# STORM WATER AND EROSION CONTROL MANAGEMENT PLAN FOR THE PROPOSED GROOTFONTEIN PV FACILITY

**Project No. SCT-002**

***DRAFT***

**March, 2022**


**HYDROLOGIC CONSULTING**

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# STORM WATER AND EROSION CONTROL MANAGEMENT PLAN FOR THE PROPOSED GROOTFONTEIN PV FACILITY

*Prepared For*

**Scatec Solar Africa (Pty) Ltd**

*Prepared By*

**Hydrologic Consulting (Pty) Ltd**

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# STORM WATER AND EROSION CONTROL MANAGEMENT PLAN FOR THE PROPOSED GROOTFONTEIN PV FACILITY

## 1 INTRODUCTION

Hydrologic Consulting has been appointed by Scatec Solar Africa (Pty) Ltd to develop a storm water and erosion control management plan for the proposed Grootfontein PV Facility, approximately 74km north-east of Ceres in the Western Cape Province of South Africa. The 774ha development area (located within farm Grootfontein 149, Portion 5 and Remainder) is comprised of three development phases. The storm water and erosion control management plan, however, only considers the development as a whole (i.e. assumes full development of all three phases).

### 1.1 SCOPE OF WORK

The scope of work was achieved by undertaking the following:

- Definition of the baseline for relevant hydrological data necessary in assessing storm water management and erosion control;
- A site visit undertaken by Mr Mark Bollaert on the 10th February 2022;
- Storm Water Management Plan (SWMP) – this involved the simulation of the 1:50 year recurrence interval storm event and the addition of diversions to route storm water out of the site;
- Erosion Control – principles from the SWMP informed additional guidance recommended as part of erosion control; and
- A technical report detailing the achieved scope of work (this report).

### 1.2 REGIONAL SETTING AND LAYOUT

The proposed Grootfontein PV Facility (hereafter also referred to as the site) is located at 19° 56' 39" E and 32° 57' 28" S. The regional setting of the site is illustrated in Figure 1-1 while the layout of the site is presented in Figure 1-2. The PV facility includes the panel arrays, substation, laydown areas and an operations and management building (O&M building). Access roads and electrical routes are also illustrated in Figure 1-2.

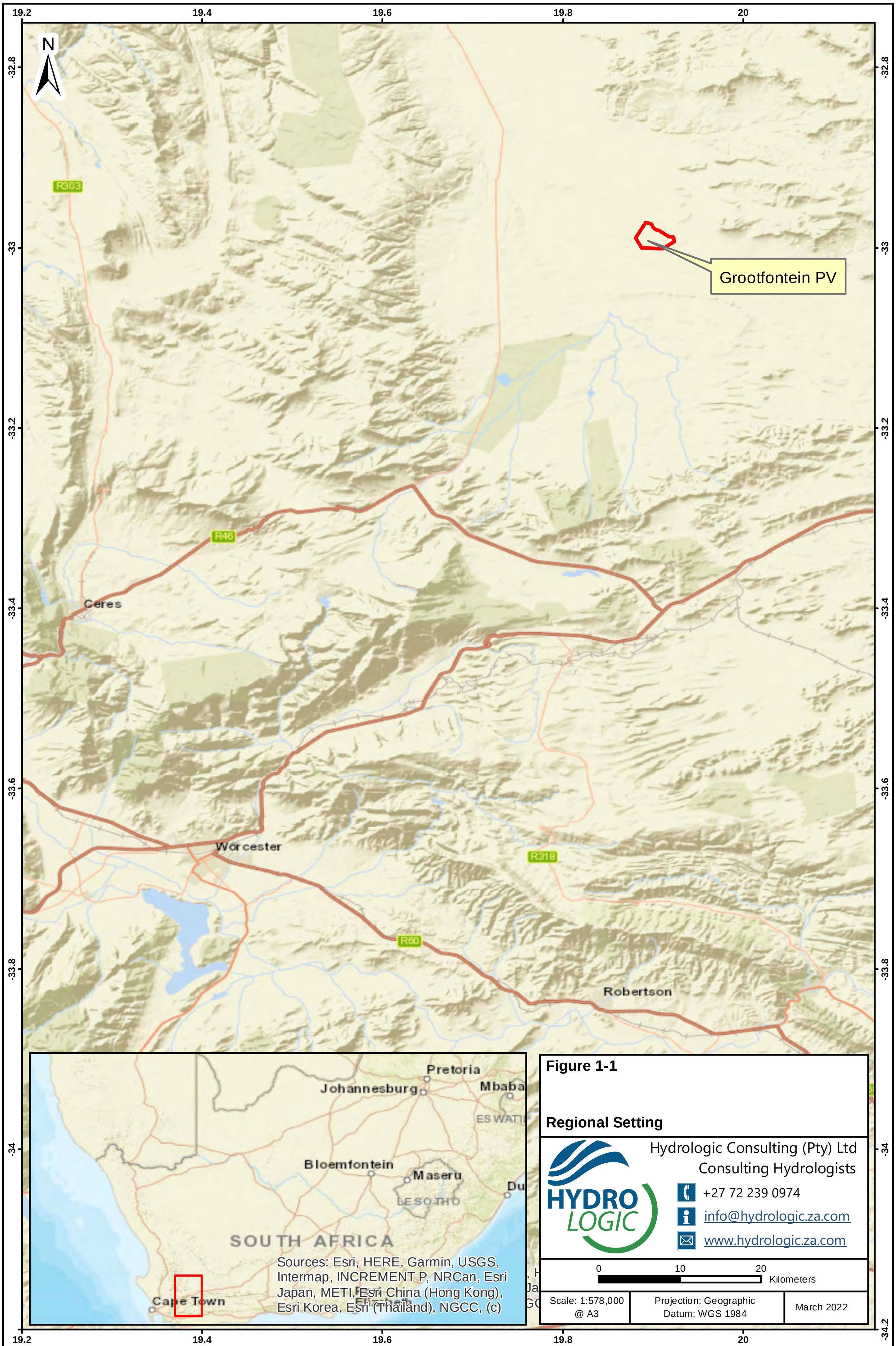
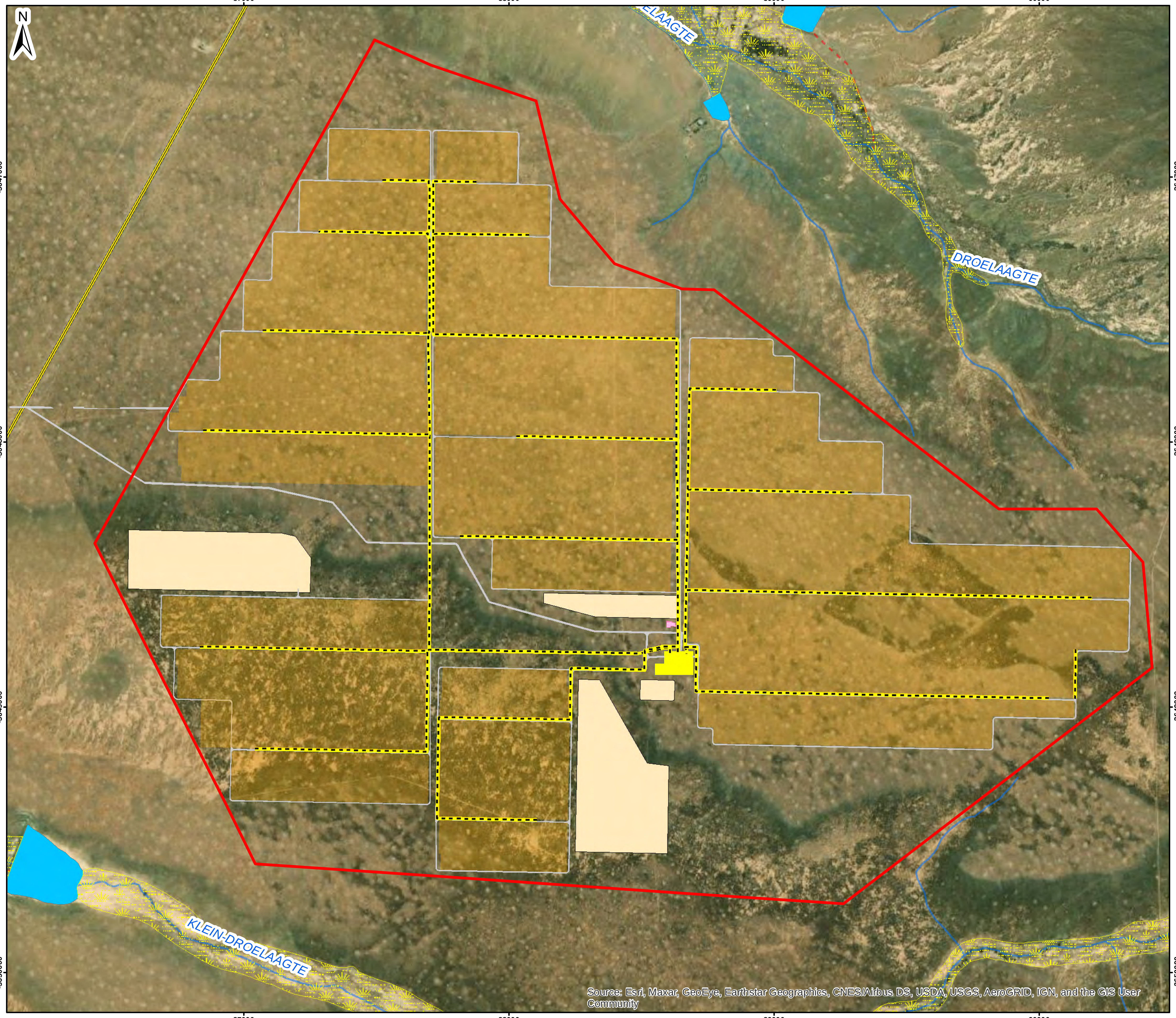



**Figure 1-1**

**Regional Setting**




**Legend**

- Boundary
- Main Road (50K Topo)
- PV Panel
- Cable
- Laydown
- O&M Building
- Road
- Substation
- Furrow (50K Topo)
- Non-Perennial River (50K Topo)
- Dam (50K Topo)
- Dry Watercourse (50K Topo)

**Figure 1-2**

**Layout**

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Meters

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# 2 BASELINE ENVIRONMENT

Baseline information in this section includes discussions on rainfall, evaporation, land cover, terrain and hydrology.

## 2.1 RAINFALL

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

South African Weather Services (SAWS) and Department of Water and Sanitation (DWS) stations are located about the site. SAWS data requires purchasing and alternative sources of average monthly site-specific data were instead utilised, sourced from Pegram (2016). Table 2-1 presents the summary of the site-specific average monthly rainfall distribution while Figure 2-1 illustrates the variation of rainfall in the region.

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

| Month | Rainfall (mm) |
|---|---|
| Jan | 18 |
| Feb | 18 |
| Mar | 20 |
| Apr | 19 |
| May | 19 |
| Jun | 22 |
| Jul | 19 |
| Aug | 18 |
| Sep | 13 |
| Oct | 15 |
| Nov | 17 |
| Dec | 16 |
| **Total** | **214** |

*Estimates were sourced at the centre of the site.

### 2.1.1 24-HOUR DESIGN RAINFALL DEPTHS

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

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

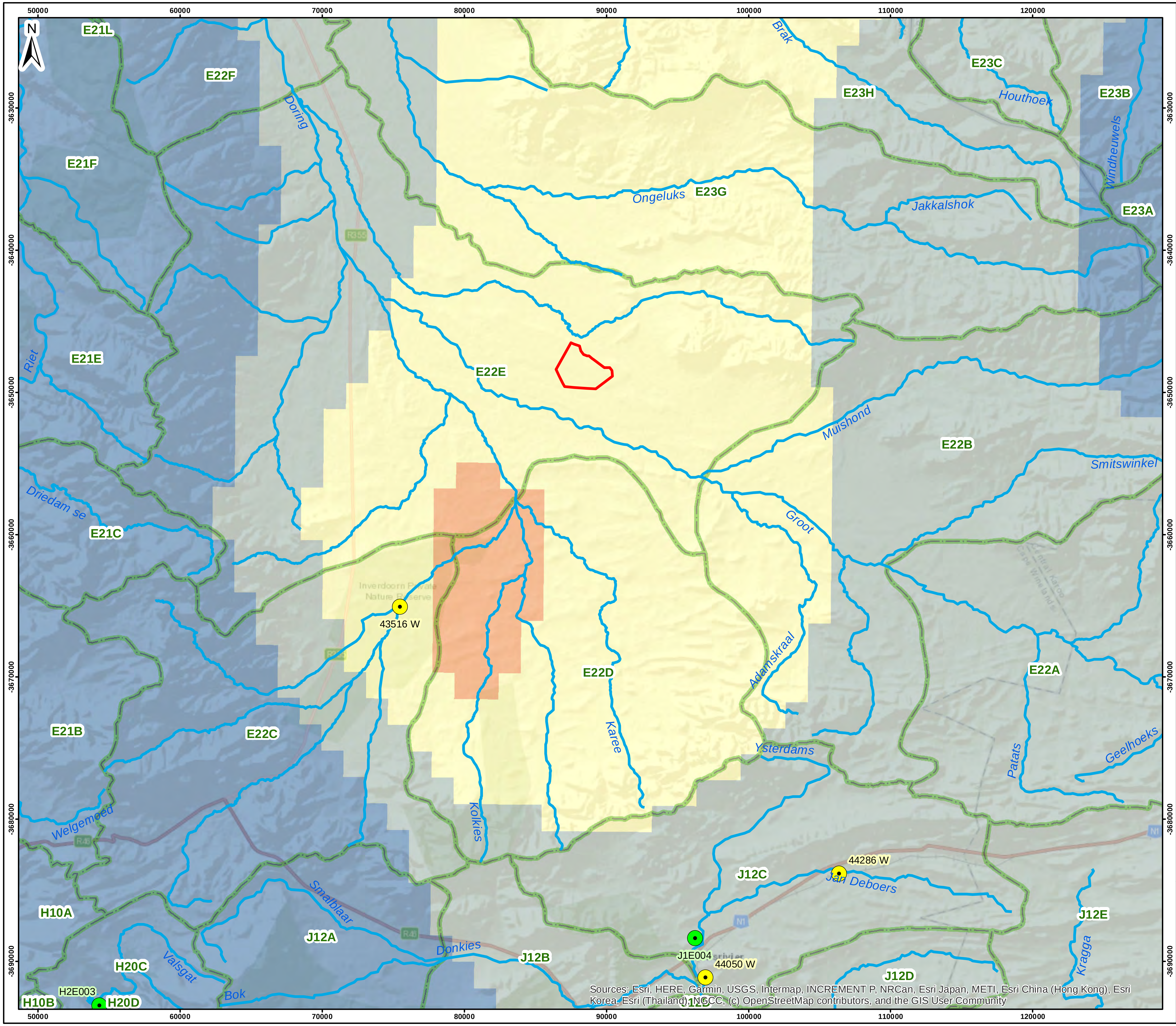


**Figure 2-1**

**Weather Stations and Mean Annual Precipitation**

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0 5 10 Kilometers

| Scale: 1:250,000 @ A3 | Projection: Transverse Mercator Datum: Hartebeeshoek, LO19 | March 2022 |
|---|---|---|

**TABLE 2-2: 24-HOUR DESIGN RAINFALL DEPTH (MM)**

| Recurrence Interval (Years) | DRESSA (Smithers/Schulze)* |
|---|---|
| 2 | 32.9 |
| 5 | 48.3 |
| 10 | 59.9 |
| 20 | 72.1 |
| 50 | 89.9 |
| 100 | 104.8 |
| 200 | 121.1 |

*Estimates were sourced for the centre of the site and represent average values (not upper or lower limits).

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

## 2.2 EVAPORATION

Evaporation data was sourced from the South African Atlas of Climatology and Agrohydrology (Schulze and Lynch, 2006) in the form of A-Pan equivalent potential evaporation. The average monthly evaporation distribution is presented in Table 2-3 and shows the site has an annual A-Pan equivalent potential evaporation of 2,511mm.

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

| Month | Evaporation(mm) |
|---|---|
| Jan | 378 |
| Feb | 295 |
| Mar | 259 |
| Apr | 159 |
| May | 109 |
| Jun | 74 |
| Jul | 79 |
| Aug | 108 |
| Sep | 152 |
| Oct | 234 |
| Nov | 307 |
| Dec | 357 |
| **Total** | **2,511** |

*Estimates were sourced at the centre of the proposed site

## 2.3 AVERAGE CLIMATE

The average climate for the site is presented in Figure 2-2 using the outcome of the investigation into rainfall and evaporation for the site. The combination of rainfall (Pegram, 2016) and evaporation and temperature (Schulze and Lynch, 2006) result in a arid hot steppe climate according to the Köppen-Geiger climate classification[1].

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

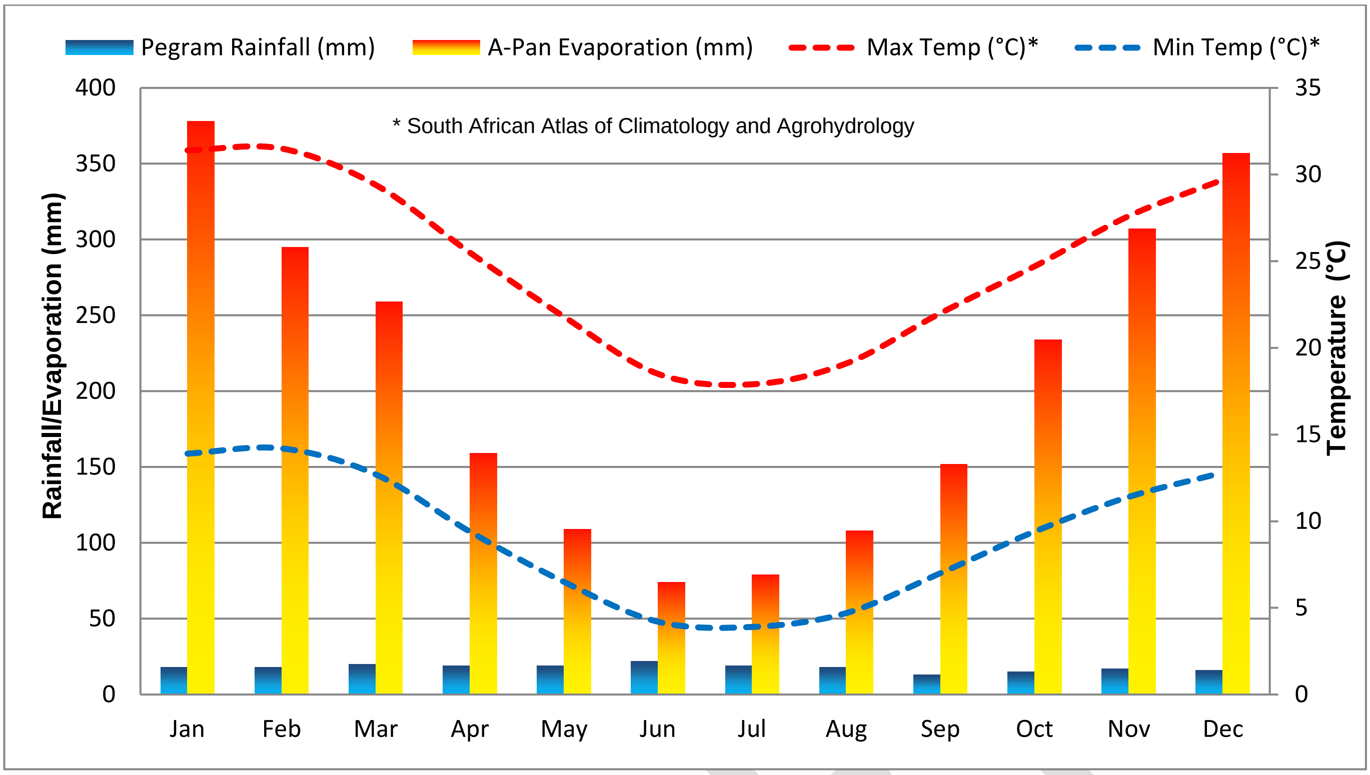



**FIGURE 2-2: AVERAGE MONTHLY CLIMATE FOR THE SITE**

## 2.4 TERRAIN

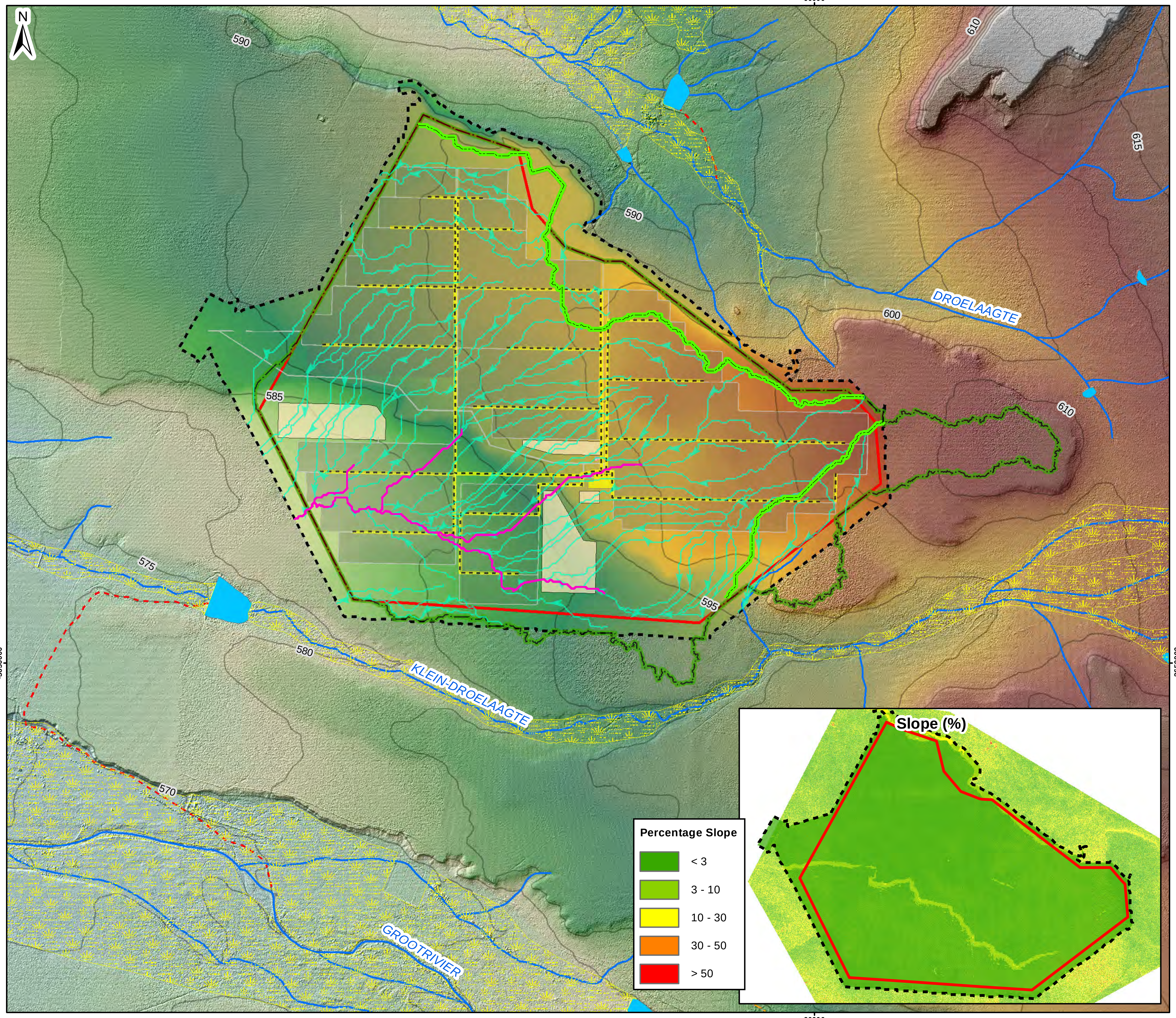
Two datasets were used to assess the terrain of the site and surrounds, namely:

1. Surveyed spot heights (from the site survey in February and March 2022) which were interpolated into a 1m Digital Terrain Model (DTM);
2. 2m Digital Surface Model (DSM);
3. National Geo-spatial Information (NGI) 1:50,000 topographical map 5m contours.

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

The 1m DTM provides an elevation (surface) dataset with a resolution of 1m, although this resolution was selected to retain maximum detail. Typical point spacing was 15m and the resulting DTM interpolated into a 1m grid is consequently likely to have a ‘smooth’ surface compared to the natural terrain. This DTM, being representative of the terrain, provides a ‘bare earth’ model of the surface of the site whereby vegetation and buildings are not reflected. A DTM is preferred for hydrological modelling compared with a DSM (where vegetation is retained which in most cases does not restrict runoff). The additional benefit of the 1m DTM is that the point data from which it is interpolated is expected to highly accurate (given its survey source).

A second elevation dataset in the form of a 2m DSM provided the make-up of terrain about the site. This 2m DSM includes vegetation, however, given the desert setting of the site, the influence of vegetation is largely limited due to the scattered and short shrubs covering the site. The vertical accuracy and horizontal accuracy of the DSM are 0.5m and 1m respectively.




**Legend**

- Boundary
- PV Panel
- Cable
- Laydown
- O&M Building
- Road
- Substation
- Containing Catchment
- 1m DEM Extent
- 5m Contour (50K Topo)
- Furrow (50K Topo)
- Non-Perennial River (50K
- Watershed (1m DTM Derived)
- Dam (50K Topo)
- Dry Watercourse (50K
- Open Reservoir (50K Topo)
- Flow Path (>50ha Accumulation, 1m DTM Derived)
- Flow Paths (1m DTM Derived)

**Elevation (mAMSL)**

High : 642

Low : 570

**Figure 2-3**

**Terrain and Hydrology**

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| Scale: 1:50,000 @ A3 | Projection: Transverse Mercator Datum: Hartebeesthoek, LO19 | March 2022 |
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The NGI's 1:50,000 topographical map 5m contours provide an illustration of the general terrain of the site and surrounds.

Figure 2-3 also includes a calculation of slope using both the 1m DTM and 2m DSM with slopes largely below 3% resulting in a relatively 'flat' site. Elevations on the site approximate 595mAMSL.

## 2.5 HYDROLOGY

Figure 2-3 also illustrates the hydrological setting of the site, while Figure 2-1 presents the river network of the greater region. The site lies within quaternary catchment E22E, situated between two primary watercourses.

Localised hydrology (per Figure 2-3), illustrates no 1:50,000 topographical map rivers intersecting the site, with non-perennial rivers passing by the site or draining away from the site. Two larger non-perennial rivers systems to the north and south of the site are characterised by larger dry channels and are labelled (i.e. the Droelaagte River and Klein-Droelaagte River).

Processing of the terrain data (1m DTM and 2m DSM) identified a watershed in the site that distinguishes between the larger portion of the site over which runoff will accumulate, draining through proposed infrastructure. Smaller peripheral areas of the site drain away to the north-east and south-east. To consider the larger portion of the site over which runoff will accumulate, a 50ha threshold was used to define a primary flow path. This flow path is expected to be associated with larger potential storm flow and is noted as intersecting a laydown area, the substation, PV panels and various linear infrastructure.

The containing catchment draining the site has been delineated in Figure 2-3. At the site's western and northern boundary, the catchment is illustrated as terminating, on the basis that terrain slopes away from the site such that management of runoff over the site is not relevant (past the site's western and northern boundary).

## 2.6 SOILS, VEGETATION AND LAND-COVER

According to the high-level soils data included in the Water Resources of South Africa 2012 (WR2012) study (Bailey and Pitman, 2015), soils on the site are classified as between a sandy loam and sandy clay loam. In considering the more detailed Soil Conservation Service for South Africa (SCS-SA) dataset of the site, soils are classified as being hydrological soil group C (moderately high runoff potential).

A geotechnical investigation of the site was undertaken which included an assessment of soil permeability[2] as well as a particle analysis of soil samples taken at different depths around the site. The results of this investigation were reviewed to inform possible soil infiltration. In considering the permeability testing, the adopted approach recorded unsaturated hydraulic conductivity (falling head tests) using a trial pits where lateral flow (in addition to vertical flow), can give artificially high infiltration results. As such, the results of the falling head tests weren't possible to integrate into this study. The soil particle analysis of various samples included near-surface or surface samples, six of which were considered. From these six, particle analysis indicated four soil samples were 'sand', one was a 'loamy sand' and one was a 'sandy loam'. A discussion with Keshan Naidoo (from Mukona Consulting Engineers on 11th March

[2] Mukona Consulting Engineers, 2022, "Grootfontein PV Study Report - Interpretive Geotechnical Investigation Report" No. MK22/637/rev.01

2022) indicated the presence of impeding calcrete layers from approximately 0.2m below ground (and deeper). Keshan also anecdotally referred to storm events noted during the geotechnical investigation whereby an estimated 15mm of rain (high-level approximation) fell during a short storm burst, resulting in standing water over parts of the site for a few hours (indicating a greater limitation in infiltration than suggested by a sandy soil).

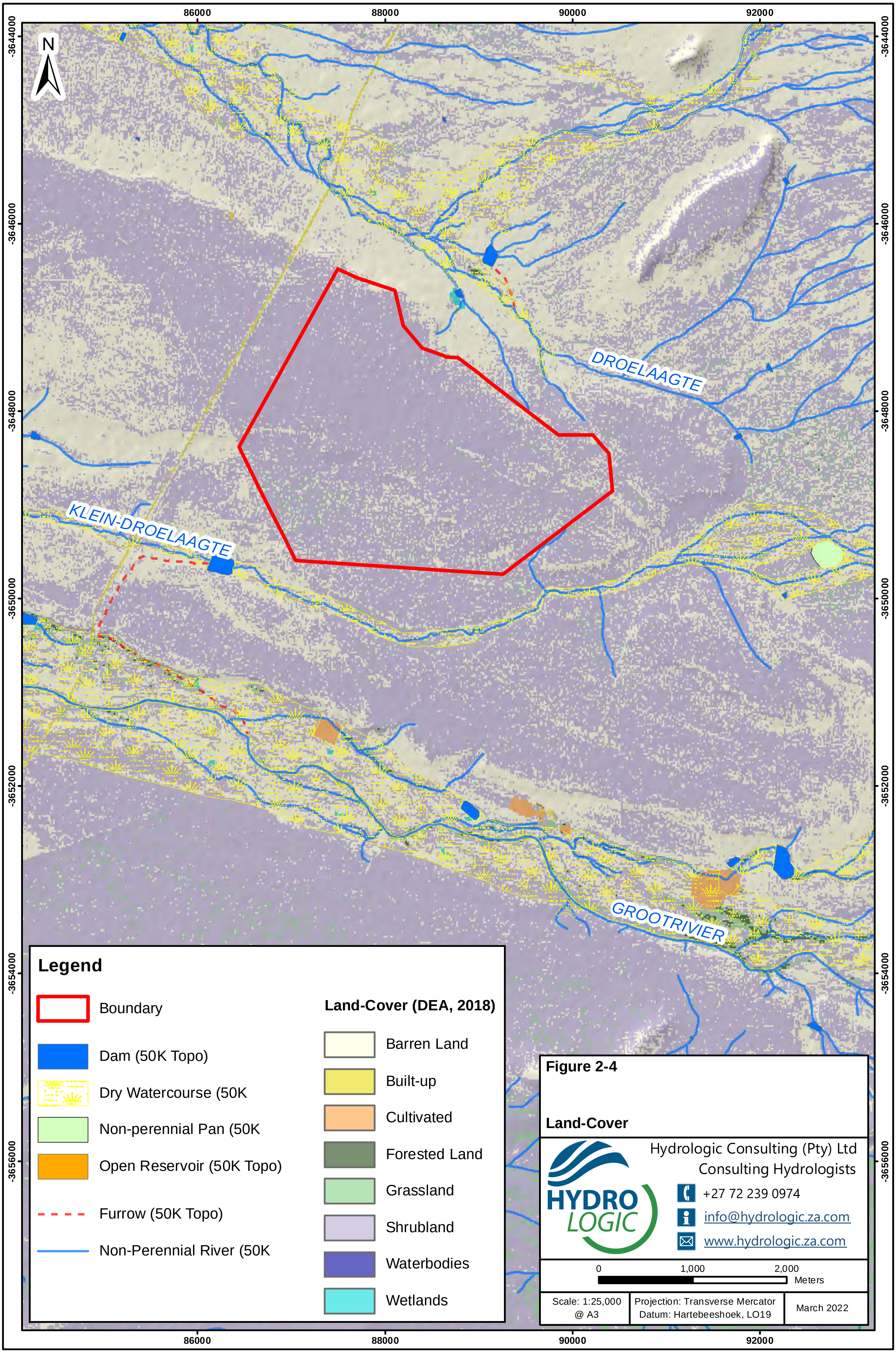
The combination of the WR2012/SCS-SA datasets and geotechnical investigation results culminated in a decision to consider the soils over the site as approximating SCS hydrological soil groups B and B/C (moderately low and moderately low to moderately high soil runoff potential), which is an reduction in infiltration potential from the previous group C soil (moderately high runoff potential).

The natural vegetation of the site is classified as 'Tanqua Karoo' and 'Tanqua Wash Rivere' and Bushmanland Basin Shrubland (according to SANBI, 2012).

Land-cover of the site is mostly classified as 'shrubland' according to the Department of Environmental Affairs (DEA) 2018 dataset, with interspersing areas of 'barren land'.

The land-cover in the region about the site is illustrated in Figure 2-4 while Figure 2-5 presents the distribution of the SCS soil types (runoff potential) and natural vegetation.

Figures 2-6 and 2-7 are photographs of the typical land-cover noted during the site visit on the 10th February 2022.



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-3648000
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-3652000
-3654000
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KLEIN-DROELAAGTE
GROOTRIVIER
Legend
Boundary
Dam (50K Topo)
Dry Watercourse (50K
Non-perennial Pan (50K
Open Reservoir (50K Topo)
Furrow (50K Topo)
Non-Perennial River (50K
Land-Cover (DEA, 2018)
Barren Land
Built-up
Cultivated
Forested Land
Grassland
Shrubland
Waterbodies
Wetlands
Figure 2-4
Land-Cover
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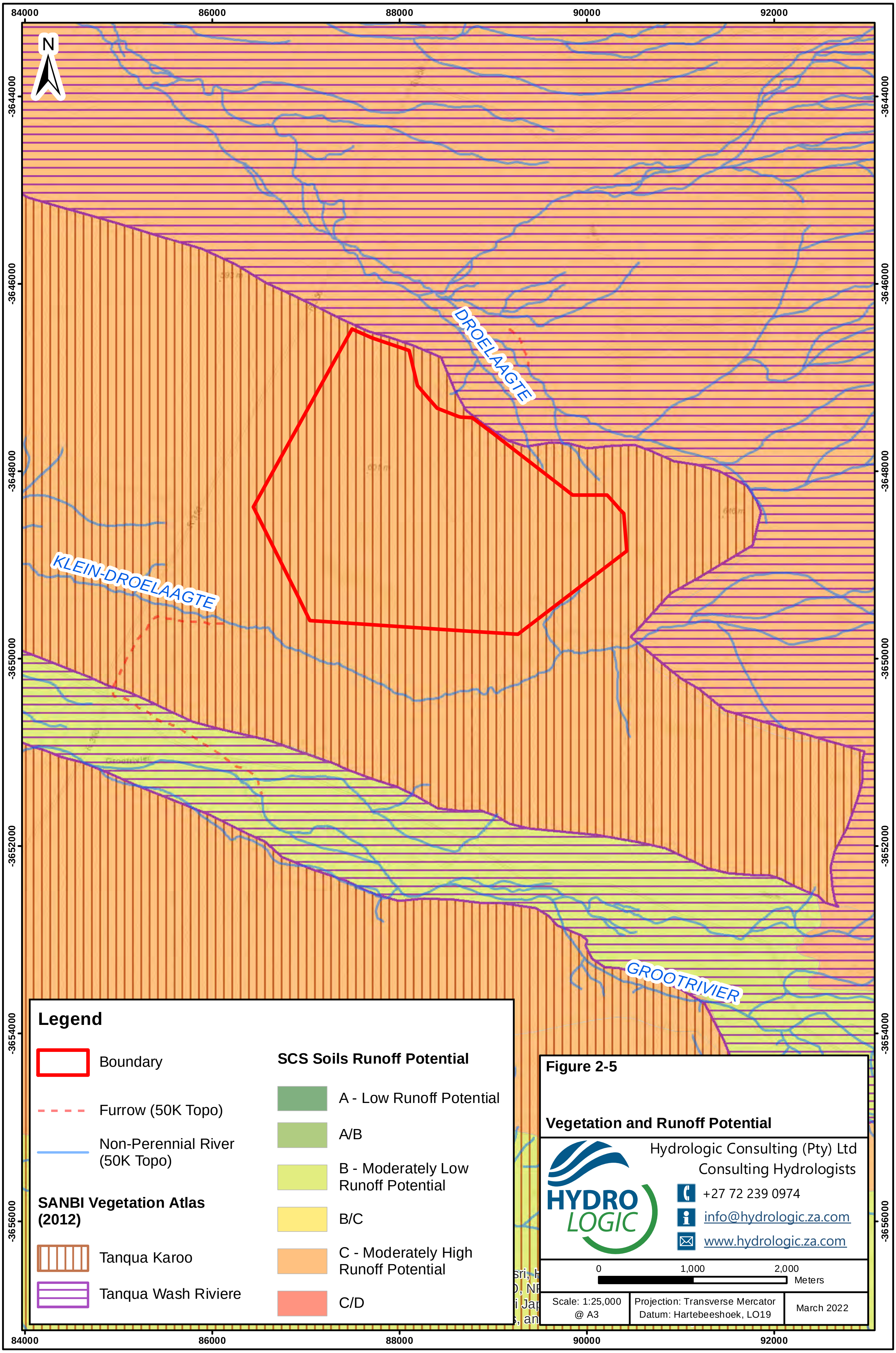

Figure 2-5

Vegetation and Runoff Potential

**FIGURE 2-6: MIX OF BARREN AREAS AND SCRUB OVER THE SITE**

**FIGURE 2-7: AREAS OF SURFACE GRAVEL AND STONES**

# 3 STORM WATER MANAGEMENT AND EROSION CONTROL

The proposed solar project will alter the natural environmental state, thereby affecting the generation of storm water and the associated potential for erosion. Volumes of storm water generated over disturbed areas are generally expected to increase because of the reduction in natural vegetation or the addition of areas of hardstanding. The quality of the stormwater generated is also expected to be affected by the removal of vegetation and excavation of soils (i.e. potential erosion will increase). The movement of vehicles over the site will also introduce possible hydrocarbons, however, this section does not deal with possible chemical pollutants (focusing instead on potentially increased sediment loads with regards to water quality).

The purpose of this section is to produce a conceptual level storm water management plan (SWMP) by which areas producing significant runoff quantities are managed appropriately and an erosion control management plan by which potential erosion can be limited.

Relevant guidance that informs the above includes the following:

- National Environmental Management Act (Act No. 107 of 1998) as amended, which states that "Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring…"
- National Water Act (Act No. 36 of 1998) includes Section 21 water uses which require authorisation from the Department of Water and Sanitation (DWS).
- Government Notice 704 (Government Gazette 20118 of June 1999), which while it focuses on mining, includes some important principles by which clean and dirty water producing areas can be managed effectively;
- Department of Water and Sanitation (DWS) Best Practice Guideline G1 for Stormwater Management;
- Landcom Soils and Construction, Volume 1, 4th edition from 2004 (otherwise known as the Blue Book) has been used widely in the South African context in providing practical recommendations regarding the management of stormwater and associated erosion controls; and
- The South African Roads Agency Limited (SANRAL) 6'th edition Drainage Manual (2013) provides some valuable insight specific to the construction and operation of various roads, a network of which will be developed as part of this proposed project.

## 3.1 AREAS REQUIRING STORM WATER MANAGEMENT

In considering the site, some hardstanding areas are proposed in the form of the O&M building, the laydown areas, substation and solar panel pylons (specifically their foundations). The solar panels themselves do not qualify as hardstanding since they do not limit infiltration beneath them. Some compaction of soils on site is expected, particularly with regards to areas of travel, such as the internal access roads and laydown area.

The development of the solar farm will likely consequently be associated with a limited change to the natural land-cover when the full site is considered, assuming disturbed land-cover (i.e. soils and vegetation) is rehabilitated. The implication of this rehabilitation (of the areas between panel foundations), is that most of the site can retain a naturalised hydrological response where both the quantity and quality of storm water is similar to the natural baseline environment. This does not consider solar panel washing or other maintenance that may introduce pollutants such as hydrocarbons.

Soils on and surrounding the site are expected to have moderately low and moderately low to moderately high runoff potential. Combined with the flat terrain and low rainfall of the region, runoff is only expected to occur during storms. The desert climate means areas of poor vegetation coverage are common with bare areas frequently noted during the site visit, between individual shurbs as well as larger expanses without any vegetation. These bare areas would increase the potential for runoff due to the absence of vegetation that may otherwise slow down runoff (and promote infiltration).

### 3.1.1 HYDROLOGICAL EFFECT OF SOLAR FARMS

A study by Cook and McCuen (2013) is of relevance to this report as it describes the hydrological effect of solar farms and whether storm water management is required to control runoff rates and volumes. This study considered a solar farm before and after the installation of panels. The study found that the solar panels did not have a significant effect on existing runoff rates, runoff volumes or time to peak of runoff. The presence of gravel or bare ground under the panels could, however, significantly increase the amount of runoff generated, while the kinetic energy of runoff falling from panels was a possible cause of erosion (at the base of panels). The study recommended that the grass beneath the panels be well maintained or that a buffer strip be placed after the most downgradient row of panels.

Neither grass below panels nor buffer strips are well suited to the site given the desert climate, while the addition of gravel strips are complicated by the 'tracking' feature of the panels which results in a moving drip-line. Given the already bare nature of parts of the site, the addition of gravel strips below panels (if possible), would be less likely to increase runoff (from the baseline).

### 3.1.2 MANAGEMENT APPROACH

Figure 3-1 presents the conceptual storm water management plan for the site.

The availability of a 1m DTM and 2m DSM covering the site and surrounds enabled the delineation of relevant subcatchments draining to or from within the site. The approach to subcatchment delineation was based upon the position of the proposed infrastructure and the natural drainage (informed by the terrain data). Areas downslope of proposed infrastructure were not considered since storm water generated from these locations would not influence the proposed infrastructure.

A 50ha minimum contributing area flow path was defined to provide an idea about areas that would receive larger accumulations of runoff, however, a 100ha contributing area was the target subcatchment threshold area, above which formal storm water management would be proposed. When reviewing the 50ha minimum contributing area flow path, it was apparent, however, that the substation and one laydown area were intersected by this flow path. So as to provide some protection (from storm water run-on), these two areas were considered in the subsequent layout of storm water management infrastructure. The 50ha minimum contributing area flow path was also noted as routing runoff towards the west of the site, whereupon, it exited at a single location on the site's perimeter.

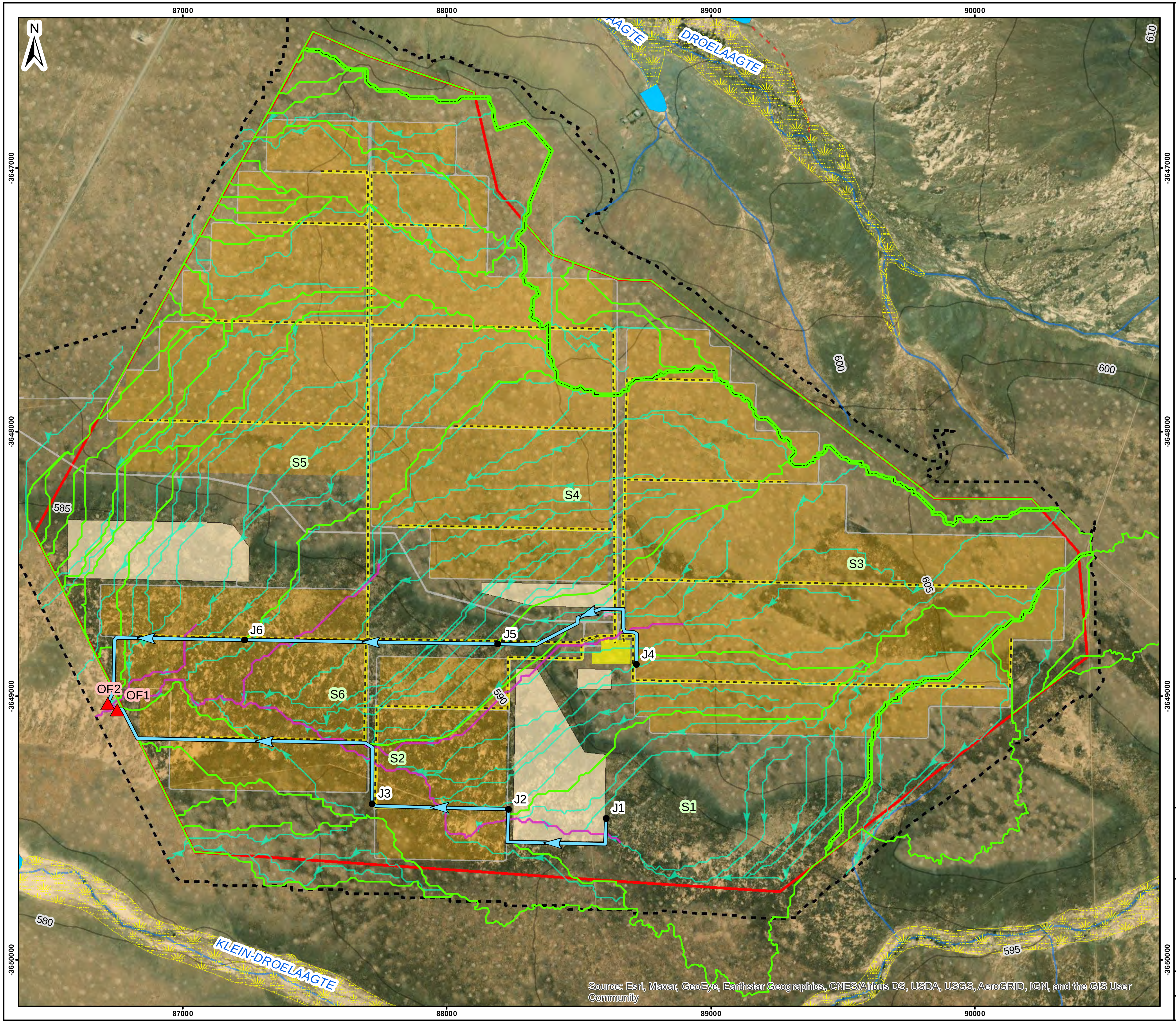


**Figure 3-1**

**Storm Water Management Plan**

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The 100ha, while the target area for formal storm water management is not, however, a limitation to the addition or reduction in the proposed diversions and this threshold should be reviewed during the detailed design phase (to be informed by this report). Although soft engineering approaches are preferred, the desert climate means that grassed swales will likely struggle to be established (the grass section) and trapezoidal channels were consequently simulated for the collection and routing of storm water.

The layout of the proposed storm water network (trapezoidal channels) is illustrated in Figure 3-1. The position of the channels took account of the proposed infrastructure layout and followed alongside access roads. It was necessary to include two storm water diversions given the existing primary flow path through the site which intersects various panel arrays (or blocks of panels),. These two diversions also facilitated the routing of areas larger than 100ha, which may otherwise have been difficult to implement through the use of a single diversion (i.e. the 100ha threshold area would potentially have been exceeded before the relevant subcatchment reached the diversion).

Although subcatchments 'S1' to 'S5' route to the proposed channels/diversions, subcatchment 'S6' located between the two diversions flows naturally towards the original primary flow path. This subcatchment ('S6') was allowed to flow out of the site without any storm water management given its area of 48.6ha which is below the 100ha threshold. Subcatchment 'S6' was the largest of the various smaller subcatchments on the site for which no storm water management was proposed. To consider the potential need for storm water management during the detailed design phase, subcatchment 'S6' was included in reporting. All other subcatchments although delineated in Figure 3-1, have not had any further reporting due to their not being above the 100ha threshold limit while all fall below 50ha in area.

Outfalls, at the termination of the two proposed channels/diversions will require consideration of the velocity (and thereby erosivity) of channelled flow. Baffles or a small detention basin may be relevant to the reduction in flow velocities. This should be considered during the detailed design.

The natural land-cover and drainage of the site should be retained insofar as is possible (as a general guideline).

## 3.2 FUELS, LUBRICANTS AND CHEMICALS

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

## 3.3 STORM WATER MANAGEMENT INFRASTRUCTURE

Figure 3-1 illustrates the conceptual SWMP while Appendix A presents details relating to the development of the SWMP using PCSWMM, which is based on the Storm Water Management Model (Rossman, 2008). Storm water management infrastructure has been conceptually designed using the 1:50 year, 24-hour RI event. No account has been taken of climate change and any potential future increases in rainfall depth or intensity. These will need to be considered depending on the expected life of the structure.

It should be noted that the results of the storm water modelling do not account for the influence of changes to the hydrological setting of the site (from that of the baseline or current setting), given the low impact development anticipated and the results of the research by Cook and McCuen (2013).

### 3.3.1 AVAILABLE INFORMATION

The following information was used to develop the SWMP:

- Climate Data: Particularly design rainfall depths;
- Elevation Data: The 1m DTM and 2m DSM as outlined in Section 2.4 were used to define flow routes and subcatchment divisions; and
- Catchment characteristics: Soil characteristics, land-cover and slopes were used to define catchment characteristics.

### 3.3.2 DIVERSIONS

Figure 3-2 represents a typical diversion channel consisting of a berm and channel component. The side slopes for all berms and channels have been kept constant at 1 vertical: 3 horizontal, while a minimum channel dimension of 0.5m channel depth and 1.0m channel base breadth has been used to simplify design.

The channel component has been sized using PCSWMM storm water modelling software to meet the requirement of accommodating the 1:50 year RI event. A Manning's 'n' roughness coefficient of 0.028 (approximating gravel with occasional shrubs) was used in the sizing of the diversions channels and would consequently also simulate the hydraulic response of a grass swale. Figure 3-2 illustrates this drainage channel where:

- a = Channel Depth
- b = Channel Base Breadth

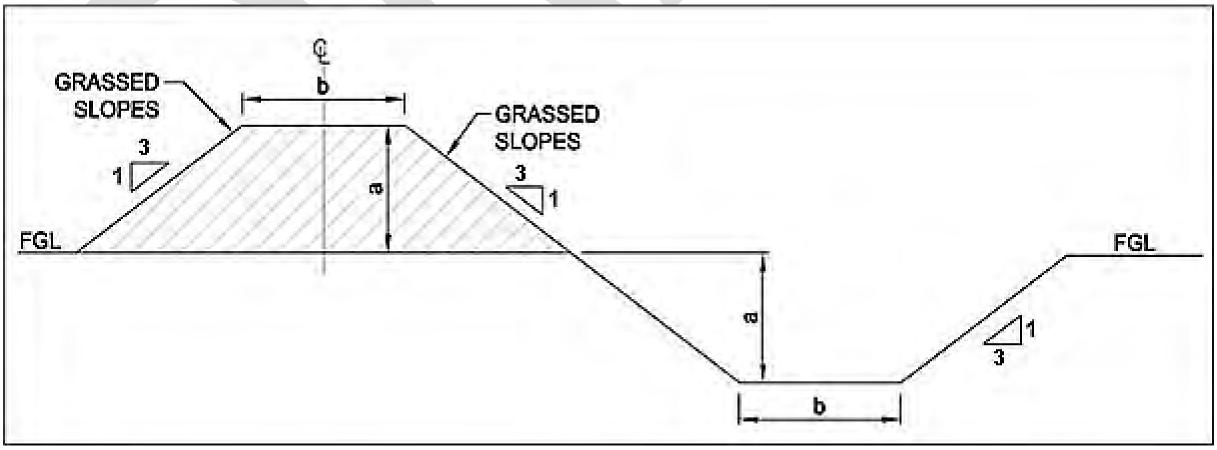


**FIGURE 3-2: TYPICAL BERM AND CHANNEL FOR STORMWATER DIVERSION SYSTEM**

Cognisance should be taken of the position of channels relative to contributing areas (i.e. upslope areas that would route runoff towards channels. Where this occurs on both sides of the channel, no berm component (as illustrated in Figure 3-2) should be included (to allow inflow from both sides). Where inflow only occurs along a single side, a berm and channel approach can be adopted.

Table 5-1 presents the dimensions of the diversions, including the average longitudinal slope. The indicated dimensions and flows may differ from final, depending on the construction method, the location of diversions and the added detail included in the detailed design. The channel dimensions should consequently be reviewed during the detailed design phase.

**TABLE 3-1: DIMENSIONS FOR CLEAN AREA DIVERSIONS (1:50 RI EVENT)**

| Diversion | a (m) | b (m) | Average Longitudinal Slope (%) | Peak Flow ($m^3/s$) |
|---|---|---|---|---|
| J1 to J2 | 1.0 | 1.0 | 0.43 | 5.5 |
| J2 to J2 | 1.0 | 4.0 | 0.36 | 9.8 |
| J3 to OF1 | 1.0 | 3.0 | 0.36 | 8.6 |
| J4 to J5 | 1.0 | 1.0 | 0.86 | 3.9 |
| J5 to J6 | 1.0 | 2.0 | 0.86 | 8.7 |
| J6 to OF2 | 1.0 | 5.0 | 0.28 | 11.8 |

The proposed channels/diversions pass through access roads in a few locations. These diversions will require consideration as to how channelled flow will pass by these roads (during the detailed design phase). This may require the addition of suitability sized culverts or the construction of a suitability sized low-level crossing. SANRAL (2013) provides some valuable insight specific to the construction of culverts and crossings.

The outfalls will direct concentrated flow to specific points of discharge and may require a reduction in velocity to limit potential erosivity of water (through the use of baffles, detention basins or similar).

### 3.3.3 SUBCATCHMENT 'S6'

A threshold subcatchment area of 100ha was used to determine the necessity of diversions, while a 50ha minimum contributing area flow path informed the potential extension of diversion to protect the proposed infrastructure. Subcatchment 'S6' has been identified as a subcatchment of interest since it falls beneath both areas (50ha and 100ha), having an area of approximately 48.6ha. The accumulation of runoff over the subcatchment results in the combined runoff exiting at a point on the site's western boundary. The peak flow for this runoff (per the 1:50 year RI event) is estimated as 3.2m³/s. This is the peak flow estimate for the baseline environment, without alterations to the site which may modify existing flow paths. The results from 'S6' nevertheless present the upper limit of potential peak flows for subcatchments on the site which do not drain to one of the proposed channels/diversions.

## 3.4 EROSION CONTROL

Erosion control has partly been considered in this section with regards to storm water management and the routing of the runoff along trapezoidal channels (runoff that may otherwise be prone to the exacerbation or development of erosion if left unmanaged). Retention or rehabilitation of the natural land-cover and drainage of the site (post construction or decomissioning) will also serve to limit potential increases in erosions.

Additional principles are, however, included in the following (a combination of the various guidelines), and should be adhered to where possible:

- Clearing of vegetation and associated excavation areas should be kept to a minimum, particularly in areas where soils are unstable.

- The construction of any roads will create areas prone to erosion due to soils being exposed. Roads should therefore be constructed in a manner to rapidly stabilise soils, while roadside drainage should be included where necessary. For more information, please refer to the SANRAL (2013).
- Construction should be scheduled to take place during the dry seasons when rainfall and associated erosion potential is at its least. However, with no clearly defined dry season (see Table 2-1), it is likely suitable to undertake construction at any point in the year.
- Excavated soils should be stockpiled and separated into separate material types to enable replacement in the same order as excavated, during rehabilitation.
- Natural vegetation should be re-established to represent the previously undisturbed environment as closely as possible.
- A practical erosion control handbook should be developed, based on the principles developed in this report and given to the construction contractors to ensure the impact on receiving water resources is limited.
- Regular inspection of the site to assess erosion which may result from a loss in vegetation or cavitation from soil slumping, with intervention to prevent erosion where it is noticed.
- Watering to ensure wind erosion is limited during construction and to assist in the establishment of vegetation where possible.
- Maintenance and/or cleaning of all diversions and roadside drainage.
- The storm water management plan as outlined in this report will be an integral part of the control of possible erosion.

Management of erosion potential through regular inspection and maintenance is also of greater importance given the possible absence of gravel strips beneath panels (such that rainfall erosivity may be a problem) as well as the absence of vegetated buffer strips due to the likely difficulty in establishing them (given the desert environment).

### 3.4.1 SILT FENCES

Silt fences may be suitable in the control of potential erosion from areas disturbed during construction or decommissioning, particularly the concentrated areas of disturbance such as the O&M Building, substation and laydown area.

The United States Environmental Protection Agency (EPA) provides a detailed guide on the installation and maintenance of silt fences and the reader is referred to the following online document[3]. As defined by the EPA guide, a silt fence "*is a temporary sediment barrier made of porous fabric. It's held up by wooden or metal posts driven into the ground, so it's inexpensive and relatively easy to remove. The fabric ponds sediment-laden stormwater runoff, causing sediment to be retained by the settling processes".* A silt fence is possibly a cost-effective approach to erosion control management and suits the temporary nature of the construction phase of the project. The EPA guide can be consulted as to recommended design standards in this regard. Figure 3-8 illustrates a typical silt fence.

[3] https://www3.epa.gov/npdes/pubs/siltfences.pdf).

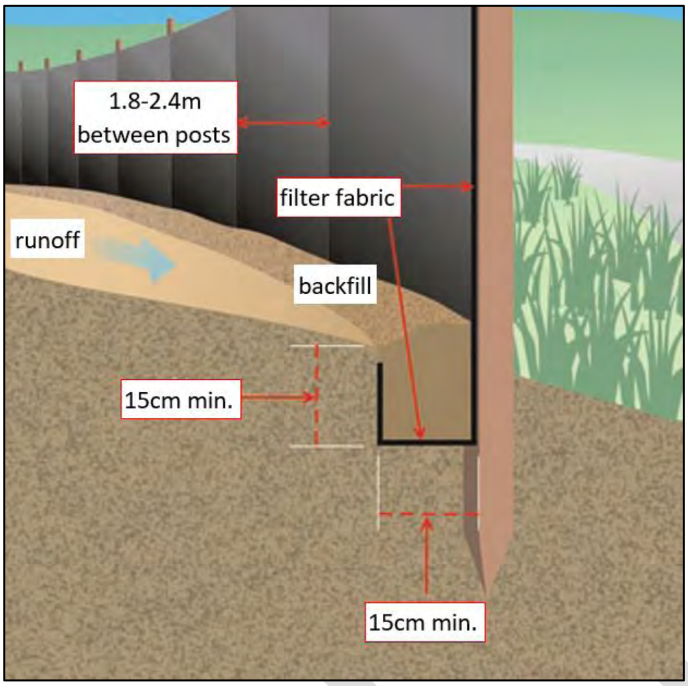


**FIGURE 3-3: TYPICAL SILT FENCE (AFTER ENVIRONMENT PROTECTION AGENCY[4])**



[4] Illustration of a silt fence installation detail, from U.S. EPA publication, "Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites." Document No. EPA-833-R-060-04.

# 4 RECOMMENDATIONS AND CONCLUSION

A baseline assessment, including the sourcing and processing of data pertaining to rainfall, evaporation, topography, land-cover, soils as well as regional and local hydrology, has been undertaken to determine the hydrological aspects relating to the proposed Grootfontein PV Facility.

The proposed solar project will alter the natural environmental state, thereby affecting the generation of storm water and the associated potential for erosion. Volumes of storm water generated over disturbed areas are generally expected to increase because of the reduction in natural vegetation or the addition of areas of hardstanding. The quality of the stormwater generated is also expected to be affected by the removal of vegetation and excavation of soils (i.e. potential erosion will increase). The purpose of this report is therefore to produce a conceptual level storm water management plan (SWMP) by which areas producing significant runoff quantities are managed appropriately and an erosion control management plan by which potential erosion can be limited.

In considering the site, some hardstanding areas are proposed in the form of the O&M building, the laydown areas, the substation and solar panel pylons (specifically their foundations). The solar panels themselves do not qualify as hardstanding since they do not limit infiltration beneath them. Some compaction of soils on site is expected, particularly with regards to areas of travel, such as the internal access roads and laydown area. The development of the solar farm will likely be associated with a limited change to the natural land-cover when the full site is considered, assuming disturbed land-cover (i.e. soils and vegetation) is rehabilitated.

A study by Cook and McCuen (2013) is of relevance to this report as it describes the hydrological effect of solar farms and whether storm water management is required to control runoff rates and volumes. This study informred the approach to storm water management as outlined in this report.

Neither grass below panels nor buffer strips are well suited to the site given the desert climate, while the addition of gravel strips below panels (to limit rainfall erosivity) is complicated by the 'tracking' feature of the panels which results in a moving drip-line. Given the already bare nature of parts of the site, gravel strips below panels (if possible), would be less likely to increase runoff (from the baseline).

A 100ha minimum subcatchment area informed an approach whereby diversions (to route storm water) are proposed, given the potentially significant volume and rate of runoff (from a contributing area larger than 100ha). This 100ha threshold is, however, not a limitation to the addition or reduction in the proposed diversions and this threshold should be reviewed during the detailed design phase (to be informed by this report). A 50ha minimum contributing area flow path was also defined to provide an idea about areas that would receive larger accumulations of runoff. When reviewing the 50ha minimum contributing area flow path, it was apparent that the substation and one laydown area were intersected by this flow path. To provide some protection (from storm water run-on), these two areas were considered in the subsequent layout of storm water diversions.

Outfalls, at the termination of proposed diversions, will require consideration of the velocity (and thereby erosivity) of channelled flow. Baffles or a small detention basin may be relevant to the reduction in flow velocities. This should be considered during the detailed design. Buffer strips are proposed downslope of panel 'blocks' which don't include a diversion. The natural land-cover and drainage of the site should be retained insofar as is possible while practical measures to limit erosion potential should be implemented as outlined in Section 3.4.

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# APPENDIX A: STORM WATER CALCULATIONS

## A.1 MODEL CHOICE

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

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

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

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

## A.2 DESIGN HYDROGRAPHS

### A.2.1 DESIGN STORM

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

### A.2.2 MODEL PARAMETERISATION

The 1m DTM and 2m DSM were used to define flow paths, subcatchments and diversions. Land cover parameters were estimated according to the surface infrastructure layout with the baseline land cover and soil type being set according to Section 2.6.

### TABLE A-1: SUBCATCHMENT CHARACTERISTICS FOR THE 1:50 YEAR EVENT

| Name | Area (ha) | Precipitation (mm) | Infiltration (mm) | Runoff Coefficient | Runoff Volume (ML) | Peak Runoff ($m^3/s$) |
|---|---|---|---|---|---|---|
| S1 | 97.5 | 90 | 34 | 0.56 | 48.8 | 5.8 |
| S2 | 98.8 | 90 | 34 | 0.55 | 48.4 | 5.2 |
| S3 | 93.2 | 90 | 34 | 0.54 | 45.0 | 4.4 |
| S4 | 119.7 | 90 | 35 | 0.54 | 57.7 | 6.2 |
| S5 | 98.9 | 90 | 35 | 0.53 | 46.9 | 4.6 |
| S6 | 48.7 | 90 | 34 | 0.56 | 24.4 | 3.2 |