Appendix I

Surface Hydrology Impact Assessment

Concentrating Solar Thermal Plant: Humansrus

Hydrology Environmental Impact Assessment Report

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Executive Summary

SolarReserve SA (Pty) Ltd have proposed a concentrating solar thermal plant (CSP) in the Northern Cape on the farm 469 Humansrus near Postmasburg, adjacent to the road R385 that links Postmasburg and Kimberley. This report is the Environmental Impact Assessment (EIA) of potential hydrological impacts of the proposed CSP.

The essence of the design is a field of heliostats concentrating sunlight onto a central tower located at the top of a "power tower". The concentrated sunlight heats the central tower, which heats a molten salt flowing through a primary circuit. While the steam cycle will use mostly dry cooling, it is likely that wet cooling will be required, especially when ambient air temperatures become too high for efficient and effective dry cooling of the steam circuit. Dry cooling uses about 90% less water than wet cooling, but is less efficient.

Water for the CSP will be taken, by agreement with Sedibeng Water, from the Vaal-Gamagara pipeline.

It is highly unlikely there will be cumulative losses or gains that result from the project operations and the project could be considered to be hydrologically neutral from a surface water point of view. There will be neither a net loss or gain to surface water in the surrounding area of Humansrus 469 and nearby or adjacent properties. There will be a net economic gain to Sedibeng Water through purchase of water supplied from the Vaal-Gamagara pipeline to support CSP operations and generation of electricity. There may be a regional hydrological effect through the supply of water to the CSP from the Vaal-Gamagara pipeline, in that it will increase competition for water from that source.

The location of the proposed design of the CSP is such that it is unlikely there will be little if any effect on the identified water courses. The major channels on the Humansrus 469 property are located in catchment systems that arise off the property. The small wetland on the property is unlikely to be affected by the construction and operation of the CSP, it is outside the area of planned construction.

The alteration of the infiltration capacity of the several square kilometers of soil where the heliostats are constructed could lead to damaging overland flow and erosion should the area receive a significant rainfalls of the order of the 1:50 and 1:100 year return period. This effect should be managed, otherwise, in the event of a heavy rainfall, damage to the site and to the R385 road could be an outcome. Initial modelling procedures indicate the possibility for surface runoff to increase by 10 – 15 times as a result of changing infiltration capacity.

There are no identifiable issues from a hydrological and surface water point of view that would indicate the prevention of construction of the CSP. Where there are impacts, these can be mitigated by appropriate actions.

Abbreviations and Acronyms

AMC	Antecendent Moisture Conditions
CN	SCS Curve Number
CSP	Concentrating Solar thermal Plant
EIA	Environmental Impact Assessment
SCS	Soil Conservation Service
Tc	Time of Concentration

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1 Introduction

SolarReserve SA (Pty) Ltd have proposed a concentrating solar thermal plant (CSP) in the Northern Cape on the farm 469 Humansrus near Postmasburg, adjacent to the road R385 that links Postmasburg and Kimberley. The site is located 30 km east of Postmasburg and about 165km from Kimberley (see Figure 1), just north-west of Lime Acres and south-west of Danielskuil at georeference 28º 17' S and 23° 22' E.

This report is the Environmental Impact Assessment (EIA) of potential hydrological impacts of the proposed CSP. This EIA was prepared as part of an assessment contracted to OneWorld Sustainable Investments of Cape Town by Worley Parsons of Pretoria. In part execution of this EIA Report, the author visited the site on Wednesday 11 May, 2011.

This impact report assesses possible impacts of the proposed CSP on local and regional surface water hydrology. Water is critical to the operation of the CSP, primarily for cooling purposes, therefore the source of the required water is of concern. Secondly, the construction and operation of the CSP may have an impact on surface water conditions on the site and locally. This report assesses both possible potential impacts.

1.1 Expertise of the Author of This Report

This hydrological Impact Assessment was undertaken and compiled by Arthur Chapman in his capacity as a hydrologist working for OneWorld Sustainable Investments in Cape Town. He has an M.Sc in hydrology and 21 years experience as a hydrologist and related environmental sciences, with a background in assessing the impacts of land-use change on runoff, hydrological modelling, as well as environmental impact assessments. These assessments range from those of similar projects (Concentrating Solar Plants at Upington and two near Groblershoop, Northern Cape – Client: ESKOM); assessments of the impacts of mines on water resources (the Hillendale and Fairbreeze heavy sands project of the then Iscor at Mtunzini, KwaZulu Natal Province), the impacts of old mine discard dumps on surface water quality at Ogies (Client: the Oil Pollution Company of South Africa – OPCSA); a review of the hydrological assessments for possible nuclear power plants in the Western Cape (Client: ESKOM); The impacts of afforestation on surface and ground water resources in South Africa (various clients) and internationally (Forestal Oriental, Uruguay) and the impacts of invasive alien plant invasion on surface water resources (research briefs). He is also consulting to international clients on the impacts of climate change in Southern Africa across a range of different sectors that includes water resources, human health and energy supply.

2 Study Methods

The study approach utilized was as follows:

- The author consulted appropriate literature on the region, which included that on regional climate, hydrology and water resources, institutional arrangements and activities in the water sector. Included in this component on background information was consultation of the technical aspects of the design concepts of the proposed CSP facility from SolarReserve and consulting engineers Worley Parsons;
- A site visit was conducted to identify and inspect hydrological features that may be relevant to the proposed development;
- The development of the Scoping Report gave guidance to the issues investigated and subject to impact ratings;
- The Terms of Reference required a determination of the 1:50 and 1:100 year flood lines – SCS procedures were applied to the problem and appropriate maps produced;
- Impact assessments result from the synthesis of the above information and appropriate conclusions are then developed

In the pursuit of the development of this report, the study author consulted:

- Mr Allan Scholtz, the farm owner at Humansrus (visit – 11 May 2011);
- Members of the Groenwater Gemeenskap Rural Development Tribal Authority (Chief J.K. Marotobolo and Councilor Esther Diraditsile; visit 11 May 2011);
- Mr Hasenjager (Manager: Business Development and Acting Regional Manager Northern Cape, Sedibeng Water); and
- Various web resources and documents with respect to regional hydrology and climatology.

3 Review of Existing Information

3.1 Description of the Proposed Facility

The proposed CSP at Humansrus is that of the "power tower" concept, modelled on that of Solar One and Solar Two, built and proved in Southern California. The essence of the design is a field of heliostats concentrating sunlight onto a central tower located at the top of a "power tower" (See Figure 1). The concentrated sunlight heats the central tower, which heats a molten salt flowing through a primary circuit (the molten salt loop). The flow of molten salt is conveyed through a heat exchanger which transfers heat into a secondary circuit of water and the resulting steam drives a high pressure turbine and generator. The exhaust steam of this process is then reheated with molten salt in a standard Rankine cycle and injected into a low ressure turbine coaxially linked with the high pressure turbine to the generator. While the steam cycle will use mostly dry cooling, it is likely that wet cooling will be required, especially when ambient air temperatures become too high for efficient and effective dry cooling of the steam circuit. Dry cooling uses about 90% less water than wet cooling, but is less efficient.

The generating capacity of the proposed CSP at Humansrus 469 is 100MW. The design considerations and consumption of water that concerns this assessment is based on this size of plant. A principle of operation is that a proportion of the captured energy is transmitted straight into the grid and the major proportion goes into heat storage (molten salt stored in tanks) for use during night times and periods of occluded sunlight. A salt is used (a mixture of pure potassium and sodium nitrate)because it has a high heat capacity (meaning the substance contains a lot of energy per degree increase in temperature) While the specific operational parameters of the proposed CSP have yet to be determined, the plant will start generating power each day when insolation is sufficient to provide heating for its primary thermal circuit, and it will when there is insufficient energy insolation to store and transmit power. Between these times (at night and during cloudy conditions, it will use the stored heat to generate electricity.

The proposed installation at Humansrus 469, which includes the central power tower and the field of heliostats, is estimated at being roughly 2.7 km in diameter or covering 8 km^2 (800 ha). The heliostat field will contain 17,350 heliostats, with the power tower located off-center and closer to the northern boundary of the round heliostat field. When the heliostats are not functioning (night time), they will likely be inverted, a position in which they can be cleaned and to prevent dewfalls and dust from quickly contaminating the reflecting surface. Dust on the reflecting surface i.e. mirror will significantly reduce reflectivity and will influence efficiency of the CSP plant – making a dust control suppression plan important during operations. The heliostat surfaces will be cleaned regularly by means of high pressure spray of demineralised water and possibly squeegee-like devices.

The area in the immediate vicinity of the central tower is likely to paved or have a concrete floor, as will the area around other supporting infrastructure (salt storage tanks, buildings, roads and some of the electricity distribution infrastructure). The area under the heliostats may be chipped stone or the natural veld with short shrubby vegetation or maintained as bare soil. Infiltration in this area is unlikely to be affected. The possible hydrological impacts of the CSP result from the water used in the construction and operation of the plant, as well as the effect of the installation on site hydrology.

3.2 Climate

The area is also known as the Green Kalahari, with a hot and dry climate. During the summer months (January) the temperatures can reach a maximum of 42°C. Observed rainfall mean is about 330 $mm.a^{-1}$, (determined from Smithers and Schulze, 2002 During wetter years, more than 600 mm has been recorded, whilst exceptionally dry years less than 200 mm has been recorded. Most of the rainfall received in the area is of convective origin and occurs in summer, leading to short, sharp downpours (Preston-Whyte and Tyson, 1988). Storms are relatively brief, but peak rainfall intensities over 5, 10 and 15 minutes differ little from other parts of South Africa that receive greater annual rainfall (Smithers and Schulze, 2002). Fifty and 100-year design rainfall return periods for the site are given in Table 4 in Section 8. On January 23rd, 2011, a maximum of ~150 mm in one day was recorded near the site. This is a record maximum daily rainfall for a local raingauge.

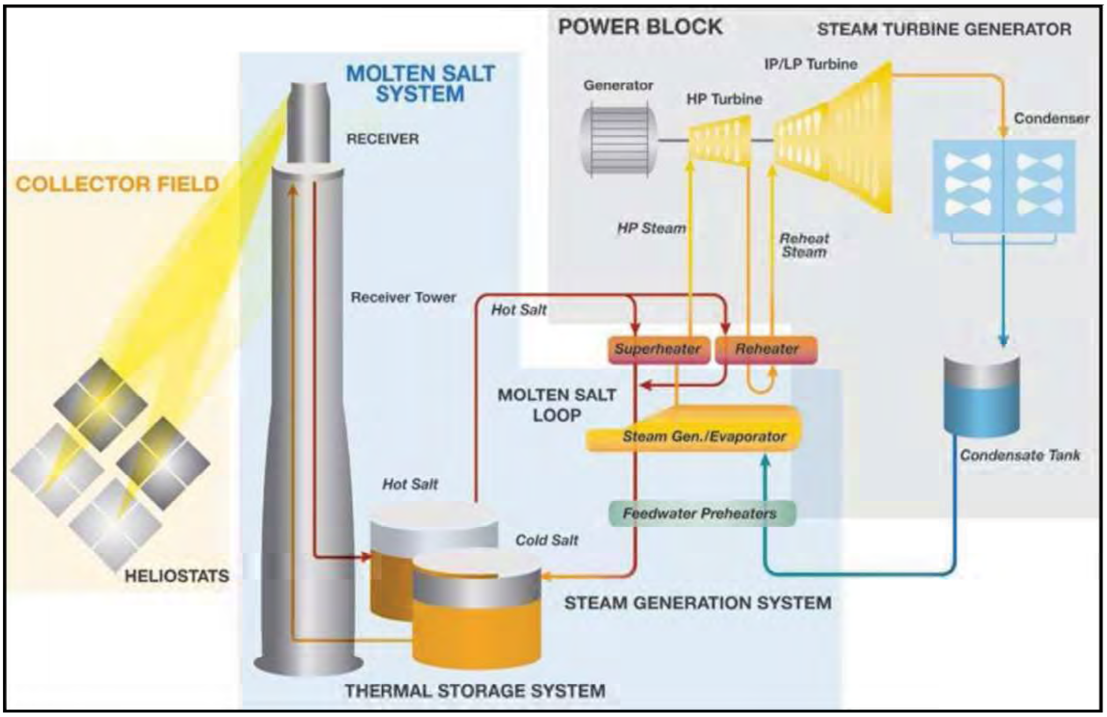

Figure 1 Conceptual layout of the proposed Concentrating Solar Thermal Plant of the type proposed for the Humansrus 469 site (source: Worley Parsons Technical).

In January daily maximum temperatures reach over 35°C on about 5 days a month, with minimum relative humidities at midday dropping to 20%-30% and even lower. During winters, frost can be severe (defined as when air temperatures at the standard thermometer measuring height of 1.3 m drops below 0°C. Air temperatures at ground level may be several degrees lower than air temperature at thermometer measuring height. The climatological definition of a frost is 2.2°C at standard thermometer measuring height). Minimum temperatures can go as low as -7°C, but these occasions are rare.

The January (14:h00) atmospheric saturation deficit averages about 40 mb (Tyson, 1986). The humidity mixing ratio (a measure of moisture content independent of temperature) for January is about 7 $g.kg^{-1}$, compared to 15 $g.kg^{-1}$ in more humid parts of the country (Preston-Whyte and Tyson, 1988. This is a measurement of the quantity of moisture in the air, measured as the number of grams of water vapour per kg of air. The quantity is controlled primarily by moisture availability, air temperature and air pressure). The dry atmosphere and good optical clarity are only a few of the reasons why this area in particular is excellent for CSP project development. Insolation of nearly 2,900 $kWh.m^{-2}.yr^{-1}$ when 1,800 $kWh.m^{-2}.yr^{-1}$ is roughly the minimum required to operate this type of CSP.

3.3 Description of Study Area and Regional Hydrology

At 330 mm.a[-1] of rainfall and evaporation rate of about 2200-2600 mm.a[-1], the area is be classified as arid (Middleton and Bailey, 2009). Regional runoff ranges from 0-25 mm.a-[1] (Middleton and Bailey, 2009). Surface water generated by rainfall is confined to stormflows following intense convective storms and quickly subsides. In general, streamflow is ephemeral, the stream beds are dry most of the time. Storage of water in dams is highly inefficient because of the high evaporation rate.

Identifiable channels are located on the southern and western boundaries and parts of the Humansrus property (See Figure 2). Small amounts of water can be found in the channels after rainfall but this is also dependent on the duration and intensity of evaporative conditions between rainfalls. The remainder of the Humansrus 469 property experiences sheet flow, most of which infiltrates into highly porous sandy soils and no channels are visible.

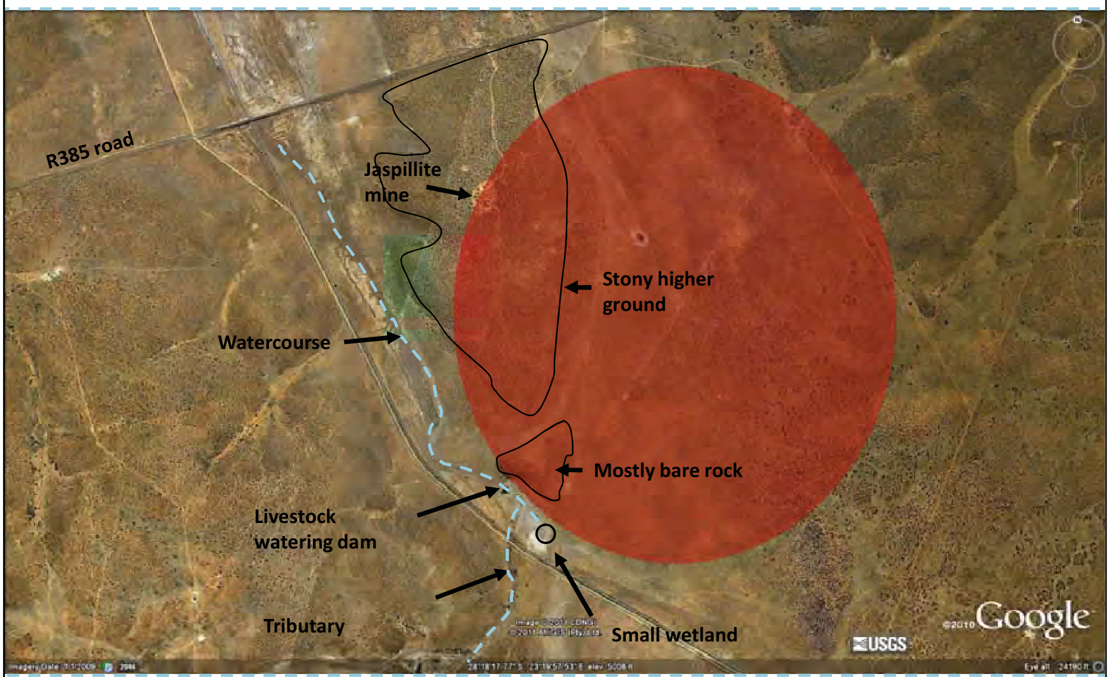

Figure 2 The proposed site of the CSP on the Humansrus farm, showing natural hydrological features (Source: Background Image: Google Earth).

3.4 Water Requirements during Construction, Operational and Decommissioning phases

The understood requirements for water for the operation of the CSP, based on Worley Parson documentation, is 1,550 $m^3.d^{-1}$ during the construction phase and about 750 $m^3.d^{-1}$ on average, during operation, or 272,400 m^3 over a full year of operation. Water demand however will vary according to cooling demands and peaking consumption can rise as high as 45 $m^3.hr^{-1}$ (See Table 1 below). The scoping report (see Chapman, 2011) identified the potential for the proposed CSP to utilize water taken from the Vaal-Gamagara pipeline and/or from local and regional groundwater resources. Water taken from the pipeline mayhave an impact on regional water supplies, through increased competition for water from the Vaal-Gamagara pipeline. The pipeline is described in further detail below.

Table 1 Water requirements during the construction and operationla phases of the CSP (Data Source: Worley Parsons, 2011)

Construction Phase	m^3 per day	m^3 over 30 months
Dust control	242	42,350
Road construction	1,170	51,100
Human use & other	137	24,050
Total	1,549	117,500

Operational Phase	m^3 per day	m^3 per year
Heliostat cleaning	8	1,319
Plant operation	746	272,400
Peaking consumption /hr	45	

3.5 Sedibeng Water and the Vaal-Gamagara Water Scheme

Sedibeng Water is the water authority for the area in terms of water supply. The proposed CSP site is located in the Northern Cape Proclaimed Service Area of Sedibeng Water. Proclamation means that the relevant water authority is the only party authorised to supply and manage water within its area of jurisdiction, unless agreed otherwise and excepting individual properties that manage their own water, as noted in this excerpt from the Water Supply Act (Act108, 1997) – that every Water Board:

"*must consider every request by a water services institution for the provision of water services within its service area and may only refuse such request if, for sound technical and financial reasons, it would not be viable to provide those water services*" (Clause 32(c));

The Vaal-Gamagara pipeline is part of a government water supply scheme managed and operated by the water authority Sedibeng Water (Jeleni and Mare, 2007). The scheme runs through six Water Service Authorities, which are composed of four local municipalities (Dikgatlong, Kgatelopele, Tsantsabane and Gamagara) and two district municipalities (Kgalagadi and Frances Baard) (See Figure 2). Key customers of Sedibeng Water using the Vaal-Gamagara scheme include mines, the agriculture sector, Public Works institutions, domestic users, Spoornet and Eskom.

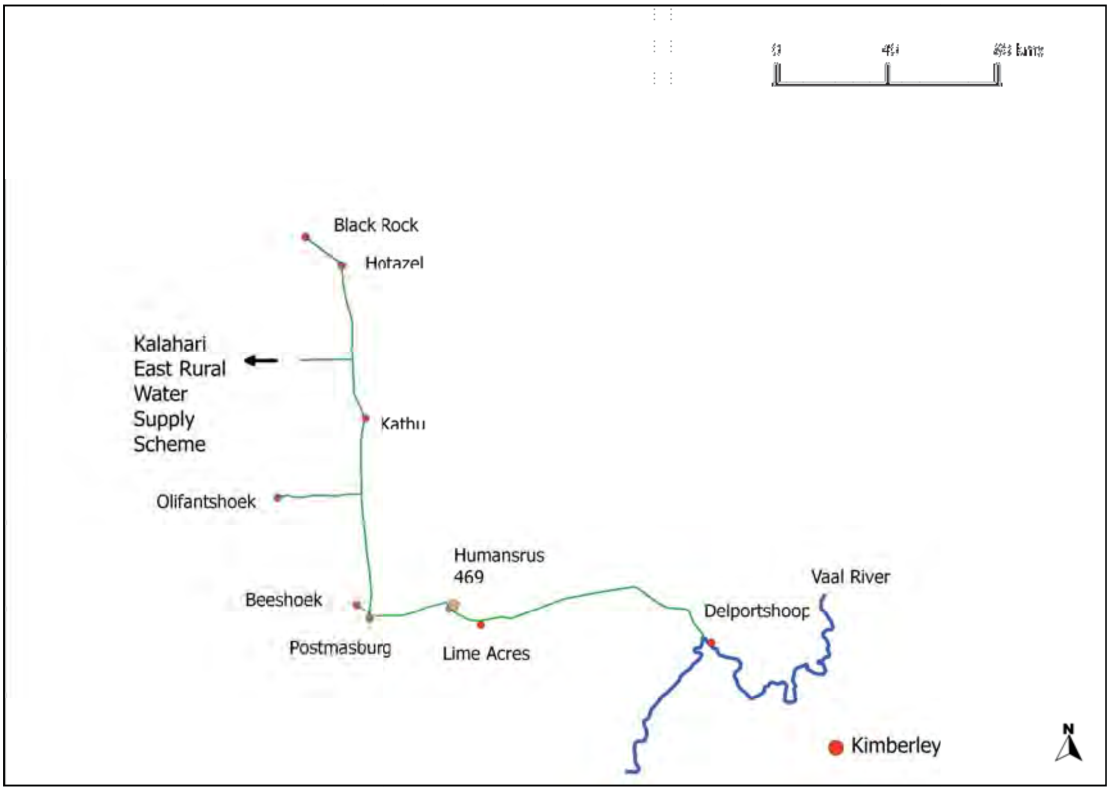

Figure 3 The approximate layout of the Vaal-Gamagara pipeline as a regional supply system operated by Sedibeng Water.

The pipeline was built in 1964 to supply water to settlements and mines in the Gamagara River catchment (Postmasburg, Beeshoek Olifantshoek Sishen/Kathu, Hotazel, and Black Rock) but was not under the control or owned by a Water Authority. The extension of the Sedibeng Water Service Area to that region serviced by the Vaal-Gamagara Water Supply Scheme was listed in the Government Gazette No 114, 8 February 2008. Water is abstracted from the Vaal River near Delportshoop upstream of the confluence with the Harts River, from where raw water is pumped to a purification plant nearby. Purified water is then pumped via intermediate booster stations at Kneukel and Tredwil through 99 km of pipeline to reservoirs at Clifton in the hills above Lime Acres (total pipeline length of the Vaal-Gamagara system is about 1700 km). From this relatively small storage capacity of 27,000 m^3, water is gravity fed over 182 km to Kathu and reservoirs at Black Rock and other parts of the pipeline. Design capacity of the pipeline is 3,637 $m^3.day^{-1}$. In total there are six booster pump stations and a total pipeline network of 1,700 km (Sedibeng Water online). Mines use most of the water (60%) and are the biggest employers in the region.

The pipeline diameters vary between 700 mm at the source (Vaal River near the confluence with the Harts River) to 200 mm towards its terminus (Black Rocks). The pipeline branches out to supply water to surrounding areas such as Olifantshoek (including the Kalahari East pipeline) and Beesthoek. The Kalahari East Rural Water Supply Scheme is a rural water supply system, constructed in the early 1990s to supply farmers in the Kalahari with water for domestic and livestock uses (See Figure 3). The Kalahari East RWSS is located north-east of Upington and west of the Vaal-Gamagara pipeline, covering a large area all the way from the Orange River to the Molopo River channel and South African border with Botswana.

The design capacity of the pipeline is 36.37 $Ml.d^{-1}$ or 1.5 $Ml.hr^{-1}$ (1,500 $m^3.hr^{-1}$). The pipeline has a maximum allocation from the Vaal River of 13.7 million $m^3.a^{-1}$ but sometimes operates at less than full capacity. During drought, water restrictions are imposed on abstractions and allocations to users are curtailed on the basis of a priority classification, as well as the short-term yield characteristics of the Vaal River.

The pipeline is critical to the economic performance of this region of the Northern Cape. There are proposals to extend the pipeline to more settlements in the Mier district (that area primarily served by the Kalahari East and West RWSS). Capacity on the pipeline is apparently fully committed (I. M. Hasenjager, Manager: Business Development and Acting Regional Manager , Northern Cape, Pers. Comm,) and Sedibeng Water is developing a concept proposal for an additional pipeline alongside the original pipe (the water in a second pipeline would be expensive because the tariffs would need to be used to defray the costs of construction over more than 100 km through rocky ground. The Vaal River is not the only source of water in the pipeline, however. High quality water available from dewatering of the Sishen mine is pumped into the pipeline at Kathu. When the new Kumba iron ore mine near Postmasburg is developed, water from that mine will also be made available to the system.

The Vaal-Gamagara pipeline is an attractive option for supplying water to the CSP because of its proximity to the project and the high quality water. It is assumed that if the pipeline has sufficient capacity, the appropriate supply options can be put into place.

4 Description of Site and Local Environment

4.1 Site Survey

The site was visited by RA Chapman on 11 May 2011. The site was inspected for all features of hydrological importance. These included channels, areas of temporary or permanent water storage, wetlands and for signs wherever surface water is active in the landscape.

4.2 Physical Description and Catchment Characteristics

The proposed site for the CSP is illustrated in Figure 1. Within this core area, no surface drainage features such as stream channels, are observable. The area is covered with sands that have a high porosity and infiltration capacity and can be classified as soils with a deep Hutton profile (See MacVicar et al., 1997). Infiltration is rapid and surface water exists for a short time only. Surface flows that may be generated in the hills to the north and east infiltrate rapidly into the substrata near the edges of the break in slope.

To the west but within the property, the ground rises slightly more steeply with a slope of about 1:50 or 2-3%. This higher ground, that is a significant part of the western part of the CSP footprint, is not evident from the 1:50,000 topographic map, which is somewhat misleading as to land shape. The ground is stony and also has a large floating rock component (boulders not attached to the parent rock system). A small jaspillite mine or quarry is located on this feature (See Figure 1 – which identifies the feature).

4.3 Channels, Wetlands and other Water Features

The runoff patterns of Humansrus 469 are complex. In the south and west, the most significant channel enters the property from the western high ground. This area (the catchment to the west of the Humansrus property) generates more flashy hydrographs than those arising from the high ground (also outside of the property) in the north and north-east. Geological and associated soils conditions control the storm flow responses from the different areas. In the south and west, channels are easily observable, but they do not exist in the north-east.

The location of potential surface flow through the site where the CSP is proposed to be located is far less discernable. No channels exist here, pointing to the lack of preferential flow paths. Sheet flow is expected in this area during intense storms. This raises the concern of how conditions for surface flow may change with construction and vehicular activity during operation of the proposed CSP.

There is only one significant identifiable drainage channel, located on the west side of site, adjacent and parallel to the railway line. The main part of the catchment lies outside of the property, to the west (Figure 4). Ephemeral, water flows only very briefly during heavy and intense storms. This channel joins another small channel on the Humansrus property and turns north-west, where it is blocked by a small dam used for watering livestock. Further downstream, the channel, which was originally wider, has been confined through erosion of a deeper channel into its floodplain with significant banks. All of these channels are ephemeral. Only small pools of water were visible in the channel despite it having rained during the night before this authors field visit.

There is a small wetland near the south-western boundary of the CSP footprint, about 0.2 ha in area (See Figures 2 and 4). Colloquially known as a pan or vlei, it is shallow, had no standing water at the time of the visit but its spongy soils were damp (it had rained within 24 hrs of the site visit). It appears to have a low biotic diversity. Covered mostly be a single tough type of grass about 0.6m height, it appears unpalatable to livestock (it has not been grazed, unlike surrounding grasslands) and is also unused by small birds (Figure 5). From observation, water retention is highly likely of short duration. Based on these observations and that at a regional scale other much larger pans near the Lime Acres and Finsch mines had observable open water at the time of the author's visit, it is suggested that this small ephemeral wetland is of little hydrological consequence, even at local spatial scales.

The high evaporation rate and general low rainfall signifies that there is very little surface water in the area. What little surface water that exists after a storm soon evaporates or infiltrates to groundwater. At the time of the site visit (11 May 2011), this part of the Northern Cape was at the end of the end of a particularly wet phase (caused partly by the La Niña conditions in the Pacific Ocean, which is known to cause above average rainfalls over large parts of South Africa, although not always). Despite the high rainfall, very little surface water was observed anywhere on the farm Humansrus 469. A small dam exists about 200 m further down the drainage systems on the western boundary of the farm did have a small amount of water and is used as a water source by large livestock (See Figure 4). This dam is usually dry for most of the year. Water flowing into this dam arrives mostly via the channel to the west, on the other side of the railway line.

It should be noted that the soils on the western side of the property (and outside of the boundary of the planned field of heliostats – see Figure 2) that underlay the main channel display erosive potentials. An erosion feature (channel) has become established 600 m below the small dam and appears to be eroding upstream and widthways during periods of high-velocity storm flow, with most of the stormflow flowing from the western catchments.

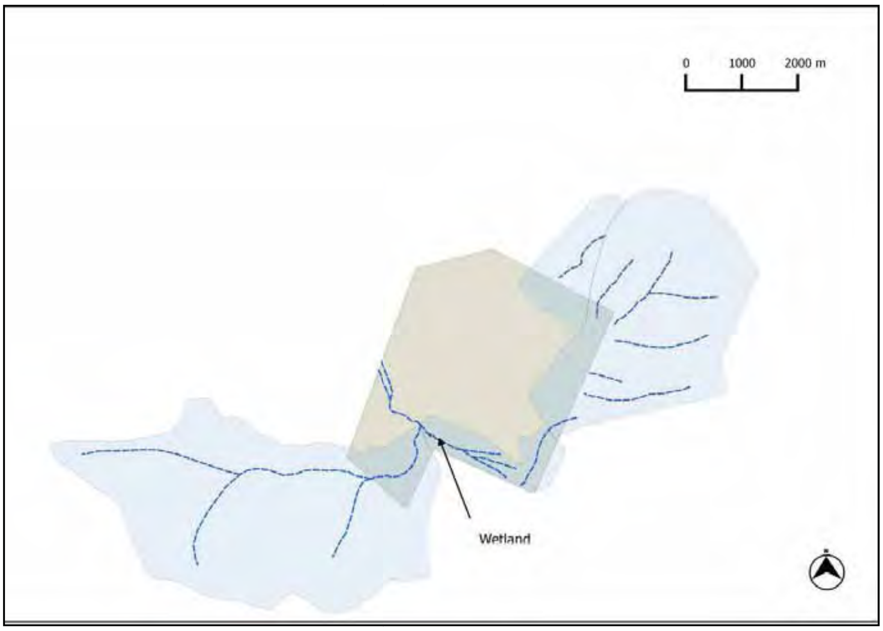

Figure 4 Drainage features and location of the wetland at the farm 469 Humansrus.

Figure 5 The small ephemeral wetland (vlei) on the Humansrus western boundary (about 0.2 ha), looking south-east.

4.4 Local Users of Water

The homestead on the farm Humansrus 469 uses groundwater supplies for its domestic and livestock supply needs. The farmer (Mr Scholtz) also irrigates about 13,8 00 m^2 of green forage for his livestock and this water also is supplied from boreholes near the homestead. The small dam on the south-west boundary of the CSP site only has water after heavy rainfalls and contains water only intermittently. The farmer does not rely on this source of water.

About 3 km west of the farm homestead, the small community of the Groenwater Gemeenskap also obtains it water from local groundwater sources. The reader is referred to the Groundwater Impact Assessment for insight into the potential impacts of the CSP on groundwater resources.

Figure 6 Natural drainage line, looking north-west, viewed from just below the wetland shown in Figure 5. The treeline indicates the livestock-watering dam wall.

Figure 7 Livestock watering dam on the drainage line on the south western boundary of Humansrus farm. The treeline indicates the livestock-watering dam wall.

5 Impact Assessment

A synthesis of available information shows that there are three possible types of impact related to hydrology and water use:

1. Regional hydrology (related to water supplies to mines, urban areas and domestic and livestock users);
2. Soil infiltration and surface flow conditions on site; and
3. Possible interference in local hydrological functioning.

Water is critical to the operation of the CSP, its water sources and cumulative impact of its water demand on other competing water users in a semi-arid region. The builders and operators of the CSP plan to use water from the Vaal-Gamagara pipelone, which could have an impact on other users dependent on water from the same pipeline, noting that the Vaal-Gamagara water supply system has a regional footprint over a large area (See Figure 3). The demand for water must be met either by regional water supplies (the Vaal-Gamagara pipeline) or by groundwater, or by a mixture of both. The groundwater assessment has been undertaken by the groundwater specialists and is not addressed here. **Table 2** below reviews likely impacts of the project on the Vaal-Gamagara Water Supply Scheme.

Local soil disturbance has the potential to reduce infiltration capacity. The surface of the proposed CSP site is notable for its lack of surface flow features such as channels, implying a high infiltration capacity of the soils. Even very heavy recent rainfalls (January 23, 2011) failed to produce observed surface runoff. The use of heavy machinery for construction of the heliostats will cause soil compaction and result in loss of infiltration capacity. This is likely to generate excess surface water through sheet flow during intense storms. Initial modelling (using SCS procedures) indicates that sheet flow of up to 13 times greater than could be generated from the same design storm in its current condition.

The effects of this increased surface flow would firstly be the significant erosion of soils on site, which would be deposited down slope where-ever water dispersion takes place or drainage flow velocities decrease. The second effect is that the increased surface flow will flow down-slope towards the R385 road. Where this road is located on the NW boundary of the intended CSP site, there is a slight dip in the road but no provision has been made by the road owners to convey water under the road through culverts. It is possible that excess surface flow generated on the CSP site will endanger the structure and integrity of the R385 at this location, either through sediment deposition or through erosion and a breach of the road, or both. This impact (of the CSP on surface flow over the site) is assessed in **Table 3**.

The construction and operation of the CSP may have an effect and disrupt local hydrological functioning. For example, it may interfere with the natural flow and storage of water in local channels and wetlands (on-site and off-site but nearby), to the detriment of their natural functioning. These possible impacts are evaluated in **Table 4**.

Table 2 Rating table on the likely impacts of the proposed project on the Vaal-Gamagara Water Supply Scheme.

Category and Scale	Rating and Description	Description and Justification	Quantitative Rating
Status of Impacts	**Neutral**: No cost to the receiving environment	Water is abstracted from the system (Vaal-Gamagara pipeline) and consumed by the CSP.	**N**
Spatial scale of impacts	**Medium and High:** Local and regional	The impact extends beyond the site boundary. Water demand by the proposed operation requires local and/or regional groundwater abstraction, as well as abstractions from the Vaal-Gamagara pipeline, which supplies water at a regional scale - the pipeline extends for 197 kms, supplies water to urban and mining operations and is of great economic importance. The pipeline requires pumping and storage capabilities. The CSP will compete for water on a commercial and first-come first serve basis (i.e. the CSP will not be able to commandeer water already allocated).	**3**
Temporal scale of impacts	**High to Very High**: Long-term: Water demands will operate for the lifespan of the project (16-30 years and longer).	The requirement for water for cooling and cleaning will last for as long as the CSP can usefully generate electricity. There is potential for the project to last >40 years, so the quantitative assessment could produce an impact lasting more than 30 years and/ or result in a permanent and lasting change that will remain in place.	**4**

Probability of Impact	**Highly probable**: Likelihood of occurrence equal to or greater than 90%	Water is critical to operation of the CSP.	**4**
Severity of Impact	**Average:**	Medium to short term impacts on other Vaal-Gamagara pipeline users and managers. Water is supplied by Sedibeng Water through the Vaal-Gamagara pipeline on a commercial and availability basis.	**2**
Significance of Impacts	**Negative, Medium**	The impact is real, in that water will be supplied from the Vaal-Gamagara pipeline that could be supplied to other users. The impact is not substantial in relation to other impacts such as alternative competing uses of the same water. Social, cultural and economic activities of communities are not affected, Sedibeng Water will not switch supplies at the expense of existing users to new users..	**6**

5.1 Impacts of the Project on Local Hydrology and Erosion Potential

Table 3 Rating table on the likely impacts of the proposed CSP on local runoff and the potential for erosion

Category and Scale	Rating and Description	Description and Justification	Quantitative Rating
Status of Impacts	**Negative**: a cost to the receiving environment	Erosion potential over the footprint of the CSP and field of heliostats is increased by hardening with the mirror field and service roads – to each heliostat. Hardening occurs to about 25% of the total ground surface – altering runoff characteristics and increasing opportunities for generating overland flow, which will increase erosivity of moving surface water.	-
Spatial scale of impacts	**Medium**: Local impacts, extending beyond the site boundary and a few hundred meters downslope of the CSP.	Extra surface water generated by heavy rainfall flows downslope. Preferential flow lines may occur (channels are created through erosion) and downslope infrastructure (the R385 road) may be affected through generating surface flow and failure of any drainage systems to cope with the size of flows, resulting in damage to the road. The development of channels means loss of productive land.	**2**

Temporal scale of impacts	**Very high**: Permanent changes to infiltration capacity on the CSP site could be expected.	Roads, infrastructure and changes to the physical characteristics of the soil on site will last longer than the presence of an operating CSP. In the event of the dismantling of the CSP, it is unlikely that the infiltration condition of the site could be returned to conditions existing prior to construction.	**4**
Probability of Impact	**Highly probable**: The impact is expected to occur, with a chance of occurrence of 50-90%.	The heliostat surfaces and the service roads linking to every heliostat mean substantial alteration of the characteristics of the soil surface. A road must go to every one of the 17,350 heliostats, as well as the central power tower site and any other related facilities.	**3**
Severity of Impact	**Severe**: Medium to long term impacts but which can be mitigated.	Planning for, and construction of, suitable storm drainage and dissipation infrastructure that protects the site and the road R385.	**2**
Significance of Impacts	**Medium:** Impacts are feasible and possible.	Planning for accommodating and dispersing storm flow off site is required	**-7**

Table 4 Rating table on the likely impacts of the proposed CSP on local hydrological functioning

Category and Scale	Rating and Description	Description and Justification	Quantitative Rating
Status of Impacts	**Neutral**: No cost or benefit to the receiving environment	The project is not expected to have an impact on local hydrological functioning concerning surface water flows and storages	**N**
Spatial scale of impacts	**Medium**: Local impacts, extending beyond the site boundary and a few hundred meters downslope of the CSP.	Any temporary impact on surface water flows would be expected to have an impact on site and to areas adjacent and down-slope to the project site. Construction in waterways and wetlands is not envisaged.	**2**
Temporal scale of impacts	**Low**: Short term; Quickly reversible in 0 – 5 years	Impacts on local hydrological functioning, if any, could be remediated by operators of the CSP	**1**
Probability of Impact	**Improbable**: The possibility of the impact materializing is negligible; Chances of occurrence 10-49%	Construction within areas of noted hydrological activity (channels, wetlands) is not envisaged. Water additions to the environment from the CSP during construction and operation will be negligible, if at all (evaporating pans will dispose of waste water from the CSP).	**2**
Severity of Impact	**Neglible/minor**: The system (environment) and parties (local water users) are marginally affected by the proposed development.	The project is not expected to have an impact on local hydrological functioning concerning surface water flows and storages	**1**

Significance of Impacts	**Negative-Low:** Any impact is of low order and therefore likely to have little real effect. In case of adverse impacts, mitigation is easily achieved. Social, cultural and economic activities continue unchanged.	Any effect (which is unlikely) on local hydrological functioning will have little if any effect of significance on social, cultural and economic activities, or on environmental conditions.	**-7**

6 Discussion and Conclusions

6.1 Impacts on Regional Hydrology

The Vaal-Gamagara pipeline is used to supply water to users such as for domestic and industrial use in urban centres such as Lime Acres, Postmasburg, Olifantshoek, Hotazel and Black Rock and the Kalahari East RWSS. The pipeline plays an extremely important role as an economic multiplier in the region. Water is also injected into the system at Sishen (from mine dewatering activities) and even more water will in future come from new iron ore mines near Postmasburg. The proposed CSP is another potential user of water supporting an important economic activity (power generation). In conducting this rating assessment of the impacts of the CSP on regional hydrology, note must be made that this assessment does not make value judgements on the relative merits of alternative beneficial uses of water. The assessment does not make recommendations on whether the projected CSP use of water is better than, or worse than, an alternative use. Therefore, EIA ratings such the Severity of Impact (see Table 2) are undertaken only from the aspect of whether there is an impact.

There will be a net economic gain to Sedibeng Water through purchase of water supplied from the Vaal-Gamagara pipeline to support CSP operations and generation of electricity. There may be a regional hydrological effect through the supply of water to the CSP from the Vaal-Gamagara pipeline, in that it will increase competition for water from that source. However, there is no effect that is unique to the CSP, its draw-off of water will be a business case with Sedibeng water as would any other business that drew water from that source. Because the CSP would be a high-value asset that is critically dependent on water for its operation, it is likely that the CSP would provide another sound core client of Sedibeng water and would have a positive effect on Sedibeng Water's financial income.

6.2 Impacts on Local Hydrology

The location of the proposed design of the CSP is such that it is unlikely there will be little if any effect on the identified water courses. The major channels on the Humansrus 469 property are located in catchment systems that arise off the property. The small wetland on the property is unlikely to be affected by the construction and operation of the CSP. It is highly unlikely there will be cumulative losses or gains that result from the project operations and the project could be considered to by hydrologically neutral from a surface water point of view. There will be neither a net loss or gain to surface water in the surrounding area of Humansrus 469 and nearby or adjacent properties of any significance.

6.3 Impacts on Local Runoff and Erosion Potential

The alteration of the infiltration capacity of the several square kilometers of soil where the heliostats are constructed could lead to damaging overland flow and erosion should the area receive a significant rainfalls of the order of the 1:50 and 1:100 year return period. This effect should be managed, otherwise in the event of a heavy rainfall, damage to the site and to the R385 road could be an outcome. Initial modelling efforts using SCS procedures indicate the possibility for surface runoff to increase by 10 – 15 times as a result of changing infiltration capacity.

6.4 Surface Water Conditions for all stages of the Project

Surface water conditions should not change during the construction or the operational phases of the proposed project. Construction is not planned to take place within any watercourses or within 100-year flood zones, with the exception perhaps of an access road on the south-western boundary (see section on Flood Calculations). Once the CSP is operational, there will be less activity on the site, based around the built components and outside of any watercourses. No permanent or temporary re-alignments of water courses, wetlands or other water bodies are expected. Activities which may have an effect on surface water conditions are the construction phase, relating to road building and installation of the heliostats, and the operational phase, when there will effectively be a larger impervious area over the site (provided by the mirror field and the central power tower and associated salt storage and generating works. This issue is addressed in earlier statements.

6.5 Concluding Remarks

There are no identifiable issues from a hydrological and surface water point of view that would indicate the prevention of construction of the CSP. Where there are impacts, these can be mitigated by appropriate actions.

7 Recommended Guideline measures to manage and mitigate impacts

7.1 Possible mitigation measures for the identified impacts

Water Use

Mitigation measures for ensuring efficient use of water include alternative designs for reducing consumption of water. These have already been considered in terms of the cooling processes adopted for CSP operation. It is unlikely that there is scope for reducing water use by the CSP for operational reasons any further than has been specified to date in the conceptual design. The remaining effort then is to optimize the cooling operations with the mixes of wet and dry cooling that maximizes cooling with the minimal use of water.

Soil Compaction and Overland Flow

The likelihood that a loss of infiltration capacity on site generates excess surface flow requires that mitigation measures be put in place during a) construction, and b) operation of the CSP. During construction, vehicular traffic on the construction site should be kept to well-defined roads or delimited zones as far as possible. Proper road drainage procedures need to be put in place and maintained to convey any surface water off the roads and into undisturbed areas. The proposers of the CSP should approach SANRAL or the owner of the R385 road about the possibility of installing a culvert under the road at the point of minimum elevation along the NW boundary of the CSP site to protect the road. During the operational phase of the CSP, vehicular traffic through the field of heliostats should be kept to a minimum, on well-defined and a minimal number of roads. Abandoned construction roads should be deep-ripped where possible to restore infiltration through the soil profile and a short vegetation cover re-established over the entire site.

Permanent or temporary re-alignments of water courses, wetlands or other water bodies

Permanent or temporary re-alignments of water courses are not envisaged by the current design of the CSP.

Location of sources, intakes and associate infrastructure

The off-take from the Vaal-Gamagara pipeline is likely to take placed at its nearest point to the CSP, which is on the boundary of Humansrus 469 on its western side, just downstream of the livestock watering dam (See Figure 2). Installed here, the pipeline will be required to cross the channel below the dam wall. The section on Best Practices for Crossing Water Courses below then applies.

Best Practices for Crossing Water Courses

The ephemeral channel on the south-west side of the property needs to be crossed by the off-take from the Vaal-Gamagara water pipeline. There are two conditions of concern regarding the nature of traverse: 1) the flood threat to the pipeline, and 2) the possibility of the physical presence of the pipeline causing opportunities for erosion to take place during flash floods. The pipeline should be buried and cross the channel below ground level at a depth of about 3 m or more. Closer to the surface, to a depth of 1.5 m or more, a gabion or wire-basket structure containing rocks of 30 cm diameter or more should be inserted into the trench to prevent turbulence removing material from the disturbed zone during peak flows. Similarly, the upslope portions of the pipe trench needs protection from washouts and erosion after heavy rainfalls. The CSP operators should inspect the pipeline route after heavy rainfalls and any incipient erosion features must be corrected immediately. As noted earlier, soils in the main channel area are prone to erosion.

7.2 Recommendations for Monitoring Programmes if any

No particular surface water hydrological monitoring programmes are recommended. Constructors and operators of the CSP should monitor soil surface conditions for signs of erosion on site during construction and during operation. Remedial measures are required if any negative erosion is noted (and signs of sediment deposition).
The proposed CSP does not impinge on surface water features, neither will its operation have effects which need a specific monitoring programme. If the CSP buys water from the Vaal-Gamagara pipeline, sufficient monitoring will be installed by Sedibeng Water with respect to impacts on regional water supplies.

7.3 Recommendations for Additional Studies

A more detailed study should be undertaken on the capability of CSP site to generate overland flow when constructed. Or, the design of the CSP layout should include the necessary drainage infrastructure to remove excess water and dispose of it safely and sustainably.

7.4 Relevant Legislation, Permits and Standards

If the CSP uses groundwater during operations, water abstraction and use licences will be required. It is likely that a supply from the Vaal-Gamagara Water Scheme will not need to be licensed – the general policy under the National Water Act (Act 36 of 1998) is that water from a local authority, a water board, an irrigation board or another bulk water supplier does not require registration of use. This policy is subject to verification. An application to use water from the Vaal-Gamagara pipeline must however be submitted to Sedibeng Water.

7.5 Assumptions, limitations and /or constraints to the Study

No particular limitations and constraints that would have a significant material effect on the impact assessment ratings given by this study to the proposed project have been observed. Best available hydrological information and data have been used in this study, which also consulted the latest conceptual design information of the CSP.

The ultimate source of water for construction and operation of the CSP has not yet been decided. This assessment considers the possibility of receiving supplies from the Vaal-Gamagara pipeline only. The reader is referred to the Groundwater Environmental Impact Assessment for conclusions with respect to that source. It is possible that the proposed CSP will use a mixture of sources, according to the availability of costs of utilizing these sources.

8 Flood Calculations

Flood level determinations for the 1:50-year and 1:100-year floods are required as a component of the EIA. This document provides the methods and results of those calculations.

8.1 Methods

SCS Unit Hydrograph methods (also known as TR20 methods) are deemed appropriate for the task. Basic steps follow. References to the source of parameter values are given in Table 1.

1. Selection of an appropriate rainfall distribution, which controls how the storm depth will be distributed over time – selected from SCS Storm Type;
2. The design storm depth, which is determined from South African hydrological literature, is based on the 50-year and 100-year return periods given in the Terms of Reference;
3. Catchment characteristics important to shaping the resulting flood hydrograph are determined from map work and field work –
    a. Time of Concentration (Tc – dependent on the SCS Curve Numbner (CN) on shape of catchment, hydraulic length, slope and area);
    b. Antecedent Moisture Conditions (AMC). Moisture condition of the soil prior to a storm exerts strong controls on stormflow response;
    c. Soil hydrological response types (according to soil texture, which controls potential infiltration characteristics);
    d. SCS Curve Number (CN), which is an index reflecting catchment surface condition and controlling likelihood of surface runoff.
4. Using Hydrocad (Hydrocad 9.10, 2010), the resulting hydrographs were modelled for the required storm return periods, at different points in the study area;
5. Channel profiles (cross-sectional channel profile, slope, roughness, with Manning's formula) were used to calculate heights of flood flow that are required to accommodate peak flows generated in the SCS calculations;
6. The resulting flood levels (in the channel profile) for the different storm return periods were mapped onto that of the physical features of the Humansrus site.

Assumptions

- Flood levels from differing AMCs were not considered. AMC level 2 is the recommended value for design work and was used in this study for the calculation of the design flood levels.
- Therefore, the flood levels estimated are based on the equivalence of 1:50 and 1:100 year design rainfalls with the 1:50 and 1:100 year peak runoffs;
- The upper and lower limits of dispersion around the predicted design storms were not included in this analysis (dispersion increases as the RP increases). The median value is used in this assessment.
- The 1-day storm is deemed appropriate as a basis for modeling stormflow response. Given the relatively short Tcs that are appropriate for the catchments within the study area (not more than a 5 hours), maximum flood peaks possible will result from intense 1-day storms and not those of storms of two or more days duration. The maximum intensities of storms longer than 1 day decline rapidly (Weddephol, 1988).

Table 5 Design storm depths for specific return periods, 1-day rainfall (Source: Smithers et al., 2002)

Design Storm Return Period (Years)	Storm Depth (mm)
50	95
100	150*

* 108 mm according to Smithers et al. (2002). The heavy rainfalls of 23 January 2011, which resulted in the floods in Postmasburg, deposited about 150 mm in one day in the Humansrus area (Mr A Scholz, Pers. Comm. – Humansrus 469 farm owner). Given that rainfall records in the area with observation periods of even 50 years are relatively uncommon, 150 mm was taken as the new 100 year Design Storm Return Period and a flood hydrograph was calculated on that basis.

Table 6 Storm flows calculated for catchments on the Humansrus 469 property.

	Design Storm Flow for Return Period	
Catchment	50 years ($m^3.s^{-1}$)	100 years ($m^3.s^{-1}$)
A	5.56	20.1
B	0.35	2.1
C	*	*
D	*	*

* Indeterminate

Catchments C and D are indeterminate (See Figure 8). While the steeper rocky high ground should produce rapid runoff and high peak flows, which the model does reproduce, there is no evidence of channels to convey that water on the site. It can be concluded then that such flows do not exist, probably because high levels of infiltration into the steeper ground occur. Models such as SCS are incapable of emulating such behavior. Even exceptional storm depths such as those of 23 January 2011 have not developed into noticeable surface flows in the north and east of the proposed CSP site.

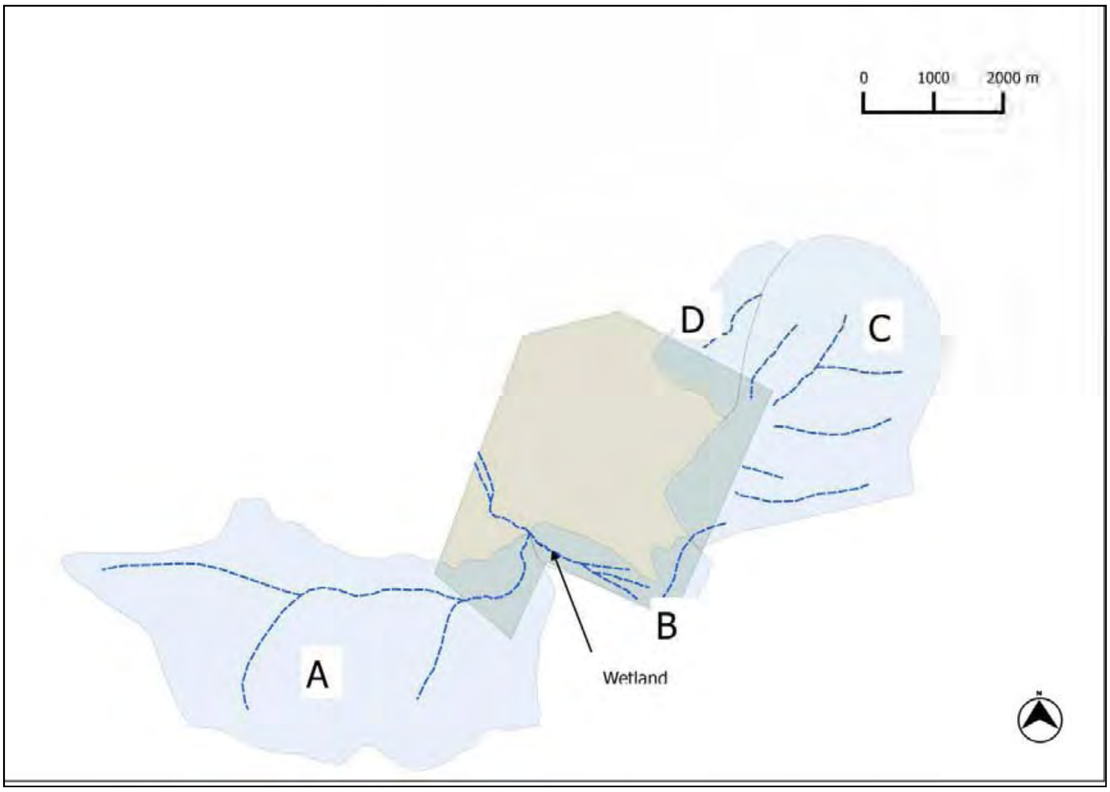

Figure 8 Catchment layout used in the flood assessment.

8.2 Assessment of Floods

The most significant floods emerge from the catchment and high ground to the west of Humansrus. Flow rates of about 20 $m^3.s^{-1}$ may be achieved, which accounts for the damage to the road and railway line on the 23 January when the heavy rainfall resulted in the failure of the road and rail culverts to accommodate the peak flows of water. The design of construction of the CSP should avoid any construction in this zone.

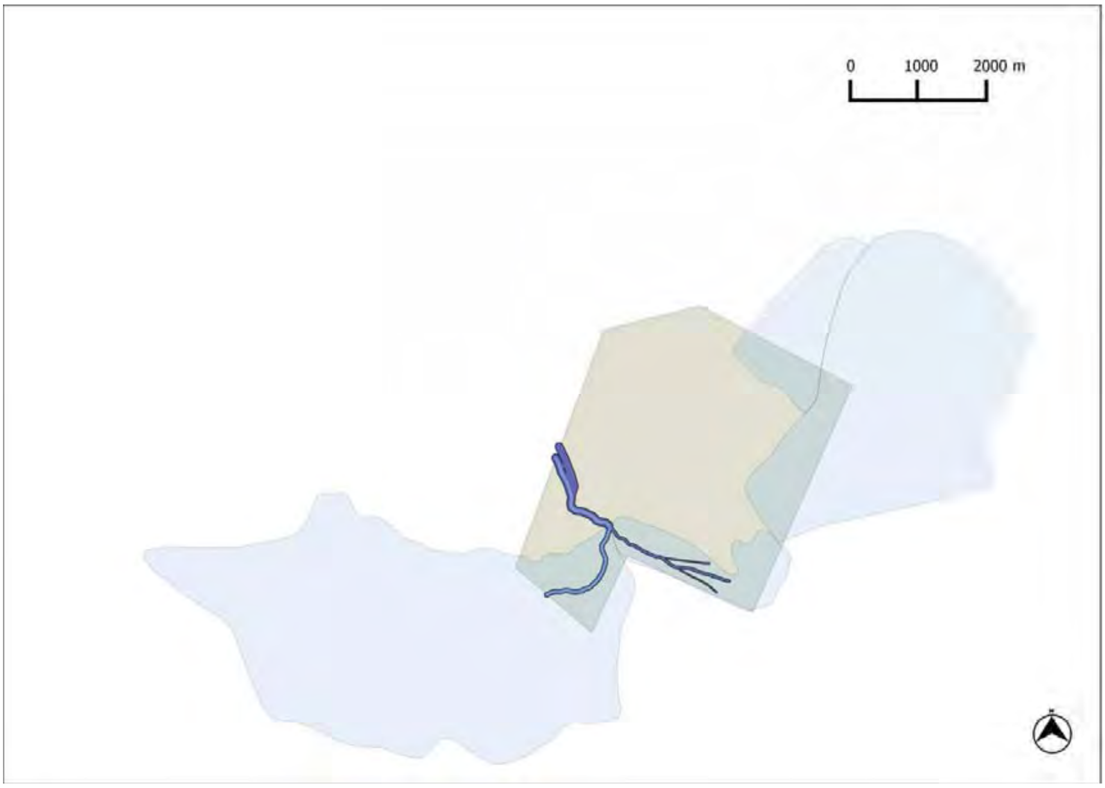

Figure 9 1:50 and 1:100 year flood lines

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