SOVENTIX SA

GOODEHOOP SOLAR POWER PROJECT
HYDROLOGICAL ASSESSMENT

Report No.: JW201/17/G486– Rev 0

October 2017

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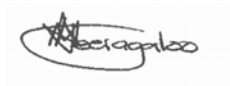
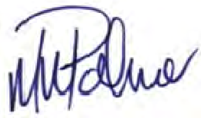
DOCUMENT APPROVAL RECORD

Report No.: JW201/17/G486– Rev 0

ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	Engineer	Malini Veeragaloo	23-10-2017	
Reviewed	Technical Director	Michael Palmer	31-10-2017	
Approved	Technical Director	Michael Palmer	31-10-2017	

RECORD OF REVISIONS AND ISSUES REGISTER

Date	Revision	Description	Issued to	Issue Format	No. Copies
24-10-2017	A	Internal review	Michael Palmer	Word Doc.	1
01-11-2017	0	Issued to Client	Ecoleges: Mr J. Bowers	pdf	1

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HYDROLOGICAL ASSESSMENT REPORT NO: JW201/17/G486– Rev 0

1. INTRODUCTION

1.1 Background

Soventix SA (Soventix) is planning to develop a 225 MW solar photovoltaic (PV) plant on several portions of the farm Goedehoop in the Hanover District of the Northern Cape Province. Soventix appointed Ecoleges Environmental Consultants (Ecoleges) to undertake the requisite environmental authorisation processes for the proposed PV plant. The location of the site is shown in **Figure 1(a)**.

A Scoping Report was submitted to the Department of Environmental Affairs (DEA) and approval was subsequently received, with several comments from the DEA. One of the comments was a requirement for a hydrological assessment of the project area.

The primary concern raised by Ecoleges, from a hydrological perspective, is a proposed power line crossing on an unnamed tributary of the Brak River, connecting the proposed electrical substation for the PV plant to the existing Eskom power line. The nature of the crossing is such that the location of a pylon within the watercourse is unavoidable. A hydrological assessment was therefore required to assess the potential impacts and risks associated with this proposed pylon.

1.2 Terms of reference

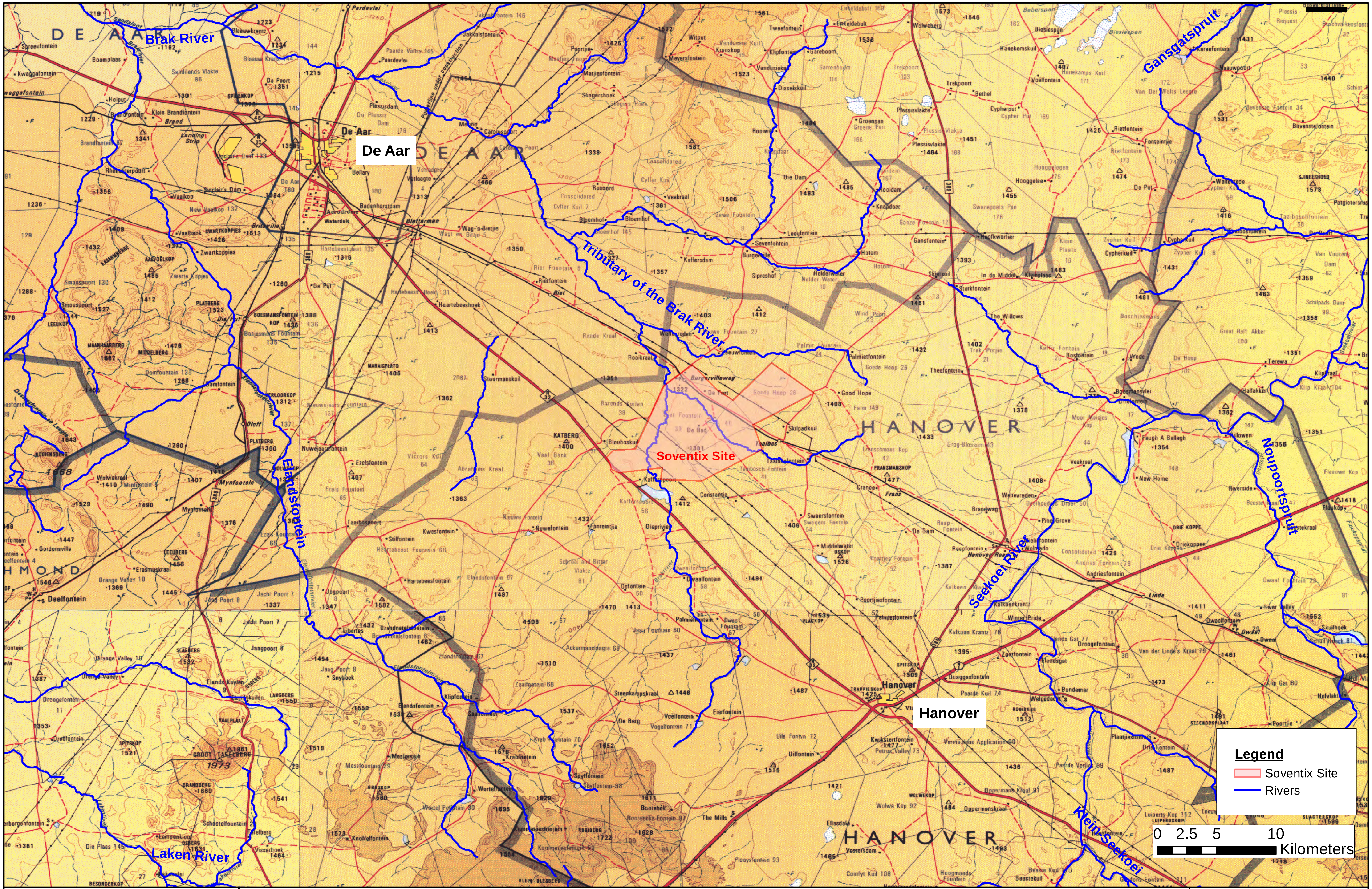
Jones & Wagener (J&W) were appointed by Ecoleges Environmental Consultants to carry out a hydrological assessment on the unnamed tributary of the Brak River, for the location of a power line pylon within or close to the watercourse, as well as to provide general guidance related to good practice storm water management at the proposed Soventix Solar PV Plant.

The scope of work was discussed and confirmed during personal correspondence between representatives of Ecoleges and J&W.

1.3 Purpose

The purpose of the above project was as follows:

- To assess the potential impact of the proposed pylon on the flow regime in the affected watercourse.
- To formulate mitigation measures for the identified potential impacts.
- To provide broad outlines of best practice storm water management at the pylon, as well as for the solar power plant.



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SOVENTIX
Hydrological Assessment
Locality Plan

Job No G486-00

Figure 1(a)

2. SITE DESCRIPTION

2.1 Study area

The proposed Soventix Solar PV project is located in the Northern Cape Province, approximately 38 km south east of De Aar, 23 km north west of Hanover and 5 km north east of the N10 National Road, which connects the two towns. The study area is shown on **Figure 2(a)**.

Three options for the location of the PV installation are under consideration, namely Sites A, B and C, as indicated on **Figure 2(a)**. The focus of this study is the proposed power line from the substation at Site B, crossing the unnamed tributary of the Brak River to link to the existing Eskom power line and specifically a pylon which is to be located within or in close proximity to the watercourse.

2.2 Hydrological setting

2.2.1 Regional climate

The regional climate can be described as a local steppe climate and semi-arid. Summers are warm to hot with an average daily high temperature of approximately 29.5ºC (with occasional extremes up to 40ºC). Winters are mild to cold with an average daily high of approximately 19.8ºC (with occasional extreme minima as low as -8ºC). Frost is frequently experienced during the winter months. (South African Weather Service (SAWS), 2003)

The majority of precipitation is experienced during the summer months, mostly in the form of afternoon thundershowers. Mean annual precipitation (MAP) is 314 mm and the mean annual evaporation (MAE) is approximately 2150 mm.

2.2.2 Catchment description

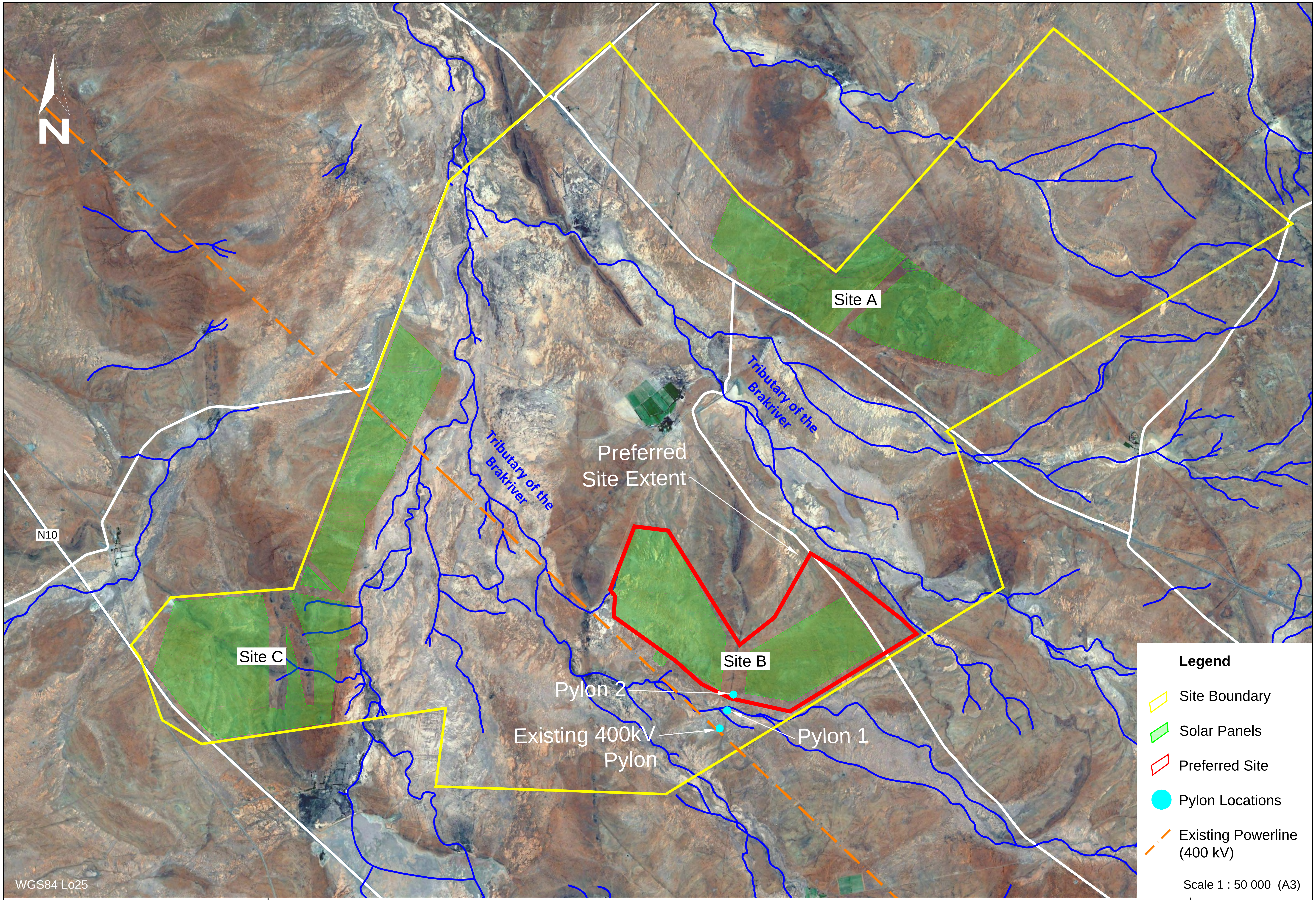
The site is located within quaternary sub-catchment D62D of the Lower Orange drainage region, as described in “Water Resources of South Africa – 2012” (WR2012) (Water Research Commission, 2012). The site is situated adjacent to an unnamed tributary of the lower reaches of the Brak River, near De Aar in the Northern Cape Province.

The drainage of the site is in a north westerly direction towards the Brak River, which eventually joins the Orange River before discharging into the Atlantic Ocean on Souyth Africa’s west coast, at the border with Namibia. The topography of the region is generally flat, characterised by wide plains and open spaces. The site where pylon is to be constructed is situated in a wide valley, where the watercourse is poorly defined.

3. METHODOLOGY

The following actions were taken as part of the hydrological assessment for this project:

- Information received from the Client, was reviewed and relevant issues were noted.
- 1:50 000 topographical maps and satellite imagery (Google Earth) were reviewed to assess catchment conditions and to delineate the catchments within the study area.



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Hydrological Assessment
Site Layout

Job No G486-00

Figure 2(a)

Peak flood flows at relevant locations within the study area were estimated for various recurrence intervals using a number of methodologies applicable to South African conditions.

- Topographical survey data was not available for the study area. A site visit was therefore conducted on the 5 October 2017 to assess the conditions on site. Several cross sections were measured on the watercourse, using a dumpy level and a hand-held GPS. The data points obtained were input to the ModelMaker software to generate a surface model for the site. Several cross-section profiles were computed across the generated surface, along the watercourse and at the location of the pylons.
- The locations of the pylons and associated substation were provided to J&W by Ecoleges as a Google Earth kmz file.
- Computed cross-sections were input into the HEC-RAS river modelling system to calculate indicative flow depths and flow velocities in the watercourse and at the pylon location, in particular. HEC-RAS was developed by the Unites States Army Corps of Engineers, and is considered industry standard software for floodline analysis in many countries, including the United States, the United Kingdom, Europe, Australia and South Africa.
- Published information in the WR2012 publication was used to estimate the seasonal flows in the watercourse, as input to the impact assessment.
- Based on the above assessment, the potential impacts of the pylon on surface water quality and quantity were assessed and mitigation measures recommended.
- A literature review was undertaken and good practice guidelines for storm water management planning at solar PV plants were documented. These incorporate principles from the South African Best Practice Guidelines for storm water management, as published by the Department of Water and Sanitation (DWS) (formerly Department of Water Affairs and Forestry).

4. HYDROLOGICAL ASSESSMENT

When assessing the positioning or location of any infrastructure in close proximity to a watercourse, there are a number of key environmental considerations, one of which being the proposed position of the infrastructure in relation to the floodlines of the watercourse or in this case a tributary of the Brak River.

Government Notice Regulation 704 (GN R704) of 1999 (in terms of the National Water Act, Act 36 of 1998) requires that any infrastructure must be located outside the 1:100 year floodline or a horizontal distance of 100 metres from the watercourse edge, whichever is the greatest. This consideration must be accounted for in the design and the final extent/alignment of the power line. Note that while GN R704 was compiled with specific reference to the mining industry, its regulations are universally applied to all industrial activities by the DWS.

To determine the impact that the proposed pylon may have on the watercourse, it is necessary to quantify the expected flow rates that will result from various storm events within the catchment, as well as the estimated water level and flow velocity at the pylon itself. In order to do this accurately, detailed topographical survey of the watercourse is required to enable a floodline study to be undertaken.

Detailed topographical survey was not available for this study. In addition, information available to J&W indicates that 5 m contours from the Surveyor-General are also not available for the site. The best available data at present is therefore the Surveyor-General's 20 m contour dataset. This cannot be used for a flood level and flow velocity determination.

In the absence of the above detailed survey information, J&W undertook a site visit during which a several cross section profiles were measured across the watercourse in the vicinity of the proposed pylon, as detailed in Section 3 above. From this, indicative water levels and flow velocities were estimated assuming steady-state flow conditions, for various recurrence interval events. This was used as the primary input to the impact assessment.

4.1 Rainfall and evaporation data

4.1.1 Rainfall data

The Daily Rainfall Extraction Utility, developed by the Institute for Commercial Forestry Research (ICFR) in conjunction with the School of Bio-resources Engineering and Environmental Hydrology (BEEH) at the University of KwaZulu-Natal, Pietermaritzburg (Kunz, 2003), was used to obtain summary data for all rainfall stations within the vicinity of the site.

The database contains daily patched rainfall data for all official South African Weather Service (SAWS) stations, and includes data up to August 2000. This data was assessed in terms of record length, completeness of the data set, mean annual precipitation (MAP) and location with respect to the site and catchment.

Key data was extracted from the database and from Smithers & Schulze (2002) for selected rainfall stations, as shown in **Table 4(a)**. Station number 014378W Hanover was selected as the representative rainfall data set for the site based on its proximity to the site, long record and reasonable MAP.

Table 4(a) Key data for selected rainfall stations

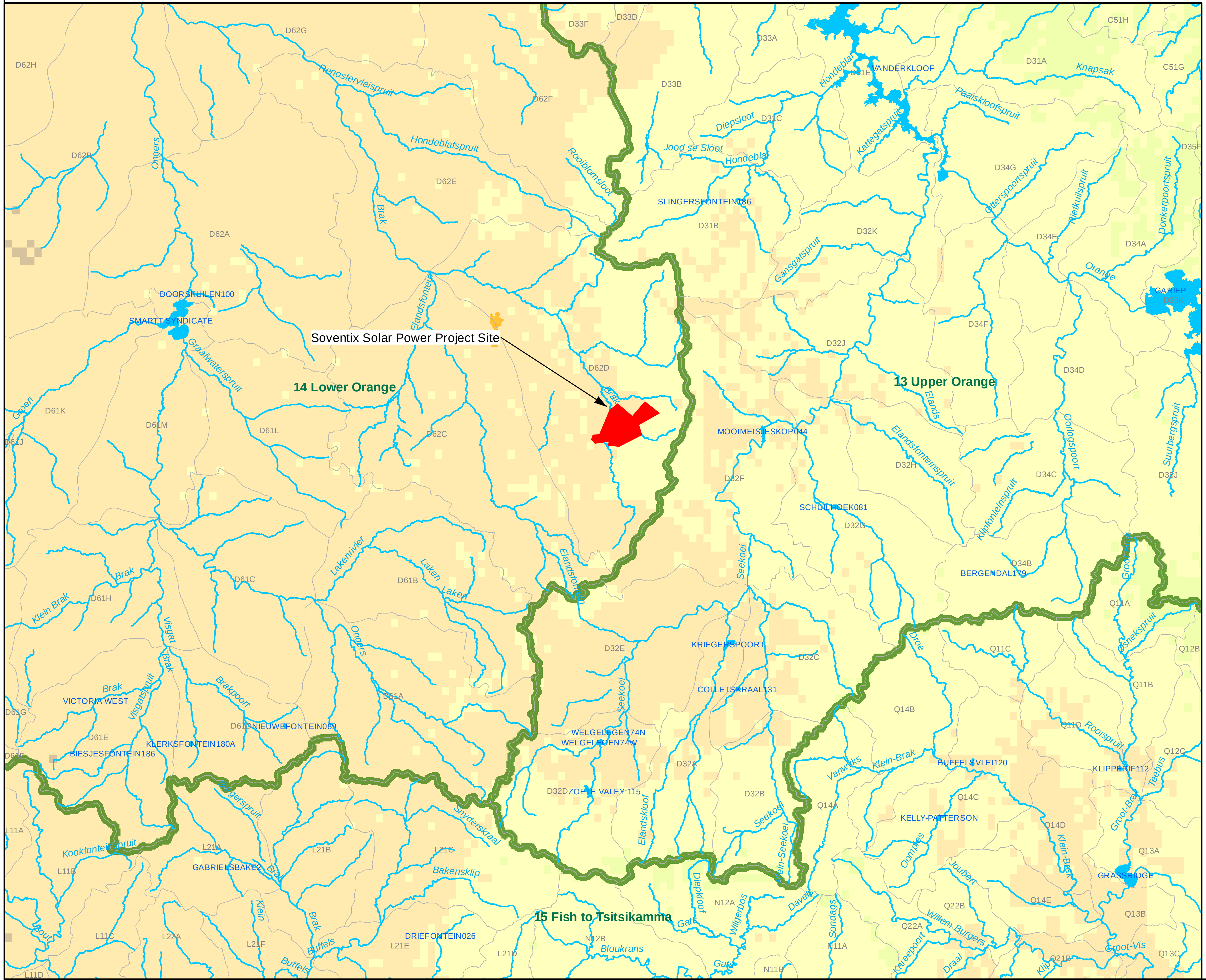
Station name	Station number	Distance (km)	Latitude	Longitude	Record (Years)	MAP (mm)
Wolmada	0171117W	24.5	30°57'	24°32'	74	286
Hanover	0143784W	23.4	31°04'	24°27'	91	314
Hartebeeshoek	0170137W	24.2	30°46'	24°06'	65	270

The MAP for the region in which the site resides can be seen in **Figure 4(a)**.

4.1.2 Evaporation data

Evaporation data was sourced from WR2012. The site lies within Evaporation Zone 17A, with a Mean Annual Evaporation (MAE) of 2150 mm. The MAE for the region in which the site resides can be seen in **Figure 4(b)**.

Monthly rainfall and evaporation data are shown in **Table 4(b)** and **Figure 4(c)**.



Legend

- Site Boundary
- Rivers
- Secondary rivers
- Impoundments
- Quaternary catchments
- International boundary
- Water Management Areas
- Major towns and cities

Mean Annual Precipitation

- 0-100 mm
- 100-200 mm
- 200-300 mm
- 300-400 mm
- 400-500 mm
- 500-600 mm
- 600-700 mm
- 700-800 mm
- 800-1000 mm
- 1000-1500 mm
- >1500 mm

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WR 2012

0 5 10 20 30 40 Kilometers

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Hydrological Assessment
Mean Annual Precipitation

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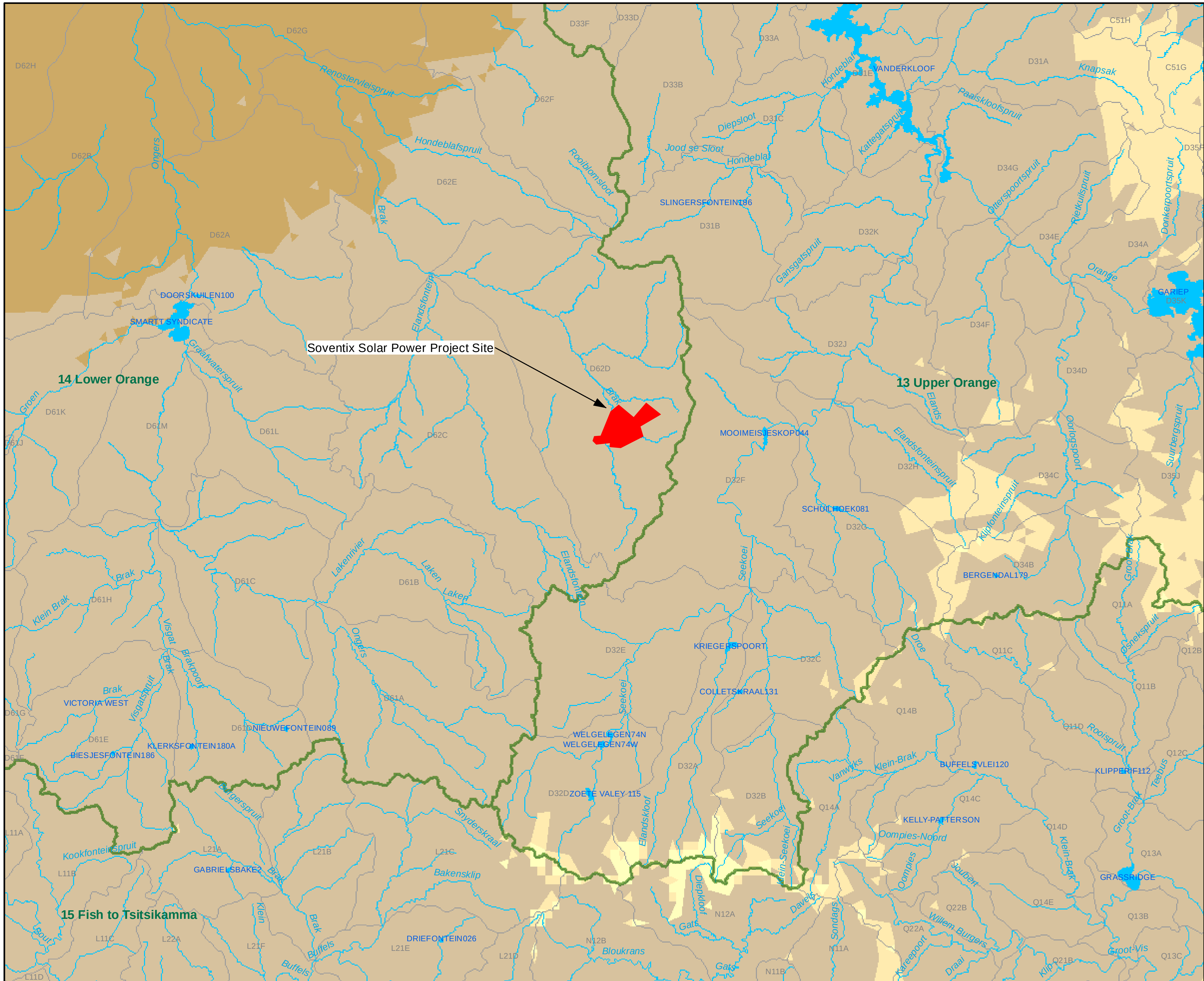
Figure 4(a)



Legend

- Site Boundary
- Water Management Areas
- Rivers
- Secondary rivers
- Impoundments
- International boundary
- Quaternary catchments

Mean Annual Evaporation A-Pan

- <1200mm
- 1200-1300 mm
- 1300-1400 mm
- 1400-1500 mm
- 1500-1600 mm
- 1600-1700 mm
- 1700-1800 mm
- 1800-2000 mm
- 2000-2200 mm
- 2200-2600 mm
- >2600 mm

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Water Research Commission

WR 2012

0 5 10 20 30 40 Kilometers

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Hydrological Assessment
Mean Annual Evaporation

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Figure 4(b)

Table 4(b) Monthly rainfall and evaporation

Month	Average rainfall (mm)	Average evaporation (mm)
October	20	219
November	28	267
December	27	314
January	36	310
February	52	229
March	57	191
April	33	127
May	19	89
June	9	64
July	10	73
August	9	109
September	9	157
Annual Total	**314**	**2150**

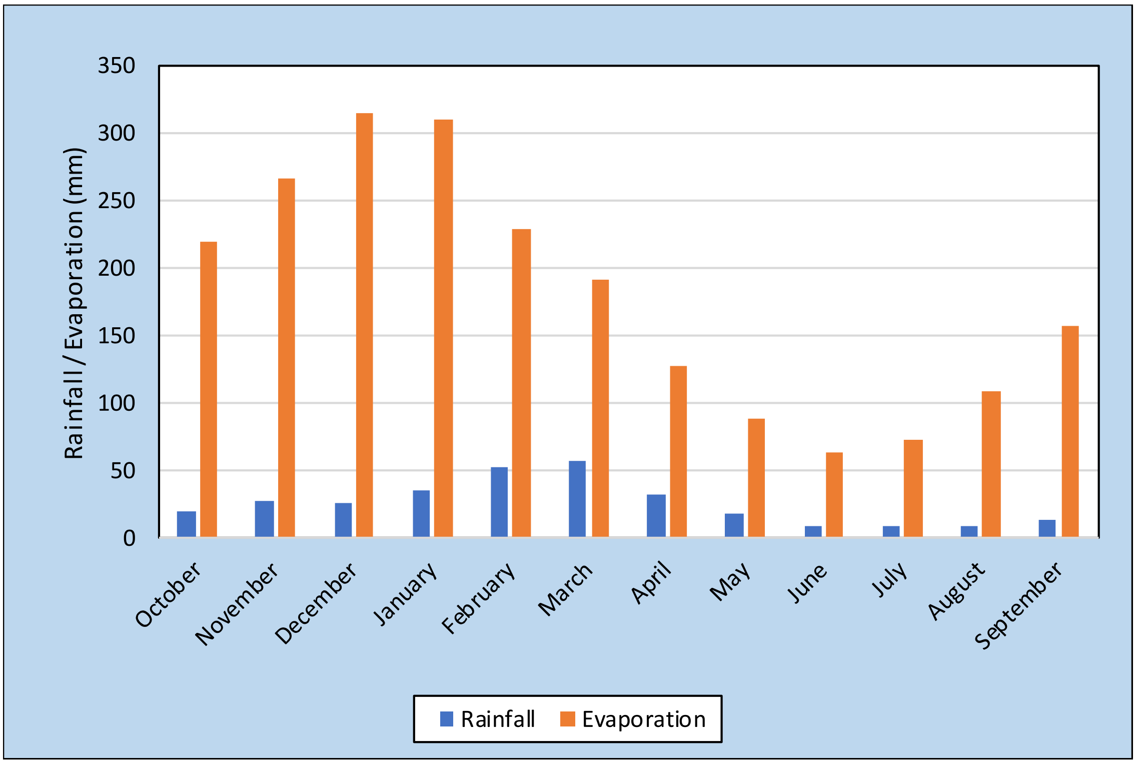


Figure 4(c) Average monthly rainfall and evaporation

4.2 Hydrology

4.2.1 Peak flows

A single node was identified for peak flow calculations, being the location of the proposed powerline crossing. This node, together with its associated catchment boundary is shown on **Figure 4(d)**.

The catchment area and slopes were determined from the 1:50 000 topographic maps (map reference 3024CD Burgervilleweg) published by the Chief Directorate, Surveys and Mapping.

The catchment parameters were determined from the 1:50 000 series topographical maps, as well as Google Earth satellite imagery and visual assessment during the site visit. This data was used as input for the calculation of the peak flow at the relevant point of interest on the unnamed tributary of the Brak River, within the study area.

Key catchment parameters are shown in **Table 4(c)**.

Table 4(c) Key catchment parameters for Node 1

Node	Catchment Area (km^2)	Average Catchment Slope (%)	Watercourse Slope		Time of Concentration (hours)	Rational Coefficient
			10-85 (%)	Equal Area (%)		
1	45.5	3	0.55	0.51	4.9	0.27

There are a multitude of methods available for the determination of peak flows. The methods used for this study included the Rational Method, the Standard Design Flood (SDF) method (Alexander, 2002), the Synthetic Unit Hydrograph method, the Regional Maximum Flood (RMF) method (Kovács, 1988) and the Direct Run-off Hydrograph (DRH) method.

The peak flow was calculated using each method above and evaluated for the node of interest and a representative value was subsequently adopted. The 1:20, 1:50, 1:100 and Regional Maximum Flood (RMF) are presented in **Table 4(d)**.

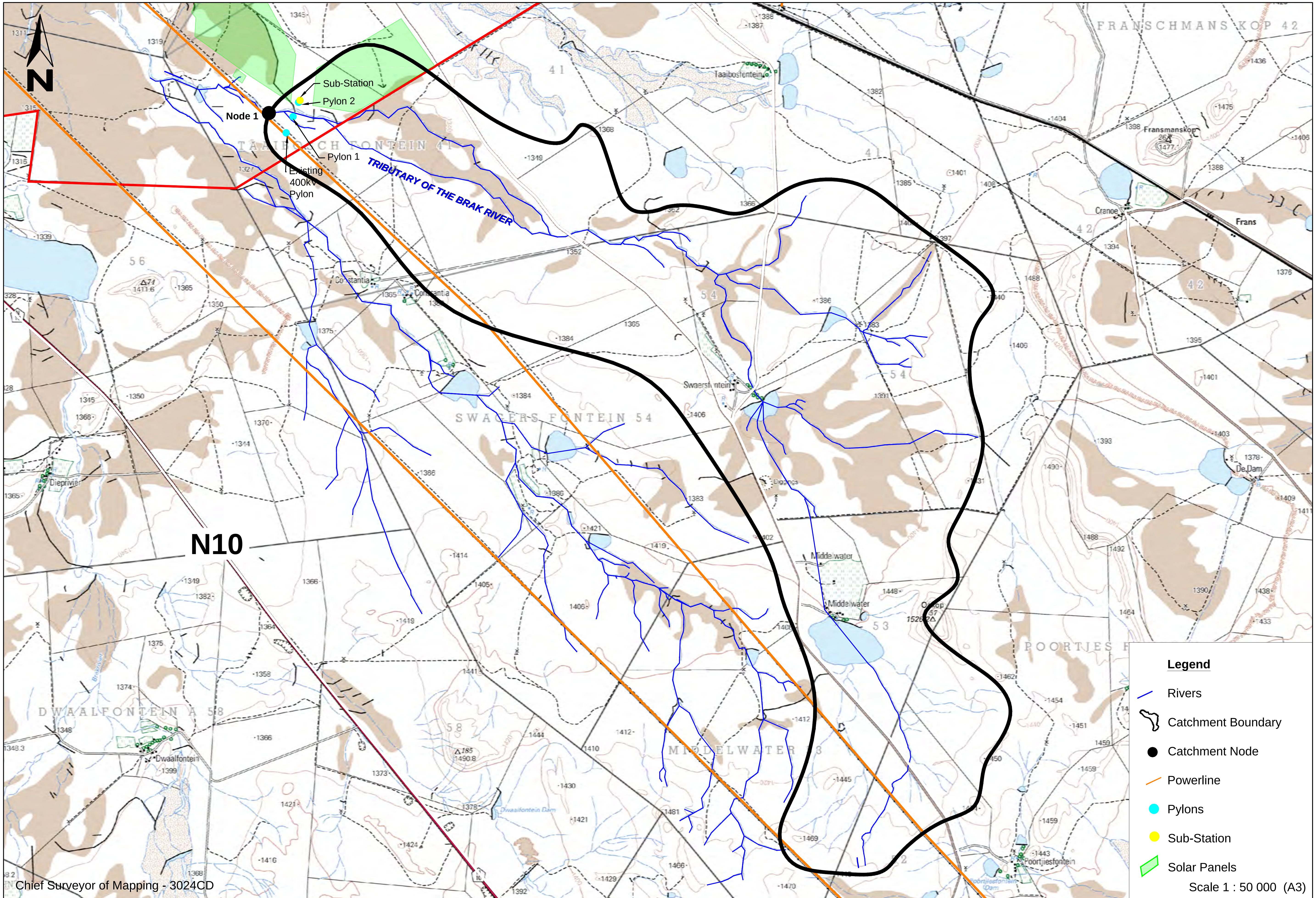
Table 4(d) Peak flows and catchment area for Node 1

Node	Peak Flow (m^3/s) for Recurrence Interval						
	1:2 yr	1:5 yr	1:10 yr	1:20 yr	1:50 yr	1:100 yr	RMF
1	23	38	56	78	117	161	427

4.2.2 Seasonal flows

Published information from WR2012 for quaternary sub-catchment D62D, in which the site resides, was used to estimate the seasonal flows in the watercourse.

The mean annual runoff (MAR) for quaternary sub-catchment D62D is quoted in WR2012 as 3.7 mm, which equates to 7.46 million m^3. The expected MAR for Node 1, at the powerline crossing is expected to be in the region of 2.5 to 5 mm. Please refer to **Figure 4(e)**.



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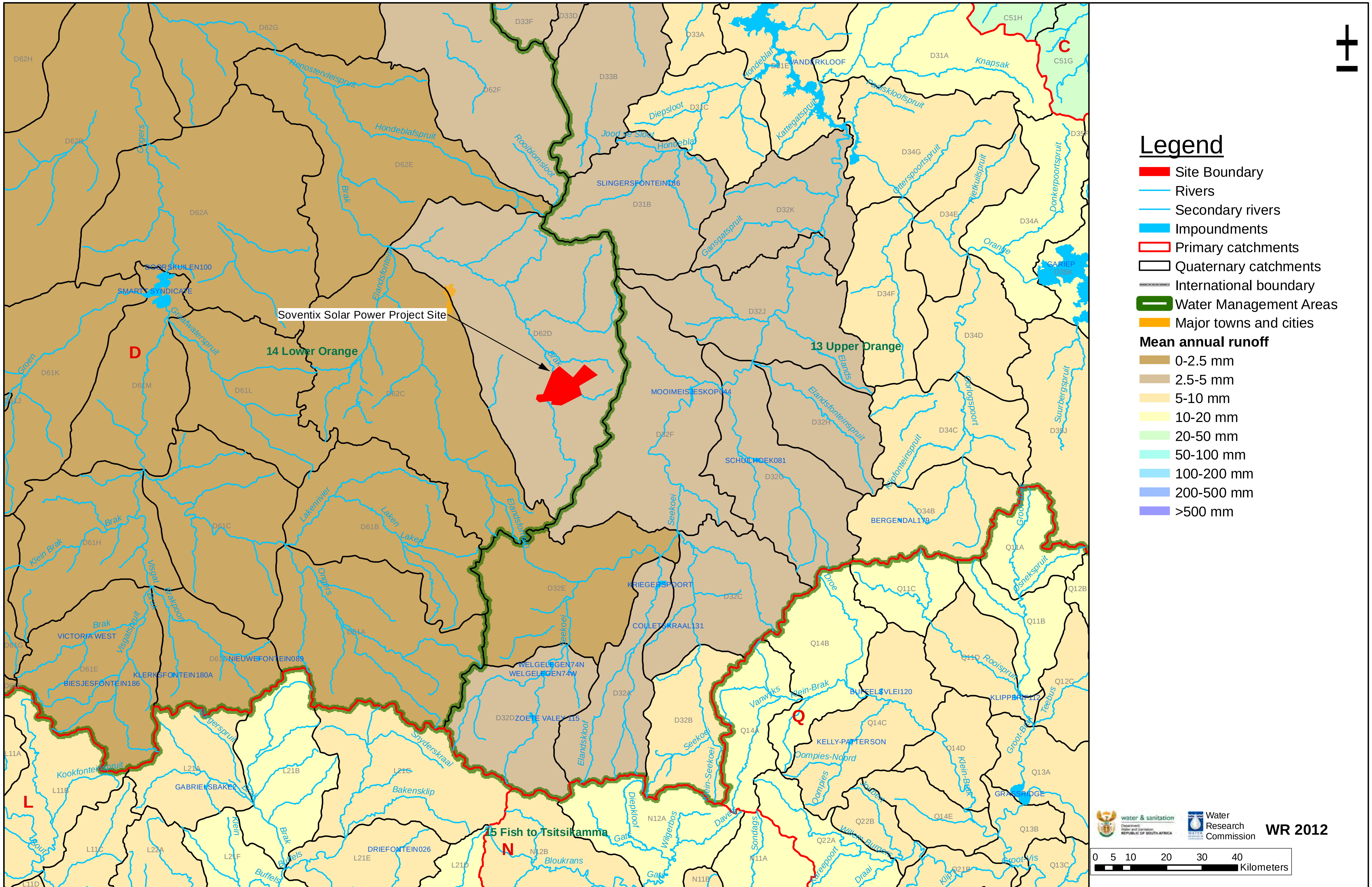
Catchment Boundary and Node

Job No G486-00

Figure 4(a)



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Hydrological Assessment
Mean Annual Runoff

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Figure 4(e)

The daily simulated runoff volumes averaged to monthly runoff values based on Hydro Zone G, as published in WR2012 are indicated in **Figure 4(f)** below. As can be seen from the figure, the streamflow shows strong seasonality, with the 8.17% of the annual runoff occurring during the summer months. Note that the indicated average monthly flows have been factored down from the published modelled flows for the quaternary catchment. It has, however, been reported verbally by the local landowners that there has been no notable flow in the watercourse for several years.

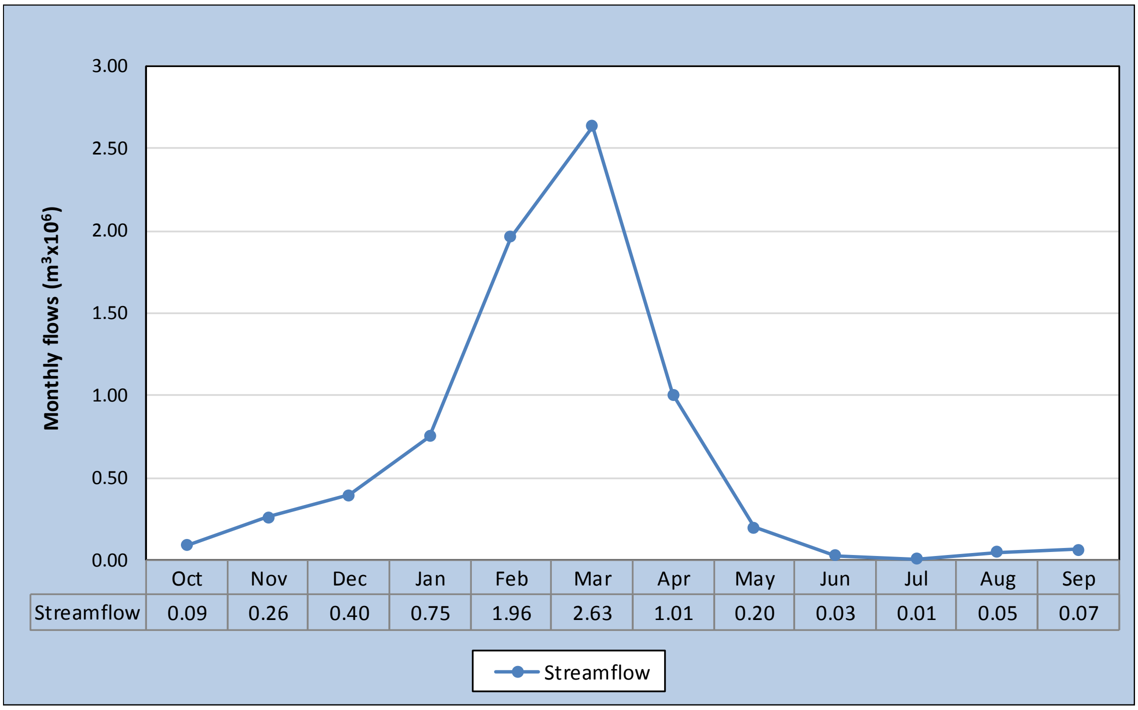

Figure 4(f) Estimated average seasonal runoff (WR2012)

4.3 Hydraulic assessment

A steady flow, backwater analysis was performed using cross-sections cut on the surface generated from the data obtained during the site visit (refer to Section 3). These cross-sections, together with flood peaks computed were input into the HEC-RAS river modelling software system to calculate indicative flow depths and flow velocities across in watercourse and at the pylon location, in particular. HEC-RAS was developed by the Unites States Army Corps of Engineers, and is considered industry standard software for floodline analysis in many countries, including the United States, the United Kingdom, Europe, Australia and South Africa. A surface roughness value (Manning's n) of 0.035 was employed.

The hydraulic analysis indicates that the pylon in question, at the location provided by the client and relative level to the watercourse, as measured in the field, will lie above the water level that can expect to be reached during a 1:100 year event. This is illustrated in the cross section, taken from HEC-RAS, shown in **Figure 4(g)**.

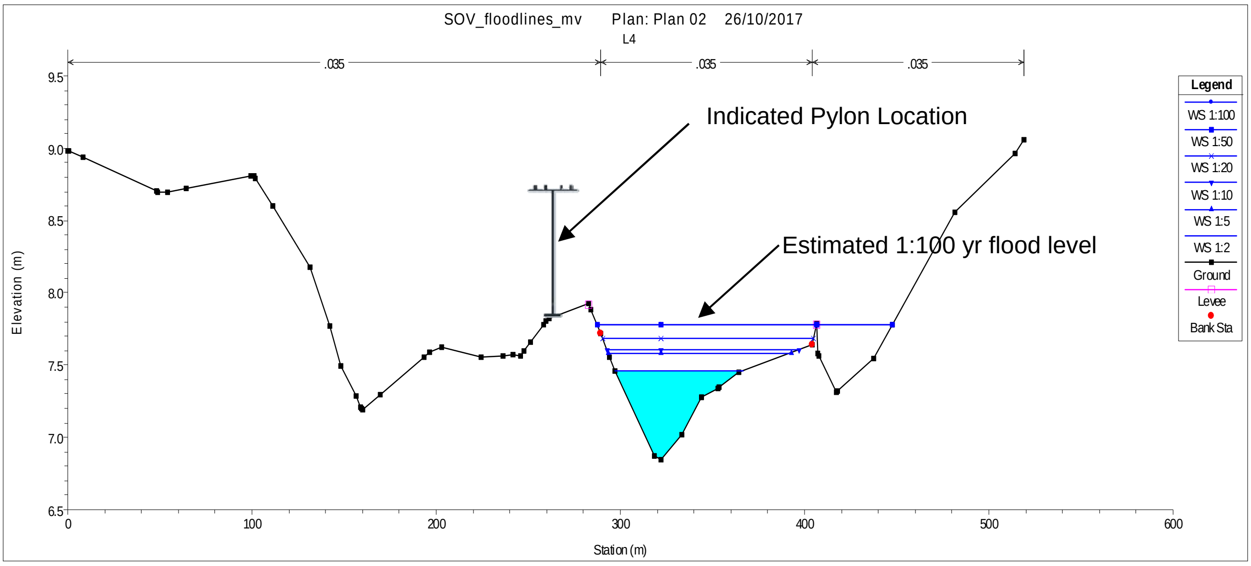

Figure 4(g) **Watercourse cross section indicating expected water levels during various recurrence interval events relative to the indicated position of the pylon**

5. POWERLINE IMPACT ASSESSMENT AND MITIGATION MEASURES

5.1 Impact assessment methodology and rating system

The rating of impacts was done according to an impact rating and assessment process that is in line with the requirements of the DEA. The methodology is outlined in **Appendix A**.

5.2 Activities to be undertaken that could potentially affect surface water

The following activities will be undertaken during the various phases of the proposed Powerline Project.

5.2.1 Construction phase

This phase will commence when the construction contractors establish on site and will end with the commissioning of the operation.

Activities to be undertaken that will potentially impact on surface water include the following:

- General construction activities:
  - Civil works.
  - Movement of materials and equipment.
  - Servicing of construction vehicles and equipment.
- Construction of powerline surface infrastructure:
  - Establishment of pylons within / in close proximity to watercourses.
  - Stockpiling of material excavated in close proximity to the excavation.
  - Barricading excavated hole.

  - o Carting and assembling of pylons, including transport and offloading of pylon sections in the vicinity of the pylon location.
  - o Erection of pylons.
  - o Backfill of pylon excavation.
  - o Spoiling of excess excavated material around the pylon. Where a pylon is situated in close proximity to a wetland care must be taken to minimise disturbance as far as possible.
  - o Using cranes trucks, LDVs and string machines to assemble cables into position.

5.2.2 Operational phase

This phase commences at the end of the construction period, and will end when the powerline is decommissioned.

Maintenance of the powerline will take place during this phase.

The activities that can impact on surface water include the repair and maintenance activities at the powerline.

5.2.3 Decommissioning and closure phase

As part of the decommissioning phase, the powerline will be removed and the disturbed area will be rehabilitated.

Activities that can impact on surface water include:

- ▪ General construction (demolition) activities:
  - o Civil works.
  - o Movement of materials and equipment.
  - o Servicing of construction vehicles and equipment.
- ▪ Rehabilitation of disturbed footprint:
  - o Taking down and removal of powerline cables.
  - o Demolition and removal of pylons.
  - o Removal of pylon foundations and backfill of voids with suitable topsoil material.
  - o Using cranes trucks, LDVs and string machines to remove cables and pylons.

5.3 Assessment of potential impacts

5.3.1 Construction phase

5.3.1.1. <u>Impact on surface water quality</u>

The potential impacts of the powerline on surface water quality are as follows:

- ▪ Erosion of topsoil on areas cleared or disturbed around the pylon site, including access routes, with resultant increased suspended solids, as well as siltation in watercourses.

- Impact on quality of storm water runoff from the pylon site, resulting from spillage of oil, grease and diesel from construction plant (increased hydrocarbon concentrations in surface waters).

The potential impact is assessed as follows:

Significance	Spatial Scale	Temporal Scale	Probability	Rating
Moderate	Study Area	Short term	Could happen	Low

5.3.1.2. Impact on surface water quantity – catchment yield and flow rates

No water will be retained on site during the construction phase. All storm water will be allowed to run off the pylon construction sites, with only temporary retention for silt management, if required.

The potential impact is assessed as follows:

Significance	Spatial Scale	Temporal Scale	Probability	Rating
No Impact	-	-	-	No Impact

5.3.2 Operational phase

5.3.2.1. Impact on surface water quality

The potential impacts of the powerline on surface water quality are as follows:

- Impact on quality of water in adjacent watercourses, resulting from scour and erosion at pylons located within the watercourse, with resultant increased suspended solids, as well as siltation in watercourses.
- During maintenance and repairs, impacts similar to the construction phase impacts could arise.

The potential impact is assessed as follows:

Significance	Spatial Scale	Temporal Scale	Probability	Rating
Moderate	Study Area	Medium Term	Could happen	Low

5.3.2.2. Impact on surface water quantity – catchment yield

All storm water will be allowed to drain freely under the powerline and no surface water quantity impacts are expected during the operational phase.

The potential impact is assessed as follows:

Significance	Spatial Scale	Temporal Scale	Probability	Rating
No Impact	-	-	-	No Impact

5.3.3 Decommissioning and closure phase

The impacts for decommissioning are expected to be as per the construction phase and the assessment has not been repeated here.

5.4 Recommended mitigation measures

This section details mitigation measures that are recommended to minimise the potential impacts on surface water.

5.4.1 Construction phase mitigation measures

- No pylons should be located within an area that would be expected to become inundated during a 1:100 flood event.
- The area of disturbance should be kept to a minimum to allow clearing of the construction right of way. The width of the construction corridor should be kept to a minimum.
- Vegetation should be removed only where essential for the continuation of the powerline. Any disturbance to the adjoining natural vegetation cover or soils should not be allowed.
- Vegetation and soil should be retained in position for as long as possible, and should only be removed immediately ahead of construction / earthworks in any specific area.
- Existing roads should be used for access as far as possible.
- The duration of construction activities at each pylon site should be minimised as far as is practical.
- Storm water management and erosion control measures should be implemented. These should include the following:
    - The excavated soil should be placed on the upstream side of construction activities in order to act as a storm water diversion berm.
    - Where such diversion berms create concentrated flows, as well as in steep and/or sensitive areas (such as wetlands) the use of swales, silt fences or other effective erosion control measures is recommended to attenuate runoff.
    - All storm water management measures should be regularly maintained.
- Drip trays should be placed under any activity requiring active lubrication or oiling at the pylon sites.
- Spill clean-up kits should be available on site for immediate remediation of any spills and removal of contaminated soils.
- No fuel should be stored at the pylon sites and no refuelling or servicing of construction plant should take place at the construction sites.
- No construction materials should be disposed of within the delineated wetlands or within the 100 m buffer zone on the watercourse.
- No concrete batching should take place within the delineated wetlands or within the 100 m buffer zone.
- All surplus spoil material from the foundation excavations (i.e. not used as backfill) should be removed from the site as soon as is practically possible.
- Once construction at a pylon site is complete, the site should be rehabilitated immediately by removing all waste material. The rehabilitation specification should be determined by the soils and vegetation specialists.

- All waste material should be removed to a licensed waste disposal facility, if it cannot be re-used or recycled.
- In areas where construction activities have been completed and no further disturbance is anticipated, rehabilitation and re-vegetation should commence as soon as possible.
- Replanting activities should be undertaken at the end of the dry season (middle to end September) to ensure optimal conditions for germination and rapid vegetation establishment.
- Should plants not successfully establish within two growing seasons after the first planting, new plant material should be provided.
- A weed and alien invasive species control plan should be implemented during the contract period.
- Any erosion channels developing during or after the construction period should be appropriately backfilled (and compacted where relevant) and the areas restored to a condition similar to the condition before the erosion occurred.
- A construction method statement should be compiled and approved prior to the commencement of construction activities.
- The method statement should take cognisance of:
    - The mitigation measures outlined above, as well as mitigation measures specified by each of the environmental specialists.
    - The conditions of the Environmental Authorisation and Integrated Water Use License.
    - The Environmental Management Program (EMPr) for the project submitted as part of the Environmental Impact Assessment Report.
- The Environmental Control Officer (ECO) must ensure that the contractor adheres to the above-mentioned documents.

5.4.2 Operational phase mitigation measures

- No pylons should be located within an area that would be expected to become inundated during a 1:100 flood event.
- Existing roads should be used for access as far as possible.
- The powerline route should be regularly inspected during the operational phase.
- Any erosion channels developing during or after the construction period should be appropriately backfilled (and compacted where relevant) and the areas restored to a condition similar to the condition before the erosion occurred.

5.5 Residual impact after mitigations

With the implementation of the mitigation measures detailed above, the residual impacts are assessed as follows, for all phases of the development:

5.5.1.1. <u>Impact on surface water quality</u>

The residual impact is assessed as follows:

Significance	Spatial Scale	Temporal Scale	Probability	Rating
Low	Study Area	Medium term	Unlikely	Very Low

5.5.1.2. Impact on surface water quantity – catchment yield

The potential impact is assessed as follows:

Significance	Spatial Scale	Temporal Scale	Probability	Rating
No Impact	-	-	-	No Impact

6. STORM WATER MANAGEMENT PRINCIPLES

All proposed developments require consideration of impacts that the project will have on storm water runoff.

6.1 Potential impacts of solar farms

In this case the development of the proposed solar PV plant involves placement of several fixed photovoltaic panels in a designated area earmarked for the development. A solar PV development does not entail chemical processes, so chemical contamination of storm water generated on the site would typically not be a concern. The primary concern with such a development would be the impact that it has on the storm water runoff patterns – they hydrologic response – of the land. Increased impervious areas (paving, etc.) typically have the effect of increasing storm water runoff volumes, as well as peak flow rates. This in turn can result in erosion of soils, which further results in increased suspended solids in the runoff water (a water quality impact), as well as deposition of transported materials downstream, which may impact aquatic ecosystems.

Research has been undertaken to determine the hydrologic response of solar farms, refer to **Figure 6(a)**, taken from the Minnesota Stormwater Manual (2017). The rain runs across the panel to the dripline and falls to the underlying surface, where it can either infiltrate or run off. Surface runoff beneath solar panels has the opportunity to infiltrate, meaning that there is no significant net loss in pervious area. Cook & McCuen (2013) indicate that the PV panels themselves do not have a significant effect on storm water runoff volumes, peak flows, or times to peak, provided that the ground cover (vegetation) beneath the panels is well maintained and is not allowed to deteriorate to a gravel or bare earth surface. Such lack of maintenance would result in significant increases in peak discharge rates, with a consequent risk of erosion at the base of the panels.

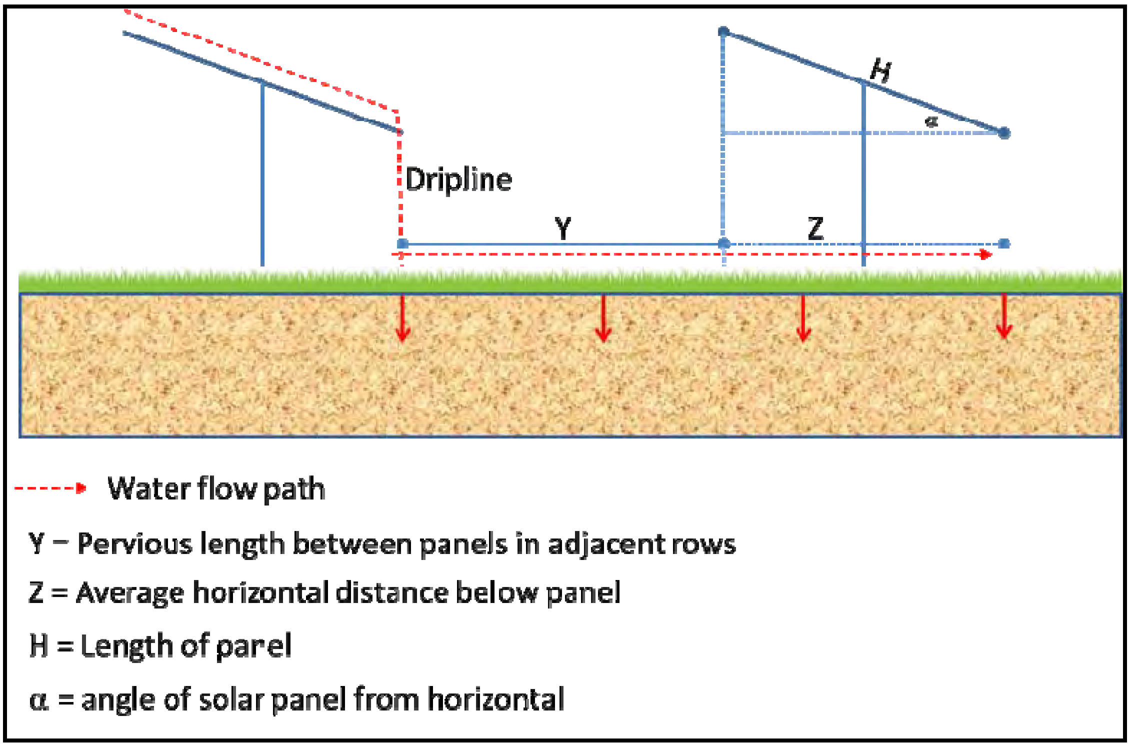

Figure 6(a) **Schematic illustrating hydrologic process for solar panels (Minnesota Stormwater Manual, 2017)**

Basic principles and guidance on best practice storm water management at solar PV farms is provided in the following section.

6.2 Storm water management principles and best practice

The objective of a Storm Water Management Plan (SWMP) is to control storm water runoff from the site. It should be designed to improve the storm water quality (i.e. sediment removal) and control runoff directly being discharged from the designated site.

The main consideration when developing a SWMP is to try and replicate the pre-development status after construction is completed.

The following aspects need to be considered when developing a SWMP for a project such as this and depending on how the proposed development differs for the conditions described below the plan and analysis may be minor requirements or if there is a large variation the plan may be more complicated.

6.2.1 Earth disturbance and grading activities

The following principles apply:

- Disturbance of the natural topography and vegetation cover should be minimised. The natural contours should be preserved as far as is practical in order to preserve the existing site drainage patterns as far as possible.
- Correct panel level and aspect should be provided in the design of the support structures and not through earthworks.

- Utilisation of low impact construction techniques should be encouraged, with the footprint of disturbed areas being minimised.

6.2.2 *Arrangement of solar panels*

The solar panels should be arranged in a manner that:

- Allows runoff to flow easily between each panel set and decrease the event of concentrated runoff from taking place.
- Allows growth of vegetation beneath and between panels.
- The mounting foundations of the panels should occupy minimal space.
- Slopes of panels to be mild allowing runoff to fall/glide easily and not at high velocities to the ground.
- A minimum vertical clearance from the ground level of 10 feet (approx. 3 m) is recommended in order to promote vegetation growth.
- Guidelines for the arrangement of panels (spacing between arrays) in order to minimise the impact on storm water runoff characteristics are provided by the Minnesota Pollution Control Agency (2017).

6.2.3 *Storm water management infrastructure, erosion and sediment control*

The following principles should be applied:

- Natural, dispersed, drainage should be encouraged, by maintaining the natural drainage characteristics of the land as far as possible, thereby minimising the concentration of flows and consequently the risk of erosion.
- Formal infrastructure, in the form of access roads, pipes, culverts, etc. should be kept to a minimum.
- A storm water drain should be provided along all access roads. The size and lining of the drain would be dependent on the peak flow rates and velocities, which should be determined through hydrological modelling.
- Storm water crossings at access roads should be provided in the form of drifts, rather than pipes or culverts. Drifts should be constructed from concrete or grouted stone pitching. Drifts should be provided at frequent spacings (recommendation is 300 m (Aurecon, 2014), again to minimise the concentration of flows.
- Diversion of upslope surface runoff around the solar PV area should be considered. Berms and/or open drains can be provided for this purpose. The size and lining of the drain would be dependent on the peak flow rates and velocities, which should be determined through hydrological modelling.
- All storm water drainage discharge points should be provided with outlet structures, designed with adequate erosion protection, to ensure that storm water is discharged from formal structures onto the natural ground at a safe and acceptable velocity.

6.2.4 *Vegetation cover*

- A vegetation cover that at least matches the natural, pre-development cover, should be maintained at all times between and beneath the solar panels.
- Grass cover at base of panels, particularly on drip line, should be actively maintained.

6.2.5 Maintenance and monitoring

The storm water management considerations need to be maintained and monitored.

The following is recommended in terms of maintenance and monitoring:

- Regular visual inspections are required to identify problems as they occur.
- Reseed bare areas.
- Inspection of the area frequently especially after intense rainfall and runoff events, with particular emphasis on the dripline areas and at access roads.
- Repair of erosion channels as soon as they develop.
- Monitoring in the form of visual inspections of the vegetation cover and erosion and sediment control features.
- Any sediment build-up should be removed immediately.

7. CONCLUSION

A field survey at the location of the proposed pylon in the unnamed tributary of the Brak River was undertaken using a dumpy level. Hydrological calculations were performed to estimate peak flows in the watercourse for various recurrence interval events. These were used to undertake a hydraulic analysis of the watercourse and to estimate indicative water levels, relative to the pylon, for various recurrence interval events.

The results of the analysis indicate that the water level in the watercourse is not expected to reach the pylon of concern, at its currently indicated location.

The impact on water quality of the construction and operation of the powerline between the solar PV array and the existing Eskom 400 kV powerline is expected to be LOW prior to mitigation, reducing to VERY LOW with the implementation of the proposed mitigation measures. The impact on catchment yield (water quantity) is assessed as NO IMPACT.

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For Jones & Wagener

31 October 2017

Document source: C:\Alljobs\G486_SoventixHydro\REP\G486_00_Rev0_mv_SoventixHydro.doc
Document template: Report Clean_tem_Rev2_Jan09.dot

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APPENDIX A

Impact Assessment Methodology

1. IMPACT ASSESSMENT METHODOLOGY

In order to ensure uniformity, a standard impact assessment methodology will be utilised so that a wide range of impacts can be compared. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology will be used to describe the impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in **Table 1-1**.

Table 1-1: Quantitative rating and equivalent descriptors for the impact assessment criteria.

RATING	SIGNIFICANCE	EXTENT SCALE	TEMPORAL SCALE
1	VERY LOW	*Isolated corridor / proposed corridor*	Incidental
2	LOW	*Study area*	Short-term
3	MODERATE	*Local*	Medium-term
4	HIGH	*Regional / Provincial*	Long-term
5	VERY HIGH	*Global / National*	Permanent

A more detailed description of each of the assessment criteria is given in the following sections.

1.1 Significance Assessment

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude, but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of area affected by atmospheric pollution may be extremely large (1000km^2) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. Similarly, if 60 ha of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type were known. The impact would be VERY LOW if the grassland type was common. A more detailed description of the impact significance rating scale is given in **Table 1-2** below.

Table 1-2: Description of the significance rating scale.

RATING		DESCRIPTION
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.
2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

1.2 Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in **Table 1-3**.

Table 1-3: Description of the significance rating scale.

RATING		DESCRIPTION
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible, and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor.
3	Local	The impact will affect an area up to 5km from the proposed route corridor / site.
2	Study Area	The impact will affect a route corridor not exceeding the boundary of the corridor / site.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the corridor / site.

1.3 Duration Scale

In order to accurately describe the impact it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in **Table 1-4**.

Table 1-4: Description of the temporal rating scale.

RATING		DESCRIPTION
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the project.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

1.4 Degree of Probability

The probability or likelihood of an impact occurring will be described, as shown in **Table 1-5** below.

Table 1-5: Description of the degree of probability of an impact occurring.

RATING	DESCRIPTION
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

1.5 Degree of Certainty

As with all studies it is not possible to be 100% certain of all facts, and for this reason a standard "degree of certainty" scale is used as discussed in **Table 1-6**. The level of detail for specialist studies is determined according to the degree of certainty required for decision-making. The impacts are discussed in terms of affected parties or environmental components.

Table 1-6: Description of the degree of certainty rating scale.

RATING	DESCRIPTION
Definite	More than 90% sure of a particular fact.

RATING	DESCRIPTION
Probable	Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Between 40 and 70% sure of a particular fact, or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact or the likelihood of an impact occurring.
Can't know	The consultant believes an assessment is not possible even with additional research.

1.6 Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus the total value of the impact is described as the function of significance, spatial and temporal scale as described below.

$$\textbf{\textit{Impact Risk}} = \frac{(\text{SIGNIFICANCE} + \textit{Spatial} + \text{Temporal})}{3} \times \frac{\text{Probability}}{5}$$

An example of how this rating scale is applied is shown in **Table 1-7**.

Table 1-7: Example of Rating Scale.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	LOW	*Local*	Medium Term	*Could Happen*	
Impact to air	**2**	***3***	**3**	**3**	**1.6**

Note: The significance, spatial and temporal scales are added to give a total of 8, that is divided by 3 to give a criteria rating of 2,67. The probability (3) is divided by 5 to give a probability rating of 0,6. The criteria rating of 2,67 is then multiplied by the probability rating (0,6) to give the final rating of 1,6.

The impact risk is classified according to 5 classes as described in **Table 1-8**.

Table 1-8: Impact Risk Classes.

RATING	IMPACT CLASS	DESCRIPTION
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

Therefore with reference to the example used for air quality above, an impact rating of 1.6 will fall in the Impact Class 2, which will be considered to be a low impact.