POSTMASBURG SOLAR PV ENERGY FACILITY 2 PROJECT

STORMWATER MANAGEMENT PLAN

Reference: A43277

Prepared for: ATLANTIC RENEWABLE ENERGY PARTNERS (Pty) Ltd

Revision: 1

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1 INTRODUCTION

Atlantic Renewable Energy Partners (Pty) Ltd has engaged Aurecon to prepare a conceptual Stormwater Management Plan (SMP) for the proposed Postmasburg Solar PV Energy Facility 2 approximately 22km north of Postmasburg on the Remainder of Farm 436 Kapstewel next to the R325. The site location is indicated on the Key Plan below:

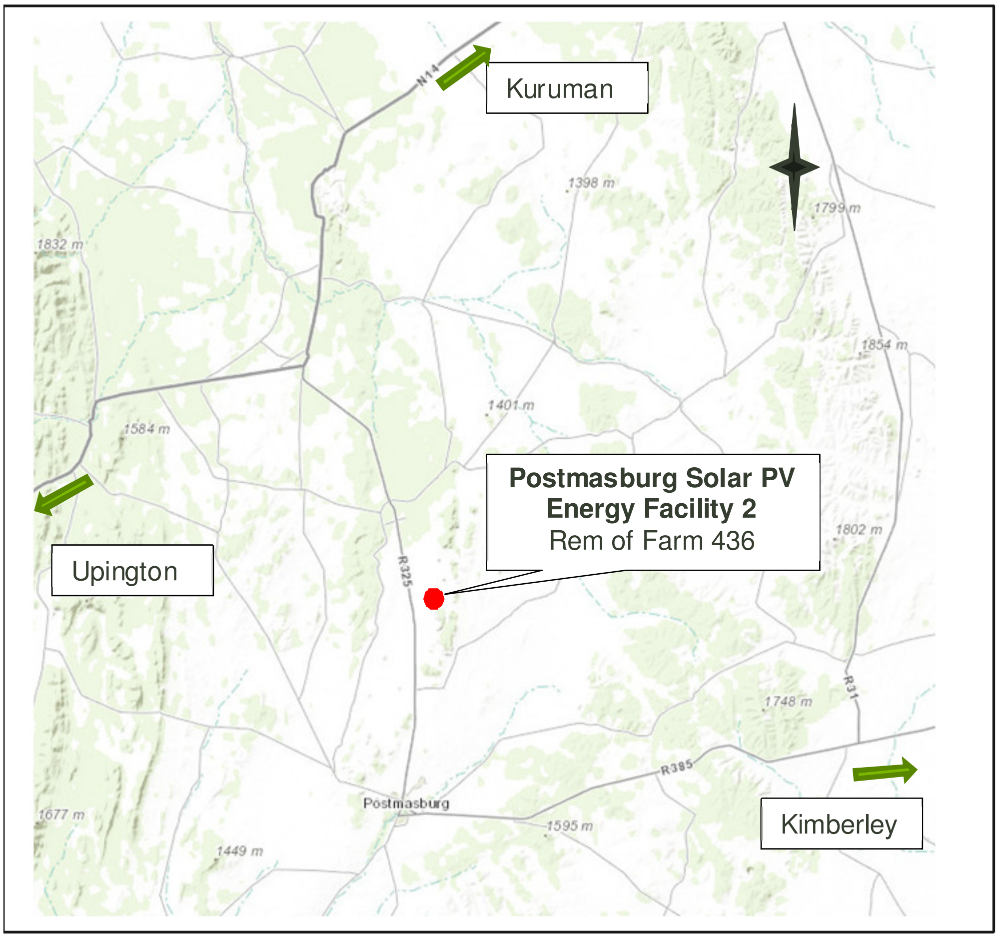

Figure 1: Key Plan

The solar site will be developed to 75 MW capacity.

The scope of the study is to prepare a conceptual Stormwater Management Plan (SMP) to support the Environmental approval of the proposed Postmasburg Solar PV Energy Facility 2. 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 was based on the existing contours. **The adjustments to grade and angle for the PV panels is assumed to be taken up by adjustments in the foundation levels**.

3 SITE STORMWATER

3.1 Climate and Land Use

The proposed site is located in a moderate to dry area with predominantly grass and shrubs as vegetation.

Figure 2: Typical Vegetation

After mining the main economic activity in the area is stock farming with cattle, sheep and goats.

The area experiences summer rainfall in the form of thunderstorms with a Mean Annual Precipitation of 404 mm per annum.

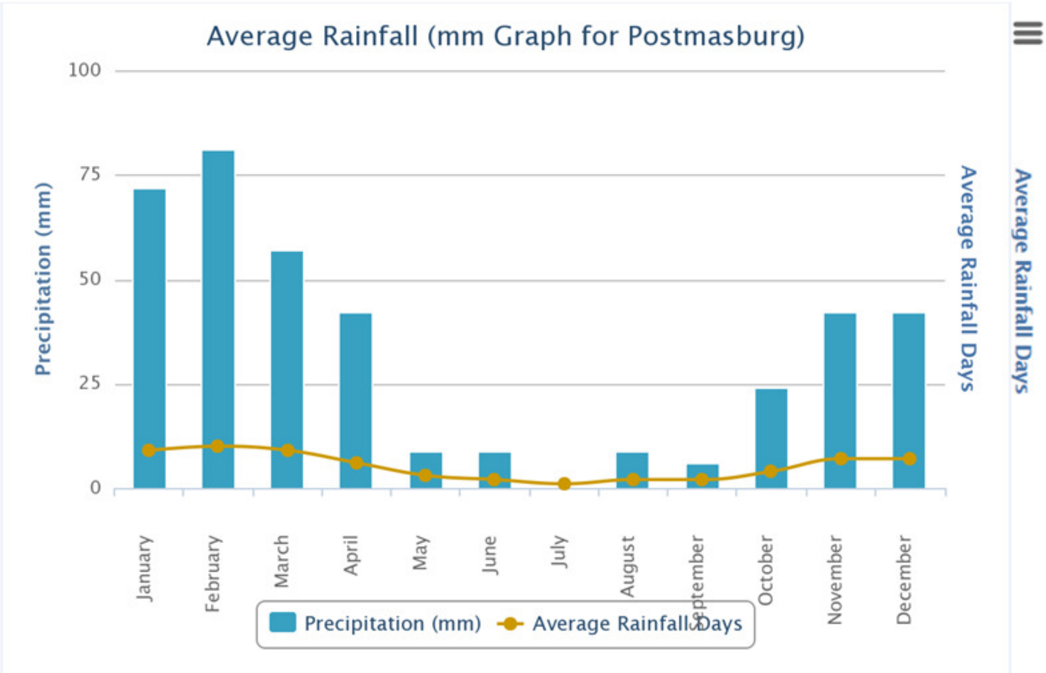

Figure 3: Average Rainfall

The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Postmasburg range from 17℃ in June to 30℃ in January. The region is the coldest during July when the mercury drops close to 1℃ on average during the night.

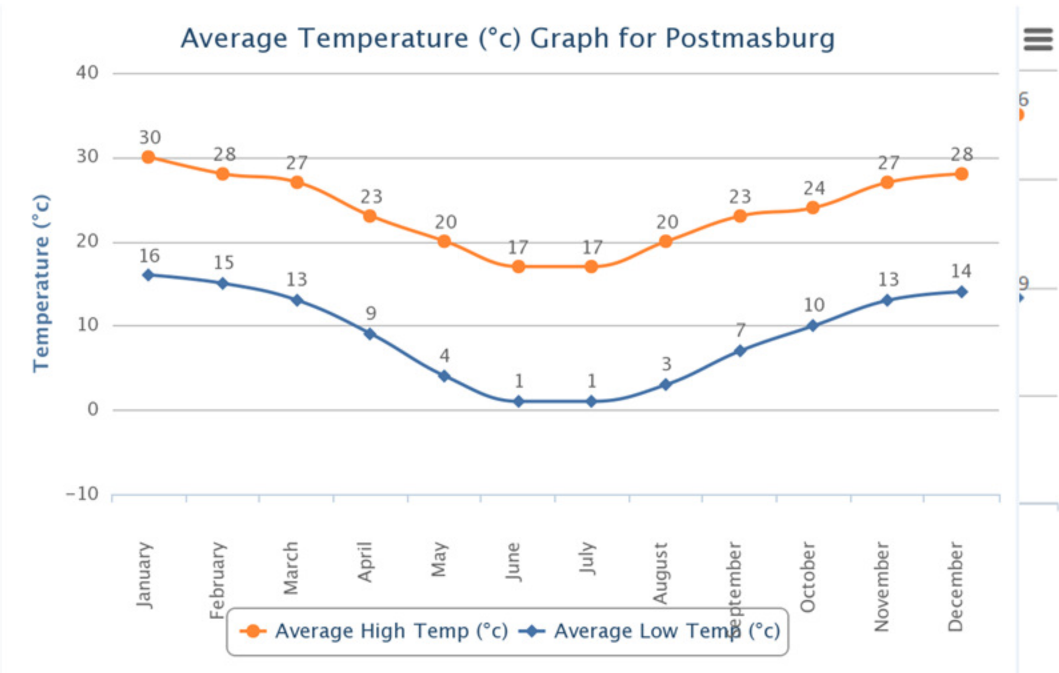

Figure 4: Average Temperature

3.2 Drainage Characteristics

The proposed site is generally flat with gradients ranging from below 1,0% to 2,0% through the site. The PV area generally drains towards the West and North-West.

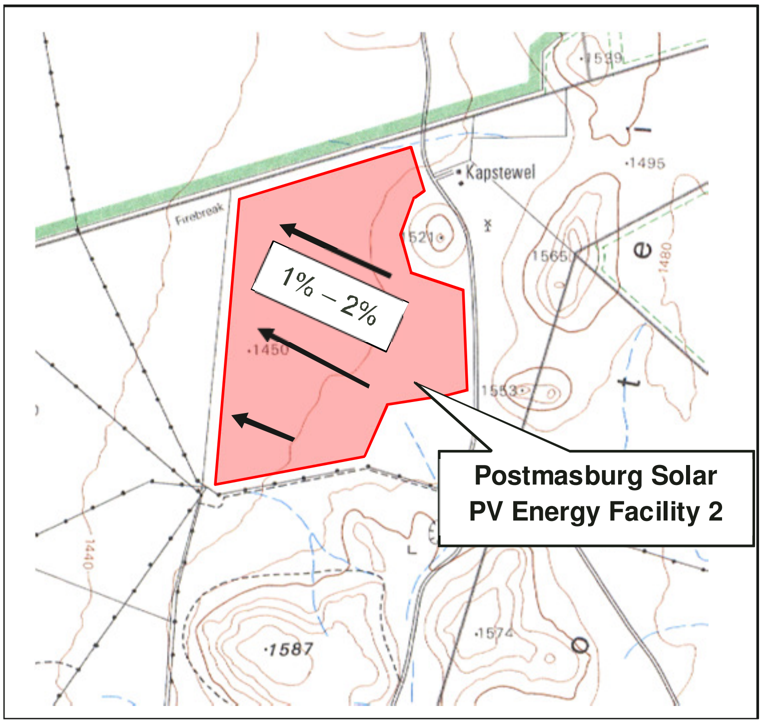

Figure 5: Drainage Characteristics

3.2.1 Drainage Patterns

3.2.1.1 PV Area

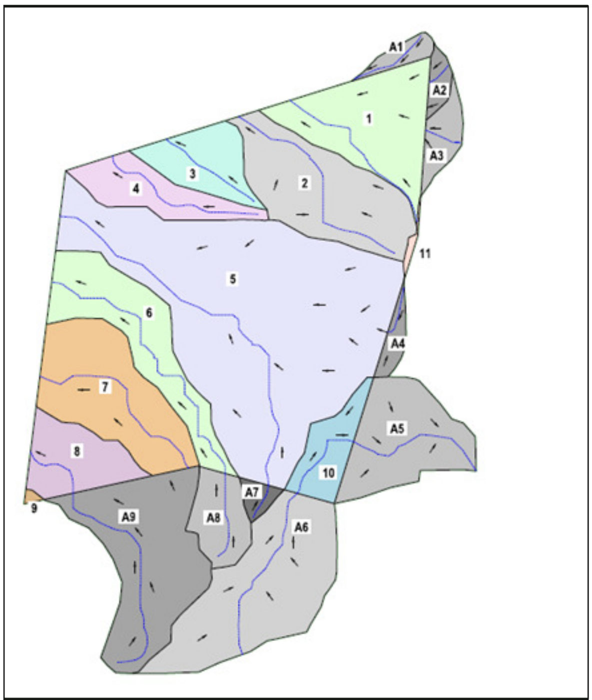

Figure 6: PV Area Drainage Pattern and Catchment Areas.

It should be noted that in absence of detailed topographical information, satellite data was used to establish the drainage patterns. The catchment areas identified in correlation to the proposed PV layout are:

Table 1: Catchment Areas

Catchment ID	Area (km²)	Catchment ID	Area (km²)
1	0.57	A1	0.05
2	0.51	A2	0.04
3	0.21	A3	0.09
4	0.22	A4	0.05
5	1.87	A5	0.37
6	0.58	A6	0.62
7	0.50	A7	0.04
8	0.82	A8	0.16
9	0.01	A9	0.59
10	0.78		
11	0.01		

3.2.1.2 Access Road

The position of the access road was not finalised at compilation of this report. However the shorter direct access is considered. The approach to stormwater management for the alternative route (if selected) will be similar.

The catchment area (approximately 1,2km²) for the access road is indicated in the following figure:

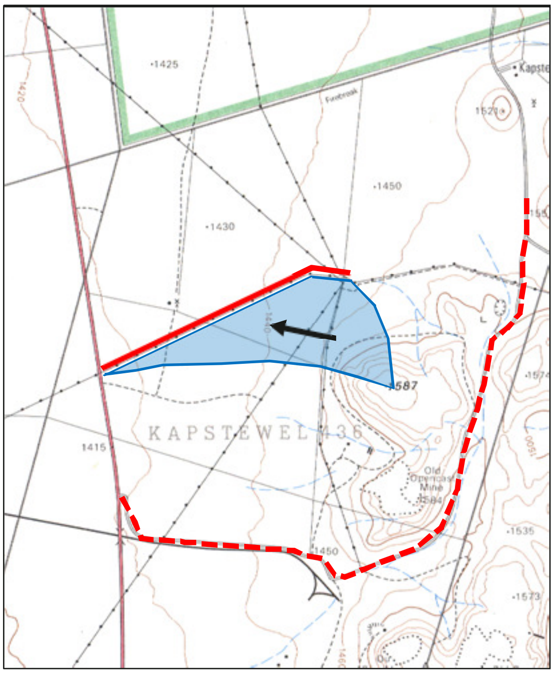

Figure 7: Catchment Areas of Access Road

3.2.2 Runoff Characteristics

The grass and bushveld vegetation in combination with flat grades and semi-permeable soils yield average 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.

3.3.1.2 Runoff Coefficient

The runoff coefficient was 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 calculations was 0,23.

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], S = average slope.

3.3.1.4 Point Intensity

Point intensity is based on standard time of concentration – rain fall depth graphs.

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 to minimise impact on natural drainage patterns.

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

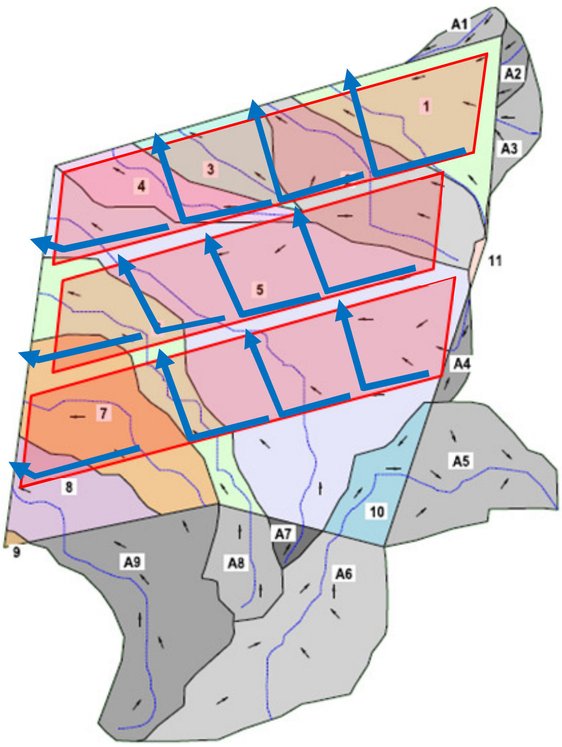

Figure 8: Flow Distribution – Facility

As it appears that there are not dominant watercourses through the site, the runoff should be distributed on the outlet side to prevent concentration of water with associated erosion and or other impacts.

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

Table 3: Runoff Calculations

Catchment ID	Runoff Coefficient	Intensity	Time of Concentration	Area	Peak Flow
		(mm/h)	(min)	(km²)	(m3/s)
A1	0.26	125	15	0.05	0.4
A2	0.26	125	15	0.04	0.3
A3	0.26	125	15	0.09	0.7
A4	0.26	125	15	0.05	0.4
A5	0.26	109	20	0.37	2.4
A6	0.26	69	43	0.62	2.6
A7	0.26	125	15	0.04	0.3
A8	0.26	125	15	0.16	1.2
A9	0.26	125	15	0.59	4.4
1	0.26	78	35	0.57	2.7
2	0.26	65	47	0.51	2.0
3	0.26	125	15	0.21	1.6
4	0.26	116	18	0.22	1.5
5	0.26	30	131	1.87	3.4
6	0.26	33	118	0.58	1.1
7	0.26	60	52	0.50	1.8
8	0.26	75	38	0.82	3.7
9	0.26	125	15	0.01	0.0
10	0.26	53	63	0.78	2.5
11	0.26	125	15	0.01	0.1

3.3.2.2 Access Road

The estimated total flood is in the order of 2,2 cumecs and will have to be distributed along the road with suitable drainage elements.

3.3.3 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 1% and 2%, the average velocity is in the order of 1,5m/s.

3.4 Proposed Measures for Stormwater Management

3.4.1 General

The existing drainage patterns and characteristics should be preserved as far as possible.

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 protection at crossings where required.

3.4.2.1 Access Road

Stormwater for the access road is through pipe / box culverts or drifts at frequent (300m minimum) spacing. Because the road will be relatively low above normal ground level (NGL), the pipes / boxes will probably have to be encased in concrete to carry the required heavy vehicle loads.

It is estimated that at least 6 such elements will be required for the estimated flood of 2,2 cumecs.

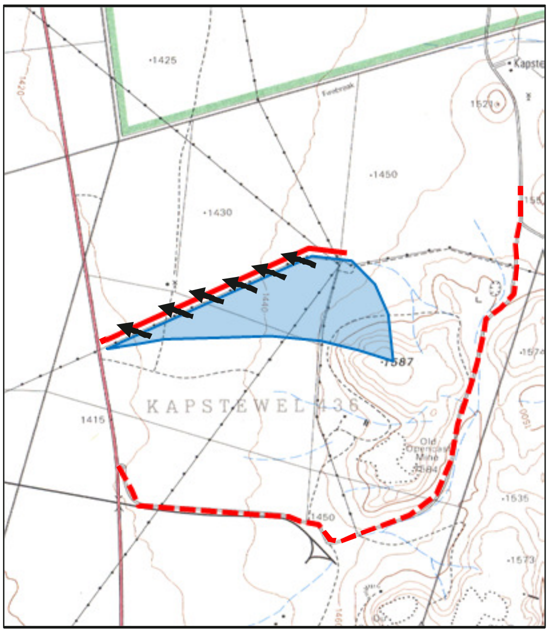

Figure 9: Drainage Elements for Access Road

3.4.3 Berms

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

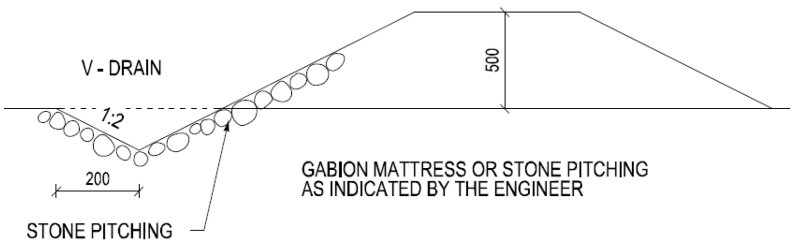

Figure 10: Typical Detail – Berm

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 at these locations.

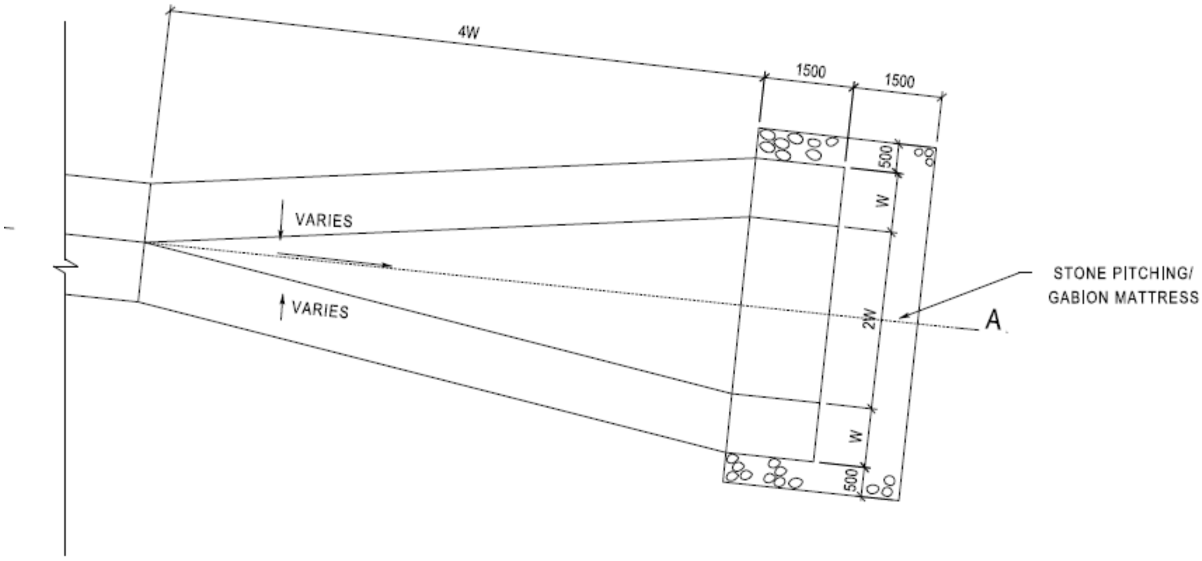

Figure 11: Typical Detail - Outlet with Erosion Protection

4 CONCLUSION

The conceptual 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.

It follows 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.

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