

Stormwater, Wastewater and Erosion Management Plan for Gamka PV

Report Prepared for

Gamka PV (Pty) Ltd

Report Number 579060/Gamka PV



Report Prepared by

 **srk** consulting

28 February 2022

Stormwater, Wastewater and Erosion Management Plan for Gamka PV

Gamka PV (Pty) Ltd
101, 1st Floor, West Quay Building
7 West Quay Road
Waterfront
Cape Town
8000

SRK Consulting (South Africa) (Pty) Ltd.
The Administrative Building
Albion Spring
183 Main Rd
Rondebosch 7700
Cape Town
South Africa

Tel: +27 (0) 21 659 3060
Fax: +27 (0) 21 685 7105

e-mail: capetown@srk.co.za
website: www.srk.co.za

SRK Project Number 579060/Gamka PV

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Compiled by:

Xanthe Adams, Pr. Eng
Principal Engineer

Email: xadams@srk.co.za

Authors:

X Adams, T Netshitangani

Peer Reviewed by:

Bruce Engelsman, Pr. Eng, Pr. CPM
Partner

Executive Summary

Gamka PV (Pty) Ltd. propose developing a commercial solar Photo-Voltaic (PV) facility and associated infrastructure on a site located approximately 13 km south-east of Beaufort West In South Africa.

This report documents the Stormwater, Wastewater and Erosion Management Plan (referred to as the SWMP) required for the proposed development. The SWMP aims to facilitate the protection of surface water resources and covers the total proposed project development area.

Based on the potential impacts, as well as legal requirements and best practice guidelines, specific objectives were developed for stormwater and erosion management. A plan was then developed to address each objective to protect surface water resources.

The report concludes that stormwater impacts can be managed on the site in a practical way that will protect water bodies and minimise erosion. It is recommended that the SWMP be further developed during the detailed design stage. The plan should be incorporated into an environmental specification for use during construction and operation of the facility.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd. (SRK) by Gamka PV (Pty) Ltd (the Client). The opinions in this Report are provided in response to a specific request from the Client to do so.

SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

1 Introduction

SRK Consulting (South Africa) (Pty) Ltd. (SRK) was approached by Gamka PV (Pty) Ltd (the Client) to develop a Stormwater, Wastewater and Erosion Management Plan (referred to as the SWMP) for the proposed new development of a commercial solar Photo-Voltaic (PV) facility. The proposed site is located approximately 13 km south-east of Beaufort West In South Africa.

2 Objectives and Scope of the Report

2.1 Objectives

The objective of this report is to prepare a SWMP that strives to protect surface water resources, manages erosion risks and complies with the relevant regulations and guidelines (listed in Section 3.2) for the construction and operation phases of the Gamka PV facility.

2.2 Scope

This report covers the following scope:

- Delineation of the catchments draining through the development area;
- Determination of the type of catchment (clean or dirty area);
- Calculations of peak stormwater discharges from each catchment; and
- Recommendations for stormwater management and erosion protection during the design, construction and operation phases of the proposed project.

The SWMP is a conceptual study at this stage. A detailed survey and SWMP study will need to be undertaken during the design of the required infrastructure.

The layout of the development area is shown in Figure 2-1 with other potential PV facilities shown in grey near to the site.

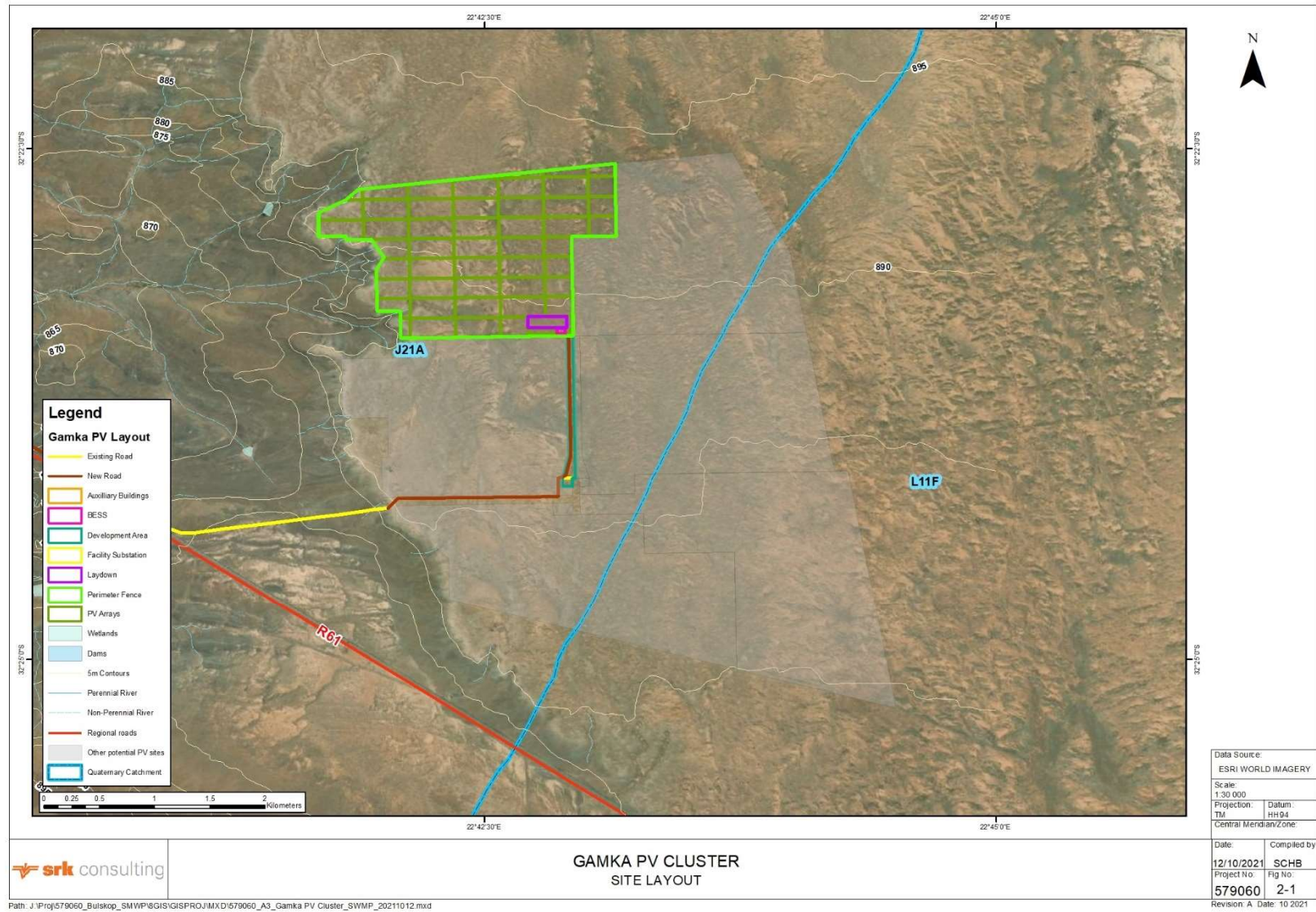


Figure 2-1: Gamka PV Conceptual Site Layout

3 Supporting Information

This section summarises all of the available information and assumptions upon which the derivation of the SWMP is based. This is done to highlight how the plan was developed: by matching regulations and guidelines to the specific needs of the project in the local natural conditions on site. The available information is therefore key to understanding the SWMP.

3.1 Site and Project information

The project information was provided by the client during a site visit in September 2021.

3.1.1 Project information

The information provided that is relevant to stormwater management is as follows:

- Fixed-tilt or tracking solar PV panels with a maximum height of 3.5 m;
- An O&M building, inclusive of laydown area, toilet facilities connected to a conservancy tank for wastewater collection and a chemical storage area;
- An electrical substation including transformers containing oil;
- On-site inverters and inverter transformers (containing oil) located between the panels to step up the power;
- Cabling between the project's components, to be laid underground where practical;
- Fencing around the development area;
- A Battery Energy Storage System (BESS). The BESS will be solid state and is therefore a non-liquid/solid-state battery technologies (e.g. Lithium ion)"
- A workshop;
- Access roads:
 - Existing roads will be used as access roads where possible; and
 - Existing roads will be extended to create access to the Gamka PV facility where necessary.
- During construction, a temporary laydown area will be used;
- Small quantities of fuel and other motor oils will be stored on site and transferred into vehicles. These will be bunded.

General waste will only be stored temporarily and taken off site regularly for disposal to landfill.

3.1.2 Other studies

Correspondence with the client indicated that, "The initial freshwater screening report indicated that part of the project site is located within the alluvial channels associated with the Platdoring floodplains, and that mitigation measures should focus on effective stormwater management to reduce erosion within the project area and in downstream reaches" (pers. comm. Peter Smith, 5 October 2021) .

3.1.3 Site Visit

The site was visited by X.Adams from SRK Consulting on 22 September 2021. The site terrain is gradual (very "flat" land with low angle slopes in colloquial terms). No erosion was observed in either

vegetated areas, cleared areas or roads. It was noted that even on a slightly steeper road near the site (where the access roads are planned) no erosion was observed.

The soils on the site were assessed visually and judged to have low to moderate permeability for the purposes of a stormwater management plan. The soils were not lab tested and judgement erred on the conservative side so that no drains would be undersized. Few natural or artificial drainage channels were observed on the site or noted on any maps. The vegetation is sparse, and composed mainly of low shrubs in between soil that appeared to somewhat compacted, perhaps naturally or by previous stock grazing. A photograph from the site is shown in Figure 3-1.



Figure 3-1 Photographs of the proposed Gamka PV site

3.2 Legislation and guidelines

SWMPs are generally required to support the Environmental Management Programme (EMPr) and Water Use License Applications. The following was taken into account in compiling the SWMP:

- Best Practice Guideline for Stormwater Management (Department Water Affairs and Forestry, 2006);
- Regulation 704 of the National Water Act (Department of Water Affairs and Forestry, 4 June 1999).

Municipal regulations, which may introduce specific standards for each municipality, but still adhere to the overall principles of the regulations and guidelines above, should be considered during detailed design (if relevant).

3.3 Natural conditions

3.3.1 Climate

The development area lies in an arid to semi-arid climatic region with average rainfall below 182 mm per year. The average evaporation rate in the area is between 2 200 - 2600 mm. In summer months, temperatures can be in excess of 40°C and in winter months dip to below -5°C.

3.3.2 Design rainfall

The rainfall analysis was based on the “Design Rainfall Estimation in South Africa” (DRE) program developed by JC Smithers and RE Schulze (Smithers & Schulze, 2002). The program implements procedures from the Water Research Commission (WRC) project entitled “Rainfall Statistics for Design Flood Estimation in South Africa” (WRC Project K5/1060).

The rainfall data is interpolated for a point within the site from nearby rainfall stations (Smithers and Schulze - Design Rainfall in South Africa). The rainfall station closest to the development area is Blouboskuil (0092386_W), which is approximately 4 km from the site. Table 3-1 indicates the relevant design rainfall for the site.

Table 3-1: Design Rainfall (mm) Data Interpolated for the site centroid.

Design Rainfall Data (mm) interpolated from six closest stations							
Mean annual rainfall	182 mm		Latitude	32 degrees 24 minutes			
Altitude	876 mamsl		Longitude	22 degrees 43 minutes			
Storm duration	Return Period (Years)						
	2	5	10	20	50	100	200
5 minutes	5.8	8.5	10.5	12.6	15.5	17.9	20.4
15 minutes	10.3	15.2	18.7	22.4	27.6	31.8	36.3
1 hour	15.5	22.8	28.1	33.6	41.3	47.7	54.4
1.5 hours	17.4	25.6	31.6	37.8	46.5	53.6	61.2
2 hours	18.9	27.9	34.4	41.1	50.6	58.3	66.6
8 hours	25.9	38	46.9	56.1	69.1	79.6	90.9
24 hours	33.1	48.7	60.1	71.9	88.4	102	116.4
5 day	39.3	57.8	71.3	85.3	105	121.1	138.2

3.4 Potential Stormwater, Wastewater and Erosion Impacts

An overall analysis of the available data and the development plans reveals the following related to potential impacts:

- The facility presents a very low risk to adversely impacting surface water resources because:
 - Apart from minor bush clearing and trampling to construct the Gamka PV, the development will leave the natural vegetation, soil conditions and topography largely undisturbed;
 - The roads have been well placed, as they lie mostly outside of the natural water ways and most river crossings are over very small drainage lines characterised with small catchments and low flows;
 - Few natural or artificial drainage channels were observed on the site or noted on any maps. The drainage lines from the national topographical map show a small

- encroachment into the south-west corner of the facility. The drainage lines from the aquatic ecologist shows an encroachment in the north-west corner of the facility;
- The access road crosses a few small ephemeral streams which rarely flow;
 - Sewage and landfill waste will be disposed of off site;
 - Rainfall in the area is low, and no steep slopes exist to generate high flow velocities.
- Some potential impacts do exist, including:
 - Possible contamination of stormwater by:
 - Sediment that is collected in runoff due to ground disturbance;
 - Oil leaks from the transformers;
 - Oil and lubricants in wash down water from the workshop; and
 - Overflow of wastewater from the conservancy tanks.
 - Potential for erosion:
 - Where any stormwater drain concentrated discharges into rivers or onto the natural land surface; and
 - At river / road crossings.
 - Potential usually exists in such developments to impede and disrupt flow and to cause damage to infrastructure and exacerbate erosion if infrastructure is placed within areas that are inundated in floods. However, this site has a few small water courses encroaching the borders with a negligible impact on flows and infrastructure.

4 Project Specific Objectives

The project specific objectives were developed based on the site specific characteristics, regulations and guidelines mentioned in Section 3.2, and are as follows:

- Dirty water should not spill into clean water systems more than once in a 50-year return period;
- Collect and treat any dirty water before discharge;
- Provide additional protection to the sensitive Platdoring floodplains, where possible
- Do not impede surface or subsurface water flows unless unavoidable;
- Minimize the potential for erosion in large storm events >1:50-year flood events;
- Include a monitoring and inspection system for spills, leaks and erosion and commit to remediating where needed;
- Review and improve the SWMP regularly.
- Ensure no infrastructure, except road crossings and solar panel supports are built within the water courses;
- Do not build infrastructure, in particular infrastructure containing potential pollutants, within 300 m of natural drainage lines.

5 Hydrology Study

The first step in the SWMP development is an analysis of the development area and the proposed facility. The analysis found that the proposed facility is likely to have an intrinsically low impact on the surface water resources because:

- The vegetation, soil and topography will remain mostly undisturbed;
- The development footprint and roads are well placed, as they lie mostly outside of the natural watercourses and most river crossings will have low flows;
- Water use on site, with the potential to generate runoff, such as solar panel washing, is negligible in volume compared to stormflows;
- Sewage and landfill waste will be taken off site for disposal; and
- Rainfall in the area is low and few steep gradients exist.

Despite the low impact on surface water resources, some potential impacts are possible including:

- Dirty areas will exist, which could contribute to contamination including:
 - Transformers, which could leak oil;
 - The workshop, which may store oils or lubricants that could contaminate wash down water; and
 - The sewage conservancy tank, which could leak or overflow.
- Erosion, where stormwater drains concentrated discharge to the natural environment or around stockpiles;
- Potential infrastructure, such as PV panels, and potential road crossings within the PV areas, which could exacerbate erosion without proper design, were identified – these crossed relatively small drainage lines of which very few existed. The drainage lines from the national topographical map and those generated by the aquatic ecologist show an encroachment, however this is of negligible impact to flows and infrastructure. This will need to be confirmed during a detail design, based on a detailed land survey of the project area; and

5.1 Delineation of clean and dirty areas

The development area is divided into clean and dirty areas as follows:

- Dirty areas:
 - The workshop where oils and lubricants may be stored and used
 - A chemical storage area will be constructed for the operational phase of the project, which will include proper containment and bunding for all chemicals stored on site;
 - The medium-voltage transformers (at the inverter stations) placed around the development area, as these will contain oil;
 - Transformers at the substation, as these will contain oil;
 - The conservancy tanks, as this will contain sewage; and,
 - Vehicle wash bay that has a hardstanding surface on which vehicles are washed, generating dirty water which drains to a sump.
- Clean areas are deemed to be all areas outside of those stated above as dirty areas.

5.2 Identification of road crossings

Potential road crossings were identified for all the roads that will be upgraded or built as part of the project, noting that the road / river crossings are conceptual at this stage, and their locations are approximate. Any internal road crossings will be minor and conceptual designs provided in this report can be used as a basis for detailed design of such crossings. The crossings are shown in Figure 5-1

It is extremely unlikely that minor modifications in road position will change the assessments and conclusions in this report. Also note that the road crossings are over minor natural drainage lines near the source of their flow. Note that the drainage lines from the national topographical maps are indicated as "Perennial" and "Non-Perennial" rivers and the drainage lines generated by the aquatic ecologist are indicated as "Riverine Areas".

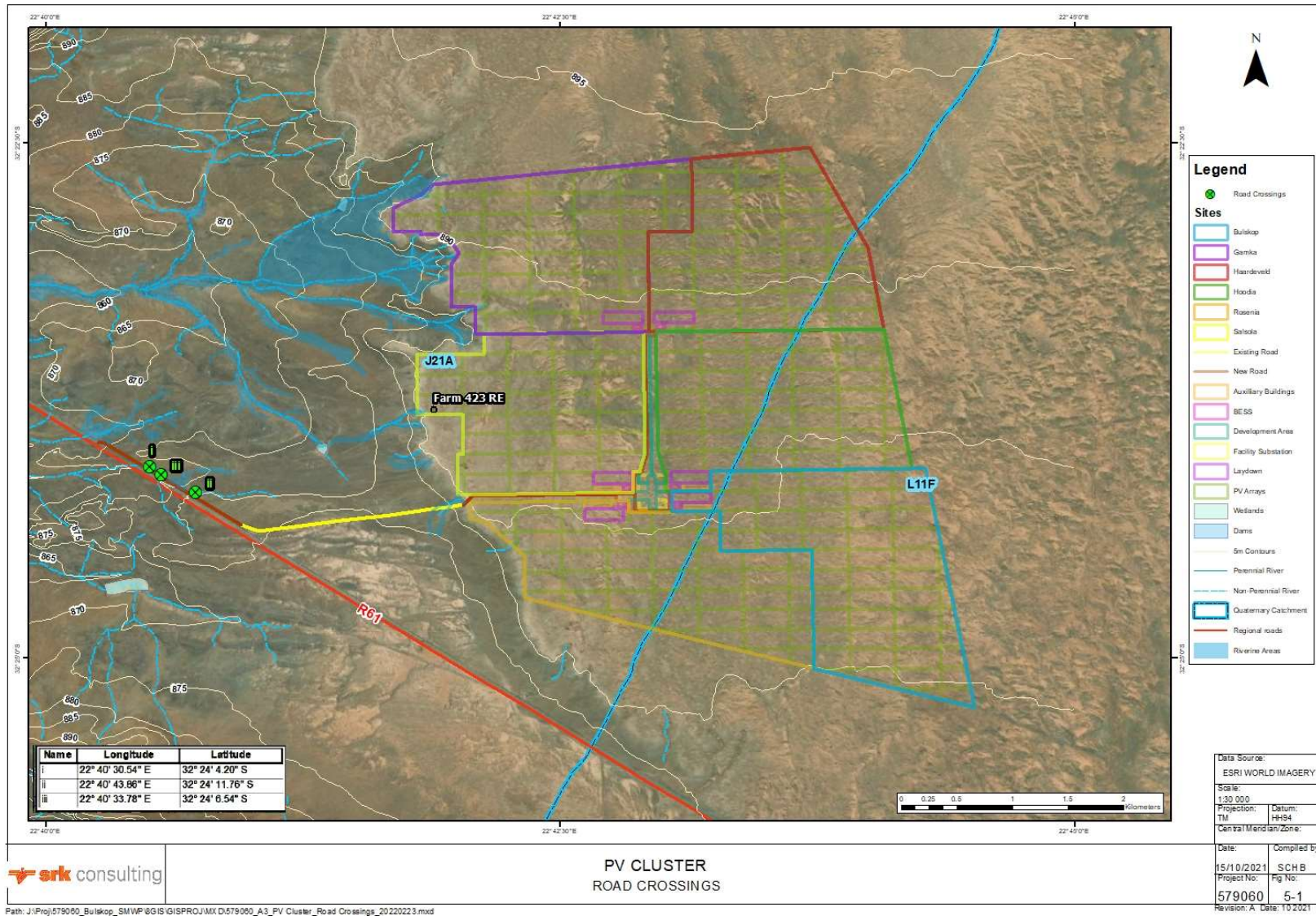


Figure 5-1: Conceptual Road Crossings

5.3 Delineation of catchments

In order to delineate the catchments, a Digital Terrain Model (DTM) was created in order to use GIS techniques to determine these delineations and characterisation of the various catchments. No detailed survey information was available at the time of the study, so 20 metre and 5 metre contours (where available) were sourced from ngi.gov.za and compared to elevation data on Google Earth.

The catchments draining to the site were delineated. The outlet of the catchment was taken as the closest likely discharge point or closest mapped water course.

The catchments are as shown in Figure 5-2 below. Catchments A, B, C, E, F and G will drain westerly towards the tributaries and consequently, the site will not affect the Platdoring River.

5.4 Catchment Parameters

The slope of a catchment is a very important characteristic in the determination of flood peaks. Steep slopes cause faster runoff shorten the critical duration of flood inducing storms, thus leading to higher rainfall intensities in the runoff formulae. On steep slopes, the vegetation is generally less dense, soil layers are shallower, and there are fewer depressions, all of which cause water to run off more rapidly. The result is that infiltration is reduced, and flood peaks are consequently elevated. For flat catchments, the opposite holds true.

Land use is another critical characteristic as it alters the vegetation present and the degree of soil compaction. Compacted soil is less permeable, and vegetation can slow down stormflows over the land surface. Lastly, the soil type can also be important with some soils allowing quicker infiltration of water. These contribute to the estimation of volume of water stored, infiltrated and ultimately resulting in runoff for each catchment.

The average slope and other critical parameters for the catchments under consideration are presented in Table 5-1.

Table 5-1: Conceptual Catchment Characteristics

Catchment	Catchment Slope (%)	Catchment Area (km ²)	Permeability (Visual assessment, not lab tested)	Flow type	Vegetation
A	0.2 – 0.4	14.4	Low to moderate	Majority overland flow, short sections of channelised flow at catchment outlet	Very sparse, low shrub, some grassy areas
B	0.2 – 0.4	2.1	Low to moderate	Majority overland flow, short sections of channelised flow at catchment outlet	Very sparse, low shrub, some grassy areas
C	0.2 – 0.4	4.3	Low to moderate	Majority overland flow, short sections of channelised flow at catchment outlet	Very sparse, low shrub, some grassy areas
D	0.2 – 0.4	19.1	Low to moderate	Overland flow	Very sparse, low shrub, some grassy areas
E	0.2 – 0.4	13.1	Low to moderate	Overland flow	Very sparse, low shrub, some grassy areas
F	0.2 – 0.4	1.1	Low to moderate	Majority overland flow, short sections of channelised flow at catchment outlet	Very sparse, low shrub, some grassy areas
G	0.2 – 0.4	6.2	Low to moderate	Majority overland flow, short sections of channelised flow at catchment outlet	Very sparse, low shrub, some grassy areas

5.5 Storm peaks

The hydrological and hydraulic parameters of all the catchments contributing towards the study area were calculated and the overland peak flow rates were determined in the study area. The SCS-SA hydrological model was used to estimate peak flow rates based on the catchment parameters and rainfall intensity.

Storm peaks were calculated for the catchments shown in Figure 5-2 and peak flows generated within each sub-catchment are considered conceptual due to lack of detailed contour data (topographical survey data).

The peaks are relevant to both pre-development and post-development scenarios, because the vegetation, topography and soil conditions will largely be the same, except where the main buildings (O&M building, stores, etc.) are placed, and this accounts for a negligible proportion of the development area from a surface area viewpoint.

Note that wash water was not considered in the storm peaks, because solar panel washing is unlikely to be done in the rainy season, and volumes will be negligible in comparison to storm volumes. The implications of the storm peaks calculated, and their impact on the SWMP, are discussed in Section 6.

Table 5-2: Peak Flows for Conceptual Catchments in cubic metres per second

Catchment	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
Catchment A	0.7	2.7	4.7	7.6	12.5	17.3
Catchment B	0.1	0.7	1.2	3	3.2	4.5
Catchment C	0.2	0.9	1.6	2.6	4.2	5.8
Catchment D	1	3.8	6.6	10.7	17.4	24
Catchment E	0.5	2.1	3.7	5.9	9.7	13.3
Catchment F	0.1	0.4	0.7	1.1	1.8	2.4
Catchment G	0.3	1.4	2.4	3.9	6.5	9

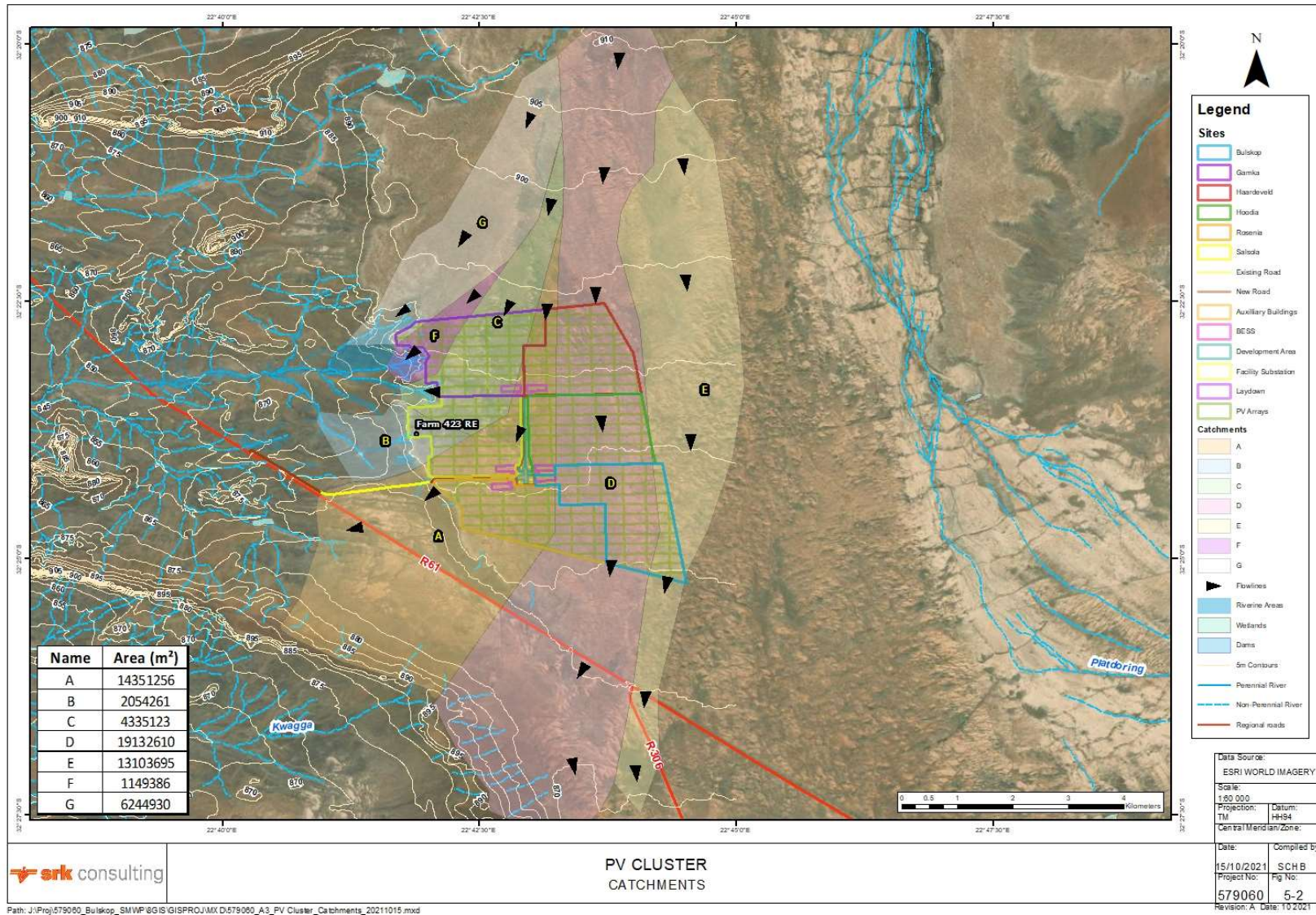


Figure 5-2: Conceptual Stormwater Catchments for the Proposed Development

6 Conceptual Design and Review

This section provides detail on why management approaches were selected, any alternatives that should be considered, and further steps required to confirm or improve the conceptual plan.

6.1 Waste and wastewater management

Waste will be disposed of at a registered landfill site and domestic wastewater at a licensed wastewater treatment plant (i.e. waste will be treated off site), hence, the SWMP only focuses on temporary storage on site.

Domestic waste should be stored out of the rain and wind, collected (and disposed of) regularly as is currently proposed for the development.

The conceptual design of the wastewater (sewage) conservancy tank was not within the scope of this report, however, the current conceptual plan was evaluated in terms of the risks that this may pose to surface water. Poor management of the tank is the main risk, because the system could fail if the tank is not emptied regularly resulting in overflows. Consequently, a float switch controlled alert system is recommended.

Oil and lubricants in the workshop, and oil from the transformers must be bunded (See Section 6.5 for bunding requirements) as per legal requirements and hence, this was recommended without any alternatives.

6.2 Channels, diversions and dissipaters

It is standard practice to place channels on the upgradient side of roads to control erosion. However, in this case channels are not recommended as the terrain is extremely flat and channels will only lead to an unnecessary concentration of flow. This is further supported by the fact that no erosion was noted on or near the existing roads and none of these roads included channels adjacent to them.

Channels should be included to divert clean water around any dirty areas unless these are already bunded.

Solar panel areas are not considered dirty, and it is not recommended that runoff from upstream catchments be diverted around these solar panel areas.

For the few places where diversions are recommended (non-bunded dirty areas), high-level conceptual designs were developed (i.e. typical drain and dissipater types). These were based on the following preliminary conclusions:

- Peak flows for the stormwater catchments are low;
- The area is under 1% grade, and it is possible to design earth or gravel drains rather than concrete drains, because low erosion potential exists at these low flow gradients; and
- Even though low velocity flows will be a feature in the drains, dissipaters are recommended at any outlets to control the transition of water from concentrated channel flow to overland dispersed flow or in-river flow – in addition, it is possible that outlets (e.g. adjacent to road/river crossings) could be locally steep.

Typical generic conceptual designs, based on the above discussions, were compiled as shown in Figure 7-1.

6.3 Road crossings

Using the conceptual infrastructure layout plans and regional contours, high-level conceptual designs were developed. These were based on the following preliminary conclusions:

- Most crossings are small and on areas with low gradients, and thus the roads are well-placed to generally avoid erosion at crossings; and
- Drifts would be the best crossing design from a practical, economic and environmental point of view for the road crossings, considering that flow will be sporadic in this arid region

Typical conceptual designs, based on the above discussions, were compiled for information purposes and are shown in Figure 7-1.

6.4 Erosion and sediment transport

In general, the main erosion risks on a solar facility are channel outlets (Section 6.1), roads, road crossings (Section 6.3) and stockpiles. However, based on the site visit, erosion on roads is excluded as a risk as it is unlikely as long as the roads have no significant camber.

The risk of erosion at road crossings is also limited because so few road crossings exist and thus few opportunities for erosion and sediment transport.

In the case of stockpiles, temporary stockpiles should have diversion berms or silt fences. One permanent stockpile is planned for the topsoil that is to be used in decommissioning of the facility. This stockpile will be placed near the substation or O&M Building. The stockpile, if possible, should have gentle slopes of 1 in 5 or less to encourage revegetation and limit erosion. The stockpile should be bunded until it revegetates. The gentler slopes will necessitate a stockpile with a larger surface area. This is considered the lower impact option as it limits erosion even though it disturbs more surface area.

Sometimes, material excavated during construction of the panel foundations might be significant (cumulative volume). If that is the case, the material should be removed from site.

6.5 Bunding

Requirements for bunding of areas housing potential contaminants are specified in detail in the National Norms and Standards for the Storage of Waste (Notice 926 of 29 November 2013, Department of Environmental Affairs, National Environmental Management: Waste Act 2008, Act No.29 of 2008). The specification, which will apply to the development area, reads as follows: *“bunds having a capacity which can contain at least 110% of the maximum contents of the waste storage facility. Where more than one container or tank is stored, the bund must be capable of storing at least 110% of the largest tank or 25% of the total storage capacity, whichever is greater (in the case of drums the tray or bund size must be at least 25% of total storage capacity).”*

Bunded areas should be sized and sealed to ensure spilled contaminants cannot leak out of the bunded areas.

6.6 Monitoring and management

Monitoring and management are key to the success of a SWMP. The following are therefore included as a key aspect of SWMP:

- Frequent inspections until the success of the design and any unexpected problems are resolved / confirmed and maintenance frequency is determined;

- Review of the plan after a few years to improve, where possible, its practicality, cost-effectiveness or efficacy;
- Alerts that do not rely on a full-time environmental manager on site (which may not be feasible) including:
 - Automatic alert systems for the wastewater conservancy tank (e.g. a float driven switch alert system);
 - Brief, annual refresher training on stormwater protection that should not take more than fifteen minutes for each staff member; and
 - Well placed signs that remind staff members of reporting of incident / issues, as soon as possible and reduce the likelihood that forgetfulness or confusion will prevent reporting.

7 Stormwater, Wastewater and Erosion Management Plan

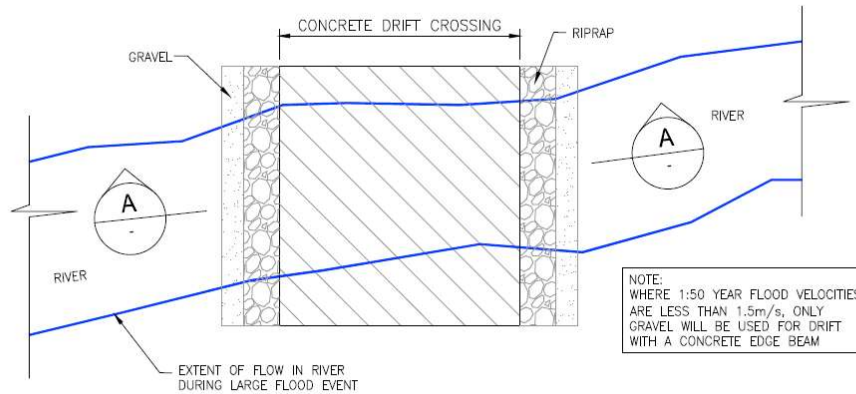
The SWMP, including wastewater management, is summarised in Table 7-1 and Figure 7-1.

Table 7-1: Construction and Operations / Maintenance SWMP

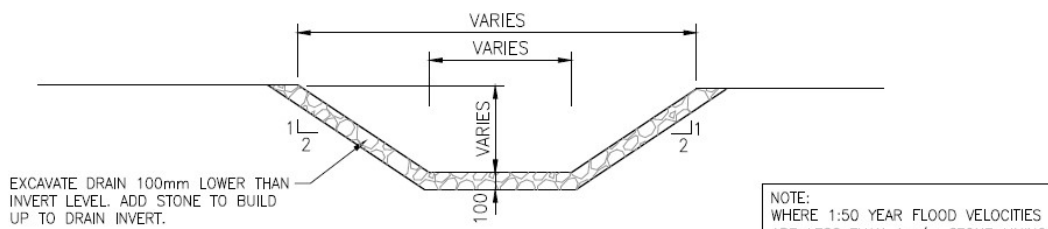
General principle	Specific outcomes	When	Ref No.	Focus area	Action	Responsible party
Separate clean - and dirty water to ensure clean water remains uncontaminated	Temporary containments and diversion (designed for a 1 in 5-year event)	During contractors site establishment	1	<ul style="list-style-type: none"> Stockpiles; Laydown areas; Workshops; and Any other area likely to generate sediment during a storm event or contain contaminants that can be disbursed. 	Clean water diversions or bunds: Construct stormwater drains or bunds to divert clean runoff around dirty areas. The diversion should be sized for 1 in 5-year event. Typical design will be an excavated earth channel or berms. For the permanent topsoil stockpile, berms and channels to remain in place until stockpile revegetates.	Construction contractor's onsite environmental officer/representative
	Permanent containments and diversions (designed for a 1 in 50-year event)	Constructed prior to operation	2	<ul style="list-style-type: none"> The workshop and chemical stores; Transformers, inverters and substations (if not banded); and Wastewater conservancy tank. 	Clean water diversions or bunds: Construct stormwater drains or bunds to divert clean runoff around the workshop, chemical stores, transformers, inverters, substations and wastewater conservancy tank. The diversion should be designed for a 1 in 50-year event.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
Collect and, where required, treat dirty water or runoff from any dirty areas.	Dirty water should not have the potential to spill into clean water systems more than once every fifty years (where influenced by stormwater)	Before stockpiles are deposited	3	Stockpiles	Construct silt fences or berms: to prevent the sediment transport into rivers. All stockpiles to be removed after construction phase ends except permanent topsoil stockpile for decommissioning. Berms to remain around topsoil stockpile until it revegetates	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Throughout construction	4	Waste	Dispose of landfill, oils and other contaminants offsite	
		During site establishment	5	Sewage	Supply chemical toilets	
		Constructed prior to operation	6	Workshop	Workshop collection drain with oil and grease trap: Construct a small concrete drain collecting all water, potentially containing oils and lubricants, from workshop floor and directing it through an oil and grease trap before discharge (or removing to offsite facility). Floor to be sloped such that all water will collect in drains.	
		Inspect every 3 months for first 2 years and then revise	7	Workshop	The oil and grease traps are to be inspected and, when necessary, cleaned and waste taken to a registered offsite facility	Workshop manager and assurance by environmental manager
		As required when the tank is full	8	Transformers	Dispose of any spent oil, removed from transformers during maintenance, to a registered offsite facility	
		As required when the tank is full	9	The sewage conservancy tank	Regularly collect sewage in the conservancy tank and disposed of at a licensed municipal sewage treatment plant.	
Bund any hazardous substance or pollutant storage areas (including any oils), as per regulations	Throughout construction	10	General	Construct temporary bunds for any chemicals such as oils or fuel stored on sited during construction. Bunds must contain at least 100% of the volume of the container. If all containers are stored together the bund must store at least 110% of the largest container or 25% of the total storage capacity, whichever is greater. Suitability of the material of bund must be investigated whenever a new substance is added to the bund	Included in detailed designs of design engineer and carried out by contractor appointed for construction	
	Constructed prior to operation	11	Transformers	All transformers will be banded with bund capacity of at least 110% of the maximum volume of oil in the transformer. Transformers and bund will be protected from rainfall by small covers or roof or housed in containers, as applicable.		
	Constructed prior to operation	12	The sewage conservancy tank	The sewage conservancy tank will be a closed tank with an automatic alert system.		
Do not impede surface and subsurface flow along drainage lines	Ensure any engineered clean stormwater drainage directs	During operation: as and when containers are purchased	13	Workshop	Small trays for workshop chemicals: Bund any containers with oils and lubricants by placing them in plastic trays that is at least 100% of the volume of the container. If all containers are stored together the bund needs to store at least 110% of the largest container or 25% of the total storage capacity, whichever is greater. Suitability of the bund must be investigated whenever a new substance is added to the bund.	Workshop manager and assurance by environmental manager
		Constructed prior to operation	14	The workshop, transformers, wastewater conservancy tank	Place diversion channels directly upstream of dirty areas such that dirty area catchments are minimised in footprint	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Throughout construction	15	<ul style="list-style-type: none"> Laydown areas; and Stockpiles 	Minimise laydown areas and stockpiles. The permanent topsoil stockpile is excluded from this as it will be the natural topsoil from the area and gentler slopes are recommended which will necessitate a larger area.	
Throughout construction	16	All drains	Ensure that any temporary stormwater drains or diversion berms direct water towards the drainage line to which it would naturally flow			

General principle	Specific outcomes	When	Ref No.	Focus area	Action	Responsible party
	water to the closest naturally receiving drainage line	Constructed prior to operation	17	The workshop, transformers, wastewater conservancy tank	Drains to follow natural topography, Ensure outlets drain towards the natural drainage line that would originally have received flow from that area	
Control, monitor and manage erosion	Prevent erosion in general	Constructed prior to operation	18	All areas	Do not disturb the natural topography or vegetation between the solar panel installations	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		During operation	19		No stockpiles if possible: except for the permanent topsoil stockpile.	Environmental manager
	Minimize erosion in large storm event of 1 in 50- years or greater	Constructed prior to operation	20	All drains	Drains sloped and sized such that velocities do no exceed 1 m/s	Included in detailed designs of design engineer and carried out by contractor appointed for construction
			21	Road crossings	Line all major drifts on road crossings with material sufficient to prevent erosion during high flow (e.g. gravel or concrete). If concrete is used, place a section of riprap (larger rocks) underlain by gravel and with gravel on either side to facilitate a smooth flow transition. Detailed modelling and design of road crossings such that erosion is controlled to be a feature of the detailed design.	
			22	All drains	Dissipaters: At drain outlets widen the channel and use riprap (can be sourced from spoil during construction) or reno mattresses to dissipate stormwater flows	
	Dissipate stormwater at all drainage outlets to velocities unlikely to cause erosion in natural soils for a 1 in 50-year storm event		23	Road crossings	Dissipation at road crossings: Detailed modelling and design of road crossings including riprap (can potentially be sourced from spoil during construction) or reno-mattresses.	
	Prevent erosion in general	Throughout construction	24	All	Maintain natural topography and vegetation: Do not disturb the natural topography or vegetation where possible	Construction contractors onsite environmental officer/representative
	Minimize erosion in large storm event of 1 in 5-years or greater		25	All drains	Engineer low velocity temporary drains: Drains sloped and sized such that velocities do no exceed 1 m/s in a 1 in 5-year event	
		Early in construction	26	Road crossings	Engineered temporary drifts: Build roads and road crossings before other infrastructure.	
	Ensure that any chronic erosion is detected and rehabilitated within 6 months	Every 3 months for the first 2 years and annually thereafter	27	<ul style="list-style-type: none"> PV cell blocks; Drains; Outlet of all Drains; and All-natural drainage lines that cross the access road. 	Inspect all focus areas for erosion. If erosion is found, remediate and redesign the drainage in the area. If erosion is found in a natural drainage line, conduct an assessment and determine the cause. Develop a plan to prevent future erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
	Ensure that any acute erosion due to large storm events is detected within 2 weeks.	Install prior to operation	28	Main office	Install a rain gauge that can measure greater than 105 mm (i.e. more than the 1 in 100 year event)	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		After a rain event of greater than 60 mm in one day (a 10 year - 24-hour rain event) or when staff notice flood damage.	29	All-natural drainage lines that run through the site	Inspect and remediate acute erosion: Inspect all focus areas for erosion. If erosion is found remediate and redesign the drainage in the area. If erosion is found in a natural drainage line conduct and assessment and determine the cause and develop a plan to prevent future erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
		Design and development prior to operation	30	All	Set up rain data system: Build or buy a basic rain program, preferably electronic, that allows site staff to enter rain data from the rain gauge. Ideally the system should let the environmental manager and site manager when a rainfall event in excess of 60 mm	
		Daily	31	Main office	Record rain data: Read and record rain gauge daily;	Onsite staff member tasked by the Environmental manager
Update annually in case of staff change		32	Signs at main office to aid problem reporting: Ensure that a sign providing the following is posed in the reception area, the control room, on each transformer and in the workshop: The name, telephone number and email address of the environmental manager. The sign should state: "If you notice any leaks or spills or erosion anywhere on the property please contact the Environmental Manager by one of these methods..."		Environmental manager	
Training	Annually	33	All	Training: Provide a short briefing to all construction staff on the dynamics of erosion and leaks that covers at least: <ul style="list-style-type: none"> How to identify erosion; How to identify a leak, including car leaks; 	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager	

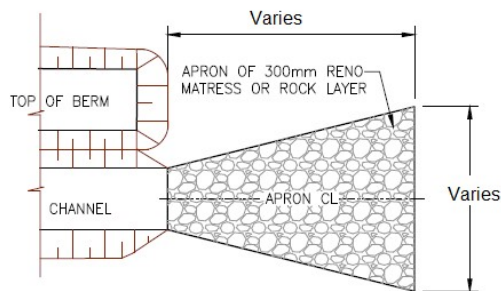
General principle	Specific outcomes	When	Ref No.	Focus area	Action	Responsible party
					<ul style="list-style-type: none"> Where to find contact details of the environmental officer/representative in case of leaks or erosion. 	
	Ensure that any erosion is detected and rehabilitated	After rain events	34		Inspect the site for erosion after rain events. If erosion is found, remediate and redesign the drainage in the area. If erosion is found in a natural drainage line, conduct an assessment to determine the cause and develop a plan to prevent future erosion.	Contractors environmental officer/representative
		During site establishment	35		Install a rain gauge that can measure greater than 105 mm (i.e. more than the 1 in 100 year event). This rain gauge will also be used during operation.	
Monitor and manage stormwater system	Include a monitoring system for spills and leaks such that they are detected as soon as possible.	Once every 2 weeks during Construction	36	All	Leak inspection: regularly check for leaks and for any breaches or evidence of spills or any other problems not in adherence to this SWMP. All cars should also be checked for oil leaks and any leaks found should be stopped immediately, the cause of the leak identified, the problem remediated such that no further leaks occur, and any contaminated soil or water assessed and remediated.	Contractors environmental officer/representative
		Every 3 months for the first 2 years and annually thereafter (Operation)	37		Leak inspection: regularly check for leaks and for any breaches or evidence of spills or any other problems that would indicate that it is not in adherence to this plan. All cars should also be checked for oil leaks during the inspection. Any leaks found should be stopped immediately, the cause of the leak sought, the problem remediated such that no further leaks occur, and any contaminated soil or water assessed and remediated.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
	Continuous	38	Data capture, training and signs: see 32, 33, 34, 35, 36, & 37		Environmental manager and staff in general	
	Include a monitoring system for spills and leaks such that they are detected as soon as possible.	Construct prior to operation	39		The sewage conservancy tank	Sewage conservancy tank alert system: Install a float switch-controlled alarm that will alert the control room when the conservancy tank has less than 2 weeks of capacity remaining.
		40	Transformers	Signs at transformers: Post a sign on transformers stating "If you notice any leaks or spills or erosion anywhere on the property please contact reception via one of the following methodsand report it"		
General	Do not build infrastructure within near to watercourses	Detailed design	41	All	Ensure no infrastructure except roads, solar panels and solar panel supports are built within 300 m of a water course. In particular, ensure no dirty areas, that may contain pollutants, are within 300 m of the water course	Design engineer or engineer appointed by the design engineer
	Do not build infrastructure containing potential pollutants in any of the natural drainage lines.		42		Ensure that final infrastructure plans do not propose any potentially polluting infrastructure, such as transformers, workshops or conservancy tanks in the natural drainage lines (currently none are proposed)	
	Review and improve stormwater management plan regularly.	Once every 5 years	43		Review and improve the stormwater plan	Environmental manager or engineer appointed by the environmental manager
	Review and inspect	Once every 2 months during construction depending schedule	44		Inspect the site to ensure adherence to the stormwater management plan	Clients' environmental representative or engineer
	Do not place stockpiles or other potentially polluting construction items within 300 m of the watercourse	Detailed design and throughout construction	45		Do not place laydown areas, stockpiles within 300 m of the watercourse	Design engineer or engineer appointed by the design engineer
	General	Detailed design	46		Develop a specific environmental specification for any construction including, but not limited to, the actions in this stormwater management plan and its principles	Clients' environmental representative or specialist
	Prepare for spills	Construction and Operation	47		Procure spill kits and place in areas where fuel or oils are transferred (e.g. workshops)	Environmental manager
	Protect water courses	Construction	52		PV Blocks	If any water courses are identified on the site then no cement stabilisation of piles shall be used within the low sensitivity drainage features. Foundation could rather utilise longer piles in these areas to achieve adequate structural



TYPICAL PLAN OF DRIFT CROSSING



TYPICAL CROSS SECTION THROUGH DIVERSION CHANNEL



TYPICAL PLAN OF DISSIPATER AT END OF CHANNEL

	<p>TYPICAL CONCEPTUAL DESIGNS OF STORMWATER INFRASTRUCTURE (TO BE CONFIRMED IN DETAILED DESIGN)</p>	<p>Project No. 579060</p>
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Figure 7-1: Typical Conceptual Designs of Stormwater Infrastructure

8 Conclusions and Recommendations

In conclusion:

- The proposed facility will have an intrinsically low impact on surface water resources;
- The potential stormwater impacts that do exist can be managed in a practical and cost-effective way; and
- The plan is conceptual, because no detailed contour data is available and only conceptual infrastructure layouts were made available at the time of the study – that said, low rainfall and low flow gradients characteristic of the area suggest that detailed design should not vary considerably from the concepts presented in this report.

It is recommended that the SWMP be developed further during the detailed design by:

- Conducting a detailed topographic survey;
- Developing a stormwater layout and designs based on the above information and infrastructure layout plan;
- Developing conceptual designs into detailed designs; and
- The plan should be incorporated into an environmental specification for use during construction and incorporated into the operational environmental management of the site.

Prepared by

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Xanthe Adams, *Pr. Eng*

Principal Engineer

Reviewed by

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Bruce Engelsman, *Pr. Eng., Pr. CPM*

Principal Engineer, Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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