and inspect	Once every 2 months during construction depending schedule	44		Inspect the site to ensure adherence to the stormwater management plan	Applicant's environmental representative or engineer
	Do not place stockpiles or other potentially polluting construction items within 300 m of the watercourse	Detailed design and throughout construction	45		Do not place laydown areas, stockpiles within 300 m of the watercourse	Design engineer or engineer appointed by the design engineer
	General	Detailed design	46		Develop a specific environmental specification for any construction including, but not limited to, the actions in this stormwater management plan and its principles	Applicant's environmental representative or specialist
	Prepare for spills	Construction and Operation	47		Procure spill kits and place in areas where fuel or oils are transferred (e.g. workshops)	Environmental manager

7 Conclusion and Recommendations

In conclusion:

- The proposed facility will have an intrinsically low impact on surface water resources;
- The potential stormwater impacts that do exist can be managed in a practical and cost-effective way; and

It is recommended that the SWMP be developed further during the detailed design by:

- Developing a stormwater layout and designs based on the above information and infrastructure layout plan;
- Developing conceptual designs into detailed designs; and
- The plan should be incorporated into an environmental specification for use during construction and incorporated into the operational environmental management of the site.

Signatures

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

This report, Stormwater, Wastewater and Erosion Management Plan for Doornhoek PV, was prepared and reviewed by the SRK personnel presented below.

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