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AEP KATHU SOLAR (PTY) LTD.

STORMWATER, EROSION AND WASHWATER MANAGEMENT PLAN

Reference: 111224

Prepared for: ~~ATLANTIC RENEWABLE ENERGY PARTNERS~~ (Pty) Ltd

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Document prepared by:

Aurecon South Africa (Pty) Ltd
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City, Cape Town, 7441

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W www.aurecongroup.com

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Aurecon Centre
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Century City, Cape Town, 7441

T +27 21 526 9400
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W www.aurecongroup.com

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1 INTRODUCTION

~~Atlantic Renewable Energy Partners (Pty) Ltd, on behalf of~~ AEP Kathu Solar (Pty) Ltd~~, has~~ engaged Aurecon to prepare a conceptual Stormwater Management Plan (SMP) for the proposed AEP Kathu Solar PV Facility; on the farm known as Kathu Farm No 460 portion 0, situated in the District of Kuruman Rd, Northern Cape Province, within the jurisdiction area of the Gamagara Local Municipality near Kathu.

The site location is indicated on the Key Plan below:

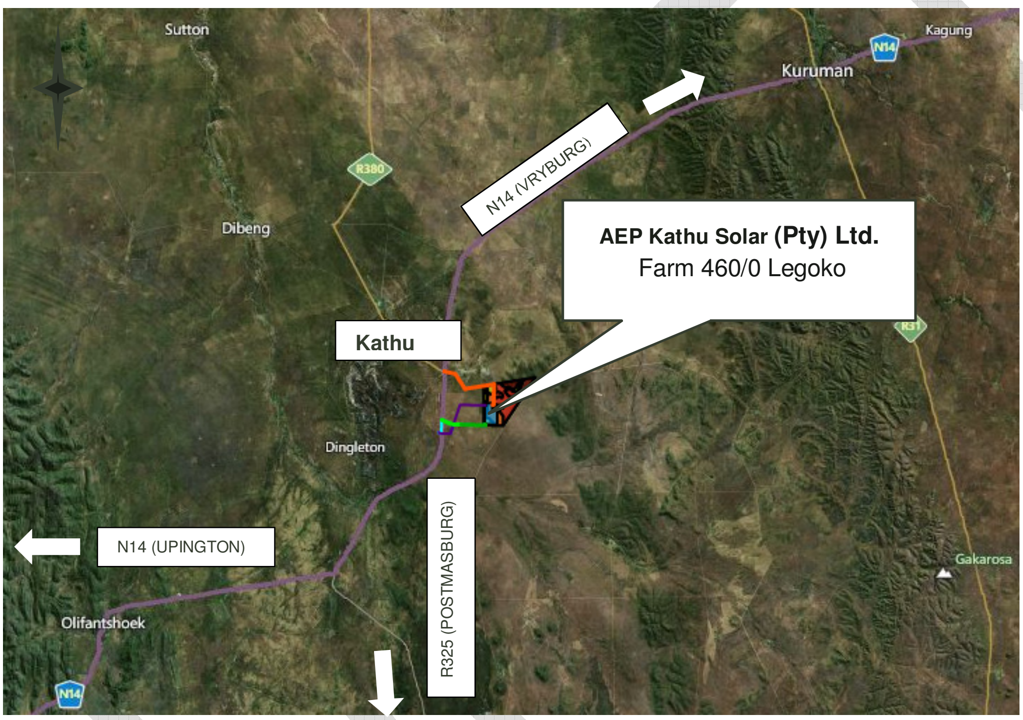

Figure 1: Key Plan

The proposed AEP Kathu Solar PV Facility will have a net generating capacity of 75 MW with an estimated maximum footprint of ± ~~220~~ ha.

The scope of this study is to prepare a conceptual Stormwater Management Plan (SMP) to support the Environmental Impact Assessment Process of the proposed AEP Kathu Solar PV Facility. The scope of the Stormwater Management Plan (SMP) includes inter alia:

- Determine catchment area for the project site.
- Estimate floods expected for the catchment.
- Confirm existing drainage pattern and streams.
- Propose drainage elements such as side drains, outlets and other mitigation measures to accommodate the flows.
- Prepare a conceptual drainage layout plan and strategy for the project site.

2 DEFINITIONS / ASSUMPTIONS

The following assumptions are made (guided by the client requirements):

- The flood calculation method used – Rational Method.
- The recurrence period normally applied for this type of development to reduce risk of increased maintenance during the operational phase, is 1:50 years.
- As a principle to minimise earthworks and to minimise changes to the existing drainage patterns, the drainage layout should be based on the existing contours. The variations in the grade and angle of the PV panels could be taken up by adjustments in the foundation or support structure levels in order to retain existing ground levels.

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3 SITE STORMWATER

3.1 Climate and Land Use

The proposed site is located in a semi-arid area with typically bushveld type of vegetation.

Figure 2: Typical Vegetation

The main economic activities in the area are mining and agriculture with cattle, sheep and game farming.

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The area experiences summer rainfall in the form of thunderstorms with a Mean Annual Precipitation of below 400mm per annum.

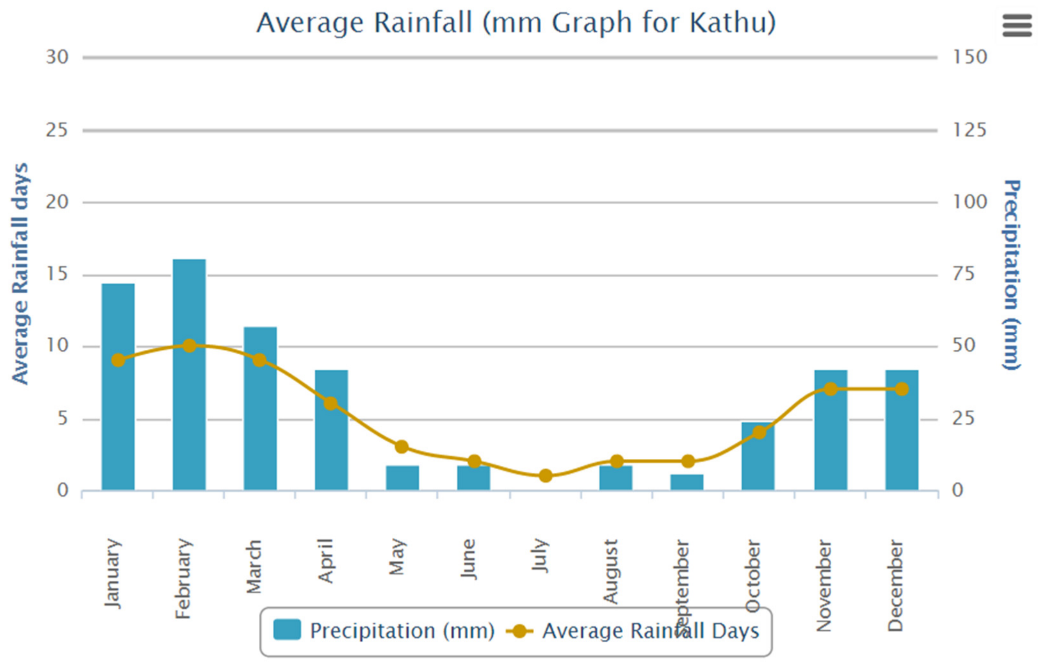

Figure 3: Average Rainfall

The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Kathu range from 17℃ in June to 30℃ in January. The region is the coldest during July when the mercury drops close to almost 0℃ during the night.

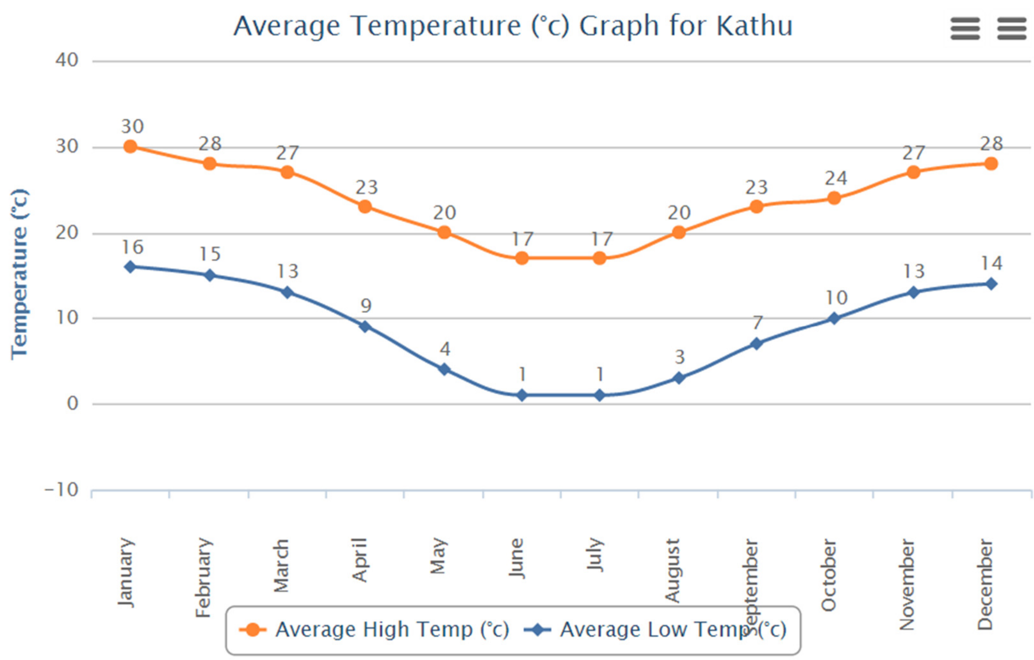

Figure 4: Average Temperature

3.2 Drainage Characteristics

The proposed site is generally flat with gradients ranging from below 0,3% to 0,5% through the site. The PV area generally drains towards the South-West.

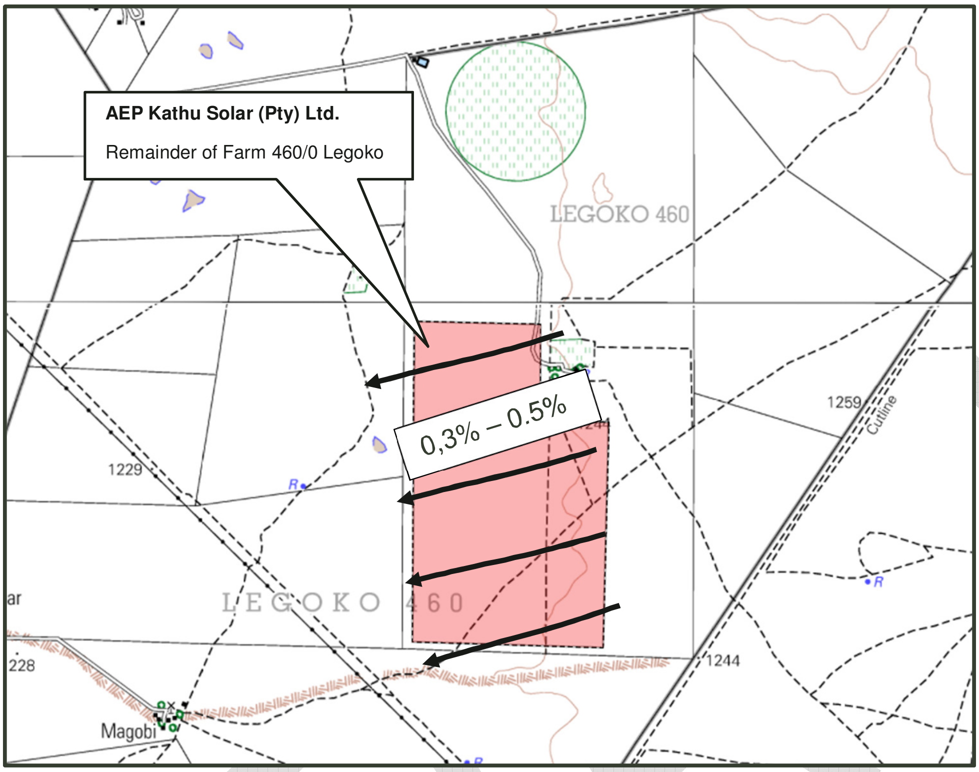

Figure 5: Drainage Characteristics

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3.2.1 Drainage Patterns

3.2.1.1 PV Area

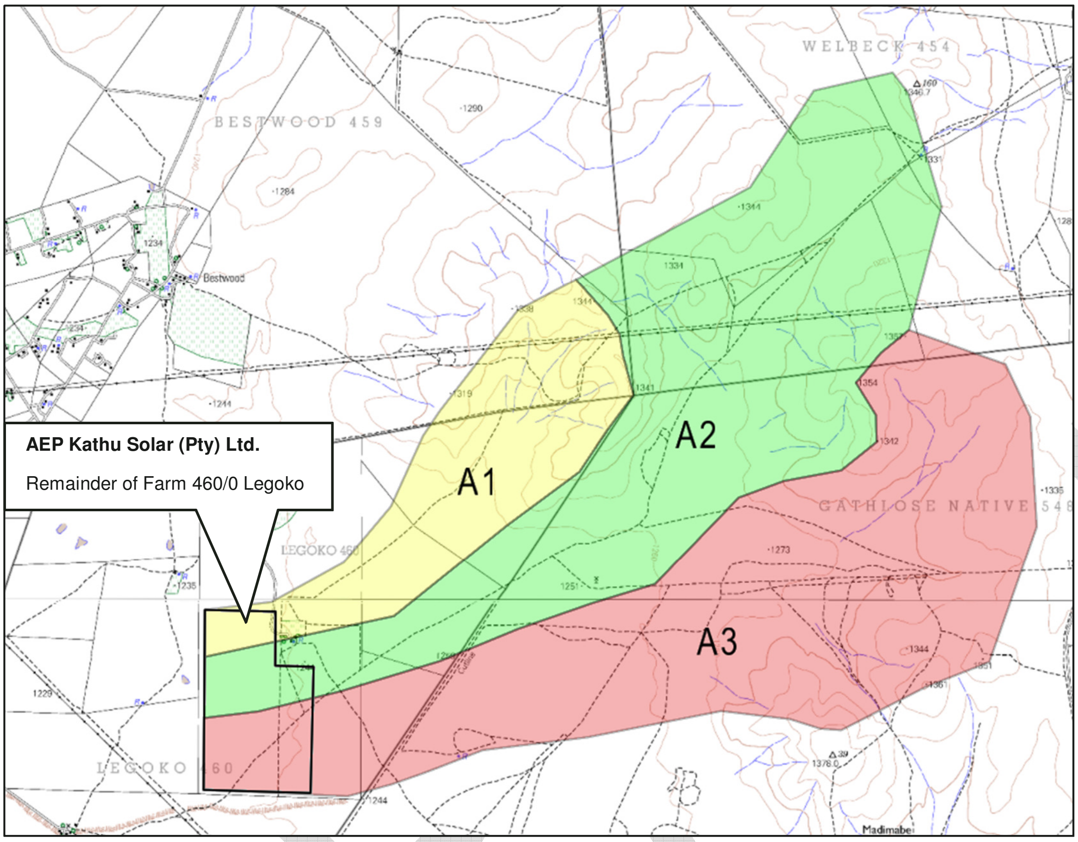

Figure 6: PV Area Main Catchment Areas.

It should be noted that in absence of detailed topographical information, 1:50000 topographical map data was used to establish the drainage patterns. The catchment areas identified are:

Table 1: Catchment Areas

Catchment ID	Area (km²)
A1	6.614
A2	18.014
A3	19.017

3.2.1.2 Access Road

The preferred access road is surfaced over the first 1, 97 km from the N14 intersection and has sufficient drainage. The remainder of the access road (2.42km), which is to be constructed, drains towards the South-West and will require provision for drainage as part of the design and construction.

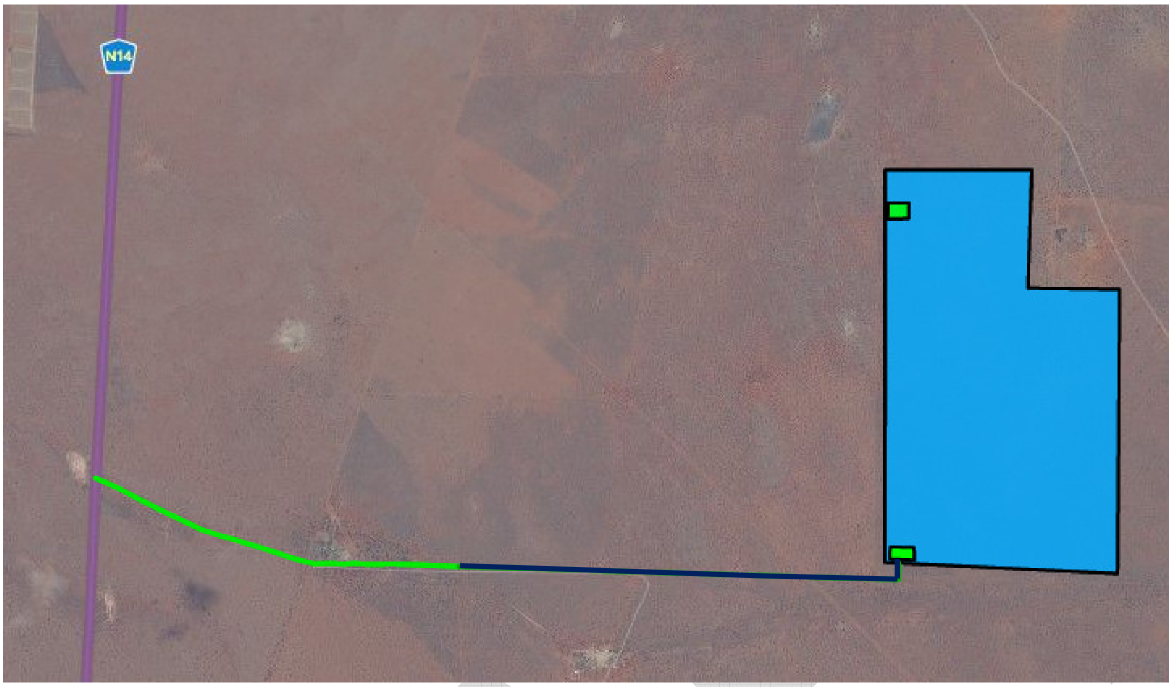

Figure 7: Preferred Access Road

3.2.2 Runoff Characteristics

The sparse vegetation in combination with flat gradient and semi-permeable soils yield low runoff coefficients.

3.3 Stormwater Calculation

3.3.1 Method and Assumptions

For purposes of the SMP the rational method was used. The runoff parameters were based on the following:

3.3.1.1 Return Period

A 1:50 year return period was considered. It should be stated that normally a 1:20 year return period should limit risks but a 1:50 year return period will reduce risk for damage and higher maintenance effort further with up to 25%.

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3.3.1.2 Runoff Coefficient

The calculated runoff coefficient is based on the following:

Table 2: Runoff Coefficient

Slope	% Area	Permeability	% Applied	Vegetation	% Applied
< 3%	100%	Very		Dense Woods	
3% to 10%		Permeable	50%	Cultivated land	
10% to 30%		Semi Permeable	50%	Grassland	100%
>30%		Non-permeable		Rock	

The runoff coefficient calculated and used in the flood estimation is 0, 27 which is typical for the area.

3.3.1.3 Time of Concentration

Time of concentration is calculated by the widely used USBR stream flow formula:

$$Tc = \left(\frac{0{,}87.L^2}{1000.S}\right)^{0.385}$$

Where:

Tc = Time of Concentration [hours],

L = Length of waterway [km], and

S = average slope.

3.3.1.4 Point Intensity

Point intensity is based on standard time of concentration – rain fall depth graphs using a MAP of 400mm/annum.

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3.3.2 Runoff

3.3.2.1 PV Area

The runoff distribution for the respective catchment areas will be dictated by the layout of the PV area as well as internal roads and channels. However the PV area (which is normally a combination of blocks of similar size) should preferably be orientated in such a way, to minimise impact on natural drainage patterns.

A typical configuration (subject to the final site development plan) is indicated in the following figure:

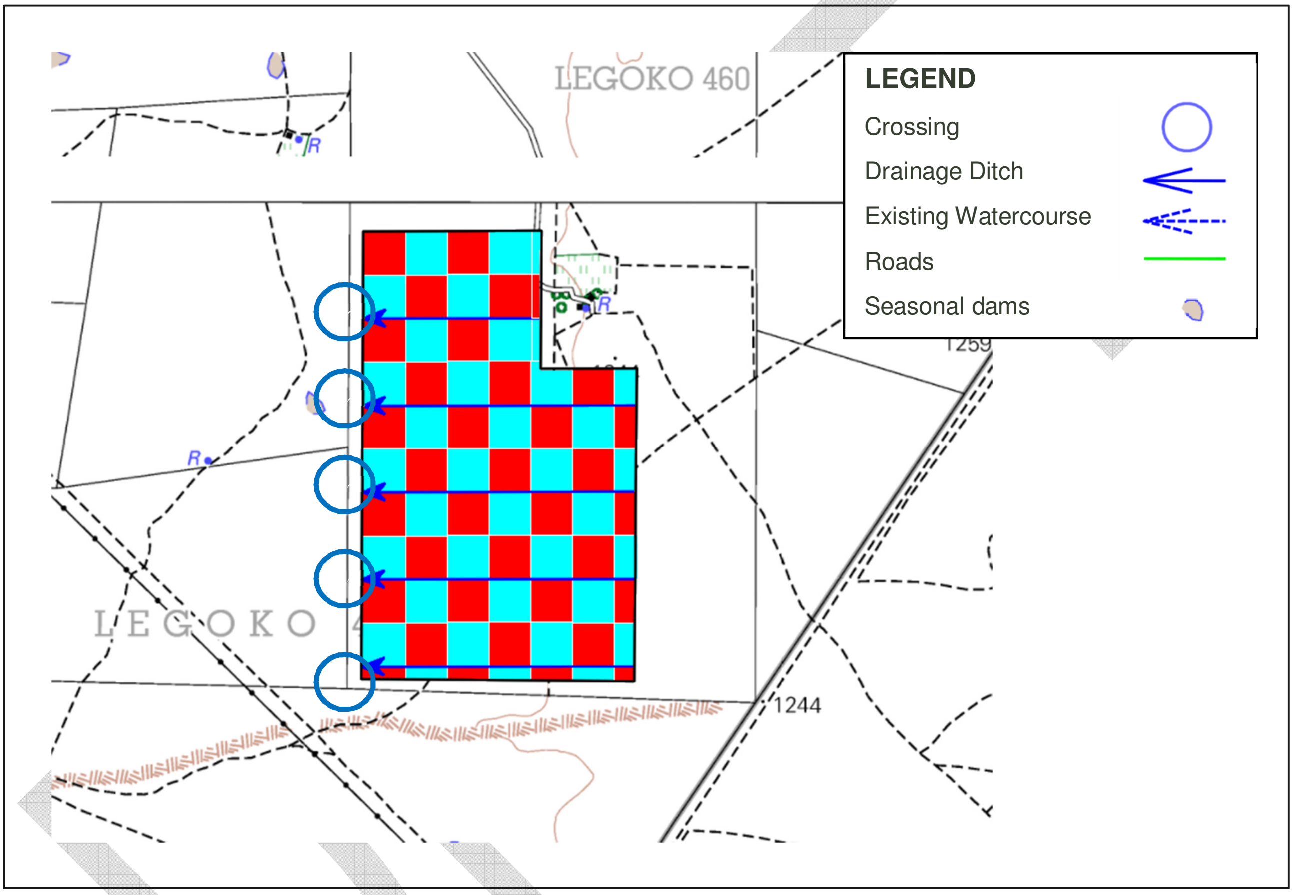

Figure 8: Flow Distribution – Facility

There are no water bodies located in the proposed site, thus no water ponding can be expected during the times of rain and the entire site can be used as PV area.

The 1:50 year runoff per catchment area is indicated in the following table:

Table 3: Runoff Calculations

Catchment ID	Runoff Coefficient	Area	Peak Flow	
			1:25	1:50
		(km²)	(m³/s)	(m³/s)
A1	0.27	6.614	9.5	13.9
A2	0.27	18.014	15.3	22.6
A3	0.27	19.017	17.3	25.5

3.3.2.2 Access Road

The run-off crossing the preferred access (Alternative 2) is nominal. Flow and Outlet Conditions

The flow velocity and depth at the various outlets will have to be confirmed during detail design stage. Generally, for slopes of between 0,5% and 1%, the average velocity is in the order of 1,0m/s with depths of less than 0,2m deep.

The flows would generally not cause any serious erosion but appropriate measures should be implemented at outlets and points of concentration caused by drainage ditches to reduce any risk of erosion damage.

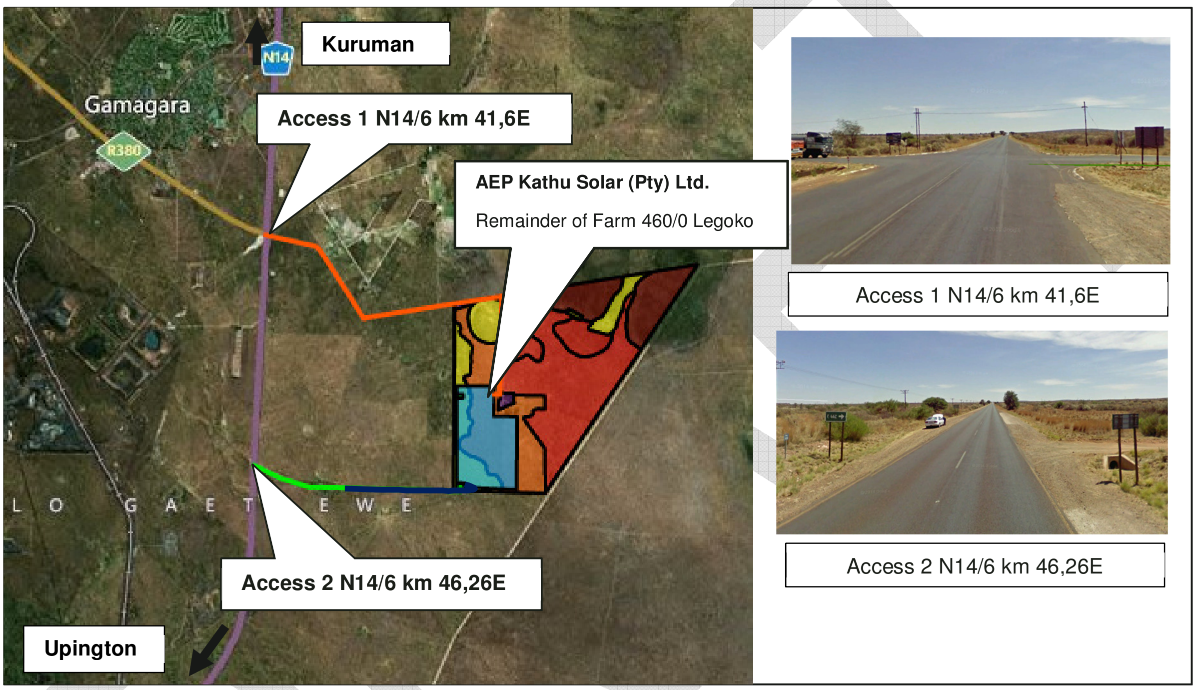

Figure 9: Access Road

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3.4 Proposed Measures for Stormwater Management

3.4.1 General

The existing drainage patterns and characteristics should be preserved as far as possible. To that end it is suggested that existing contours (and vegetation) be retained as far as possible and that internal roads are kept to minimum standards.

Drainage structures would generally be small diameter pipes (encased in concrete because of the low fill anticipated) or preferably gravel or concrete drifts. Gravel drifts should be provided with a cut-off wall on the down-stream side as a minimum requirement.

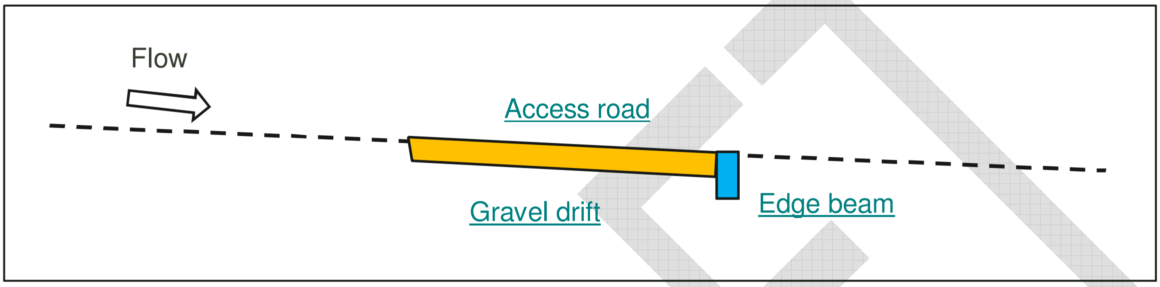

Figure 10: Typical Cross Section - Gravel Drift

3.4.2 Side Drains

In general open drains will be provided along the proposed internal roads or between PV panels.

The open drains would be gravel drains with concrete or edge beam protection at road crossings where required.

3.4.2.1 Access Roads

No changes to the drainage are required for the first 1,2 km of the main access road except for potential strengthening of shallow pipes. Frequent nominal drainage should be provided at 200m – 300m intervals on the upgraded gravel portion of the access road. This could be provided as drifts where the road alignment is close to the natural ground level.

Adequate drainage elements -preferably drifts - should be provided for the internal service roads within the PV area.

3.4.3 Berms

Berms are proposed to prevent external water from entering the PV area and directing flow to suitable areas of release.

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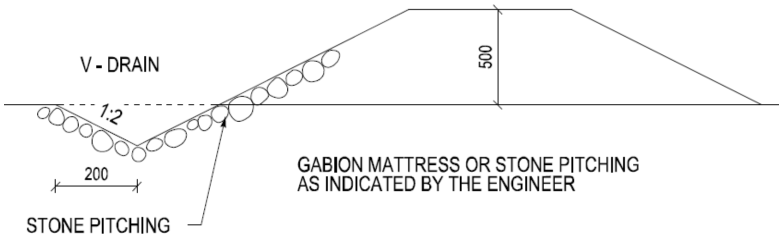


Figure 11: Typical Detail – Berm

3.4.4 Outlets

All culverts located on the access road have concrete outlets with erosion protection.

Side drain outlets should be terminated with suitable erosion protection to reduce the velocity and flow depth.

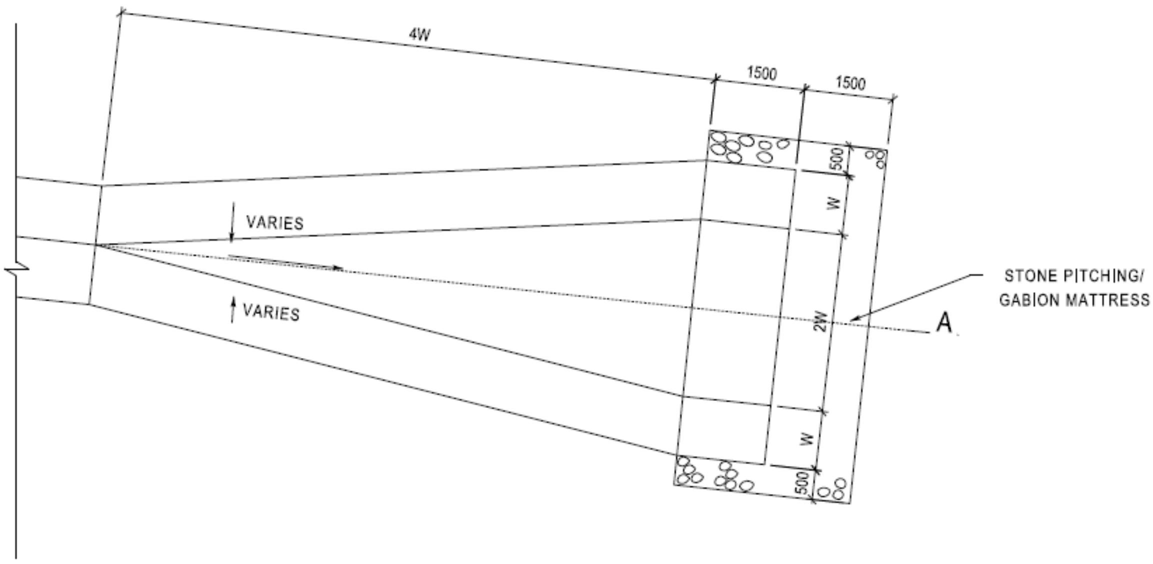
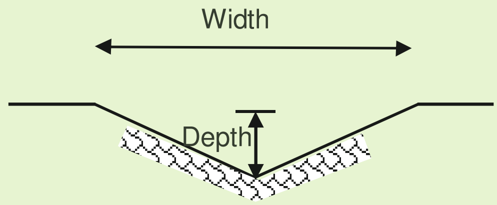
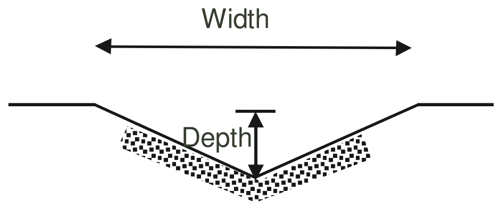
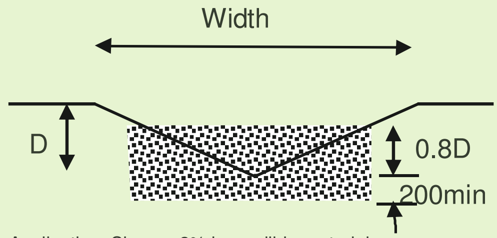
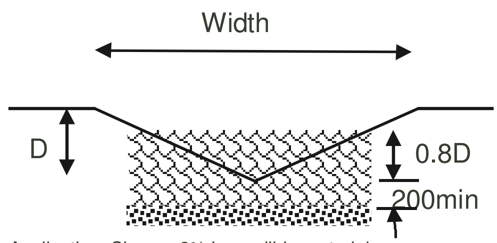
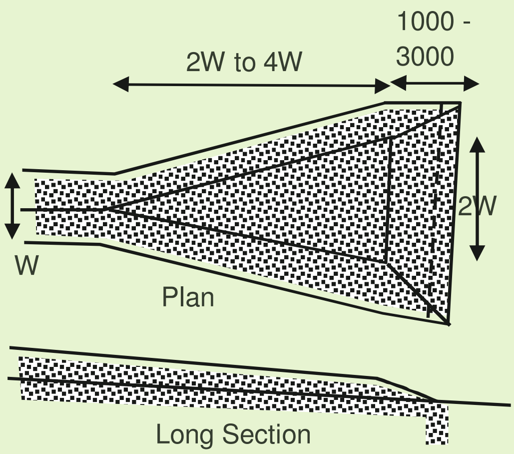


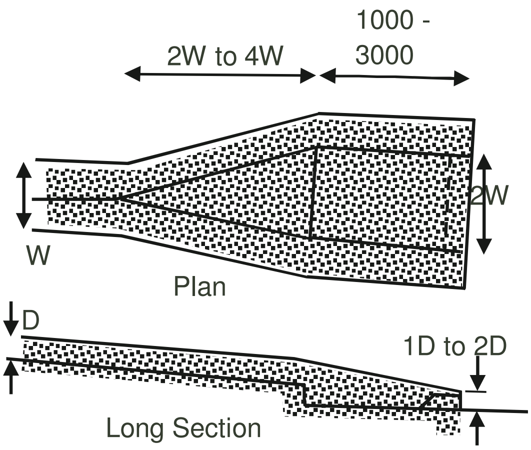
Figure 12: Typical Detail – Outlet with Erosion Protection

3.5 Erosion Protection Measures

It will be important to evaluate all elements during the detail design phase with regard to the volume and in particular the velocity of storm water on the site. The following areas should be identified as potential impact areas:

Element	Possible Protection Measure		Likeliness to be Used (1 – Very Unlikely to 5 – Very likely)	Typical Details
Project Life				
Side Drain	Lining	Stone Pitching	3	 Application: Slope > 1% in erodible material
		Concrete	1	 Application: Slope > 2% in erodible material
	Transverse Walls	Gabions	3	 Application: Slope > 2% in erodible material Top width = 300mm 1m invert protection downstream

Element	Possible Protection Measure		Likeliness to be Used (1 – Very Unlikely to 5 – Very likely)	Typical Details
		Stone Masonry with 1:5 slopes	4	 Application: Slope > 2% in erodible material Width = 300mm 1m invert protection downstream 100 mm concrete blinding class 15/19
In/Outlets	Structure	Concrete	2	 Application: Lined drain outlet with typical dimensions Actual dimensions to be verified with detail design
		Stone	5	Same as for concrete
		Gabions	2	Same as for concrete

Element	Possible Protection Measure		Likeliness to be Used (1 – Very Unlikely to 5 – Very likely)	Typical Details
	Stilling Basin	Concrete	1	 Application: Lined drain drop outlet with typical dimensions Actual dimensions to be verified with detail design
		Stone	1	Same as for concrete
		Gabions	1	Same as for concrete

Although these measures are potentially required, it is highly unlikely that such measures will be required due to the flat nature of the terrain and the relative moderate run-off volumes. It is therefore envisaged that only minimal of these measures will be required such as:

- Stone masonry walls to reduce the flow velocity in steeper local areas
- Side Drain Outlet with stone pitching to prevent erosion
- Temporary berms and straw bales during construction in the vicinity of identified streams to reduce flow and sediment transport during this phase.

It will also be important to pay attention during the construction phase that no construction activities will result in ponding water particularly in the vicinity of the roads and structures.

3.6 Waste Water Management

3.6.1 Wash Water Runoff

After construction, the washing of the solar panels is likely to cause nominal additional run-off. This process is estimated to occur twice a year and introduce approximately 3 l/m² to the site over a period of approximately 2 weeks depending on the workforce. This runoff would however be spread throughout the site and due to the low water volumes, would cause minimal if any erosion on the site and may help as a form of dust control. The methods used for washing the panels would impact on the necessities for erosion mitigation. The impact on erosion will be mitigated by phasing the washing of panels or optimising the methods used. The overall effect on the natural water courses is expected to be very low provided the cleaning water is free from detergents or comprise of approved bio-degradable substances.

Figure 13 Washing Panels

3.6.2 Risk of Pollution

Construction of the AEP Kathu Solar PV Facility could potentially cause localised, short term, deterioration in surface water quality. Construction activities are likely to increase the risk of hydrocarbon and other hazardous chemical spills. Contractors should submit method statements on how this risk will be mitigated, while complying with the approved Environmental management Programme.

3.6.3 Liquid Effluent

The liquid effluent generated will be minimal and limited to the ablution facilities. All workers will be transported to site on a daily basis and no workers will be housed on site. Chemical toilets will be on site during construction and during operation of the facility. These chemical toilets will be serviced and emptied on a regular basis by a private contractor. The sewage will be transported to a nearby waste water treatment works, located in the Gamagara Local Municipality, for treatment.

The use of a septic vs. conservancy tank during operation will be determined by the local authority. Due to the remote locality of the farm, sewage cannot be disposed in a municipal waterborne sewage system.

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4 CONCLUSION

The proposed Stormwater Management Plan presents a proposed strategy for drainage elements required to accommodate the stormwater through the site, between the PV panels and for the access road to the facility.

The strategy is to follow the existing contours to minimise impacts on the existing drainage patterns.

The proposed drainage elements should be included in the detailed design to ensure effective management of the stormwater through the site and prevent erosion at the outlets.

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T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W www.aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, China,
Ethiopia, Ghana, Hong Kong, Indonesia,
Lesotho, Libya, Malawi, Mozambique,
Namibia, New Zealand, Nigeria,
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