GEELSTERT 1

PHOTOVOLTAIC FACILITY AND ASSOCIATED INFRASTRUCTURE

CONCEPTUAL STORMWATER MANAGEMENT PLAN

AUGUST 2020

Knight Piésold CONSULTING

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Rev	Description	Date
0	Issued in Draft	July 2020
1	Revised in accordance with client's comments	August 2020

This report was prepared and reviewed by the undersigned.

Prepared: ______________________________

Sonet Gerber,
Civil Technologist

Reviewed: ______________________________

Andrew Cleghorn
Principal Civil Engineer

SPECIALIST EXPERTISE

SONET GERBER

Profession:	Civil Technologist
Position in Firm:	Senior Civil Technologist
Qualifications:	PrTech 201470085
Years of Experience:	15 years

Summary of Experience: Sonet Gerber is a Senior Civil Technologist in the Transport and Infrastructure division in Knight Pièsold's Cape Town Office. She has 15 years of engineering experience. After completing he in service training at Ninham Shand Consulting Engineers in Port Elizabeth, she started her career abroad working at the London Borough of Newham where she was employed at the Highways Department in 2003 and gaining valuable experience working on various Road Safety Schemes. In recent years, she concentrated on the design and maintenance of various roads and engineering infrastructure projects. She is currently a Civil Technologist in the Roads and Civil Engineering Services Design division in Cape Town.

Specialist Experience:

COCT: Public Transport Interchange: Project Manager: Concept Design and Detail Design.

Drakenstein Municipality: Assistant Contract Engineer & Resident Engineer: Bulk Water pipe, HDPE 450mm dia of 2.3km.

SANRAL: The Periodic Maintenance (Resurfacing) of National Route 12, Assistant Contracts Engineer of 3 projects running simultaneously, Section 9 between Voetpaddrift and Kimberley, Section 10 between Kimberley and Riverton and Section 10 between Riverton and Windsorton.

City of Cape Town: Non Motorised Transport Eastern Region Phase 2 Phase 3 Master Planning design, compilation of tender documentation and adjudication. Project Management. Oversee Resident Engineers of individual projects, including site administration.

Greenfield Properties: Aan De Wijnlanden Phase 2 Phase 5, Eersteriver Assisting in Development Rights approval, Services Report and Stormwater Management plan and supporting documentation for EIA and Water Use licence. Assistant RE and Contracts Engineer.

Drakenstein Municipality: Wellington Industrial Area Upgrade Project Manger team of 6 Specialist sub-consultants in the process of Conduction specialist studies and obtaining rights for the Wellington Industrial Park. KP also appointed to deal with Civil Engineering aspect of the application including for Services report ad Stormwater Management Plan

Greenfield Properties: Aan De Wijnlanden, Eersteriver Tender documentation, Assistant Resident Engineer and project management.

City of Cape Town: Non Motorised Transport Eastern Region Design and draughting, compilation of tender documentation as well as adjudication. Project Management and Resident Engineer for 4 individual projects, including site administration.

City of Cape Town: Quality Public Spaces Design and draughting, compilation of tender documentation as well as adjudication. Assistant Resident Engineer for 5 Individual projects, including site administration.

City of Cape Town: Non Motorised Transport Central Region Design and draughting, compilation of tender documentation as well as adjudication. Assistant Resident Engineer for 5 individual projects, including site administration.

City of Cape Town: Non Motorised Transport Central Region Design and draughting, compilation of tender documentation as well as adjudication. Assistant Resident Engineer for 4 individual projects, including site administration.

Hout Bay: Pick 'n Pay Shopping Centre Development Responsible for the design and draughting of civil engineering services for construction, including road signage. Monitoring and site inspections.

Philippi: Shopping Centre Development Preparation of civil engineering services drawings for construction.

Jeffreys Bay Windfarm: Mainstream Renewable Power South Africa Proposed road cost estimate

DCD Dorbyl: Foul Sewer Services Design and draughting. Monitoring and site inspections including site administration.

SPECIALIST DECLARATION

I, **Sonet Gerber**, as the appointed independent specialist, in terms of the 2014 EIA Regulations, hereby declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favorable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing – any decision to be taken with respect to the application by the competent authority; and – the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable on terms of section 24F of the Act.

Signature of Specialist:

Name of Specialist: Sonet Gerber

Date: 03 August 2020

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1. INTRODUCTION

Knight Piésold Consulting was appointed by Geelstert Solar Facility 1 (Pty) Ltd to investigate and compile a Conceptual Stormwater Management Plan for a proposed photovoltaic (PV) energy facility and associated infrastructure, known as Geelstert 1.

The purpose of this study is to prepare a conceptual Stormwater Management Plan (SWMP) to support the Environmental Impact Assessment Process of the proposed Geelstert 1 facility. This report should be viewed as a localised high-level study and not as a detailed design report. The objective is purely to demonstrate that stormwater from the new development could be managed and controlled in an optimised and non-destructive manner.

This SWMP includes the following:

- Determining the catchment area of the project site;
- Defining the topography, slope gradients and rainfall intensities;
- Estimating expected floods for the catchment;
- Confirming of existing drainage patterns and streams; and
- Proposing drainage elements such as side drains, outlets and other mitigation measures to accommodate the resultant stormwater flows.

2. DEFINITIONS AND ASSUMPTIONS

The following assumptions are made on stormwater calculations and are deemed to be adequate for a conceptual investigative report:

- The Rational Method will be used for flood calculations, which is widely accepted to be very accurate for areas of this size;
- The recurrence period applied is a 1:50 year design flood; and
- There are no rivers or streams that will affect the planning and design of the solar facility therefore the 1:100 year design flood was not applied.

3. EXISTING SITE CONDITIONS

3.1. Location

The Remaining extent of Farm Bloemhoek 61 is situated approximately 11km south-east of Aggeneys, see *Figure 3.1*. Other towns in proximity of the project include Pofadder, located approximately 57km north-east, and Springbok located approximately 116km south-west of the project site. The proposed site falls within the Khâi-Ma Local Municipality of the Namakwa District Municipality. The Loop 10 Road is situated along the northern boundary of the property with the R358 (Gamoep Road) situated towards the eastern boundary.

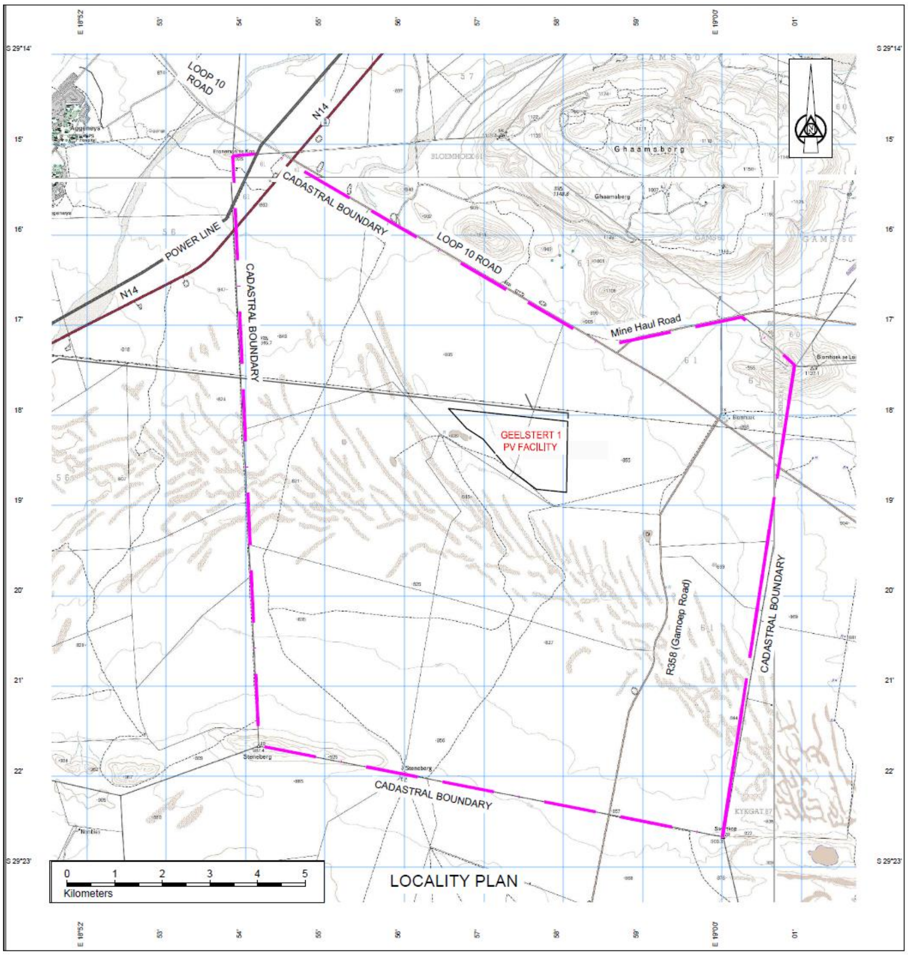

Figure 3.1: Locality Plan

3.2. Topography, Geomorphology and Vegetation (Drainage Characteristics)

The Northern Cape Province is situated in the north-western extent of South Africa and is the country's largest province. The Remaining extent of Farm Bloemhoek 61 is reported to have a flat topography with an average slope gradient of approximately 0.7%. It is presently not in use and is characterised by bushmanland sandy grassland.

3.2.1. Drainage Patterns and Runoff Characteristics

The approximate drainage area of the existing site is in excess of 12 379 hectares. Evidence of a dry watercourse exists. The natural drainage pattern is observed to slopes towards the centre of the proposed site and then proceeds in a westerly direction. The lowest point on the proposed site is located near the centre of the western perimeter. Approximately one third of the site drains in a north-westerly direction and the remaining two-thirds drain in a south-westerly direction. The natural drainage pattern is graphically depicted in *Figure 3.2.* The average gradient for the longest drainage path identified within the catchment area has been determined to be 0.7%.

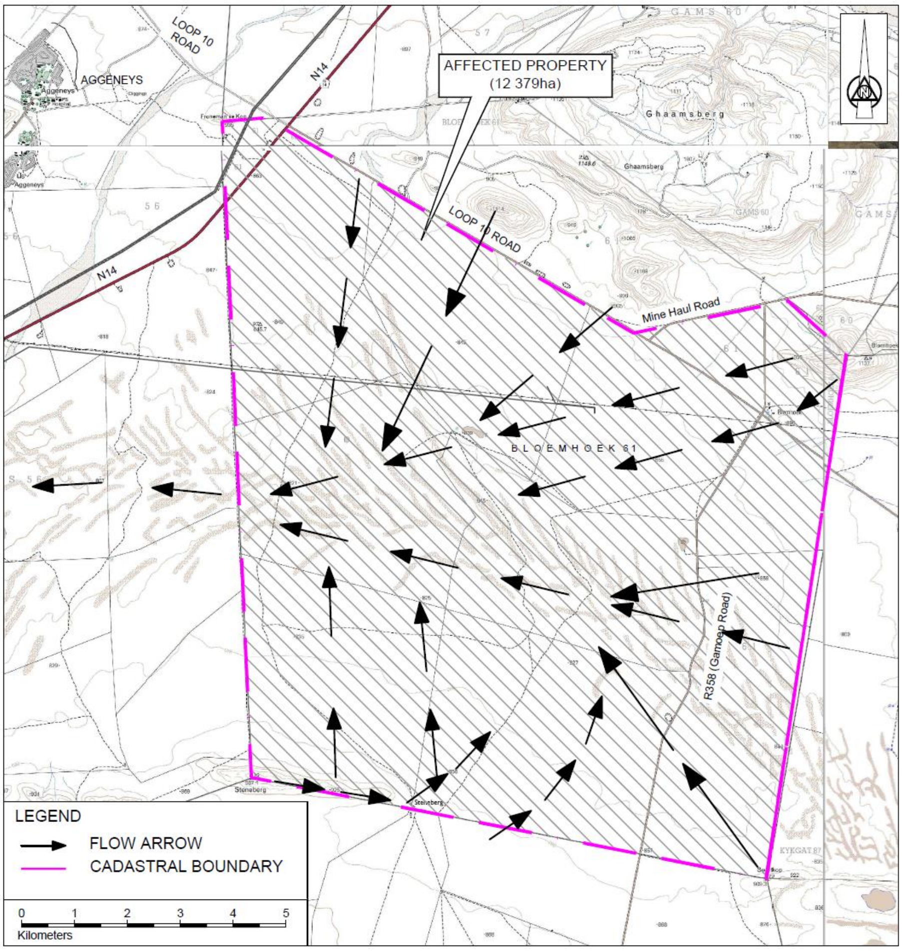

Figure 3.2: Drainage Pattern of Existing Site

It should be noted that, in the absence of detailed topographical survey information, 1:10 000 orthographical maps and 1:50 000 geographical maps together with spot height data taken on site were used to establish the drainage patterns. The greater catchment area is 38 772ha, see *Figure 3.3* below. The sparse vegetation, together with the flat gradient and permeable soils yield very low runoff coefficients.

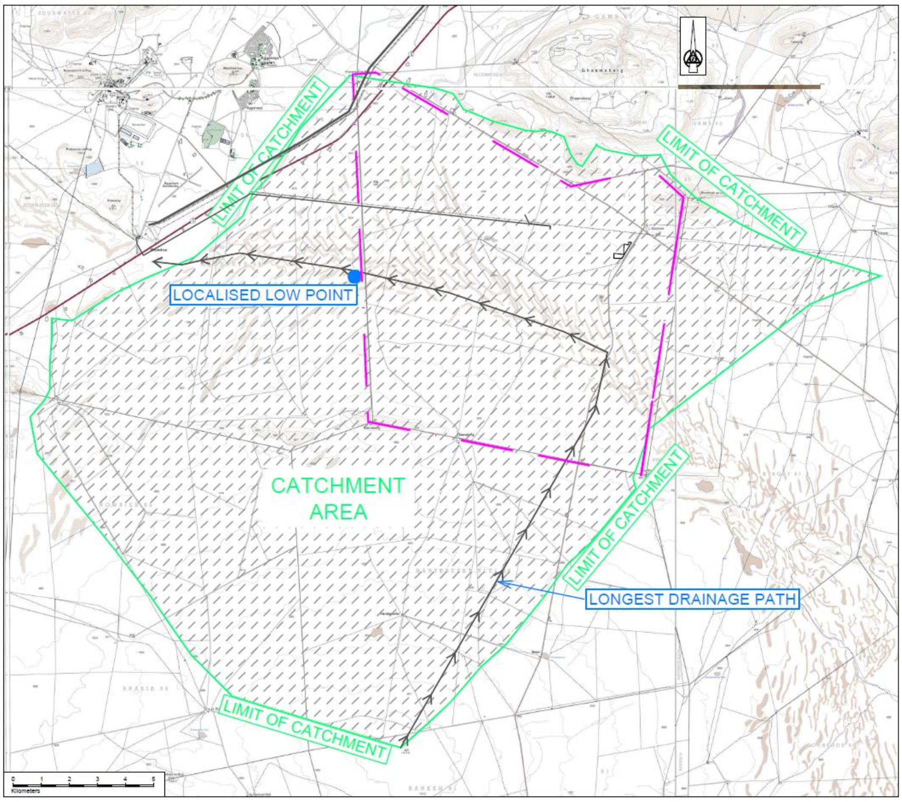

Figure 3.3: Catchment Areas

3.3. Geology and Soils

The Black Mountain and Gamsberg Mines are copper and zinc mines operating within close proximity of the project site. The Gamsberg Mine is located immediately north of the project site and as a result, waste rock dumps associated with the zinc mines are located within the vicinity of the project site.

Geological maps in conjunction with field observations in the region suggest that the area around the mines and the town of Aggeneys are characterised by two distinct landform types; flat plains characterised by dunes in places and rugged low mountains that rise in distinction from the surrounding plains. This is as a result of the presence of quartzite and iron formation layers within the stratigraphy that are less prone to weathering than the other rocks.

The altitude of the catchment area ranges between 800 and 1500 metres above sea level, sloping towards the low lying plain or dry watercourse situated in the central region of the catchment area. The ephemeral stream slopes towards the national route N14 to the west.

Soil forms in the region can be described as red, excessively drained sandy soils with high base status, on bedrock with presence of lime.

3.4. Climate and Hydrology

Aggeneys receives below average rainfall, resulting in arid desert-like conditions. There is a slight increase in rainfall during the summer months. Extended periods of drought feature prominently on historic records and in the recent past, some parts of the Bushmanland have no recorded rainfall for a period of ten years. In Aggeneys the annual rainfall varies between 50mm and 190mm, averaging just over 90mm. This information is based on historic rainfall data available from nearby mines. Average monthly rainfall figures and mean monthly temperature data, depicted in *Figure 3.4,* has been gathered from the weather station at Pofadder, located approximately 57km to the east of the proposed site.

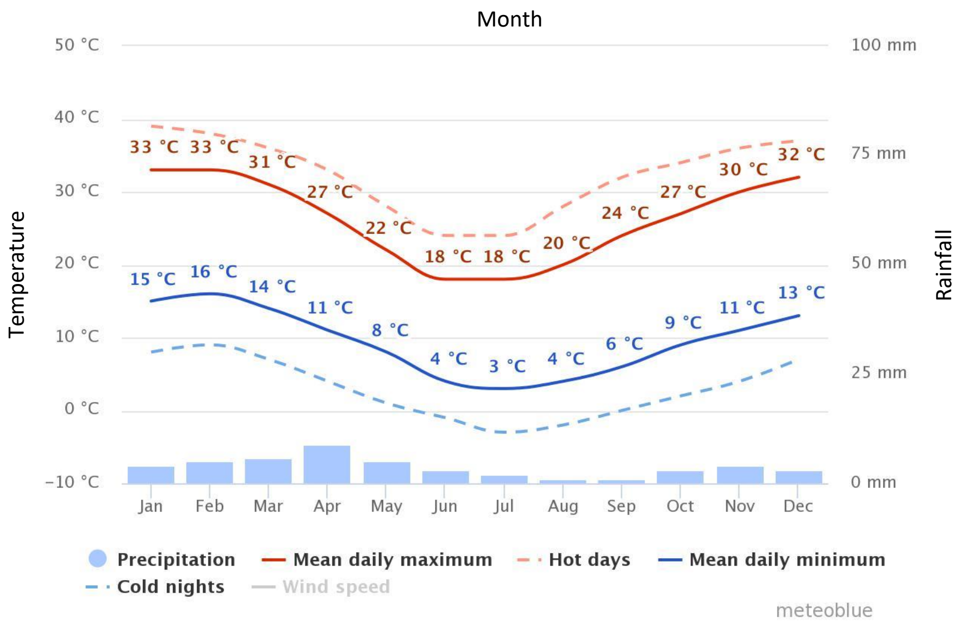

Figure 3.4: Monthly Rainfall and temperature for Aggeneys

The highest solar radiation intensity in South Africa is reportedly the highest within the Northern Cape province. Aggeneys experiences an average summer temperature of 31.4 °C, January is observed to be the hottest month of the year. July has the lowest average temperature of the year at 17.7 °C as seen in *Figure 3.4*.

4. STORMWATER CALCULATIONS

As mentioned previously, the calculations to determine the run off volumes and intensities of the site are based on the Rational Method with a return period of 1:50 years.

4.1. Runoff Coefficient

4.1.1. Pre-development

The pre-development runoff coefficient was calculated by making an allowance for rock outcrop; and a 10% was therefore allowed for semi-permeable soil. Because the site consists mainly of Bushmanland Sandy Grassland, 60% was allowed for in the calculations; see run-off coefficient percentages listed in *Table 4.1* below.

Table 4.1: Pre-development Runoff Coefficient Percentages

Permeability	% Applied	Vegetation	% Applied
Very	50	Thick bush & Forest	0
Permeable	40	Light Bush & Cultivated Land	00
Semi-Permeable	10	Grasslands	60
Impermeable	0	Bare	40
TOTAL	*100*	*TOTAL*	*100*

Based on the above, the calculated runoff coefficient for the pre-development phase is 0.326m (see *Annexure A* for further detail calculations).

4.1.2. Post-development

The post-development runoff coefficient takes the installation of the panels into account, as well as the vegetation alterations that may occur post-construction. An area of 245ha (approximately 0.6% of the catchment area and 1.98% total property) is required for the development of Geelstert 1. Even though the PV panels are impermeable, they will be mounted on bases that only cover a small surface area. A small percentage of the run-off coefficient was thus allowed for hardened surface. Geelstert 1 will make use of driven/ rammed piles, or ground/ earth screw mounting systems, and in certain instances resort to concrete foundations, should geotechnical studies necessitate this. Concrete foundations may be used for the solar panel sun tracker at the end of each row.

The vegetation that will be lost during construction may not fully recover due to the shade that will be created by the panels post-construction. Allowance was made for this by amending the vegetation area when calculating the post-development peak runoff flows, increasing the bare areas by 5%. These percentage figures are reflected in *Table 4.2* below.

Table 4.2: Post-development Runoff Coefficient Percentages

Permeability	% Applied	Vegetation	% Applied
Very	45	Thick bush & Forest	0
Permeable	40	Light Bush & Cultivated Land	00
Semi-Permeable	10	Grasslands	55
Impermeable	5	Bare	45
TOTAL	*100*	*TOTAL*	*100*

Based on the above, the calculated runoff coefficient for the post-development phase is 0.340 (see *Annexure B* for further detail calculations).

4.2. Time of Concentration

The following formula was used to calculate the time of concentration, which is the time it takes for surface water at the furthest point on the site to reach the lowest area:

$$Tc = \left(\frac{0.87 \times L^{2}}{1000.S}\right)0.385$$

Where Tc = Time of Concentration (hours), L = Length of waterway (km), S = average slope.

4.3. Point Intensity

Point Intensity is based on standard time of concentration, and information was extracted from rain fall intensity depth graphs for the area.

4.4. Runoff

4.4.1. *PV Area*

The runoff distribution of the respective catchment area will be dictated by the layout of the larger PV area, as well as the internal roads and channels. Each PV area which is a combination of smaller blocks, should preferably be orientated in such a way to minimise the impact on natural drainage patterns. A typical PV panel configuration (subject to the final site development plan) is indicated in *Figure 4.1,* with the resultant drainage pattern indicated in *Figure 4.2*.

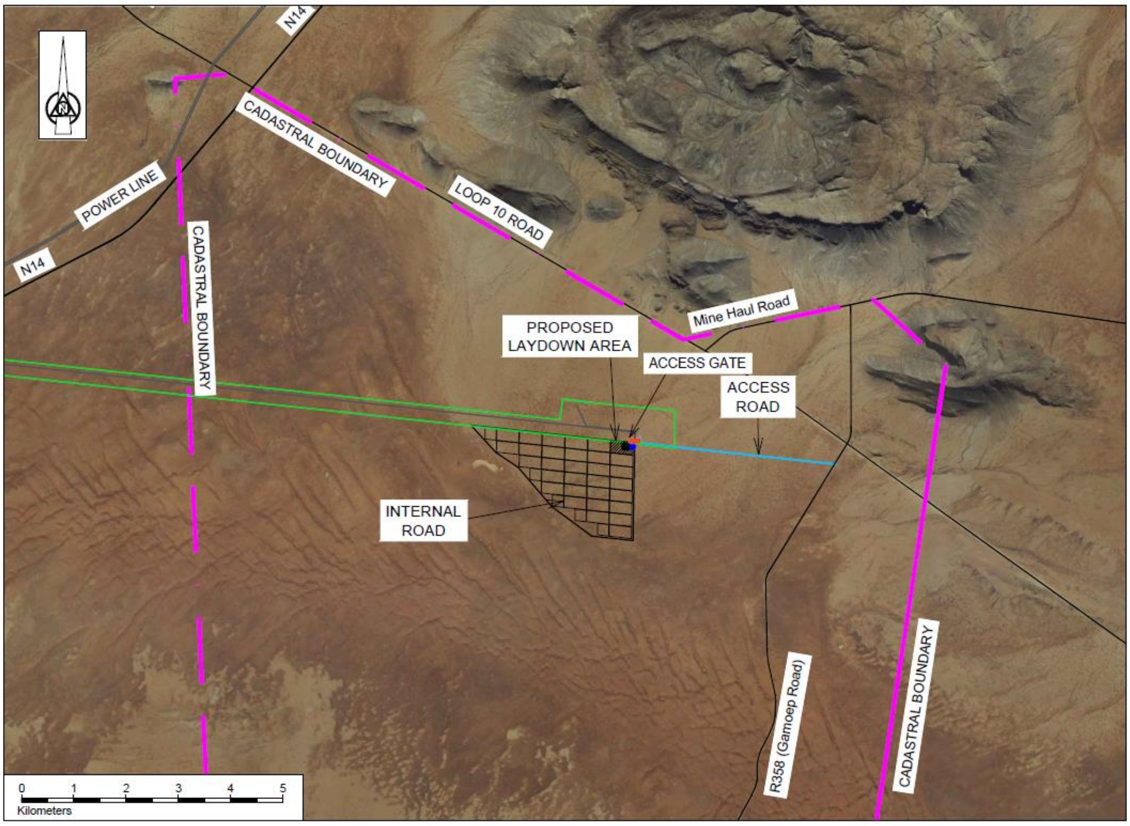

Figure 4.1: Conceptual Layout of the proposed solar facility

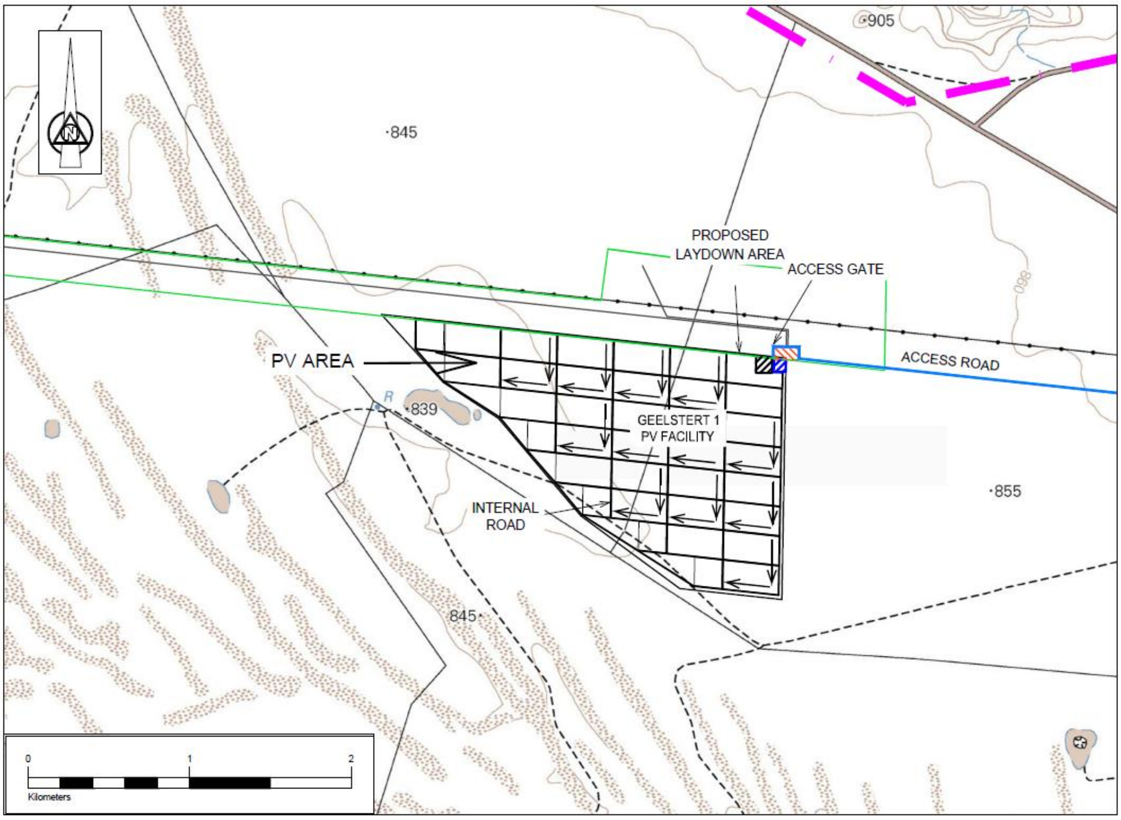

Figure 4.2: Drainage pattern for conceptual layout of PV panels

There are no waterbodies or places of ponding visible on the proposed site. The 1:50 year flood occurrence for pre and post-development runoff for the catchment area is shown below:

Catchment Area (A)= 388 km^2

Pre-Development Run-off Coefficient (C) = 0.326

Post-Development Run-off Coefficient (C) = 0.340

Time of Concentration (TC) = 5.6 hours

Rainfall Intensity (I) = 5.7 mm/hr

Rational Method Pre-Development Peak Runoff (Q) = $\frac{\text{CIA}}{3.6}$ = **188.69 m^3/s**

Rational Method Post-Development Peak Runoff (Q) = $\frac{\text{CIA}}{3.6}$ = **196.50 m^3/s**

4.4.2. Access Roads

A new site access road is proposed from the R358 (Gamoep Road), located to the east of the project site, see *Figure 4-3*. The R358 is a formal gravel road which is connected to the N14 by the Loop 10 Road.

During construction, the project site will be accessed via the new access gate, approximately 430m from the intersection with the Loop 10 Road, which will subsequently be utilised for maintenance purposes, during operation.

The intersection of Loop 10 road and the N14, has been recently upgraded with an asphalt surfacing through the maintenance contract on the N14. The Loop 10 Road is a gravel graded road, 8m in width with existing drainage provisions. The access road R385 (Gamoep Road) has limited drainage provided, mainly natural earth drains in sections.

Permanent internal access roads will be constructed between the solar panels. These roads are generally stabilised gravel or informal tracks that are 4m to 5m wide. It is anticipated that the length of these roads will be approximately 23 km. The final site layout will determine the exact extent of the internal roads.

The envisaged run-off across the internal gravel access roads is viewed to be limited. The average velocity is in the order of 1.0 m/s for the gentle slopes on this site, which is around 0.7%. Such flows will not cause any serious erosion, but appropriate measures should be implemented at outlets and points of concentration caused by drainage channels in order to reduce the risk of erosion damage.

Frequent nominal drainage measures, typically piped culverts and/or mitre drains cut by a grader, must be provided at 200m to 300m intervals, as dictated by the site conditions, and must be taken care of in the detail design. These could also be in-situ formed drifts where the road alignment is close to the natural ground level.

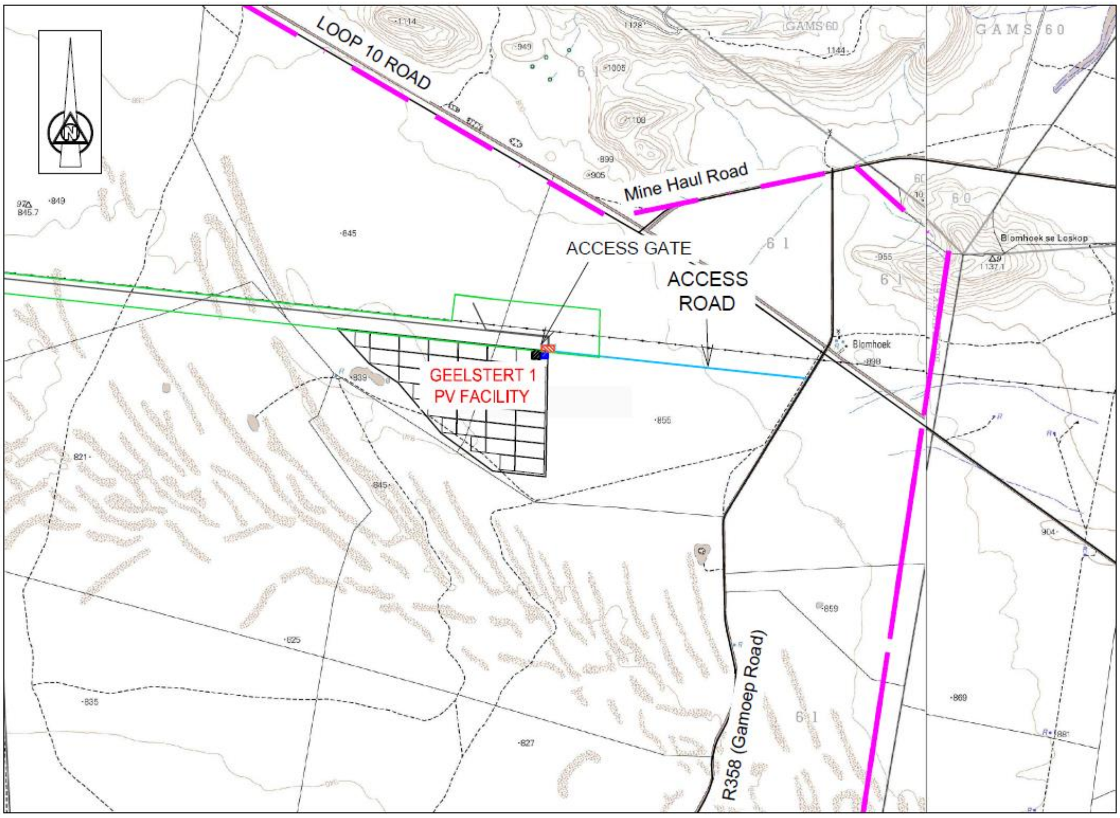

Figure 4.3: Access Roads

5. PROPOSALS FOR STORMWATER MANAGEMENT

The existing drainage patterns and characteristics should be preserved as far as practically possible. It is therefore suggested that the existing contours and vegetation be retained and that the internal roads are designed and constructed to minimum standards. The runoff calculations indicate that an additional 7.8 m^3/s or roughly a 4% increase in peak runoff (Q) will have to be accommodated when designing the stormwater management measures.

Drainage structures could include smaller diameter pipes (encased in concrete because of the low fill anticipated) or preferably concrete culverts or drifts. These drifts should have cut-off walls on the down-stream side as a minimum requirement

5.1. Side Drains

Open drains will be provided along the proposed internal roads. These drains would be gravel drains with concrete or edge beam protection at road crossings, where required.

5.2. Berms

Overland flow is in a south-westerly direction across the proposed PV facility. The Loop 10 Road serves to minimise runoff from the bigger catchment area across the PV area at the northern boundary and serves as a cut off drain from the larger catchment area, so too does the R358 near the eastern boundary (see *Figure 3.3*). Berms are therefore not proposed. As mentioned previously there are longitudinal earth drains along sections of the Loop 10 Road leading to culverts, most of which are not directly opposite the proposed site. Runoff through these culverts will discharge at concentrated points onto the farm and can therefore be managed at places where it does occur in the vicinity of the PV facility site.

5.3. Outlets

Any additional culverts on the access road must be provided with concrete outlets as well as erosion protection. Side drain outlets should be terminated with suitable erosion protection to reduce the velocity and the flow depth.

6. EROSION PROTECTION MEASURES

The volume and velocity of the stormwater runoff must be thoroughly evaluated during the detailed design phase. The following erosion protection measures should be considered:

- Side drains, see *Figures 6.1 and 6.2*
- Inlet and outlet structures, see *Figures 6.3 and 6.4*

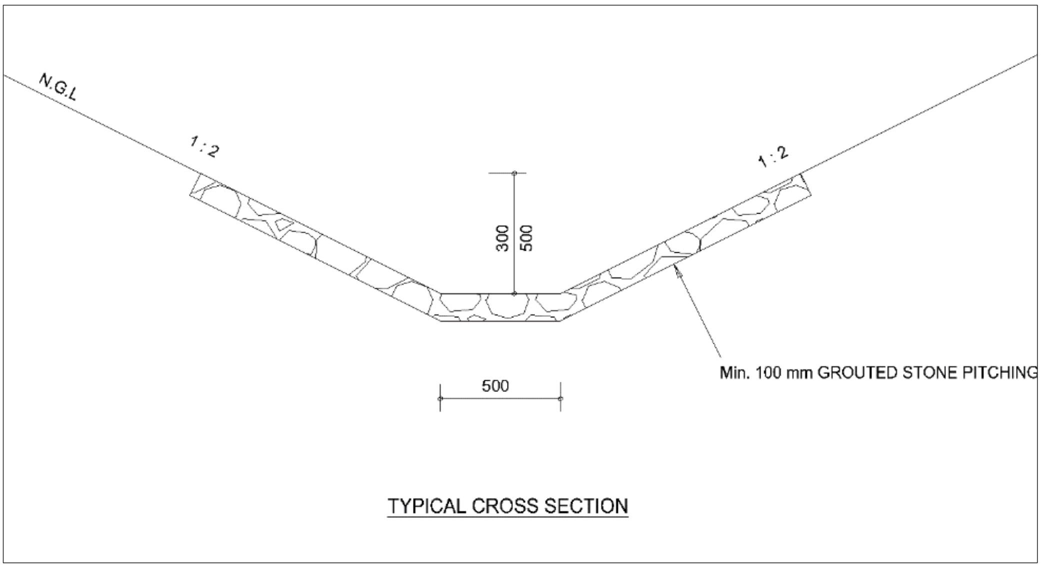

Figure 6.1: Typical Stone Pitched Side Drain

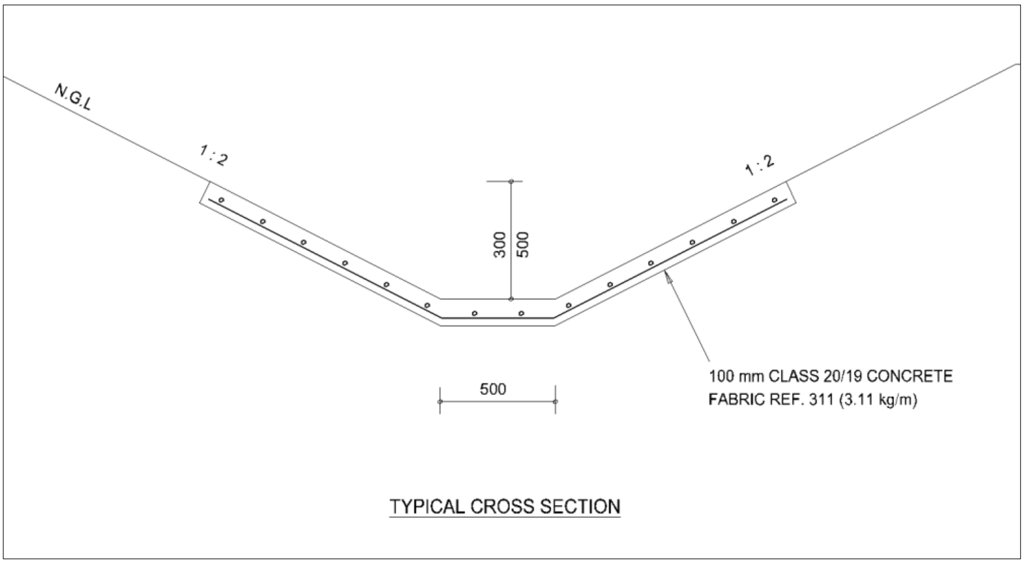

Figure 6.2: Typical Concrete Lined Side Drain

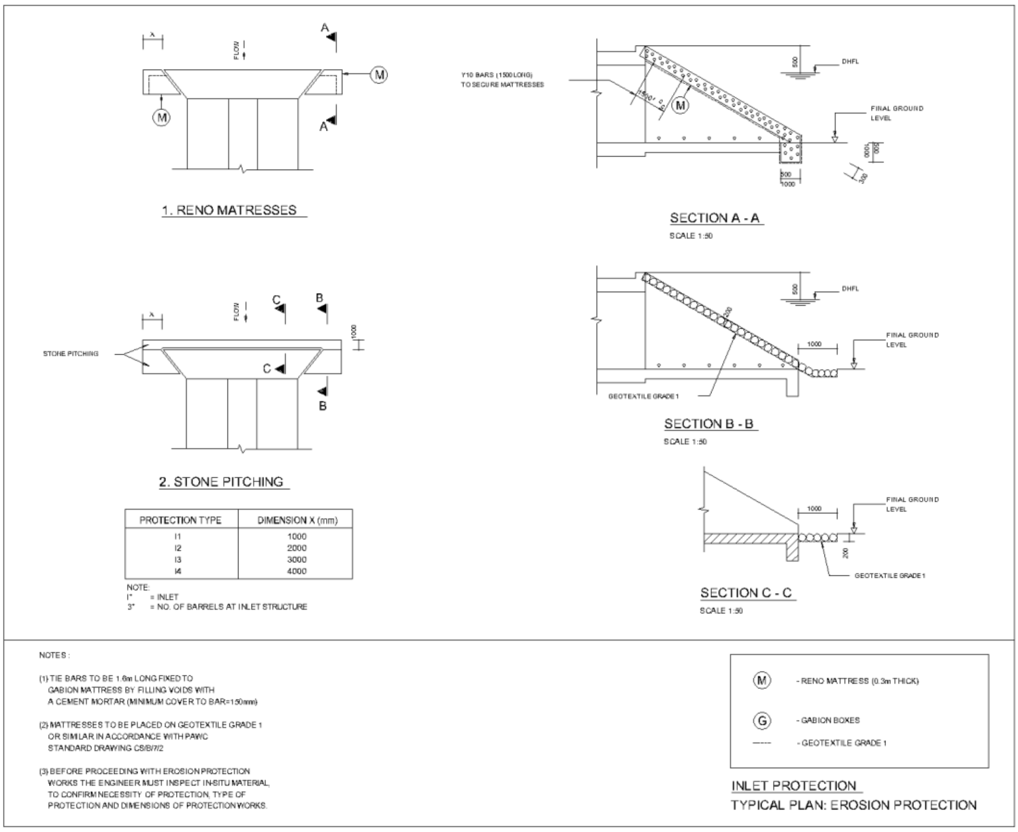

Figure 6.3: Typical inlet erosion protection measures

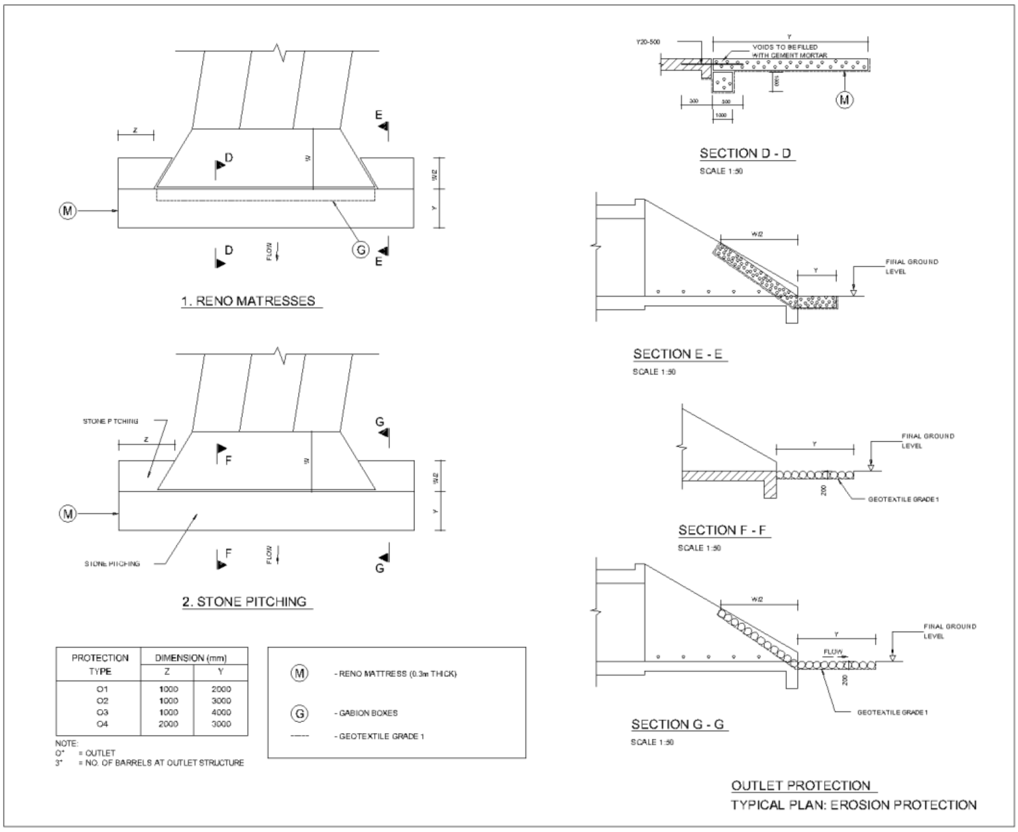

Figure 6.4: Typical outlet erosion protection measures

It is envisaged that in combination with the above the following may be required:

- Side Drain Outlets with stone pitching to prevent erosion; and
- Temporary berms and straw bales during construction in the vicinity of streams (should there be any) to reduce flow and sediment transport during this phase.

During the construction phase, special attention must be given to stormwater such that construction activities do not result in water ponding, especially in the vicinity of the roads and structures.

7. WASTE WATER MANAGEMENT

Gamsberg mine is located to the north of Geelstert 1. Venturing closer to mining areas will expose the PV energy facility to increased dust levels, thus reducing the efficiency of the solar PV modules. After the installation of the panels, the cleaning (washing) of the solar panels is likely to generate small amounts of additional runoff. This process is estimated to occur twice a year and add approximately 3l/m^2 of additional runoff to the site, over a period of approximately 2 weeks. This runoff would however be spread throughout the site, and due to the low localised water volumes would cause minimal, if any, erosion on the site and may even help as a form of dust control. The methods used for washing the panels determine the mitigation measures to be applied. This could be in the form of phasing the washing of panels or optimising the methods used. The overall effect on the site is expected to be very low, provided the cleaning water is free from detergents and includes only approved bio-degradable substances.

Rain will also aid in keeping the PV panels clean. The solar module surfaces are installed at a relatively large incline with gaps between modules. This does not allow significant water build-up on the modules while also reducing the energy generated by the falling rain droplets.

On large structures or buildings, appropriate guttering could be used around the building to avoid water erosion caused by roof water flowing off the roof. Wherever practically possible, stormwater run-off from the gutter/roofs should be captured and stored in rainwater tanks. If this water cannot be captured, water should be channelled into energy dissipating structures to spread the water and slow it down to reduce risk of erosion. Such structures could be constructed from precast concrete, loosely packed rock or perforated bags filled with stone.

8. CONCLUSIONS AND RECOMMENDATIONS

The additional stormwater runoff generated from the new facility, post-development, is almost negligible compared to the pre-development. It is therefore envisaged that limited stormwater management will be required to reduce the impact of the proposed development on the environment. It would however be necessary to consider flow control measures along internal roads as well as erosion protection during the detail design stage. Erosion protection measures should protect the internal network of the site as well as be installed at stormwater discharge points to allow drainage into the landscape.

By implementing earth drains, lined drains and limited erosion protection structures, the stormwater on the site can easily be accommodated in a safe and in a non-destructive manner. The development of the site should also be done in accordance with the existing slopes. The contours should be followed closely in order to minimise impacts on the existing drainage patterns.

9. REFERENCES

- Various Municipal Management of Urban Stormwater Impacts Policies
- The Georgia Stormwater Management Manual
- The South African National Roads Agency Limited. (2006). Drainage Manual Fully Revised 5th Edition
- Adamson P.T. (1983). Technical Report TR 102. Southern African Storm Rainfall

10. ANNEXURES

Annexure A: Pre-Development Runoff Calculations

Project name:	Geelstert 1 Solar Facility
Analysed by:	SG
Name of river:	N/A
Description of site:	Pre-Development: Remaining Extent of farm Bloemhoek 61
Filename:	C:\Users\PGounden\Desktop\Flood Calcs\Geelstert 1 Pre.fld
Date:	16 July 2020

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Flood Frequency Analysis: Rational Method

Project                              = Geelstert 1 Solar Facility
Analysed by                          = SG
Name of river                        = N/A
Description of site                  = Pre-Development: Remaining Extent of farm Bloemhoek 61
Date                                 = 2020/07/16
Area of catchment                    = 388.0 km²
Dolomitic area                       = 0.0 %
Mean annual rainfall (MAR)           = 90.00 mm
Length of longest watercourse        = 33.0 km
Flow of water                        = Overland flow
Height difference                    = 233.0 m
Value of r for over land flow        = Sparse grass (r=0,3)
Rainfall region                      = Inland
Area distribution                    = Rural: 100 %,  Urban: 0 %,  Lakes: 0 %

Catchment description - Urban area (%)
Lawns                        Residential and industry Business
Sandy, flat (<2%)        0   Houses             0     City centre       0
Sandy, steep (>7%)       0   Flats              0     Suburban          0
Heavy soil, flat (<2%)   0   Light industry     0     Streets           0
Heavy soil, steep (>7%)  0   Heavy industry     0     Maximum flood     0

Catchment description - Rural area (%)
Surface slopes               Permeability             Vegetation
Lakes and pans           0   Very permeable     50    Thick bush & forests           0
Flat area                85  Permeable          40    Light bush & cultivated land   0
Hilly                    15  Semi-permeable     10    Grasslands                     60
Steep areas              0   Impermeable        0     Bare                           40
-----------------------------------------------------------------------------------------------
Average slope                        = 0.00706 m/m
Time of concentration                = 5.60 h
Run-off factor
Rural - C1                           = 0.326
Urban - C2                           = 0.000
Lakes - C3                           = 0.000
Combined - C                         = 0.326
The HRU, Report 2/78, Depth-Duration-Frequency diagram was used to determine the point rainfall.
```

Return Period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:20	5.60	24.8	98.6	4.4	0.90	29.3	138.11
1:50	5.60	32.3	98.1	5.7	0.95	31.0	188.69
1:100	5.60	39.7	97.7	6.9	1.00	32.6	243.38

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Annexure B: Post-Development Runoff Calculations

Project name:	Geelstert 1 Solar Facility
Analysed by:	SG
Name of river:	N/A
Description of site:	Post-Development: Remaining Extent of farm Bloemhoek 61
Filename:	C:\Users\PGounden\Desktop\Flood Calcs\Aggeneys 1 Post.fld
Date:	16 July 2020

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Flood Frequency Analysis: Rational Method

Project	= Geelstert 1 Solar Facility
Analysed by	= SG
Name of river	= N/A
Description of site	= Post-Development: Remaining Extent of farm Bloemhoek 61
Date	= 2020/07/16
Area of catchment	= 388.0 km²
Dolomitic area	= 0.0 %
Mean annual rainfall (MAR)	= 90.00 mm
Length of longest watercourse	= 33.0 km
Flow of water	= Overland flow
Height difference	= 233.0 m
Value of r for over land flow	= Sparse grass (r=0,3)
Rainfall region	= Inland
Area distribution	= Rural: 100 %, Urban: 0 %, Lakes: 0 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	0	Very permeable	45	Thick bush & forests	0
Flat area	85	Permeable	40	Light bush & cultivated land	0
Hilly	15	Semi-permeable	10	Grasslands	55
Steep areas	0	Impermeable	5	Bare	45

Average slope	= 0.00706 m/m
Time of concentration	= 5.60 h
Run-off factor	
Rural - C1	= 0.340
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.340

The HRU, Report 2/78, Depth-Duration-Frequency diagram was used to determine the point rainfall.

Return Period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:20	5.60	24.8	98.6	4.4	0.90	30.6	143.83
1:50	5.60	32.3	98.1	5.7	0.95	32.3	196.50
1:100	5.60	39.7	97.7	6.9	1.00	34.0	253.46

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0