STORM WATER MANAGEMENT PLAN

FOR THE PROPOSED RIETRUG WIND ENERGY FACILITY AND ASSOCIATED INFRASTRUCTURE (12/12/20/1782/1/AM5) NEAR SUTHERLAND, KAROO HOOGLAND LOCAL MUNICIPALITY, NAMAKWA DISTRICT, NORTHERN CAPE

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DRAFT REPORT

Acronyms

SWMP	Storm Water Management Plan
DEDTEA	Department of Economic Development, Tourism and Environmental Affairs
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
UPD	Utility Programme for Drainage

Table of Contents

Tables

Figures

Annexures

Specialist Details & Declaration

This report has been prepared in accordance with Section 13: General Requirements for Environmental Assessment Practitioners (EAPs) and Specialists as well as per Appendix 6 of GNR 982 – Environmental Impact Assessment Regulations and the National Environmental Management Act (NEMA, No. 107 of 1998 as amended 2017) and Government Notice 704 (GN 704). It has been prepared independently of influence or prejudice by any parties.

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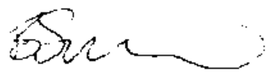
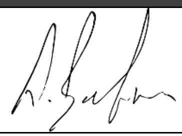
Author signature			Co-author signature		
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1. INTRODUCTION

1.1 Project Background and Description of the Activity

Rietrug Wind Farm (Pty) Ltd received an Environmental Authorisation (EA) (DFFE Ref: 12/12/20/1782/1) dated (10/11/2016), for the development of a 140MW Wind Energy Facility (WEF) and associated infrastructure near Sutherland and located within the Komsberg Renewable Energy Development Zone (REDZ) in the Northern Cape Province, with further amendments to the EA as stated below:

- Replacement of the first issue EA Reference: 12/12/20/1782/1 issued on: 10 November 2016;
- First Amendment - Amendment of Listed activities on the EA Reference: 12/12/20/1782/1/AM1 issued on 25 November 2016;
- Second Amendment – Amendment of turbine specifications & change of technical details of the proposed facility EA Reference: 12/12/20/1782/2/AM2 issued on: 25 August 2017;
- Third Amendment - Change in contact details of the holder of the EA & selected project description changes EA Reference: 12/12/20/1782/1/AM3 Issued on: 10 March 2020;
- Fourth Amendment – Name correction EA Reference: 12/12/20/1782/1/AM4 issued on 27 July 2021; and
- Fifth Amendment - Amendment to the co-ordinates of the access road EA Reference: 12/12/20/1782/1/AM5 issued on 06 December 2021.

The project will include (as authorised):

- Up to 37 wind turbines with a height of up to 200m and rotor diameter of up to 200m.
- The wind turbines will be connected to another by means of medium voltage cable.
- An internal gravel road network will be constructed to facilitate movement between turbines on site. These roads will include drainage and cabling.
- A hard standing laydown area of a maximum of 10 000 m2 will be constructed; and
- A temporary site office will be constructed on site for all contractors, this would be approximately 5000m2 in size.
- A 10km portion of the existing access road will be upgraded and widened to a width of 7 metres to facilitate abnormal loads to the Rietrug WEF site.

The properties associated with the Rietrug Wind Energy Facility include:

- Portion 1 of Beeren Valley Farm 150;
- Remaining Extent of Beeren Valley Farm 150; and
- Remaining Extent of Nooitgedacht Farm 148.

The Rietrug Wind Farm (Pty) Ltd will also share the on-site Acrux substation located on the adjacent Sutherland WEF site. The Rietrug Wind Farm (Pty) Ltd also received EA's for a new proposed onsite substation and associated electrical grid infrastructure to support issued on 14 March 2022 for the Sutherland WEF in the Northern Cape Province of South Africa. The EA for the onsite substation has been split into an Independent Power Producer (IPP) Portion EA Reference 14/12/16/3/3/1/2458, Switching Station Portion and 132kv powerline EA Reference 14/12/16/3/3/1/2457/AM1. Both will be included in the layout for the Rietrug WEF for completeness and demonstrate its connection to the National Grid. The authorised Rietrug WEF and Sutherland WEF are located adjacent to each other and will operate as a cluster. The infrastructure associated with the IPP Portion of the on-site substation located on Remaining Extent of Nooitgedacht Farm 148 and includes:

- IPP Portion of the on-site substation (Acrux)
- Laydown area;
- Operation & Maintenance Building;
- Fencing of the proposed on-site substation
- Battery Energy Storage Infrastructure (BESS)

The infrastructure associated with the Switching Station portion of the on-site substation and 132kV Powerline located on Remaining Extent of Nooitgedacht Farm 148 (DFFE Ref: 14/12/16/3/3/1/2457/AM1) includes:

- Switching Station portion of the on-site substation:
- Fencing;
- 132kV Powerline from the proposed Sutherland WEF on-site substation to the third party Koring Main Transmission Substation (MTS) including tower/pylon infrastructure and foundations;
- Connection to the Koring MTS third party substation
- Service road below the powerline
- Switching Station portion of the on-site substation

The Rietrug Wind Energy Facility will also consider the Environmental Authorisation for Electrical Grid Infrastructure that supports the Sutherland, Sutherland 2 and Rietrug Wind Energy Facilities, Northern & Western Cape Provinces (Ref; 14/12/16/3/3/1/2077/AM2) authorised within a 500m grid corridor.

The infrastructure associated with the project includes:

- Koring Main Transmission Substation (MTS); including O&M building and laydown area.
- Fencing of the proposed on-site substation
- Overhead 132kV powerline from the Sutherland WEF on-site substation to the Koring MTS;
- Overhead 400kV powerline connecting to the proposed 400kV Koring MTS and an existing 400kV Eskom powerline
- Service roads will be constructed below the powerline (jeep tracks)

The properties associated with the Electrical Grid Infrastructure to support the Rietrug WEF includes:

- Remaining extent of Hartebeeste Fontein Farm 147;
- Remaining Extent of Nooitgedacht Farm 148;
- Remaining Extent of Beeren Valley Farm 150;
- Portion 1 of Farm 219;
- Remaining extent of Farm 219;
- Remaining extent of Farm 280;
- Portion 1 of Rheebokkenfontein Farm 4;
- Portion 2 of Rheebokkenfontein Farm 4;
- Portion 2 of De Molen Farm 5;
- Portion 6 of Hamelkraal Farm 16;
- Portion 7 of Farm Hamelkraal 16; and
- Remainder of Spitzkop Farm 20

The Rietrug WEF has been awarded preferred bidder status in round 5 of the Renewable Energy IPP Procurement Programme (REIPPPP) and in order to meet financial close requirements and comply with the requirements of the EA (as amended), as per condition 16 and 18 which specifies that the applicant must submit a Final Layout plan and EMPr to DFFE for written approval prior to commencement of the activity.

Nala Environmental (Pty) Ltd has been commissioned to undertake the Final Layout plan and EMPr associated with the authorised WEF and it's authorised grid infrastructure. As per the conditions of the relevant EAs various specialist pre-construction walkthroughs have been undertaken to inform the placement of infrastructure for the Final Layout.

A storm water management plan (SWMP) is required to mitigate potential sedimentation and contamination from the proposed activities. A SWMP has subsequently been compiled to mitigate potential sedimentation and contamination from the proposed activities associated with the construction and operation of the WEF, as well as managing post-development discharge to the pre-development state. This is in part due to the potential presence of watercourse features on site and the partially impervious nature of the proposed activity (pit, spoil and roads). A key component of the investigation will be potential flood concentration areas, accommodation of peak storm events, best practice erosion control and the general impact of the development on downstream surface water resources for water users in the catchment.

1.2 Impact of Wind Energy Farms on Hydrology

WEFs in South Africa, which are becoming more abundant, may impact on the distribution of rainfall entering a catchment. The largest impacts are during construction as the size of the turbines require large vehicle/machines to transport to their destination, require deep piled foundations and large temporary storage areas. This results in potential erosion and an increase in stormflow. This is particularly relevant where slopes are steep. Following the construction phase, the impacts of WEFs on the hydrology is relatively low as natural and/or agricultural activities can continue and the disturbed footprint can be allowed to be rehabilitated without further disturbances.

In the context of this report, the following impacts are relevant:

- Change in runoff rates due to impeding structures (excavation and installation of foundations/crane pads for turbines).
- Reduction in surface and groundwater quality through excavation for cables, foundations and crane pads leading to sedimentation and potential spills.
- Increased flood risk due to increased impervious areas.
- Potential erosion around construction areas, impervious surfaces and drip from blades.
- Potential erosion due to the widening of existing roads.

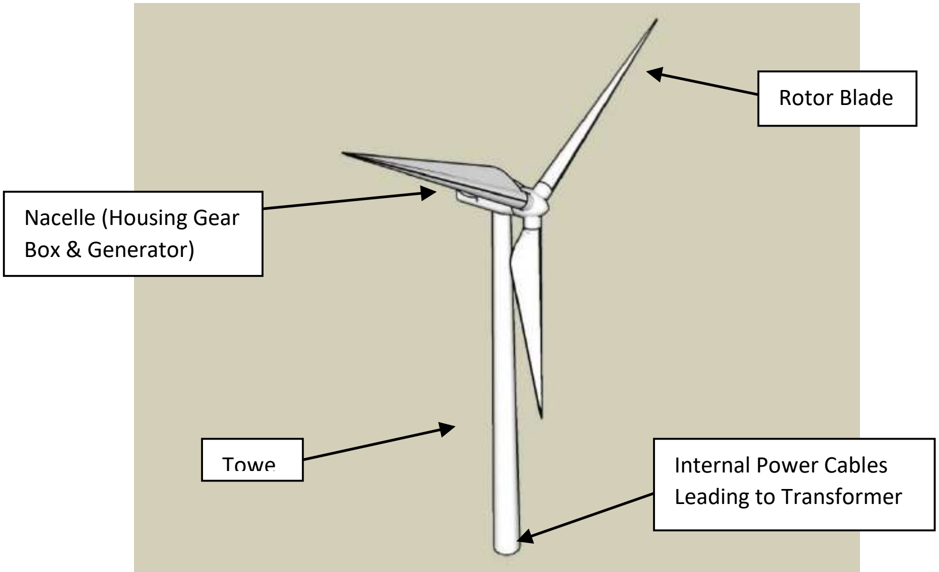


Figure 1 Typical design of a wind turbine (Suzlon model)

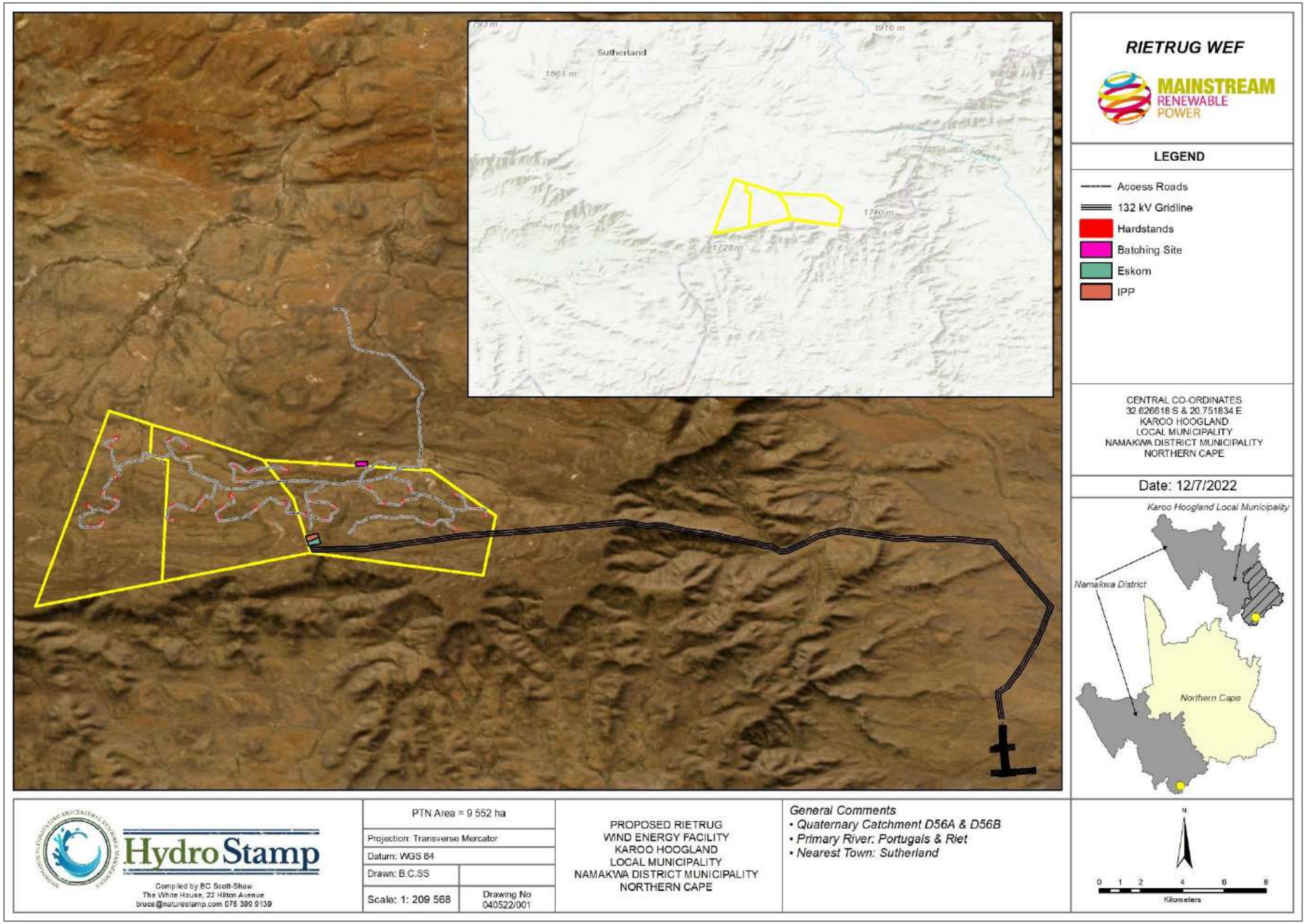


Figure 2 Locality map of the proposed Rietrug WEF

1.3 Terms of reference

NatureStamp has been appointed to compile a storm water management plan (SWMP). The SWMP is in accordance with Government Notice 704 (GN 704).

The terms of reference are as follows -

i. SWMP

- Revision of background data and SWMP near the site:
  a. Summarise report for inclusion in report;
  b. Update of data obtained since study completion;
  c. Revision of SWM structures
- Site hydrological assessment, undertaken by the:
  d. Analysis of surface areas of the site;
  e. Analysis of sensitive areas on site;
  f. Analysis of existing storm water structures on site; and
  g. Determination of areas with clean and dirty water.
- Hydraulic design analysis, illustrated by the:
  a. Determination of the design storm event (1:2, 1:10 & 1:50 year return period);
  b. Calculate PCD sizes and attenuation amounts;
  c. Determination of the capability of proposed structures; and
  d. Recommendation of mitigation options and improvements.
- Erosion control plan
  a. Compilation of erosion control measures;
  b. Identification of high risk areas, exclusion areas and potential stockpile areas;
  c. Identification of clean and dirty water areas/volumes.
  d. Final SWM, erosion mitigation measures and rehabilitation objectives.
- Consolidate results in a report with:
  a. Storm water maps;
  b. CAD storm water drawings and flood extents; and
  c. A storm water management plan report.

2. STUDY SITE

The site is located along the catchment divide of Quaternary Catchment D56A, falling under the Orange Management Area (WMA). The proposed WEF area sits on the plateau of Oliviersberg mountain range that is almost entirely natural excepts for some small structures and gravel roads. Liebenbergskop trig beacon is located on the property.

The proposed WEF is in the Karoo Hoogland local Municipality and the Namakwa District Municipality. The property is currently zoned as natural land with some agricultural land use with low agricultural potential, it was previously used for low intensity grazing however the properties are no longer actively used for agricultural activities, likely due to limited water.

Rainfall in the region occurs throughout the year (mostly March to August), with a mean annual precipitation of 253 mm (observed from rainfall station 0044765 W – Lynch, 2003). The reference potential evaporation (ET_o) is approximately 2 490 mm (A-pan equivalent, after Schulze, 2011) and the mean annual evaporation is between 1 800 – 2 000 mm, which exceeds the annual rainfall. This suggests a high evaporative demand and a water limited system. Summers are warm to hot and winters are cold with snow events. The mean annual temperature is approximately 22.5 °C in summer and 8.8 °C in the winter months (Table 2 – Schulze, 2003). The underlying geology of the site is sedimentary Adelaide Shale of the Karoo formation (Permian period) and the soils overlain are shallow sandy-clay-loam ranging from Mispah to Glenrosa form in this particular area.

Table 1 Mean monthly rainfall and temperature observed at Sutherland (derived from historical data)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Rainfall (mm)	7.4	10.4	18.2	21.4	29.8	43.1	32.9	32.2	19.1	15.9	11.8	11.5	**253.8**
Average Maximum Temperature (°C)	31.9	31.7	28.9	23.9	19.1	15.2	15.2	16.7	20.2	24.2	27.3	30.0	**23.7**
Average Minimum Temperature (°C)	13.7	14.0	12.8	10.5	8.0	5.6	4.8	5.5	6.9	9.0	10.8	12.8	**9.5**

Figure 3 General setting of the proposed Rietrug WEF site

3. METHODOLOGY

The following methodology was followed in order to meet the objectives as detailed in the terms of reference.

Table 2 Data type and source for the stormwater assessment

Data Type	Year	Source/Reference
Aerial Imagery	2013, 2016	Surveyor General
1:50 000 Topographical	2011	Surveyor General
2 & 5m Contour	2010	Surveyor General
River Shapefile	2011	NFEPA
Geology Shapefile	2011	Council of Geoscience, 2015/National Groundwater Archive
Borehole Data	Ongoing	National Groundwater Archive, WARMS
Land Cover	2015	Department of Environmental Affairs, Republic of South Africa
Water Registration	2013, 2016	WARMS - DWS

*Data will be provided on request

3.1 Catchment Assessment

The pre-development conditions were assessed as follows -

- The vegetation and surface characteristics of the watercourse were assessed for the determination of the Manning's n-values;

- The presence and dimensions of any storm water structures, such as culverts, bridges, drains, berms and gutters that would divert flow during a storm event were noted;
- The overall state of drainage channels, streams and nearby rivers was assessed;
- The slope of the study site as well as evidence of erosion around the site were noted; and
- The elevation throughout the site in order to verify contour data.

In accordance with Government Notice 704 (GN 704), the main objectives of a SWMP were:
1. To accommodate post-development storm events;
2. To keep clean and dirty water separated;
3. To contain any dirty water within a system; and
4. To prevent contamination of clean water.

A range of storm water design events were considered. 5-meter contours obtained from the Surveyor General were obtained and improved using a GPS. Rainfall data was extracted using the rainfall extraction utility tool (Kunz, 2003). Contributing catchment areas were calculated using the derived elevation model.

The critical contributing catchment area was determined for use in both the watershed delineation tool and HEC-HMS and SWAT models. The sub-catchments were delineated using the 5m contour set as an input. This was used to create a Digital Elevation Model (DEM) that was then used as an input to the watershed tool (Figure 4).

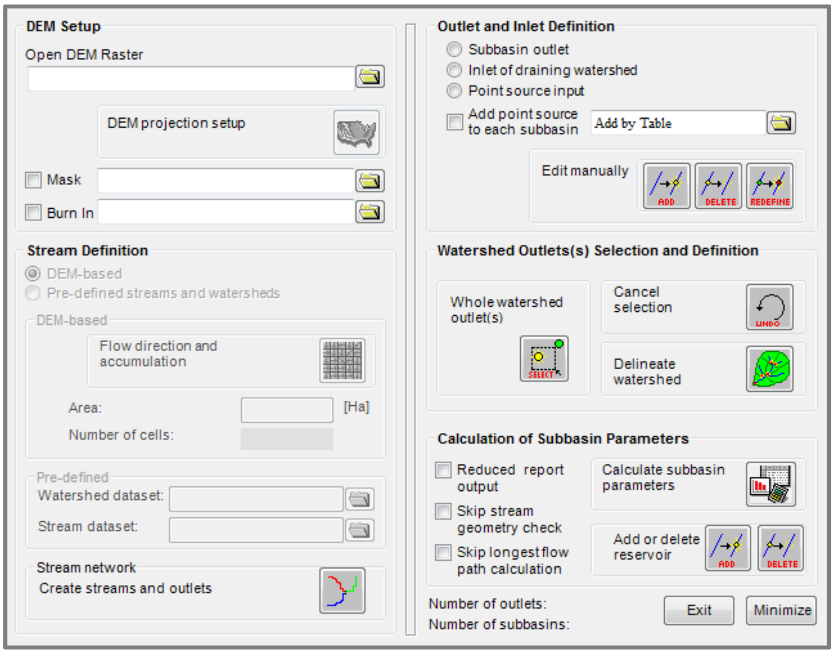


Figure 4 Soil Water Assessment Tool (*SWAT*) watershed delineation tool for sub-catchment delineation and stream network creation

Rainfall depths and design storm events were calculated using the Op Ten Noort (1983) method. This allowed for rainfall intensity curves to be generated. Additionally, the design rainfall depths using the Design Rainfall Estimation (DRE) tool was used for the nearest rainfall station.

3.2 Design Storm Determination

The peak flows for the 1:2, 1:5, 1:10, 1:50 and 1:100 storm events were calculated for the catchments using the SCS-SA method as outlined in the SANRAL Drainage Manual (6th Edition, 2013). The type of surface in the drainage basin is an important component in the design calculations. The SANRAL Rational Method becomes more accurate as the amount of impervious surface, such as pavements and rooftops, increases. As a result, the Rational Method is most often used in urban and suburban areas (ODOT Hydraulics Manual, 2014). The Utility Programme for Drainage (Sinotech) was used to run the rational method, determine drainage grid and kerb drainage calculations.

It is recommendations that the 1:50 year return design for a 30-minute storm was is used as a typical event to design for. The areas of the proposed infrastructure can be seen in Table 3.

Table 3 Activity/Infrastructure areas

Activity/Infrastructure	Impervious	Area
Access Roads and culverts	Partial	430 000 m^2
Transformers/Substation (Eskom & IPP)	Yes	250 000 m^2
Batching Plant	Yes	120 000 m^2
Lay Down Area (incl. Turbine Footprint)	Yes	380 000 m^2

3.3 Storm Water Design Principles

The objective of the Stormwater Management Plan is to control runoff flows and prevent detrimental impacts on receiving waters, considering both the quality and quantity of the stormwater runoff. As the existing site has natural impervious areas, gentle slopes and moderate soils, the velocity of stormwater runoff would be considered to be low. Furthermore, as the site is located near the catchment divide, there are little upper catchment contributions.

Stormwater management design principles to be followed on site include:

- Clean water should be kept clean, as far as possible, and be routed to a natural watercourse by a system separate from the dirty water system and should be allowed to pass through to downstream users, while preventing or minimising the risk of spillage of clean water into dirty water systems.
- The establishment and maintenance of grass and plants adjacent to newly constructed infrastructure and graded roads.
- Dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage or seepage into clean water systems must be minimised. The containment of dirty or polluted water will minimize the impact on the surrounding water environment.
- The design standard stipulated by GN704 is not that a 1 in 50-year flood should be captured, but that the structure may not spill more than once every 50 years. Design storage volumes are a function of peak storage requirements that often correspond to abnormally wet conditions that continue for an extended period of time, and not to a specific flood event
- Reasonable measures must be taken to ensure that dirty water is contained. All dirty water must be captured and transported in channels (capable of containing 1:50-year design floods) to prevent the seepage of contaminated water into groundwater resources. Dirty water runoff must be stored in a PCD, where reasonable precautions are taken to prevent leaks or seepage.
- Hazardous or environmentally dangerous chemicals kept on site must be kept outside of the 1:100 year flood line and watercourses or appropriately bunded.
- Regulations stipulate a clear hierarchy of water use. Firstly, recycle any captured dirty water and minimise the import and use of clean water resources. Should excess water released from a dirty water area must be treated to a standard agreed to by the regulator, Department of Water Affairs and Sanitation (DWS), and any plan to treat and release excess water must be approved and licensed.
- Special attention should be paid to early rehabilitation of laydown and other dirty water areas to reduce the dirty water footprint area to an absolute minimum. This will reduce the total volumes of dirty water and simplify the final measures to be taken. Part of any SWMP will include processes that identify and implement opportunities to reduce the dirty water footprint areas. A benefit of smaller dirty water footprint areas is that possible polluted runoff is reduced, fewer drains are required and PCDs can often be smaller. (Smaller surface area equates to cheaper and more effective storm water management).
- The SWMP must be sustainable over the life cycle of the SEF and over different hydrological cycles and must incorporate principles of risk management. Portions of the SWMP, such as those associated with the footprint, may have to remain after potential closure since management is required till such time that the impact is considered negligible and the risk no longer exists.
- Groundcover should be maintained during construction to ensure erosion protection.
- Flow concentration points should avoid unstable soil areas and/or stockpiles.
- All pollution from the surfaces should not flow directly into water resources.
- Ensure aesthetic designs.

The above-mentioned principles are to be used as a conceptual stormwater management guide.

4. LIMITATIONS AND ASSUMPTIONS

In order to apply generalized and often rigid design methods or techniques to natural, dynamic environments, a number of assumptions are made. Furthermore, a number of limitations exist when assessing such complex hydrological systems. The following constraints may have affected this assessment:

- Manning's n - values (the channels roughness coefficient) was estimated on site. However, most of these values were general assumptions as all of the flow on site would be overland flow (limited channels exist within the site).
- There were no sub-surface servitudes identified on site. It was assumed that storm water concentrations points would be undertaken at strategic locations.
- It was assumed that the roads are partially impervious (compacted gravel).
- It was assumed that all storm water systems on site were 90 % unblocked.
- Given the setting of the site it was difficult to determine which channels would be fully active in a small event and which are remnant channels which have since been bypassed.
- Potentially polluted runoff from the "dirty" water areas must (in terms of GN704) be captured and contained in a PCD.
- The larger the disturbed area the larger the required PCD and storm water infrastructure will be and management is likely to become both more complex and more expensive. Therefore, it is important to keep the dirty water areas as small as possible and divert clean water around and away from these areas as much as possible.

5. RESULTS AND DISCUSSION

The following results were used as input to the selected models and have been provided here.

5.1 Desktop Assessment

5.1.1 National Freshwater Ecosystem Priority Areas (NFEPA) Project / Assessment

In accordance with the NFEPA guidelines, the site does fall within 500 meters of a recognized NFEPA wetland or watercourse. These are small depression and seep wetlands, typical of the area. There are three main channels within the property boundaries. These are a tributary of the Portugals (Catchment 1 & 2) and two tributaries of the Rietrivier (Catchment 3). The layer codes for River FEPAs and associated sub-quaternary catchments, Fish Support Areas and associated sub-quaternary catchments and Upstream Management Areas. Through the site investigation, it is clear that this boundary needs to be refined as some important areas (ox bow lake etc.) are not indicated as NFEPA wetlands with some dryland areas digitized as NFEPA systems. This is common through desktop/model derived databases.

5.1.2 Terrain, Soils, Geology & Vegetation

Contour lines (2 meter) were used to calculate the slope of each of the banks. The soils and geology were obtained from GIS layers. Various vegetation databases were used to determine the likely or expected vegetation types (Mucina & Rutherford, 2006; Scott-Shaw & Escott, 2011). A number of recognized databases (*c.f.* Table 4) were utilized in achieving a comprehensive review and allowing any regional or provincial conservation and biodiversity concerns to be highlighted.

Natural vegetation of the area is Roggeveld Shale Renosterveld (FRs 3, Mucina and Rutherford, 2006). This occurs within the Fynbos biome. The desktop analysis revealed that the area is a least threatened area, with the potential for some flagged fauna and flora (e.g. red data species and endangered wildlife) being found from the C-plan, SEA and MINSET databases. However, this does not necessarily mean that rare or endangered species will occur in the area of interest.

- **Distribution**: Northern and Western Cape Provinces: Major part of the Roggeveld bordered by the edge of the western Great Escarpment mostly above the Tanqua Basin. South of the Hantam Plateau region in the upper parts of the range of the Keiskieberge and isolated high plateaus to the south including plateaus such as Grootberg, Saalfontein se Berg, Sneewkrans and Swaarweerberg encompassing the vicinity of Middelpos and Sutherland, reaching as far east as the higher-lying areas of the Teekloof Pass south of Fraserburg along the northwest summit plateaus of the Nuweveldberge.
- **Altitude**: 1 200–1 900 m.
- **Vegetation & Landscape Features**: Undulating, slightly sloping plateau landscape, with low hills and broad shallow valleys, supporting mainly moderately tall shrublands dominated by renosterbos, with a rich geophytic flora in the wetter and rocky habitats.
- **Geology & Soils**: Mudrocks and sandstones of the Adelaide Subgroup (Beaufort Group of the Karoo Supergroup) dominate the geology. Some intrusions of the Karoo Dolerite Suite are also present. Glenrosa and Mispah forms are prominent.
- **Land types**: mainly Fc and Da.
- **Climate**: MAP 180–430 mm (mean: 305 mm), even throughout the year, showing a slight peak in March. Mean daily maximum and minimum temperatures 29.3°C and 0.2°C for January and July, respectively. Frost incidence is remarkably high for a renosterveld type (30–70 days per year).

5.1.3 Site Analysis

The site is currently mostly modified from grazing. The small combined contributing catchment area of 144.0 km^2 is predominantly vegetated with sparse grassland and cultivated lands. Patches of low schrubland occur throughout the catchment. The grasslands are in fair condition. There is a lack of drainage lines as the site is completely flat. The drainage lines lower in the catchment would have a slow response to storm events.

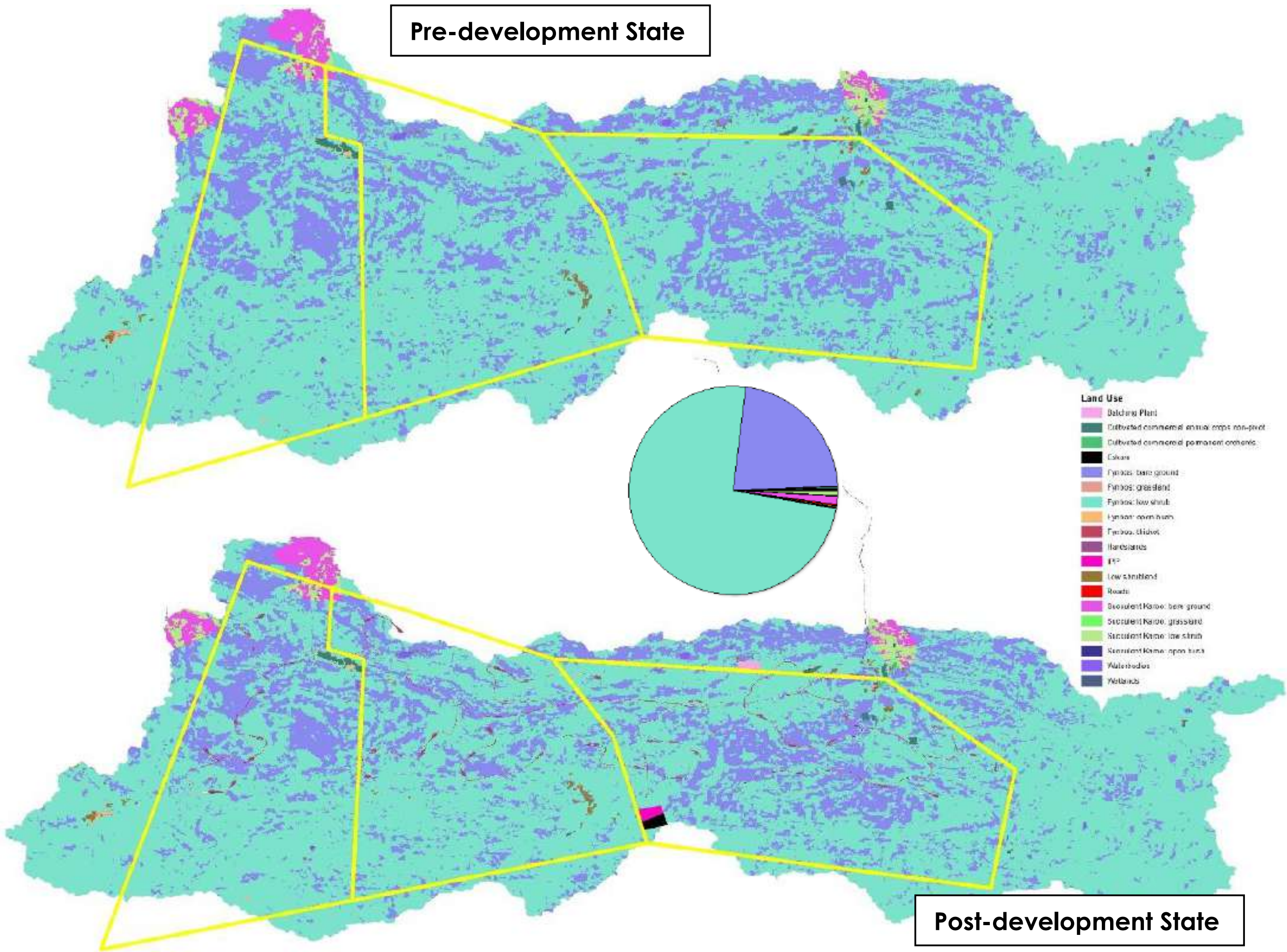


Figure 5 land cover for the contributing catchment of Rietrug WEF

Table 4 Land cover area for the contributing catchment area

Land Cover	Pre-development Area (ha)	Percentage	Post-development Area (ha)	Percentage
Hardstands	0	0.00	38.3	0.26
Batching Plant	0	0.00	12.1	0.08
Cultivated commercial annual crops non-pivot	26.9	0.18	26.8	0.18
Cultivated commercial permanent orchards	2.6	0.02	2.6	0.02
Eskom	0.0	0.00	12.5	0.08
Fynbos: bare ground	3333.1	22.66	3308.0	22.47
Fynbos: grassland	6.0	0.04	6.0	0.04
Fynbos: low shrub	10989.4	74.70	10902.7	74.07
Fynbos: open bush	6.7	0.05	6.7	0.05
Fynbos: thicket	3.8	0.03	3.8	0.03
IPP	0.0	0.00	12.7	0.09
Low shrubland	35.5	0.24	35.1	0.24
Roads	0.0	0.00	43.8	0.30
Succulent Karoo: bare ground	182.0	1.24	181.9	1.24
Succulent Karoo: grassland	3.0	0.02	3.0	0.02
Succulent Karoo: low shrub	106.8	0.73	106.8	0.73
Succulent Karoo: open bush	0.6	0.00	0.6	0.00
Waterbodies	12.3	0.08	12.3	0.08
Wetlands	3.3	0.02	3.3	0.02
Total	**14712**	**100.00**	**14719**	**100.00**

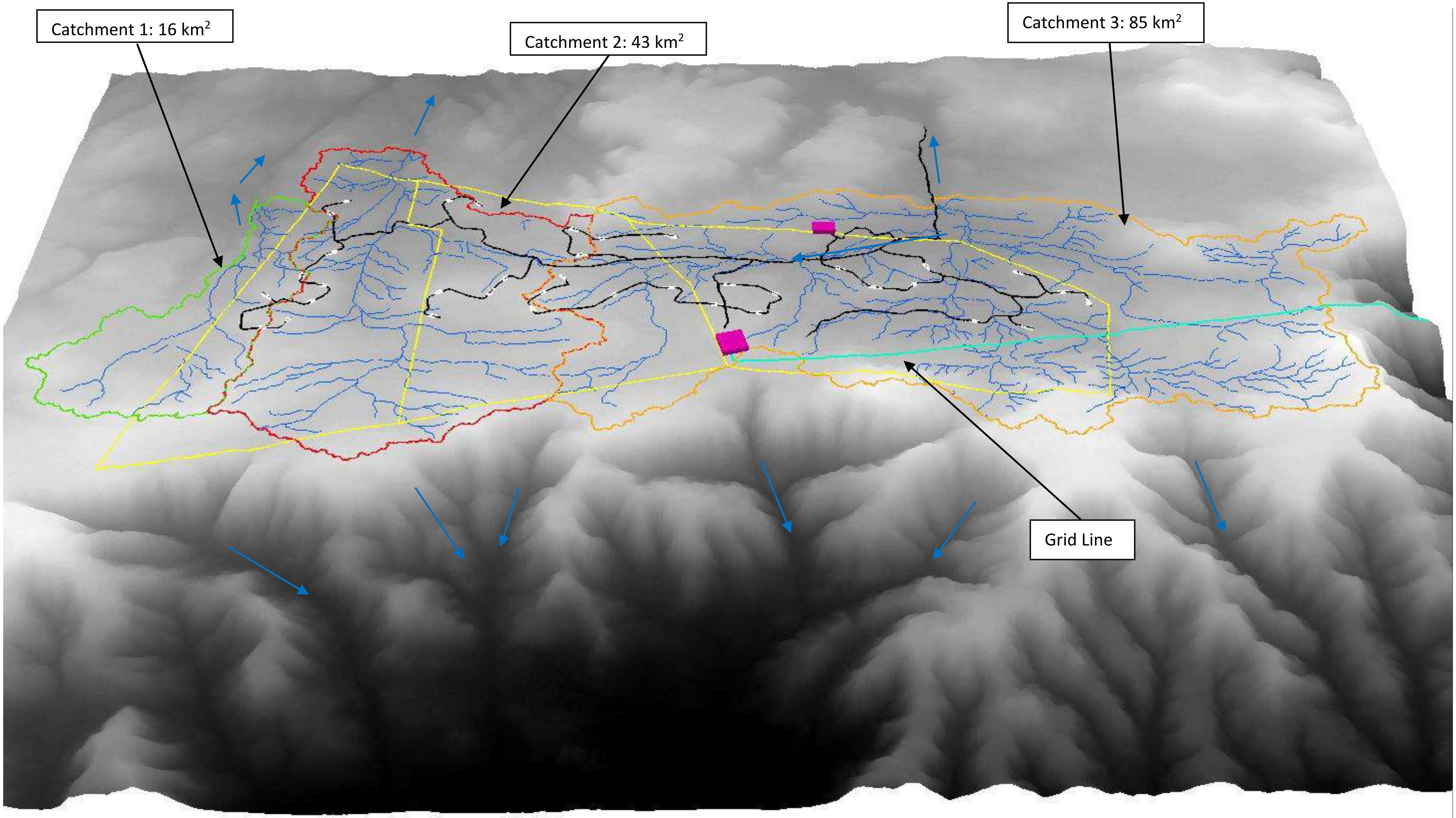


Figure 6 Exaggerated terrain model for the catchment area of the Rietrug WEF

5.2 Climate Analysis

The long term annual rainfall data (Station 074363 W – 50 km from the site) as well as design rainfall was sourced for the study area. The long term annual rainfall for numerous stations was extracted using the Daily Rainfall Extraction Utility (Lynch, 2003). Mean Annual Precipitation (MAP) for the study area is approximately 254 mm (Figure 9 – Lynch, 2003; Climate Forecast System Reanalysis (CFSR)). Some inconsistencies were identified in this record (e.g. some missing data in the early1900s and some large flood events not being recorded), these were verified using nearby stations and corrected as such. The best rainfall records were synthesized with the more recent data to create a new rainfall record that could be used in the design flood estimation. The station in close proximity, with similar altitude and MAP and a reliable record was selected.

Table 5 Comparison of values from some of the rainfall stations that were assessed during the data analysis

Station No.	Estimated MAP (mm)	Observed MAP (mm)	Years	Reliable	Patched	Altitude (m)	Station Name
004050 W	224	225	122	32.4	32.9	776	Touwsrivier (SAR)
074363 W	254	254	84	45.6	42.1	637	Klipfont
074285 W	222	222	58	51.8	38.3	520	Uitkomst
0044134 W	315	314	120	16.7	82.5	836	Nooitgedag
0044765 W	252	252	120	58.7	40.5	1067	Pieter Meintjies (SAR)
0044286 W	206	207	122	41.0	58.7	866	Jan De Boers
0045134 W	170	173	120	80.3	19.3	902	Matjiesfontein (SAR)

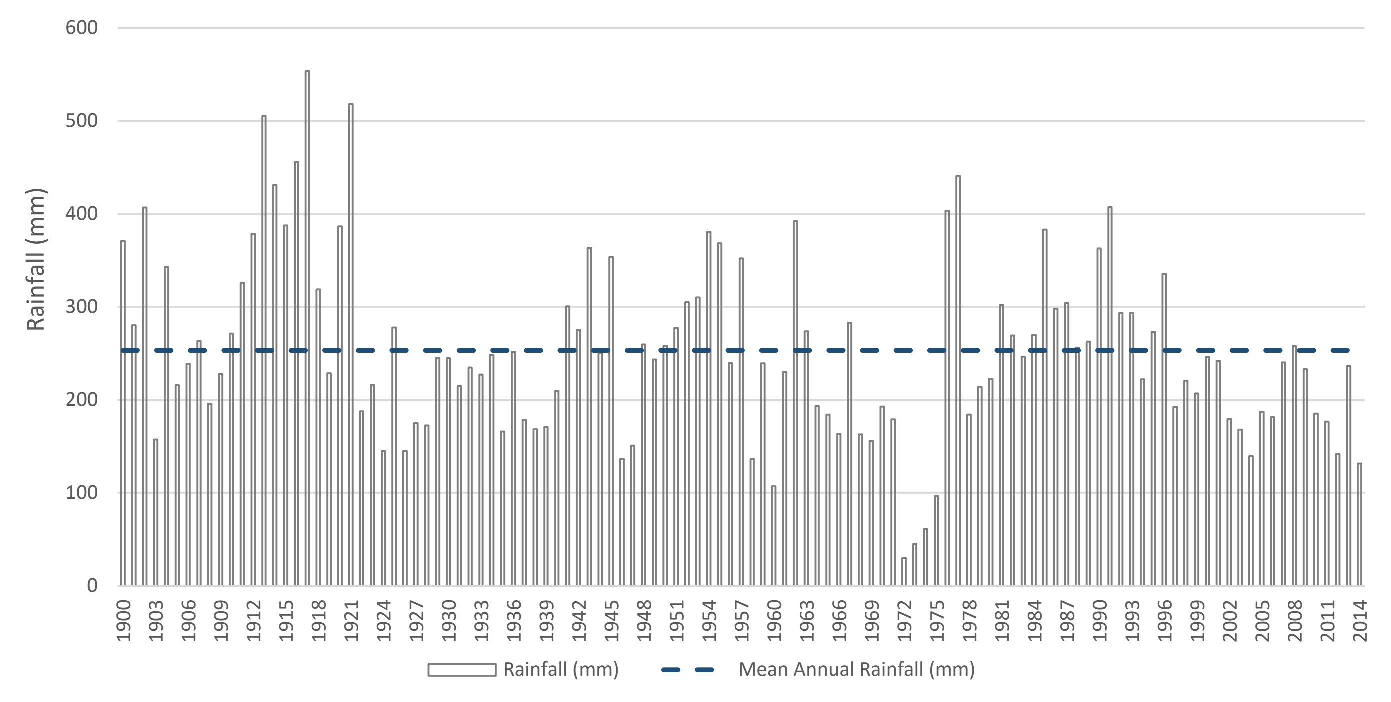


Figure 7 Long-term annual rainfall (annual in blue) near Sutherland

5.3 Design Rainfall

Design rainfall differs from mean annual rainfall as it is rainfall associated with an events rainfall depth for a specified storm duration and a recurrence interval (frequency of occurrence). The design rainfall used is dependent on the method used to determine the peak discharge. The SCS-SA method uses 1 day-rainfall for various return periods while the Rational and SDF Methods use rainfall intensity linked to the catchments Time of Concentration (Tc) and Storm Duration. The Design Rainfall Estimation (DRE) tool which uses observed rainfall data was included for comparative purposes. The results of the design rainfall assessment have been provided in Annexure A. A summary of these results has been provided in Table 7.

Table 6 Design rainfall for the Rietrug WEF

Station Name & ID	Obs MAP	Years	Altitude (m)	Design Rainfall (mm)						
				2	5	10	20	50	100	200
Klipfont - 074363 W	254	84	637	34	49	61	73	91	107	124

5.4 Design Storm Determination

5.4.1 Delineation of Clean and Dirty Water Catchments

Clean and dirty water areas were mapped out, based on the WEF infrastructure provided and the topography. The layout is still being finalised. As such, the recommendations will be amended once this information becomes available.

Runoff from surrounding upstream catchments of the dirty areas were considered to be clean. All clean water must be diverted around the dirty water areas into a nearby channel, as per the GN 704 requirements, to ensure that clean water never mixes with dirty water. The clean water catchments are presented in Figure 6 for each of the WEF areas and a summary of each catchment is presented in Table 8.

Table 7 Calculated peak runoff for each clean and dirty water sub-catchment for a 1:50 year return period using the rational method

Sub-catchment	Area (ha)	Runoff Depth (mm)	Peak Runoff ($m^3.s^{-1}$)	Runoff Coefficient
1 (Clean)	1600	29.1	28.6	0.11
2 (Clean)	4300	35.6	36.2	0.11
3 (Dirty)	8500	42.8	44.0	0.11

5.4.2 Storm Water Volumes

The storm water volumes were calculated for the contributing catchment of the Rietrug site as well as for the sub-catchments.

Table 8 Calculated peak runoff for the pre- and post-development state sub-catchments for a 1:50 year return period using the SCS-SA method

Structure (50yr RP)	State	Area (ha)	Peak Runoff ($m^3.s^{-1}$)	Discharge Depth (mm)	Attenuation Required (m^3)
Substation	Pre-development	0	0.99	795	1275
	Post-development	25	2.44	1 238	
Batching Plant	Pre-development	0	0.47	550	612
	Post-development	12	1.1	858	
Lay Down (each)	Pre-development	0	0.04	161	52
	Post-development	1.03	0.099	251	

For the substations, based on a 25 ha area, it was calculated that **1 275 m^3** attenuation is required. It is assumed that the access roads that will be utilized will have open drains which are recessed into the ground. Cut-off drains would be placed strategically and increased in high slope areas (*c.f.* Figure 11). Drains were assessed to determine if they could handle certain design events, the following calculation was used (SANRAL Drainage Manual 5th Edition):

$$Q = 1.77 \times A\sqrt{H}$$

Where: Q = Flow Capacity ($m^3.s^{-1}$)
A = Area of inlet (m^2)
H = Submergence (m)

Therefore A = (0.65 * 0.375) = 0.24 m^2
H = 0.2 (assumed for the site)

Drowned conditions were assumed and a blockage coefficient of 0.3 was assumed due to the small amount of debris likely on site. The equation $Q = CFA\sqrt{2gH}$ was used in this setting. Although open drains are being used, the aforementioned calculation was used as a guideline to see if the excess runoff could be accommodated.

5.4.3 Storm Water Management Structures

- Proposed channel drainage measures for the Rietrug WEF include a set of naturally lined channels using the shallow rock layer (to capture and transport dirty water) and unlined earth channels (to capture and transport clean water) presented.

- It is proposed that runoff from all dirty water catchment be captured in a naturally lined channel (roughness of n = 0.013 s/m1/3) and stored in a PCD for reuse in the maintenance and/or dust suppression.
- Clean water from the clean water catchment are diverted away/around to ensure that this water does not mix with the dirty water areas. Where clean water runoff cannot be diverted, water is captured in clean stormwater/attenuation structures.
- In most cases the clean storm water could be diverted around the pits and other dirty water areas via earth channels (roughness of n = 0.025 s/m1/3).
- The clean water catchments should flow in the natural drainage line and should then be diverted around via an earth channel (roughness of n = 0.025 s/m1/3).
- Sizing of drainage channels for each sub-catchment area was based on the South African SCS type 2 method (SANRAL, 2013).
- Cut-off drains as per the design recommendations must be installed to facilitate the control of surface water runoff velocities from roads.
- Any erosion caused from excess discharge adjacent to road and/or pit and stockpile areas must be rehabilitated immediately. This would involve re-vegetation, geotextiles or rock gabions. This would be identified by the ECO.
- Runoff around the overburden dump areas need to be protected by erosion protection, diversion channels to increase infiltration and promote the natural runoff regime. Runoff should not be concentrated at one point.
- All sewage will be removed from the site by a suitable waste disposal company.

All runoff under the development footprint can and should be contained and managed within the site boundary. Temporary storm water structures should be put in place if pollution and spills are evident on site. The WEF area should be completely rehabilitated after completion through re-vegetation and erosion control. Guidelines should also be followed based on the wetland/riparian assessments and rehabilitation plan.

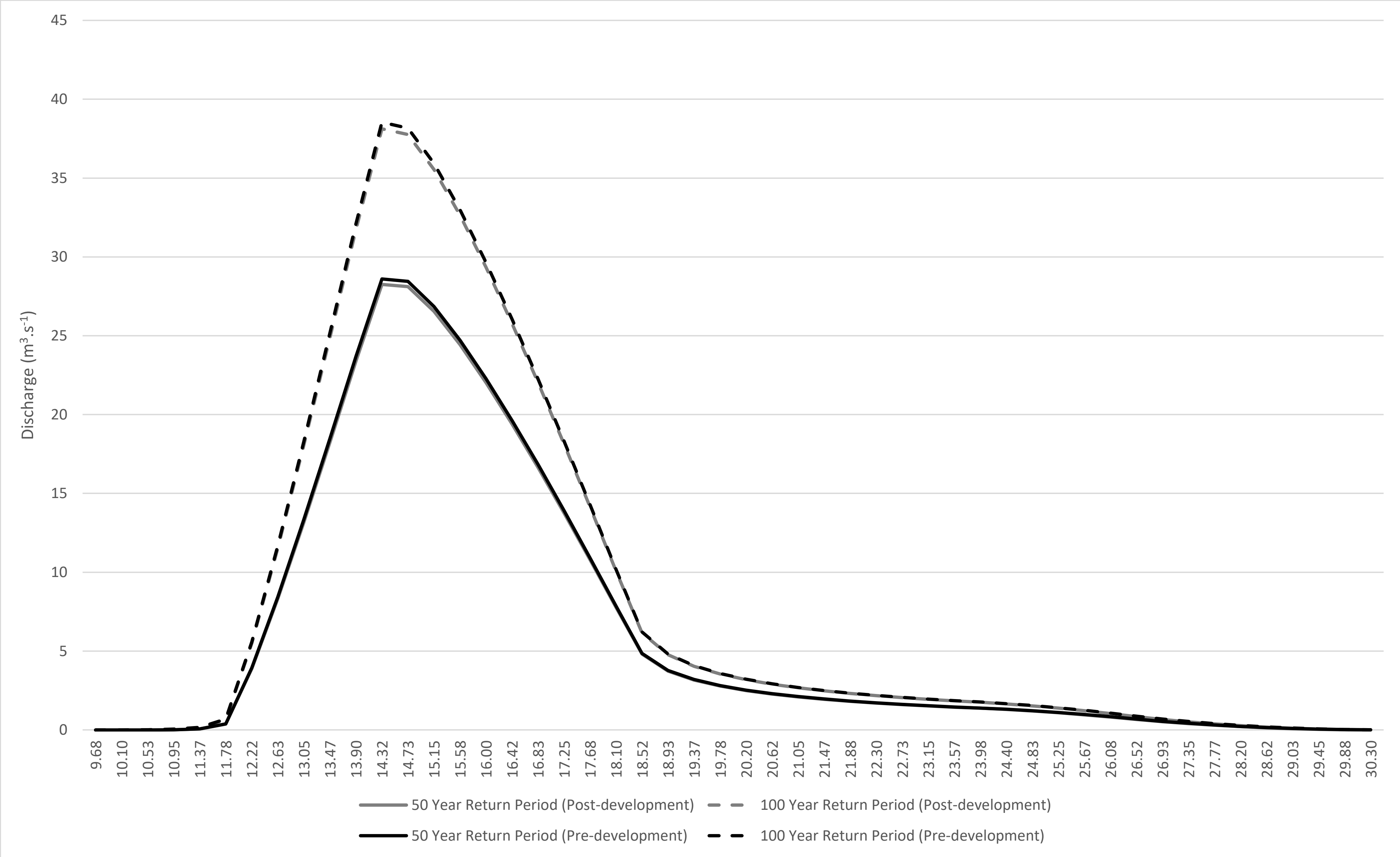


Figure 8 Hydrograph for the entire catchment area pre- and post-development

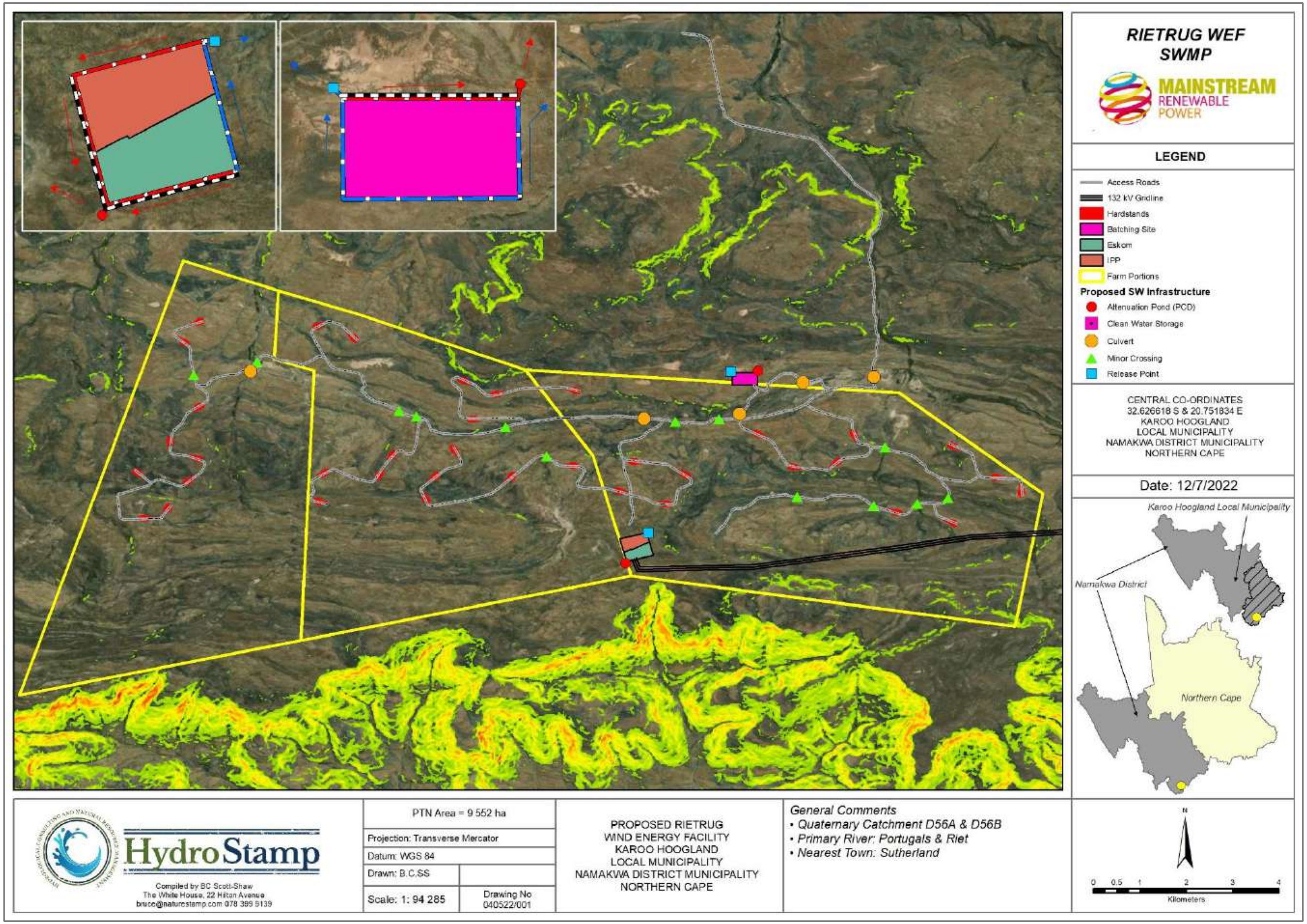
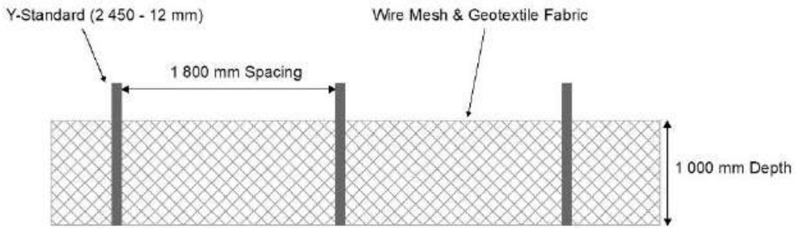
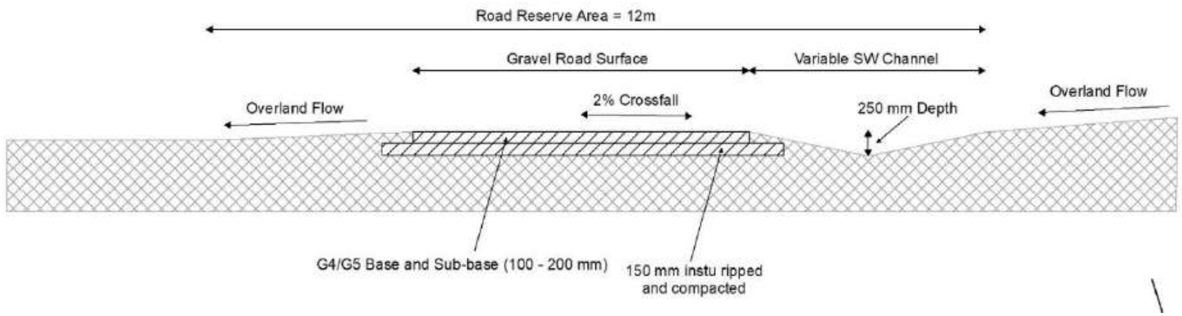
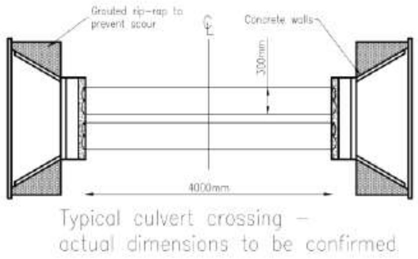
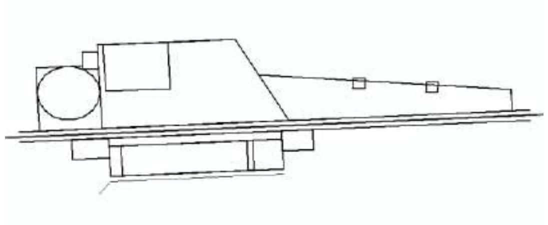
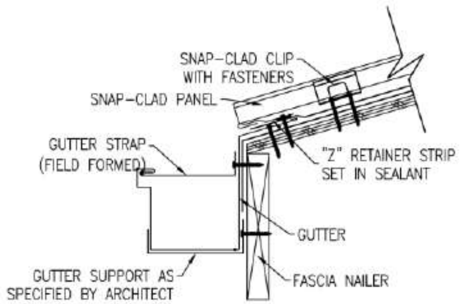
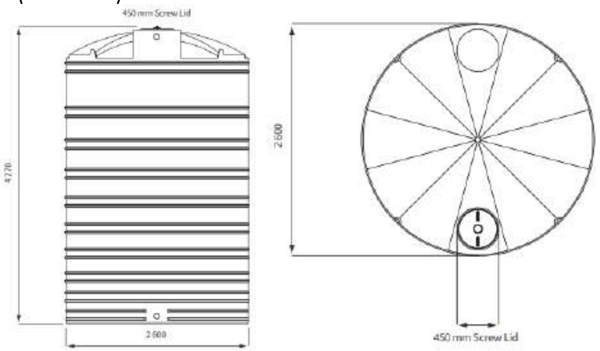
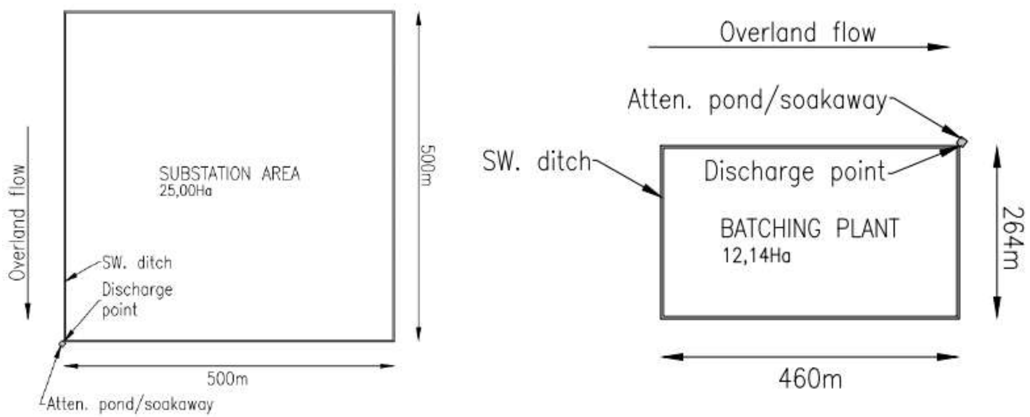


Figure 9 Storm water management plan for Rietrug WEF

Table 9 Intervention measures per phase at the Rietrug WEF area

Unit	Activity/Risk	Severity	Intervention
Preliminary Stage			
Access Roads	Route planning	Low	• Ensure watercourse crossings are kept to a minimum; • Ensure steep slopes are avoided where possible; • Ensure existing roads are used where possible.
Laydown Areas/Camps	Site planning	Low	• Ensure sites are flat; • Ensure sites are away from watercourses; • Ensure the bearing capacity and bed rock is stable for foundations and platform weight.
OHL	Route planning	Low	• Ensure watercourse crossings are kept to a minimum;
Construction Stage			
Access Roads	Expansion of gravel roads to between 8 to 12 meters. Grading of roads. Risk of erosion and sedimentation	Moderate	• Temporary silt traps in any development areas where the slope exceeds 12° (see design and layout in light blue below).  • Storm water runoff be directed to the lower side of the gravel roads. At this point it should then be collected in side drains and disposed of in designated places by means of suitable outlet structures (cut-off drains and rockeries) and berms.  • No dirty water must be directed into watercourses. • Roads should be constructed at-grade to allow for continued flow; • Only include side drains where inundation or damage may occur otherwise the natural flow path would be interrupted; • At crossings, stone protection walls should be constructed on either side to reduce scour; • all storm water runoff be directed to the lower side of the gravel roads. At this point it should then be collected in side drains and disposed of in designated places by means of suitable outlet structures and berms.

			• Any significant crossing must use a culvert. 
Laydown Areas & Hardstands	Contamination from construction activities. Risk of erosion and sedimentation	Moderate	• Compounds, storage and lay-down areas must be clear of all debris, and the area must be level and free draining and have the same bearing capacity and proof testing as the Crane Pad. • No dirty water must be directed into watercourses. • Emergency pumps should be in place to remove any water at the bottom of excavated areas if needed. • Temporary silt traps and berms should be constructed around the footprint (see above) • Hardstands should follow road interventions with a cutoff drain to discharge water to the lowest point. 
Construction Camp	Potential pollution from staff. Potential oil spills from vehicles and equipment. Risk of erosion and sedimentation	Moderate	• Drains and berms at concentration points to manage and divert surface flow/ runoff from all structures during operation. • Gutters, downpipes and storage tanks (10 000 L) should be installed to attenuate storm events.  • No dirty water must be directed into watercourses. • Flows must be attenuated and subsequently directed towards natural flow paths.

			• Effluent from construction staff must be treated on-site otherwise it should be removed from the site. • The calculated attenuation volume required for the entire camp is 943 m^3. Some of this could be accommodated within rainwater harvesting structures.
IPP/Eskom Substation & Batching plant			• Temporary silt traps in any development areas where the slope exceeds 12°. • Revegetation of any disturbed areas. • Dirty water from the footprint must be diverted and treated. 
OHL	Disturbance of soil and vegetation from collector footprint.	Low	• Temporary silt traps in any development areas where the slope exceeds 12°. • Revegetation of any disturbed areas. • Underground cabling areas should ensure sub-soil and top-soil are layered as per their natural state. • Steep areas should have additional erosion control measures put in place.
Operation Stage			
Access Roads	Operation of vehicles along roads. Potential erosion channels.	Low	• Undertake a periodic site inspection to verify and inspect the effectiveness and integrity of the storm water run-off control systems. • Immediate rehabilitation should erosion occur. • Temporary silt traps to continue for 1 year during operation in any areas where the slope exceeds 12°.
Laydown Areas/Camps	Increased stormflow from surface Risk of erosion and sedimentation	Low	• Undertake a periodic site inspection to verify and inspect the effectiveness and integrity of the storm water run-off control systems. • Immediate rehabilitation should erosion occur.
OHL	Continued disturbance of soil and vegetation from collector footprint.	Low	• Undertake a periodic site inspection to verify and inspect the effectiveness and integrity of the storm water run-off control systems. • Immediate rehabilitation should erosion occur.

5.5 Potential Spill Scenarios

Due to the nature of the activity, there is a chance of potential spills occurring on site (equipment etc.). This is largely due to construction equipment/machinery. The potential spill scenarios are outlined as follows:

1. Spills and leaks from vehicles. These incidents are likely to take place on site. Regular removal of spills and leaks should be undertaken on-site. Eco-friendly detergents should be used.

2. The potential for sediment contamination from spoil sites.

3. A storm or flood event occurs during construction activities, resulting in structures being exceeded. All activities should stop and a spill management plan be executed. Furthermore, erosion control actions should be initiated.

5.6 Mitigation Measures and Recommendations (Spill Management Plan)

The Rietrug WEF site should employ best practise stormwater management practises, as outlined below–

- Site preparation should take place during the dry season wherever possible. Construction should stop during heavy rains.
- Vegetation clearing should be limited as much as possible and plants rescued for rehabilitation.
- Directing clean stormwater towards natural drainage lines, contours and dispersing over grassed, flat areas (preferably the existing watercourses).
- Vehicles and equipment must be kept outside of watercourse buffers and flood lines.
- Vehicles and equipment must be kept clean and serviced off site.
- Staff/workers on-site must be educated on identifying potential erosion areas and best practice guidelines.
- Energy dissipating measures with regards to stormwater management would be installed where necessary to prevent soil erosion.
- The engineer or contactor must ensure that only clean stormwater runoff enters the environment.
- Drainage should be controlled to ensure that runoff from the project area does not culminate in off-site pollution, flooding or result in any damage to properties downstream, of any stormwater discharge points.
- Any temporary storage area must have the following:
  - Completely lined infrastructure (concrete bunded area), with the capacity to contain 110% of the total amount of petrochemicals stored;
  - Spills must be completely removed from the site; and
  - Fire extinguisher equipment installed within the facility.

Furthermore, as guided by the DWS, the following soil erosion measures should be put into place –

- Erosion control measures should be put in place to minimize erosion along the construction areas. Extra precautions must be taken in areas where the soils are deemed to be highly erodible.
- Soil erosion onsite should be prevented at all times, i.e. post- construction activities.
- Erosion measures should be implemented in areas prone to erosion such as near water supply points, edges of slopes etc. These measures could include the use of sand bags, hessian sheets, retention or replacement of vegetation if applicable and in accordance with the EMPR and the biodiversity impact assessment.
- Where the land has been disturbed during construction, it must be rehabilitated and re-vegetated back to its original state after closure.
- Stockpiling of soil or any other material used during the construction phase must not be allowed on or near steep or unstable slopes, near a watercourse or water body. This is to prevent pollution of the impediment of surface runoff. The layout of the proposed sites have accounted for these areas and have been strategically placed.

In order to reduce the potential impact of spills on site the following must be adhered to:

- Emergency numbers are provided on site – e.g. Spilltech, fire department, ambulance, etc.;
- Spill cleaning kits such as a Drizit kit are available on site;

- All chemicals on site are recorded in the inventory of hazardous substances (Safety Data Sheets (SDS) will be available on-site);
- Equipment, machinery and vehicles are regularly checked and maintained in good order;
- Machinery and equipment maintenance is undertaken in designated areas; and
- Drip trays are to be placed underneath machinery and equipment during maintenance.

In the instance of a spill on site the following procedure must be followed:

1. Locate the source of the spill;
2. Stop the spill and prevent further spreading;
3. The appropriate oil sponge, absorbent or spill kit (e.g. DriZit) can then be used to clean and remove the spilled substance(s);
4. Spills from trucks must be contained within a lined site area and prevented from spreading;
5. Spilled petrochemicals can then be cleaned up and removed using the appropriate oil sponge, absorbent or spill kit (e.g. DriZit);
6. The spill must be reported to the site manager / supervisor and ECO;
7. Depending on the significance of the spill, the incident may also need to be reported to the DMR, DEDTEA and/or DWS.

5.7 Erosion Control Plan

There is an overlap between the storm water management and erosion control. The erosion control is particularly relevant during the construction period and at certain locations after closure. The removal of vegetation also leaves the site at a higher risk.

- Immediately rehabilitate eroded areas:
    - Install protective structures, e.g. geotextiles;
    - Ensure the slope remains gentle and stable;
    - Use vegetation plugs, rock packs or gabions where erosion is visible;
    - Immediately revegetate the area.
- Ensure that steeper areas are avoided and that the vegetation remains at these sites.
- Continual erosion monitoring should occur by a trained staff member.

The site should take into account the following erosion control mechanisms:

- Geotextiles;
- Gabion baskets;
- Soil binding chemicals;
- Hydroseeding techniques (only if feasible);
- Vegetation plugs;
- mulch

To ensure rehabilitation is effective, it is vital that the working area is managed correctly during the construction phase. An important part of this management will be that careful preservation and management of stockpiles should be implemented from the start of the site. The following points have been provided for use with the rehabilitation actions:

- Top- and subsoil stockpiles (used for road levelling and bank lifting) must not be stockpiled within 100m or within the 1:100 year floodplain of a watercourse.
- Naturally occurring vegetation removed by site clearance operations may be grubbed in with the topsoil for stockpiling.
- The topsoil shall not be buried or rendered in any other way inappropriate for rehabilitation use.
- Topsoil stripping (in widening and realignment areas) shall not occur in wet weather and during stripping and stockpiling, the topsoil shall not be subject to a compaction force greater than 1 500kg/m² and shall not be pushed for more than 50m.
- Topsoil shall also only be handled twice, once to strip and stockpile, and secondly to replace, level, shape and scarify if necessary.
- Top soil stockpiles must be protected against erosion and a record kept of all top soil quantities and should there be shortfalls of topsoil required for rehabilitation, adequate replacement material from commercial sources should be obtained as approved by the Engineer (preferably from areas identified with sourced excess topsoil).

- Equally, excess topsoil shall be landscaped and stabilized in accordance to the requirements of the Engineer and in consultation with the Contractor's Land Rehabilitation Specialist.
- The stockpiles will need to be enriched or upgraded prior to rehabilitation. The Contractor shall consult with the Engineer with regards to matching preconstruction conditions or existing adjacent conditions.
- All stockpiles left for extended periods of time shall be stabilized using approved vegetation cover or other erosion control measures.
- Any excess subsoil must be removed from the road fringe once back filling is completed, and spoiled at an agreed spoil site (spoil sites to be agreed between landowner, ECO and Engineer).

6. CONCLUSION

The work undertaken for this report provides information on the storm water components for the proposed Rietrug WEF facility. The areas associated with the development are relatively small. However, the contributing catchment area is moderate as the development is distributed along a catchment divide. The site has existing roads. The site has a low vegetation cover and a gentle terrain indicating that it is at lower risk of erosion. However, it essential that storm water and erosion control measures are strictly adhered to. Pollution control measures should also be appropriately implemented for the construction and operational phase. Temporary silt traps must be placed, as recommended in this SWMP, during construction. Additional structures such as cut-off drains, natural rockeries, rainwater harvesting and storage have been recommended for the operation of the site. Roads that cross watercourses require open drains and natural rockeries.

Regular checks should be made by the ECO and site manager. These measures should also be incorporated into the EMPr. Monitoring and follow up assessments are essential to maintaining the overall state and continued management of the watercourse system. **Monthly audits** should be undertaken by the ECO and reports submitted identifying potential/existing erosion areas should they occur. Should any erosion areas be identified, the erosion control plan should be immediately implemented. These audits should continue for two years after the start of the operation phase. Focus should be placed on maintaining the integrity of the watercourse and the impact the development may have on soil structure.

The following conclusions and recommendations can be drawn from this report:

- The site (laydowns and buidings) has already been placed away from watercourses, apart from unavoidable crossings;
- Certain layout areas have been made to better manage the separation of clean and dirty water. PCD's were adapted to suite the topography and to ensure that it is position in such a way as prescribed by GN704 of the National Water Act (Act 36 of 1988).
- Through the SWMP, dirty water was identified as water containing sediments. Water would be attenuated, passed through attenuation structures to allow for the sediments to be contained.
- Potential spills would be contained within lined structures, such as drip trays, on site and removed.
- All effort was made to ensure that PCD's are sized correctly to ensure that clean and dirty water are kept separated as far as possible.
- Regular checks should be made by the ECO and site manager. These measures should also be incorporated into the EMPr. Monitoring and follow up assessments are essential to maintaining the overall state and continued management of the watercourse system.
- Should any erosion areas be identified, the erosion control plan should be immediately implemented.

Should the aforementioned measures not be put into place, the site will have a moderate risk to downstream peak flows. However, **if the recommendations are adhered to, the site would have a low risk, largely due to its gentle slope**. Furthermore, the site has a very small water use requirement and water quality constraints are mostly linked to sediment discharge.

7. REFERENCES

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ANNEXURE A Design Rainfall Values for Rietrug

Design Rainfall in South Africa: Ver 3 (July 2012)

User selection has the following criteria:

Coordinates: Latitude: 32 degrees 37 minutes; Longitude: 20 degreess 57 minutes

Durations requested: 30 m, 24 h, 1 d

Return Periods requested: 2 yr, 5 yr, 10 yr, 20 yr, 50 yr, 100 yr, 200 yr

Block Size requested: 0 minutes

Data extracted from Daily Rainfall Estimate Database File

The six closest stations are listed

Station Name	SAWS	Distance	Record	Latitude		Longitude		MAP	Altitude	Duration	Return Period (years)																				
	Number	(km)	(Years)	(°)	(')	(°)	(')	(mm)	(m)	(m/h/d)	2	2L	2U	5	5L	5U	10	10L	10U	20	20L	20U	50	50L	50U	100	100L	100U	200	200L	200U
ANYSRIVIER	0067074_W	15.5	67	32	44	21	2	241	1204	1 d	28.6	28.3	28.9	42.1	41.8	42.4	51.7	51.0	52.3	61.2	60.0	62.5	74.3	72.2	76.8	84.6	81.7	88.3	95.3	91.2	100.6
SKIETFONTEIN	0066582_W	17.0	27	32	42	20	49	408	1356	1 d	38.3	38.0	38.6	56.4	56.0	56.8	69.2	68.3	70.1	82.0	80.4	83.8	99.5	96.7	102.9	113.3	109.5	118.2	127.7	122.2	134.8
GUNSFONTEIN	0066304_W	31.1	39	32	34	20	40	318	1554	1 d	33.7	33.4	33.9	49.6	49.2	49.9	60.8	60.0	61.6	72.0	70.7	73.6	87.4	85.0	90.4	99.5	96.1	103.9	112.2	107.3	118.4
RHENOSTERVLEI	0089385_W	36.0	65	32	25	21	13	293	1645	1 d	39.2	38.8	39.5	57.7	57.3	58.1	70.8	69.8	71.7	83.9	82.3	85.7	101.8	98.9	105.2	115.9	112.0	121.0	130.6	125.0	137.9
SUTHERLAND	0088293_W	39.6	95	32	23	20	40	339	1459	1 d	26.6	26.3	26.8	39.1	38.8	39.4	48.0	47.3	48.6	56.9	55.8	58.1	69.0	67.1	71.3	78.6	75.9	82.0	88.6	84.7	93.5
SUTHERLAND	0088293_A	39.6	92	32	23	20	40	339	1459	1 d	32.1	31.9	32.4	47.3	47.0	47.7	58.1	57.3	58.8	68.8	67.5	70.3	83.5	81.2	86.3	95.1	91.8	99.2	107.1	102.5	113.1

Gridded values of all points within the specified block

Latitude		Longitude		MAP	Altitude	Duration	Return Period (years)																				
(°)	(')	(°)	(')	(mm)	(m)	(m/h/d)	2	2L	2U	5	5L	5U	10	10L	10U	20	20L	20U	50	50L	50U	100	100L	100U	200	200L	200U
32	37	20	57	317	1524	30 m	15.7	13.5	18.0	23.1	19.9	26.4	28.4	24.2	32.6	33.6	28.5	39.0	40.8	34.3	47.9	46.5	38.8	55.0	52.4	43.3	62.7
						24 h	43.0	36.8	49.3	63.4	54.3	72.5	77.7	66.2	89.5	92.1	78.0	107.0	111.7	93.7	131.4	127.2	106.1	151.0	143.4	118.4	172.1
						1 d	36.4	31.1	41.7	53.6	45.9	61.3	65.7	55.9	75.7	77.9	65.9	90.5	94.5	79.3	111.1	107.6	89.7	127.7	121.3	100.1	145.5