Karoshoek Solar Valley Development, Northern Cape Province

EIA Phase Report: Water Resources Assessment

ENVIRONMENTAL IMPACT ASSESSMENT – SPECIALIST STUDY: WATER RESOURCES ASSESSMENT STUDY

Prepared for:

May 2012

Savannah Environmental (Pty) Ltd.
PO Box 148
SUNNINGHILL, 2157

Prepared by:

Scherman Colloty & Associates
10 Fitzroy Street
GRAHAMSTOWN, 6139

Scherman Colloty and Associates cc
Environmental and Aquatic Management Consulting
(CK 2009/112403/23)

EXECUTIVE SUMMARY

Background

Scherman Colloty & Associates (SC&A) was appointed by Savannah Environmental (Pty) Ltd to conduct the water resources assessment for the Karoshoek Solar Valley Development Environmental Impact Assessment (EIA). The proposed development site is situated south east of Upington, with the main source of water being the Orange River.

Methods / Approach

The following approach was taken during the Water Resources Study:

- » The Project Ilanga specialist report was used as a template for this report as expected impacts and background are similar, other than the expansion in site and larger water volumes to be used.
- » A desktop assessment of available information, including an evaluation of the study area using available maps and databases.
- » Ground-truthing surveys were conducted in the area for other projects during 2010 and May 2011 (the latter being for Project Ilanga), in order to confirm the habitats and the ecological integrity of the Study Area from an aquatic perspective. Although no fish sampling was undertaken during the field survey, information on available fish habitat and the ecological integrity of the Orange River within the area was obtained from previous studies. Fish species likely to be present in the area of the abstraction point are therefore inferred from catch data from adjacent areas and the riverine habitats found at the site.

Description of the affected environment

The Lower Orange River can be defined as that stretch of the Orange River between the Orange-Vaal confluence and Alexander Bay or Oranjemund. Land-use is primarily irrigation and mining, with the area highly dependent on water from the Orange River. Water quality between Boegoeberg Dam (near Groblershoop) and Onseepkans is generally good despite extensive irrigation and settlements in the Upington area, although eutrophication is evident in localised areas and salt loads are increasing. The fish biodiversity in the Lower Orange River within the Study Area (i.e. from Upington to Onseepkans) is relatively high compared to the entire river system, with a total of 13 indigenous species being recorded, including five of the six endemic Orange River species. The Lower Orange River Management Strategy (2005) study found that the overall present state of the Lower Orange River is in a *D category*, i.e. Largely modified. The ORASECOM Ecological Flow Requirements (EFR) study completed during 2011 found that both sites assessed, i.e. EFR O2 at Boegoeberg upstream of the project area, and EFR O3 downstream at Augrabies, were in a C category. However, the recommendation is that conditions at both sites be improved to meet ecological requirements (Louw and Koekemoer, 2010).

Sensitivity assessment

From a habitat and ecosystem point of view, all the dry river beds and the associated riparian systems in close proximity to the development area would be rated as extremely sensitive to development, in particular the mainstem systems such as the Klein-leerkransspruit and Majties (Matjes) River within the study area.

Impact statement

With suitable mitigation and implementation of the proposed layout, the development should have limited impact on the overall status of the riparian systems within the region. Impacts on the Orange River system due to water abstraction, and site-specific impacts on instream biota are difficult to quantify due to the highly regulated nature of the system, but are assumed to be limited as dry cooling will be utilized for the 1 GW development. However, the assessment of the potential impacts of the proposed facility on the fish biota of Orange River did not reveal any significant impacts on the fish fauna and associated aquatic habitats, provided the appropriate mitigation measures are taken. All impacts that were assessed as being of moderate significance could readily be reduced to low significance by appropriate mitigation, apart from the moderate impact of water abstraction from the Orange River.

In conclusion therefore, the facility is deemed to have a low - moderate potential impact on the aquatic environment. It is assumed that any areas of concern, e.g. changes to the hydrological regime or instream habitat by sedimentation, will be managed appropriately. The only significant risk to the project is the water use license not being granted by the Department of Water Affairs. Although dry cooling will be practiced which will reduce water requirements, the Orange River system is under pressure in terms of water requirements.

ACRONYMS

AEC	Alternative Ecological Category
CBD	Central Business District
CD: RDM	Chief Directorate: Resource Directed Measures
CEMP	Construction Environmental Management Plan
CPVPD	Concentrating photovoltaic or Parabolic Dish
CSP	Concentrated Solar Power
D: NWRP	Directorate: National Water Resource Planning
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (pre-April 2010)
EFR	Ecological Flow Requirements
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EWR	Ecological Water Requirements
GIS	Geographical Information Systems
LF	Linear Fresnel
LFT	Linear Fresnel or Parabolic Trough
LFTT	Linear Fresnel or parabolic Trough or Tower
LOHEPS	Lower Orange Hydroelectrical Power Scheme
LORMS	Lower Orange River Management Strategy
MRU	Management Resource Unit
ORASECOM	Orange Senqu River Commission
PES	Present Ecological State
PT	Parabolic Trough
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RO	Reverse Osmosis
SANBI	South African National Biodiversity Institute
SBR	Sequential Batch Reactor
SC&A	Scherman Colloty & Associates
SWMP	Storm Water Management Plan
WTW	Water Treatment Works
WUA	Water Users Association
WULA	Water Use License Application

1. INTRODUCTION

Scherman Colloty & Associates (SC&A) was appointed by Savannah Environmental (Pty) Ltd. to conduct the water resources assessment for the Karoshoek Solar Valley Development Environmental Impact Assessment (EIA).

The project proponent, FG Emvelo (Pty) Ltd., has selected a 34 000ha area located approximately 30 km south east of the Upington Central Business District (CBD) in the Northern Cape Province (Figure 1) for the construction of the 1 GW Karoshoek Solar Valley Park, to be developed in several phases. The first phase of the park is the 100 MW Project Ilanga plant, which has already been authorised. This forms Site 1.2 on the attached map of the area (Figure 1). The sites to be covered by this document are all other sites shown on Figure 1, i.e. Sites 1.1, 1.3, 1.4, 2, 3, 4 and 5 on farms Karos 959, Annashoek 3/41, Matjesrivier 2/41 and RE/41, and Zandemm 944. The Ilanga report (completed May 2011) has been used as a basis for the water assessment, as most components, including the proposed water abstraction point, are valid for the larger site. *The information contained within this document is therefore valid for all sites, unless where indicated.*

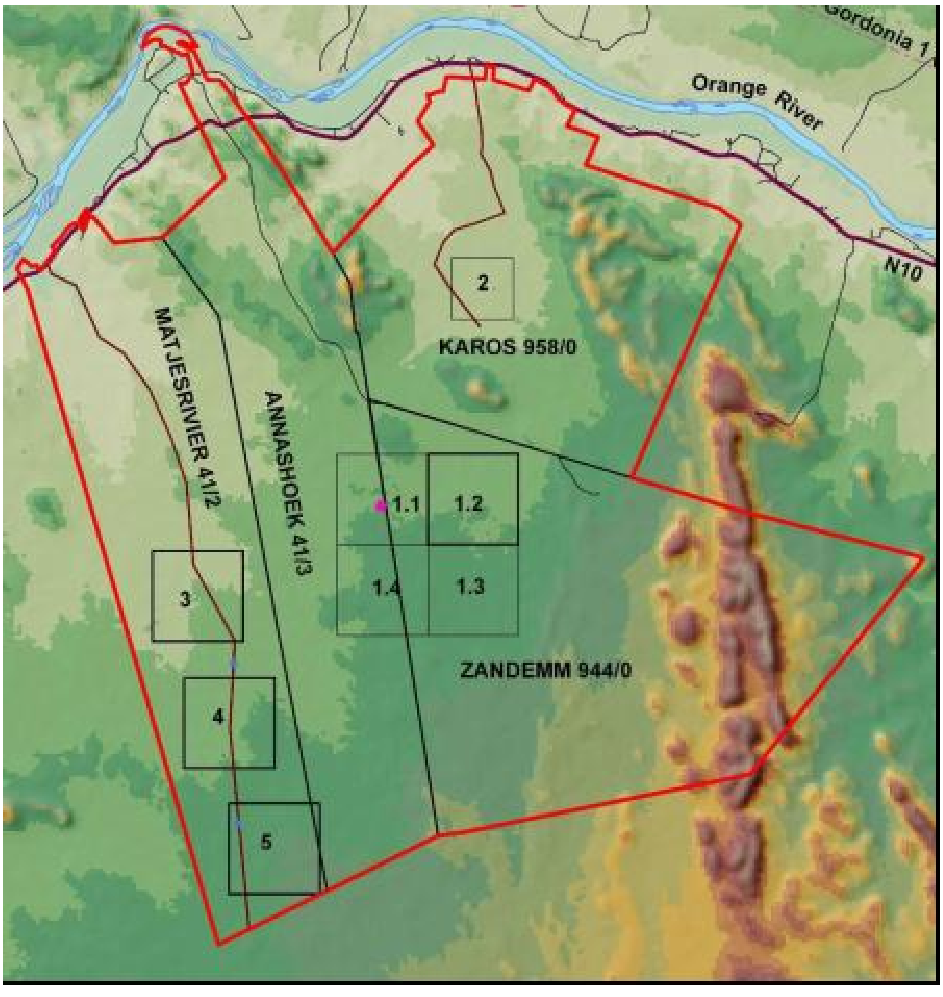

Figure 1: Locality map of the Karoshoek Solar Valley Development

The purpose of this EIA Phase Report is to describe and assess any potential water resource related issues that could arise as a result of the proposed project. Note that the annual bulk daily water demand for the entire Karoshoek Solar Valley Development, inclusive of Project Ilanga, is 4 136 m^3/day. All water volumes and related technical information have been sourced from the Bulk Water Study report produced for the 1 GW development by WorleyParsons (WorleyParsons, 2011).

2. PROJECT DESCRIPTION

The project focuses on a dry cooling concept with a consequent lower water demand. A description of the entire Karoshoek Solar Valley Development to be assessed during this study is shown below (Savannah Environmental Terms of Reference for EIA, May 2012):

- Site 1.1: 100 MW Linear Fresnel (LF 1)
- Site 1.3: 100 MW Parabolic Trough (PT)
- Site 1.4: 100 MW Linear Fresnel (LF 2) or Parabolic Trough (LFT)
- Site 2: 4 x 25 MW Concentrating photovoltaic or parabolic dish (CPVPD 1-4) technology
- Site 3: 2 x 50 MW Tower (Tower 1 and 2)
- Site 4: 100 MW Linear Fresnel or Parabolic Trough or Tower (LFTT 1)
- Site 5: 100 MW Linear Fresnel or Parabolic Trough or Tower (LFTT 2)

The development will include the associated infrastructure such as roads, water pipelines, water storage reservoirs, electricity distribution lines, accommodation facilities, offices, storerooms and waste storage facilities. The same water pipeline infrastructure will be used as Project Ilanga to get water from the abstraction point on the Orange River to the sites, although pipelines will need to be extended to each site where water is required.

The water required for the activity is proposed to be abstracted from the Orange River (28.402094°S; 21.497401°E) using an existing Boegoeberg Water Users Association (WUA) abstraction point equipped with floating pumps (Plate 1). The abstraction point is approximately 14km from Site 1, which comprises sites 1.1, 1.2, 1.3 and 1.4. *This assessment will therefore evaluate the impact of higher water abstractions, rather than the position of the abstraction point, as this was already covered in the Project Ilanga EIA.*

The following extract is taken from the *Project Ilanga EIA: Water resources chapter (Colloty and Scherman, 2011)*, and describes the water-related infrastructure of the project. Changes to the infrastructure from Project Ilanga are italicised and shown in red text.

A *400mm* Ø underground pipeline will transfer water from the abstraction point on the Orange River (28.404520°S; 21.495449°E) to the site (Figure 2) after passing through a stilling basin and high pressure sand filter (about 270m from the abstraction point) to remove any sediment or organic particulates. Any backwash from this pre-treatment system, which would contain mostly sediments and possibly organic matter, will be stored in a backwash open coffer dam. Sludge from the pond will then be removed and disposed of at a licenced landfill site as and when required, with overflow from the coffer dam re-used.

Plate 1: The proposed abstraction point (28.404520°S; 21.495449°E) and the typical infrastructure that would be used

Water will be treated to potable / drinking water standards (SABS 2100) within a Water Treatment Works (WTW) on site and stored in a 12-hour holding reservoir. The water will then be transferred (via a *400mm* rising main pipeline) to a 72-hour holding reservoir at a high point so that water can be distributed to the remainder of the site/s under gravity through a *450mm* Ø gravitation pipeline.

2.1. Reservoirs and ponds

The following reservoirs and ponds will need to be expanded, with the 1 GW capacities shown on Table 1 below (WorleyParsons, 2011).

Table 1: Storage volumes of reservoirs/ponds for a 1 GW plant

Reservoir description	Coordinate	Raw / treated water	Capacity (m^3 – hours storage)
Stilling basin	S 28˚24'15"; E 21˚29'46"	Raw	*10 100 m^3 – 48 hrs*
Backwash open coffer dam	S 28˚24'15"; E 21˚29'46"	Raw	*4 100 m^3*
Raw water closed storage reservoir at WTW	S 28˚25'06"; E 21˚29'13"	Raw	*4 136 m^3 – 24 hrs*
Potable water closed steel reservoir at WTW	S 28˚25'06"; E 21˚29'13"	Treated	*8 272 m^3 – 48 hrs*

Potable water closed steel reservoir at residential area	Approximate coordinates: S 28˚26'20"; E 21˚28'26"	Treated	261 m^3 – 48 hrs
Potable water closed steel elevated reservoir	S 28˚27'05"; E 21˚30'50"	Treated	*12 408 m^3 – 72 hrs*

The 48hr potable water reservoir at the residential area and the two reservoirs at each of the sites will not require expansion as the demand will stay the same.

2.2. Water purification

The following treatment units will be required by the 1 GW facility, assuming pumping between sites is not an option and treatment at individual sites is required (WorleyParsons, 2011):

- Potable water treatment plant for all 8 phases (including Project Ilanga): 5 ML per site
- Demineralization treatment (Reverse Osmosis (RO) is proposed) plant at each site: 265 m^3/d per site. [Water of <0.02ppm silica and Electrical Conductivity (or salinity) values of <10 S/cm, will be produced during demineralization].
- Condensate polishing plant at each individual site: 160 m^3/h per site
- Blow-down water treatment and softening: 2.2 ML/d per site
- Brine concentration and recovery at evaporation ponds or central point
- Sewage treatment: 0.3 ML per site
- Evaporation ponds (based on internal water recovery at each site): 800 m^3/d per site

Each of the development phases / sites will therefore be provided with a tertiary treatment works to further treat the water to meet the required specifications suitable for the power generation process, e.g. cleaning mirrors and the ultrapure water needed for steam generation.

2.3. Effluent streams and disposal

All information in this section is taken from WorleyParsons (2011). Effluent streams from the plants include backwash water, sludge from clarifiers, neutralized effluent from the regeneration process of the condensate polishing ion exchange vessels, the brine stream from the RO plants, mirror washings, blow-down water from the cooling cycle and sewage effluent. All effluent streams, excluding mirror washings and sewage effluent, will be sent to the evaporation ponds.

After final control of the quality of the waste waters and depending on local regulations, waste waters may be released to landscape, either in a drain to a river or lake, a local installed drainage system or evaporation/infiltration area (Hampel, 2011). Rain and flooding waters will be directed directly out of the plant area.

A small package treatment plant, using Sequential Batch Reactor (SBR) technology, is proposed to treat domestic sewage effluent. Sewage will be collected and screened prior to biological treatment in the SBR tanks. The tanks will be fitted with an aeration system and all auxiliary process equipment, e.g. pumps, blowers, pipes, electrical supply and chlorine contact system. Wastewater stabilisation ponds will be used (Ndebele, FG Emvelo, pers. comm., May 2012), with secondary sludge to be dried in two drying beds.

3. SCOPE OF WORK

The following Scope of Work was outlined in the proposal for the Water Resources Assessment study. Task 2 is the focus of this report, with specialist areas covered being *water resources and water availability* and *riverine ecology*.

- **Task 1:** Input to the Scoping Report, including an evaluation of Matjiesrivier 41 RE and production of a map indicating the drainage lines and alluvial fans (if present) within the study area. *Note: Input to Scoping Report not required, although sensitivity mapping completed.*

- **Task 2:** Identification and assessment of potential impacts of the larger 1 GW development on the water resources of the area, particularly additional access roads (in terms of Section 21c and i WULA applications) and the proposed accommodation facility. This task will include a site survey. *Note: As the entire study area was covered during the Project Ilanga field survey, an additional survey was not required.*

  As the same abstraction point will be utilized as for Project Ilanga, the site survey will not include an assessment of abstraction points. The Water Resources Assessment will rather focus on the impact of higher abstraction rates, using information sourced from the Bulk Water Study report produced for the 1 GW development by WorleyParsons.

- **Task 3:** Preparation of the Water Use License Application (WULA) for the 1 GW development (excluding the allocation already requested for Project Ilanga). *To be undertaken after the EIA has been completed.*

Due to the large amount of research, information and on-site data available for the Upington area of the Lower Orange River catchment, a desktop assessment was conducted.

4. SPECIALIST TEAM

Scherman Colloty & Associates (SC&A) is a specialist consulting firm based in Grahamstown in the Eastern Cape. The two partners have more than 28 years combined experience in the environmental management and aquatic assessment fields, with a diverse suite of clients based nationally and internationally. Key team members will be Patsy Scherman and Brian Colloty of SC&A.

Dr. Patsy Scherman has a Ph.D in Biotechnology and has been actively involved in a number of Reserve determination projects over the years, having been the project technical team manager or water quality specialist on a number of these projects. The management includes the co-ordination of technical teams, including socio-economics, wetland, groundwater, estuary and river teams. She has also developed and managed integrated environmental and water quality monitoring programmes; and conducts water specialist studies for EIAs. Patsy has providing training and specialist water quality services to the Chief Directorate: Resource Directed Measures (CD: RDM), DWA, for the past few years, and has served as the water quality specialist on the Orange-Senqu River Commission (ORASECOM) project.

Dr. Brian Colloty has a Ph.D in wetland ecology and importance rating, and has conducted wetland and riverine / estuarine assessments for projects throughout Africa. Brian has produced more than 57 wetland studies in the last 5 years, part of which includes the production of GIS related sensitivity maps with site-specific Environmental Management Plan (EMP) recommendations with regard construction and operational phases of developments.

Note that the fish-based ecological information is reproduced as for the Project Ilanga report, as the same abstraction point will be used. The original fish assessment was conducted by Dr Anton Bok of Anton Bok Aquatic Consultants cc.

5. APPROACH / METHODS

Due to the large amount of research and information available for the Upington area of the Lower Orange River catchment, and the work done for Project Ilanga, the following approach was followed:

» The Project Ilanga specialist report was used as a template for this report as expected impacts and background are similar, other than the expansion in site and large water volumes to be used.

» A desktop assessment of available information, including an evaluation of the study area using SANBI (South African National Biodiversity Institute) wetland maps and the DWA Rivers Database. Maps and Geographical Information Systems (GIS) were employed to ascertain which portions of the proposed development would have the greatest impact on the riverine areas or associated habitats.

» Although no fish sampling was undertaken during the field survey, information on available fish habitat and the ecological integrity of the Orange River within the area was obtained from previous studies, e.g. communication with fish specialists with extensive knowledge of the area (Ben Benade, Dr. Piet Kotzé and Dr. Anton Bok). Fish species likely to be present in the area of the abstraction point are therefore inferred from catch data from adjacent areas and the riverine habitats found at the site.

» Riparian vegetation areas were assessed on the following basis:
  - o Vegetation type: verification of type and state or condition-based, supported by species identification using Germishuizen and Meyer (2003) and Vegmap (Mucina and Rutherford, 2006 as amended).
  - o Plant species were further categorised as follows:
    - Terrestrial: species not directly related to any surface or groundwater base-flows and which persist solely due to rainfall.
    - Facultative: species usually found in wetlands (inclusive of riparian systems) (67 – 99% of occurrences), but occasionally found in terrestrial (non-wetland) systems (DWAF, 2005).
    - Obligate: species that are only found within wetlands (>99% of occurrences) (DWAF, 2005).

6. DESCRIPTION OF THE AFFECTED ENVIRONMENT: NATIONAL, REGIONAL, LOCAL AND SITE-SPECIFIC CONTEXT

The focus of the study is at a range of levels, i.e. 1) the impact of abstraction from the Orange River for the study, 2) potential on-site impacts, 3) impacts related to infrastructure such as the water supply infrastructure (pipelines and treatment works), and 4) impacts related to waste water treatment. This section of the report provides information on the Orange River system, as water supply is critical to the solar facility, as well as riparian vegetation and fish fauna at the abstraction point and on-site.

6.1. The Lower Orange River System

The Lower Orange River is found within Water Management Area (WMA) 14 of South Africa and can be defined as that stretch of the Orange River between the Orange-Vaal confluence and Alexander Bay or Oranjemund where the river meets the ocean (Figure 2). The area is hot and dry with rainfall varying from 400mm in the east to 50mm on the west coast and large parts of the catchment considered desert with annual precipitation dropping to below 25mm in some areas (ORASECOM, 2007).

Land-use is primarily irrigation and mining, with the area highly dependent on water from the Orange River. Sheep and goat farming is practised over most of the area, with large parts falling within conservation areas. Cultivation is restricted to isolated patches where somewhat higher rainfall occurs, and extensive irrigation is practised in the fertile alluvial soils along the Orange River valley. This irrigation is supplied with releases from Vanderkloof Dam. The water quality in the Lower Orange WMA is affected by upstream activities in the Vaal and Orange River catchments. Given the arid nature of the Lower

Orange River and the high potential evaporation, the evaporative losses result in an increase in overall nutrient and salt concentrations along the length of the lower Orange River (ORASECOM, 2007).

A number of developments are currently planned for the Lower Orange River, including the NamPower 100 MW run-of-river Lower Orange Hydroelectrical Power Scheme (LOHEPS), a proposed dam at Vioolsdrif and numerous solar power schemes. The Namibian hydropower scheme would entail the development of up to nine small hydroelectric power stations, ranging from 6 MW to 12 MW, along the Lower Orange river, which has an estimated power generation potential of between 80 MW and 120 MW. The power utility noted that LOHEPS would be used to divert the flow of the river through canals and tunnels into water turbines to produce electricity.

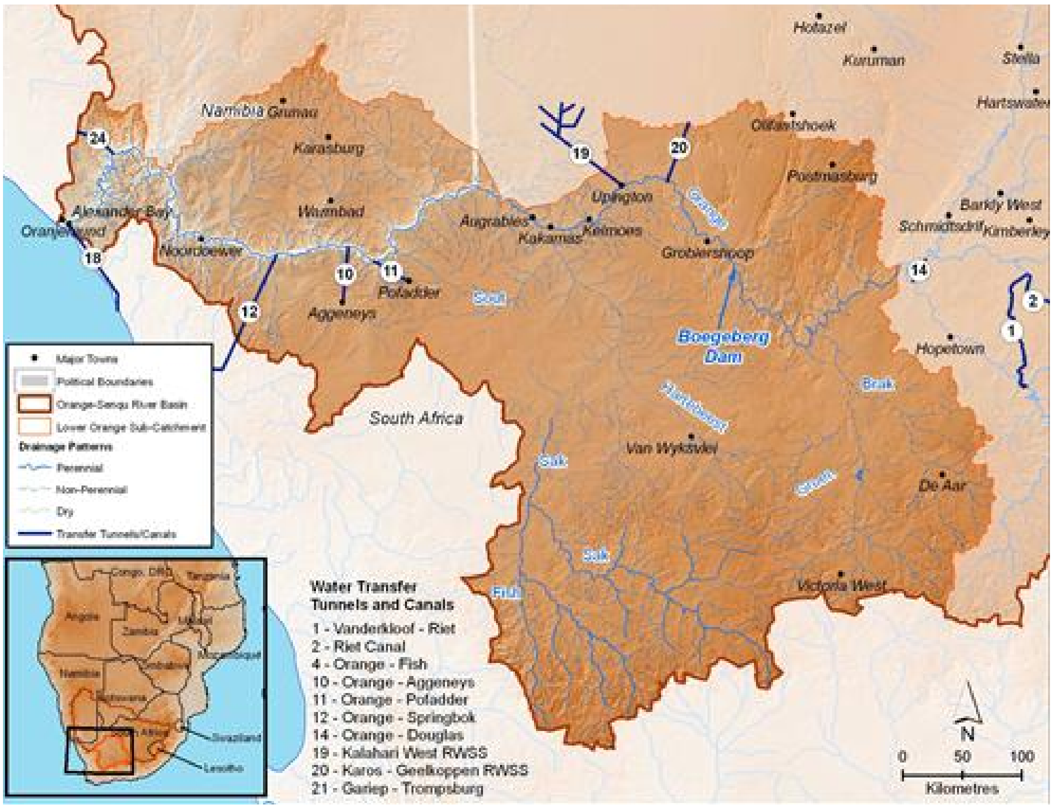

Figure 2: Major rivers and transfer schemes in the Lower Orange sub-basin (From Hatfield (2009) after UNDP/GEF 2008, and cited in ORASECOM, 2007)

6.2. The ORASECOM EFR or Reserve Study

An Ecological Flow Requirements (EFR) study for the Orange River was conducted for the Orange Senqu River Commission (ORASECOM) during 2009 - 2011. The EFR study (or Ecological Water Requirements (EWR) or Ecological Reserve) assesses the present state of the system and defines the Recommended Ecological Category (REC) for the various river reaches, based on the flow and quality requirements of the biota components of the system (i.e. fish, macroinvertebrates, diatoms, and riparian vegetation). The outcome of the study is therefore the flow and quality requirements that will satisfy the Ecological Reserve, which needs to be defined before water available for other users can be determined. This information will go into the strategic planning for the system, conducted by the DWA, as is captured in a Reserve template which forms part of the documentation required during the WULA process. The text box below provides some information and Reserve terminology (modified from Scherman, 2010a).

Reserve: The quantity and quality of water needed to sustain basic *human needs* and *ecosystems* (e.g. estuaries, rivers, lakes, groundwater and wetlands) to ensure ecologically sustainable development and utilisation of a water resource. The ***Ecological Reserve*** pertains specifically to aquatic ecosystems.

Reserve requirements: The quality, quantity and reliability of water needed to satisfy the requirements of basic human needs and the Ecological Reserve.

Ecological Reserve determination study: The study undertaken to determine Ecological Reserve requirements.

Licensing applications: Water users are required (by legislation) to apply for licenses prior to extracting water resources from a water catchment.

Ecological Water (or Flow) Requirements: This is the quality and quantity of water flowing through a natural stream course that is needed to sustain instream functions and ecosystem integrity at an acceptable level as determined during an EWR or EFR study.

Water allocation process (compulsory licensing): This is a process where all existing and new water users are requested to reapply for their licenses, particularly in stressed catchments where there is an over-allocation of water or an inequitable distribution of entitlements.

Present Ecological State (PES) is a term for the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State.

Reference State/Condition is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development.

EcoStatus is the overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component EcoStatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).

The first step of the EFR process is the delineation of the study area. Ecological Regions (or EcoRegions), geomorphological zones and Management Resource Units (MRUs) are defined. Figure 3 shows the delineation of the main stem of the Orange River from the ORASECOM study. Land-use information is also shown (Louw, 2010).

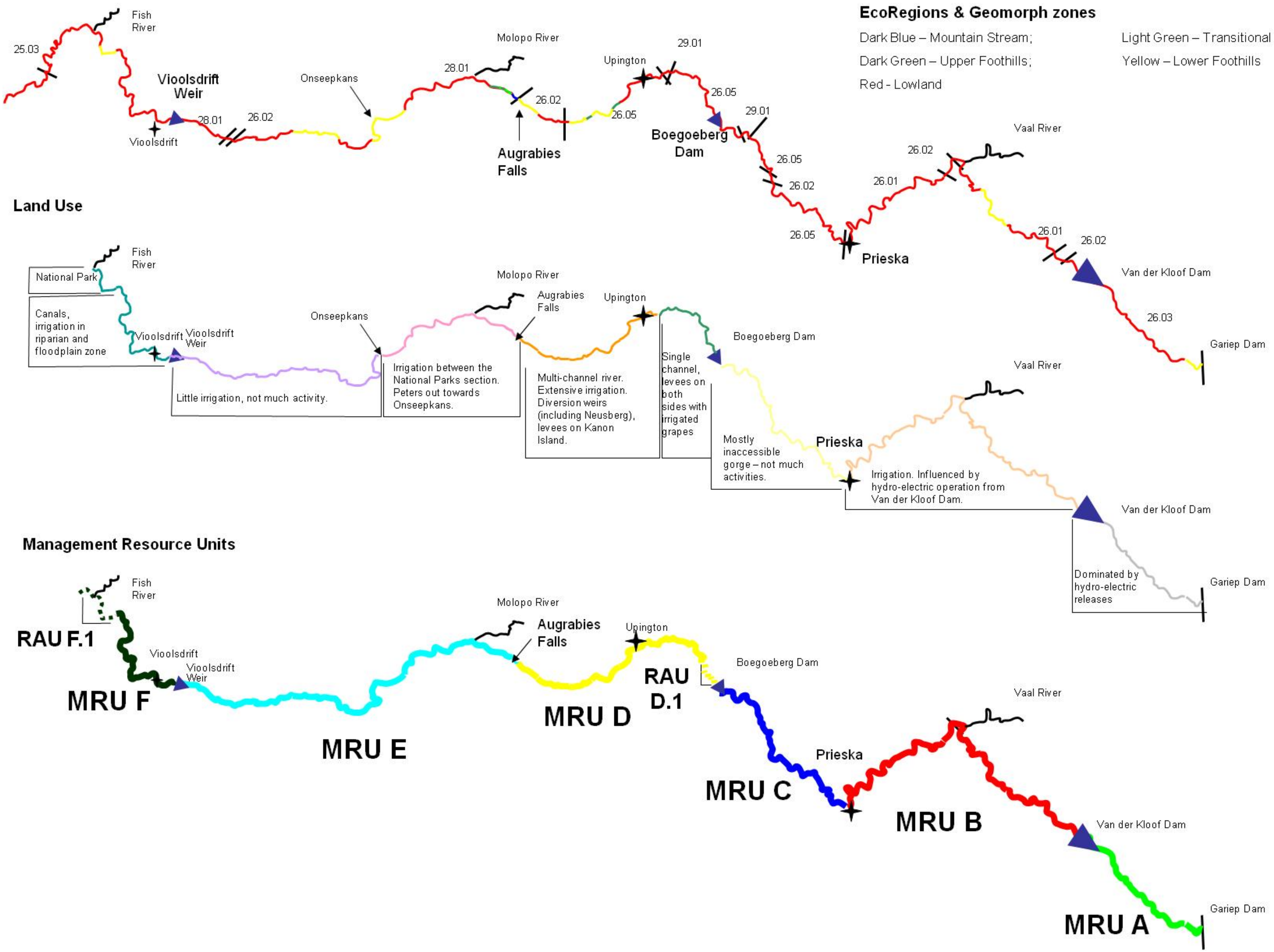

Figure 3: Management Resource Units for the Lower Orange River

Two EFR sites selected by the ORASECOM study are in proximity to the Karoshoek Solar Valley Development, i.e. EFR 02 upstream at Boegoeberg and EFR 03 downstream at Augrabies. Detailed biological and physical surveys are undertaken at these sites to set flow requirements for the Lower Orange River. Figure 4 shows the position of the EFR sites in relation to the Ilanga (and also Karoshoek) abstraction site, and Plates 2 and 3 show more information regarding the sites.

Figure 4: Google image showing the positions of EFR O2 and 03 in relation to the Ilanga (and therefore Karoshoek) abstraction point

EFR no. & name	EFR O2 Boegoeberg	
River	Orange	
Previous IFR site	-	
National RHP site	-	
Decimal Degrees	-29.0055, 22.16225	
EcoRegion (Level II)	26.05	
Geozone	Lowland	
Altitude (m)	871	
RU	MRU Orange D	
Quaternary	D73C	
Farm name	Blinkfontein 10	
Hydrological gauge	D7H008	

Plate 2: Information regarding EFR O2 at Boegoeberg, upstream of the Karoshoek abstraction point

EFR no. & name	EFR O3 Augrabies	
River	Orange	
Previous IFR site	-	
National RHP site	-	
Decimal Degrees	-28.42867, 19.9983	
EcoRegion (Level II)	28.01	
Geozone	Lowland	
Altitude (m)	434	
RU	MRU Orange E	
Quaternary	D81B	
Farm name	Oranjestroom 386	
Hydrological gauge	D7H014	

Plate 3: Information regarding EFR O3 at Augrabies, downstream of the Karoshoek abstraction point

6.3. Flow distributions at Upington

A number of monitoring points exist on the Orange River system (Figure 5). Information on flows in the Lower Orange River are taken from the ORASECOM EFR study for EFR site O2 at Boegoeberg (below Boegoeberg Dam), i.e. the most upstream site from the abstraction point near Upington. Data from hydrological gauging weir D7H008 (real time gauge downstream of Boegoeberg Dam) was used for the assessment. The length of the hydrological record is 1932 – 2007 (as shown on the DWA database, although data recordings are up to present day).

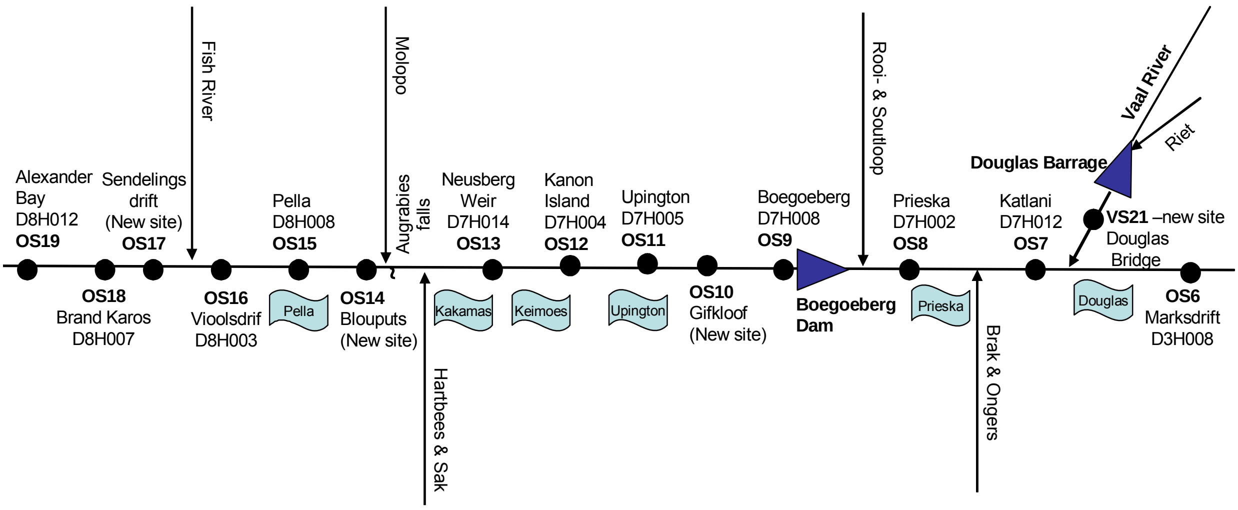

Figure 4: Monitoring points on the Lower Orange River system

The distribution of flow is still similar to the natural seasonal distribution, but much lower in the wet season and a little bit lower in the dry season. The reason for the difference is the large dams upstream and highly regulated flows from Vanderkloof Dam. Figure 5 is a seasonality representation of average monthly flows for the total flow record (WRP Consulting, pers. comm., September 2010, for the ORASECOM EFR study).

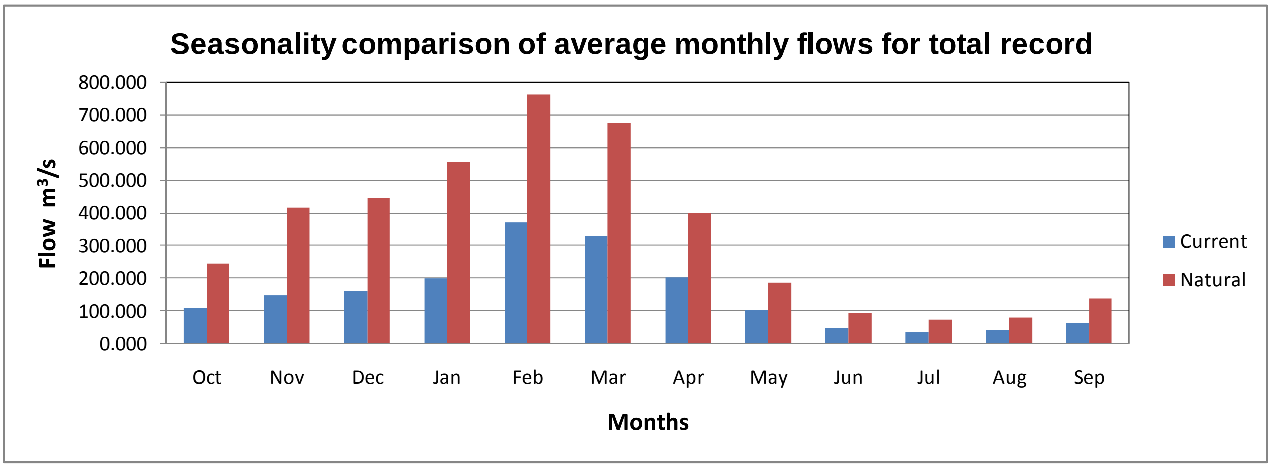

Figure 5: Average monthly flows for the total flow record of gauging weir D7H008 for the total flow record (1932 – 2007)

6.4. Water availability

Water for the proposed development will be sourced from the Orange River. Water demand from the Orange River is dominated by use for irrigation along the river at various points and small quantities for urban use and stock watering within the Upington / Kanoneiland region (ORASECOM, 2007).

The natural runoff of the entire Orange River catchment is estimated at 11 490 million m^3/a, with approximately 4 000 million m^3/a originating from the Lesotho Highlands, and 900 million m^3/a from the contributing catchment downstream of the Orange/Vaal confluence, which includes part of Namibia and a small portion in Botswana feeding the Nossob and Molopo rivers. Runoff originating from the Orange River downstream of the Orange/Vaal confluence is highly erratic and cannot be relied upon to support the various downstream demands unless storage is provided (ORASECOM, 2007). Storage is provided by the dams in the system, e.g. the upstream Vanderkloof Dam, which is situated near the town of Petrusville, approximately 170 km South West of Bloemfontein.

Irrigation accounts for about 1 800 million m^3/a of water use from the Orange River system, while mining activities occurring along the Orange River downstream of the Orange / Vaal confluence, require 40 million m^3/a water. Additional water demands include the Fish River transfer scheme via the Orange/Fish Canal, which in periods of drought is the only source of water for certain hinterland regions (e.g. Cookhouse, Cradock and Grahamstown) of the Eastern Cape. Evaporative losses from the Orange River and the associated riparian vegetation account for between 500 million and 1 000 million m^3/a depending upon the flow of water (and consequently the surface area) in the river (Mckenzie *et al.*, 1993, 1994 and 1995, cited in ORASECOM, 2007). An approximate water balance for the Orange River is provided in Table 2 to provide perspective on the various demands supported from the river. Note that these figures are as at 2005. Updates in figures such as the environmental requirements have since become available, as well as allocations to emerging farmers, proposed Namibian hydropower studies and proposed solar power plants.

Table 2: Orange River water balance as at 2005 (ORASECOM, 2007)

Water Balance component	Volume (million m^3/a)
Environmental requirement	900 (includes natural evaporative losses from the Orange River)
Namibia	120 (includes water use from the Orange and Fish rivers)
Lesotho & transfers to South Africa	820 (with full Lesotho Highlands Water Project Phase 1 active)
South Africa Orange River demand	2 560 (Includes transfers to the Eastern Cape)
South Africa Vaal River demand	1 560 (Vaal demand supplied from locally generated run-off)
Evaporation & losses	1 750 (Evaporation not accounted for in the estimated Environmental Requirement)
Spillage	3 780
TOTAL	**11 490**
Spillage under natural conditions	**10 900**

The updated environmental requirement (or more accurately, the EFR or EWR) is shown on Table 3 below for the Orange River EFR sites, including the most downstream site at Vioolsdrift. Note that the results of Alternative Ecological Categories (AEC) are also shown (Koekemoer and Louw, 2011). These are scenarios to present ecological consequences to DWA, should the present state or REC in the system not be met.

Table 3: Summary of EFR results as a percentage of the natural Mean Annual Runoff (nMAR) and in Million Cubic Metres (MCM)

EFR site	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
		(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM
Virgin MARs									
EFR O2	PES/REC	11.6	1226.55	4.4	465.24	5.4	570.98	15.2	1607.20
	AEC↓: D	5.8	613.27	3.1	327.78	5	528.69	11.3	1194.83
EFR O3	PES: C	8.4	883.10	2.6	273.34	4.7	494.12	11.9	1251.06
	REC: B	17.6	1850.31	3.4	157.37	4.7	494.12	19.2	2018.52
	AEC↓: D	4.1	431.04	2.2	231.29	4.4	462.58	9	946.18
EFR O4 (Vioolsdrif)	PES: C	6.3	651.11	0.9	35.16	4.2	434.07	8.9	919.82
	REC: B/C	10.1	1043.85	1.3	134.36	4.2	434.07	12.2	1260.88
	AEC↓: D	3.1	320.39	0.8	31.25	3.8	392.73	6.9	713.12

The determination of water availability for the project was determined by using the following information previously available to the consultants:

1. Liaison with the national Directorate: National Water Resource Planning (D: NWRP) of DWA in February 2010, who advised that the D: NWRP had incorporated the use of water for alternative energy technologies as a potential future water use for the small surplus of water (i.e. 44 million m^3/a (Rademeyer, DWA, pers. comm., February 2010)) available in the system at the time.

2. Consultation was held with members of the DWA, stakeholders and the Steynsvoor Irrigation Board in the Upington area in 2010 regarding water use and availability in the Lower Orange River area. Additional consultation took place during a second field survey of May 2011 for Project Ilanga.

3. Consultation with the Northern Cape Regional Director, Mr Louis Snyders and Mr Abe Abrahams, Director: Water Regulation and Use, based in the Regional Northern Cape DWA Office in Kimberley, and Mr Ernest Kubayi of the Upington DWA office. Further consultation will take place with DWA during the WULA process for the project.

6.5. Surface water quality

The water quality state within the Orange River can be summarized as follows (ORASECOM, 2009 and Golder Associates, 2009, as cited in Scherman, 2010b):

- Water quality between Boegoeberg and Onseepkans is generally good despite extensive irrigation and settlements in the Upington area.
- The salinity deteriorates downstream of the confluence of the Vaal and Orange rivers but still remains good. There is an increase in Electrical Conductivity (EC; or salinity) from Prieska to Vioolsdrift along the reaches of the lower Orange River. This is due to irrigation return flows and evaporative losses along the river.
- Eutrophication is evident in localised areas along the Lower Orange River; intermittent blooms of toxic algae have been reported in the Upington area.
- Some of the water withdrawn for irrigation is returned to the river environment for reuse, but its quality is seriously degraded with considerably higher salts and nutrient concentrations which contribute significantly to the salts load in the Orange River.

Although the inflows from the Vaal River systems are low, the poor water quality from this system would seem to have a significant impact on the sub-basin and the Lower Orange WMA. In its natural state, water in the Orange River is of good quality. The ORASECOM study (2007) indicated that the salinity in this sub-basin deteriorates downstream of the confluence of the Vaal and Orange rivers, but remains acceptable for human use. Detailed information on the water quality data is contained in the Lower Orange Management Study (LORMS) (LORMS, 2005).

The present state for water quality for the stretch Upington to Vioolsdrif, was rated as a B/C category on a negative trajectory by the LORMS study (LORMS, 2005), which means that the quality is Minimally to Moderately modified – see definitions below on Table 4. This assessment was updated during the ORASECOM EFR study, with Table 5 showing the water quality assessment for the upstream ERF 02 at Boegoeberg (Scherman, 2010b), following the assessment methods of DWAF (2008). Categories are shown per variable, with the integrated water quality category produced by inputting data into a model called the Physico-chemical habitat Assessment Index (PAI). Note that the assessment by Scherman shows water quality to be a C category at EFR O2, which indicates a deterioration in quality since the 2005 study. Water quality state at EFR O3 (Augrabies) and EFR O4 (Vioolsdrif) were a C and C/D respectively (Scherman, 2010b).

Table 4: Generic ecological categories (modified from Kleynhans *et al.*, 2005)

Ecological Category	Description
A	Unmodified, natural.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 5: Water quality data assessment for EFR O2 at Boegoeberg (Scherman, 2010b)

RIVER	Orange River	**WATER QUALITY MONITORING POINTS**		
		RC	Orange River @ Boegoeberg Reserve (D73B; ecoregion II: 26.05) D7H008Q01 (1966 – 1979; n=43 - 57)	
EFR SITE	O2 (D81B; ecoregion II: 28.01)	**PES**	1) Orange River @ Boegoeberg Reserve (D73B; ecoregion II: 26.05) D7H008Q01 (2000 – 2009; n=348) 2) Data from diatom sample collection in 2005, 2008, 2009, 2010	
Confidence assessment	Moderate confidence. Although sufficient data for most variables, data gaps exist, particularly in the case of herbicides, pesticides and metal ions. Note that water quality and EFR sites are <u>not</u> in the same EcoRegion level II.			
Water Quality Constituents		**RC Value**	**PES Value**	**Category/Comment**
Inorganic salts (mg/L)	TEACHA was not used for data assessment, as salinity levels not elevated.			
Salt ions (mg/L)	Ca	37.40	34.06	Concentrations similar for the PES, except for sulphate, sodium and chloride which show increases from the RC, particularly sulphate and chloride.
	Cl	20.36	46.28	
	K	3.70	3.99	
	Mg	15.10	18.00	
	Na	23.70	35.36	
	SO_4	48.10	63.99	
Nutrients (mg/L)	SRP	0.014 *	0.022	A category
	TIN	0.14	0.22	A category
Physical Variables	pH (5^{th} + 95^{th} %ile)	7.05 + 7.91	7.71 + 8.60	A/B category
	Temperature	-	-	Site downstream of numerous dams upstream, with significant changes expected from natural.
	Dissolved oxygen	-	-	
	Turbidity (NTU)	-	Avg: 7.92 95^{th} %ile: 30.67	Levels not very significant. A/B category (qualitative assessment)
	Electrical conductivity (mS/m)	35.68 *	50.80	A/B category. RC shows slightly elevated natural salt levels.
Response variables	Chl a: periphyton (mg/m^2)	-	-	-
	Chl a: phytoplankton (µg/L)	-	46.5 (n=2; 2008) (Koekemoer, 2010)	E category
	Macroinvertebrates	ASPT: 6.6 SASS: 165	ASPT: 5.8 SASS: 116 MIRAI: 63.7%	C category (Palmer, 2010)
	Fish community score		FRAI: 66.9%	C category (Kotzé, 2010)
	Diatoms	-	SPI: avg – 12.9 (n=4; Boegoeberg + EFR O2)	B/C category (Koekemoer, 2010)

Toxics	Fluoride (mg/L)	0.452	0.260	A category
	Ammonia (mg/L)	0.002	0.011	A category
	Aluminium (mg/L)	0.02 **	0.166 (n=2; 2008) (Koekemoer, 2010)	D category
	Iron (mg/L)	-	0.110 (n=2; 2008) (Koekemoer, 2010)	No guideline + insufficient data
	Arsenic (mg/L)	0.02 **	297 (n=2; 2008) (Koekemoer, 2010)	E category
	Cadmium (mg/L)	0.000 3 **	0.005 (n=2; 2008) (Koekemoer, 2010)	E category
	Lead (mg/L)	0.002 **	0.011 (n=2; 2008) (Koekemoer, 2010)	E category
	Other	-	-	Impacts expected due to farming-related pesticides and fertilizer use.
OVERALL SITE CLASSIFICATION		**C: 69.34%** (from PAI model)		

** boundary value for the A category recalibrated*
- no data
*** benchmark value, as no data*

6.6. Groundwater quantity and quality

It is estimated that approximately 60% of the Lower Orange sub-basin depends solely on groundwater for rural domestic supplies, stock watering and supply to inland towns. The low rainfall for the area impedes recharge, resulting in only small quantities that can be abstracted on a sustainable basis. Groundwater abstracted near the river induces recharge from the river, i.e. surface water from the Orange River is drawn into the surrounding aquifers as a result of water being abstracted. The hard geological formation underlying most of the region has resulted in unfavourable aquifer characteristics, i.e. low borehole yields and poor storage of groundwater (ORASECOM, 2007).

The quality of the groundwater is considered brackish or mineralised, but is suitable for the majority of uses and is commonly used in drier areas. The mineralogical groundwater quality class is relatively high within the Lower Orange sub-basin, with Total Dissolved Solids (TDS) values ranging between 601 and 1800 mg/L (DWAF, 2002 cited in ORASECOM, 2007). This can be compared to the overall surface water TDS values ranging between 260 and 600 mg/L (DWAF, 2002), which is a tolerable range or class in terms of its fitness for human use range criteria. The potential for faecal contamination is considered low due to the type and extent of local aquifers.

Groundwater is a component of an additional EFR study currently taking place for the Lower Orange / Fish rivers in Namibia.

6.7. Local water resources and supply infrastructure

Three major areas downstream of the Karoshoek development receive water directly from the Orange River, namely Upington (urban and surrounds), Upington Irrigation Scheme controlled by the Upington Irrigation Board, and Kakamas /Keimoes (urban and irrigation). Various canal schemes within the region are used to supply the irrigated areas. Table 6 summarises the various water requirements in the study area (ORSECOM, 2007).

Table 6: Water requirements, as well as know system losses for the various regions surrounding the study area in million m^3/a (ORASECOM, 2007)

Region	Irrigation Board	Urban & Other	Canal losses	Return flows	Canal net losses
Upington	165	65	17	10.47	6.98
Kakamas / Keimoes	64	Unknown	13	8	5.39

6.8. Abstraction point near Upington

From aerial photographs it is apparent that the proposed abstraction point is located on a 100 wide section of the main channel of the main Orange River (see Figure 6). The channel consists of riffles/rapids and braided sections above and below the abstraction point. The instream habitat appears to be fast deep habitat (rapids) and deep pools, with the river banks and channel margins densely lined with reeds (*Phragmites australis*). This locality provides the type of habitat preferred by a number of sensitive fish species.

Figure 6: The proposed water abstraction point which will serve the Karoshoek Solar Valley Development

6.9. On-site data

The study area site is situated within quaternary catchments D73D and D73E (Figure 7). These quaternaries are dominated by a large number of highly ephemeral river systems that flow directly towards the Orange River (DWAF, 2004). Potential runoff from the site would flow in a northerly direction towards the Orange River via drainage systems such as the Klein-leerkransspruit and Majties (Matjes) River or directly into the canal systems and siphons that run along the Orange River (Figure 8).

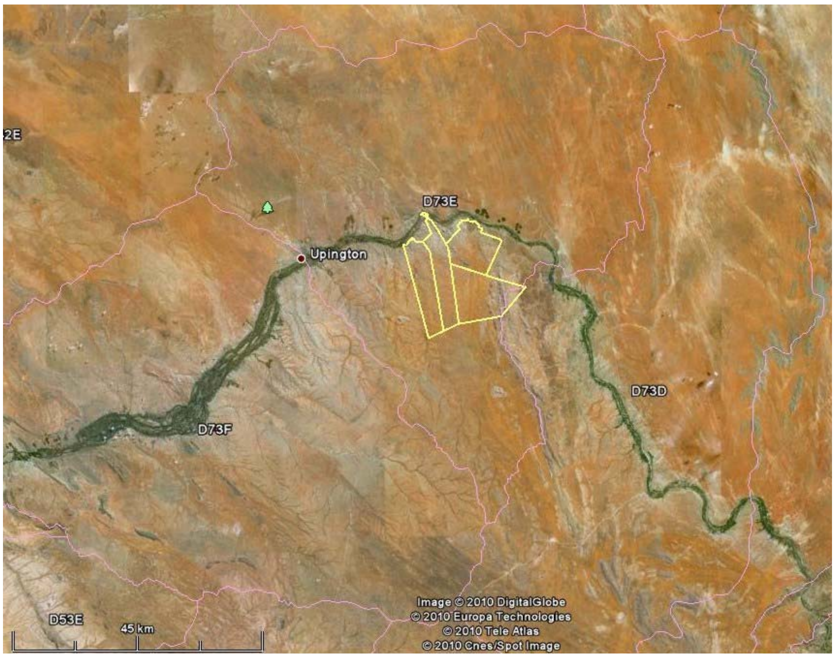

Figure 7: Quaternary catchments shown in relation to the study area farms (in yellow)

No wetlands, other than the riparian systems found along the Orange River are shown on the SANBI National Wetlands Map v2 (SANBI, 2010). Wetland or water bodies within the site were confirmed during the specialist site visit as a number of reed-bed wetland systems evident along the Orange River. Figure 8 is a sensitivity map of the area, showing all drainage lines and alluvial fans in the study area. This map can be read in conjunction with those shown in the Terrestrial Fauna and Botanical Specialist Report for the EIA (Todd, 2012), to identify areas of ecological sensitivity.

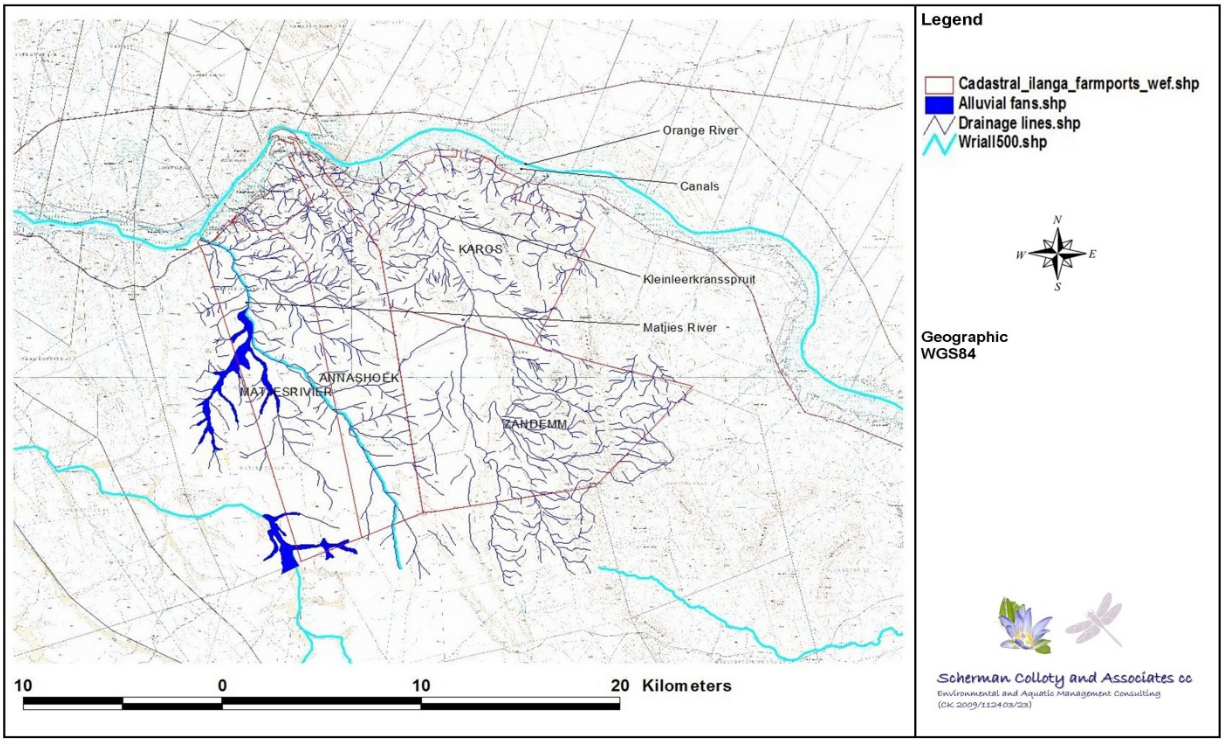

Figure 8: Map indicating the drainage lines and alluvial fans found within the study area

6.9.1. Riparian vegetation

This assessment was based on a broad evaluation of the natural vegetation found within the region and how localised surface and groundwater systems function in the formation of any recognisable riparian systems. During the site visits in 2010 and 2011 these areas were ground-truthed so as to produce a GIS map of the study site, as well as indicate any additional areas that may be impacted upon by the proposed development.

Five woody plant species were found associated with the riparian systems within the study site. Although none of these were obligate or facultative river/wetland species, they do show a preference for riparian soil conditions. Species within the site were dominated by *Acacia haematoxylon* (Grey Camel Thorn) and *Boscia foetida* (Stink Shepard's Tree), notably protected under the National Forest Act.

The only obligate wetland plants observed were those found in association with the man-made canals and along the Orange River itself. Species observed included *Typha capensis, Phragmites australis* and *Cyperus latifolius*.

The *Terrestrial Fauna and Botanical Specialist Report* for the EIA (Todd, 2012) should be read for a complete assessment of the importance and status of the plant species observed within the study area.

6.9.2. Fish fauna

Note that this information is taken from Savannah Environmental (2010), Appendix H, as the information is relevant to the Karoshoek Solar Valley Development area, which is located along the Lower Orange River.

The fish biodiversity in the Lower Orange River is relatively high compared to the entire river system, with a total of 13 indigenous species being recorded, including five of the six endemic Orange River species (Table 6). The endemic Namaqua barb, *Barbus hospes* only occurs below the Augrabies Falls, as does an isolated population of the indigenous river sardine, *Mesobola brevianalis*. The nearest adjacent population of river sardine occurs in the Okavango system.

As seen in Table 7, the IUCN 2010 Red List for the fish species found in the Lower Orange River included only largemouth yellowfish (*Labeobarbus kimberleyensis*) as “Near Threatened” (Impson and Swartz, 2007), with the remaining fish listed as of “Least Concern”. However, correspondence with local fish experts, who have been involved with fish studies in the Lower Orange River for the ORASECOM EFR study (Kotzé, Clean Stream Biological Services, pers. comm., 2010), consider that this IUCN Red Listing is not applicable to the endemic fish populations in the Lower Orange.

Fish researchers feel that the Namaqua barb (*Barbus Hospes)* and the rock catlet (*Austroglanis sclateri)* may be threatened in the Lower Orange River and recommend that these species require further studies to establish their true conservation status in this locality. In this regard, the Namaqua barb (*Barbus hospes)* was IUCN listed as Near Threatened in 1996 (Swartz and Impson, 2007), and the rock catfish (*A. sclateri)* as Data Deficient in 1996 (Swartz *et al*., 2007). The other two endemic fish species, Smallmouth Yellowfish (*Labeobarbus aeneus*) and Orange River mudfish (*Labeo capensis*) are fairly abundant. However, the conservation status of these two species are also of some concern due to the deterioration of their habitat in the Lower Orange (LORMS, 2005), as discussed below.

Table 7: List of indigenous fish species found in the Lower Orange River, with the most recent IUCN (2010) Red listing for the various species. The IUCN fish species Red List category marked with an * (and shaded) are considered to be "near threatened" or even "vulnerable" in the Lower Orange River by local fish experts - see text. LC = least concern; NT = near threatened; E = endemic; I = indigenous.

FAMILY	SPECIES		STATUS		
	Scientific Name	**Common Name**	**E**	**I**	**Red List**
Anguillidae	*Anguilla mossambica*	Longfin eel		x	LC
Cyprinidae	*Mesobola brevianalis*	River sardine		x	LC
	Labeo capensis	Orange River Mudfish	x		LC
	Labeo umbratus	Moggel		x	LC
	Barbus hospes	Namaqua barb	x		LC*
	Barbus palidinosus	Straightfin barb		x	LC
	Barbus trimaculatus	Threespot barb			LC
	Labeobarbus kimberleyensis	Largemouth yellowfish	x		NT
	Labeobarbus aeneus	Smallmouth yellowfish	x		LC
Cichlidae	*Pseudocrenilabrus philander*	Southern mouthbrooder		x	LC
	Tilapia sparrmanii	Banded tilapia		x	LC
Clariidae	*Clarias gariepinus*	Sharptooth catfish		x	LC
Austroglanididae	*Austroglanis sclateri*	Rock catfish	x		LC*

A brief description of the habitat requirements and abundance of the five endemic fish species present in the Lower Orange is therefore of relevance to the present investigation in terms of potential impacts of the proposed solar power facility.

- Largemouth yellowfish *Labeoarbus kimberleyensis* is the largest yellowfish species in South Africa reaching over 800 mm in length and over 22 kg in weight. This species was listed as Vulnerable by Skelton (2003) due to a decline in numbers and distribution throughout its natural range. The adults (fish over 300 mm in length) are pisciverous and prefer flowing water in deep channels. This species matures at about 6 -8 years of age and breeds in mid to late summer over clean, silt-free gravel beds in running water, often below rapids (Skelton, 2003).
- Namaqua barb *Barbus hospes* is a small barb that attains about 75 mm in length and prefers open water in the mainstream and backwaters where it feeds on zooplankton ad aquatic insects (Skelton, 2003). Little is known about its breeding biology, but it probably spawns in running water in riffles. This is one of the few species that may have benefited from the regulated flows in the Lower Orange (Skelton, 2003), but more data is needed to confirm this suggestion.
- Smallmouth yellowfish *Labeobarbus aeneus* reaches about 500 mm in length and is widely distributed in large numbers throughout the Orange-Vaal system. Its preferred riverine habitat is clear, fast-flowing waters with sandy to gravel substrates, but this species also flourishes in large impoundments. It migrates

upstream to spawn over clean gravel substrates in spring to mid-summer after the first post-winter floods or high flows.

- Orange River Mudfish *Labeo capensis* attains 500 mm in length and prefers running waters in large rivers, but appears to do well is a variety of habitats including large impoundments, grazing on firm surfaces of rocks and plants. This species breeds in summer in shallow water over cobbles and rapids and possibly on flooded vegetation. The numbers of this species were reported to be declining in the Lower Orange River by Benade (1993 vide LORMS 2005).
- Rock catfish *Austroglanis sclateri* is a medium-sized species reaching 300 mm and prefers rocky habitats in flowing water, favouring rapids, where breeding is also thought to take place. This species appears sensitive to poor water quality and numbers have declined in areas subject to siltation and deterioration in water quality (Benade 1992 vide LORMS 2005; Kotzé, Clean Stream Biological Services, pers. comm., 2010).

Environmental impacts affecting the spawning habitats of riverine fish can threaten the survival of vulnerable species with specific spawning requirements. The above description of the breeding requirements of the endemic fish in the Lower Orange River emphasizes the importance of suitable river flows in summer and the presence of clean, silt-free gravel or cobble spawning areas in flowing water habitats. Altered river flows and increased sediment input are impacts that could theoretically be associated with the proposed solar thermal facility, as discussed later.

Vulnerable fish species requiring specific environmental conditions such as good quality water flowing over clean rocks and gravel substrate for feeding and particularly for breeding, include the two most important fish species of concern in the Lower Orange River, namely largemouth yellowfish (*Labeobarbus kimberleyensis)* and the rock catlet (*Austroglanis sclateri*). It is therefore of particular concern that in recent fish surveys in the lower Orange very few of these two species were captured (Kotzé, Clean Stream Biological Services, pers. comm., 2010). In addition, the rock catlet is considered the best indicator species to use when determining instream flow requirements when designing future water projects due to its specific habitat requirements related to river flow and water quality (ORASECOM, 2007).

The three other endemic fish species present in the Study Area (Orange River Mudfish, smallmouth yellowfish and Namaqua barb) were found to be well represented in EFR survey catches by Kotzé for the ORASECOM EFR study and appear to be relatively tolerant of the habitat alteration that has occurred. All the fish species expected at EFR O2 (Boegoeberg) and EFR O3 (Augrabies) were found during the EFR survey, albeit in a slightly to moderately reduced frequency of occurrence (Louw and Koekemoer, 2010).

7. RESERVE (or EFR) RESULTS

The Present Ecological State (PES) of a river represents the extent to which it has changed from the reference or near pristine condition (Category A) towards a highly impacted system where there has been an extensive loss of natural habit and biota, as well as ecosystem functioning (Category E). The LORMS (2005) study found that the overall PES of the Lower Orange River, including fish and the other biota (algae, vegetation, macroinvertebrates), to be in a *D Category*. This is defined as where the habitat integrity has been largely modified and where a large loss of natural habitat, biota and basic ecosystem functions has occurred.

In addition, the LORMS (2005) study found fish in the Lower Orange to be on a negative trajectory of change with the PES dropping to D/E in 20 years unless the current impacts are reduced or reversed.

The ORASECOM EFR assessment (completed 2011) supersedes all previous reserves conducted for the system. The results of assessments at the EFR site at Boegoeberg in quaternary catchment D73C, i.e. EFR site O2, will inform the Water Use License Application (WULA) process for the Karoshoek project. The results of the downstream EFR site O3, at Augrabies, will also be considered. Tables 8 and 9 provide the EcoClassification results from the ORASECOM study (Louw and Koekemoer, 2010). Both sites show a Present Ecological State (PES) of a C category, however, it was recommended that the downstream Augrabies site (EFR O3) be managed for a better category for ecological purposes (a REC of a B category), than EFR O2, i.e. a REC of a B/C category.

Note that the outcomes of the EFR study therefore suggest that the system be managed so as to improve its ecological state. However, operational scenarios were not considered during the ORASECOM study, so although flow, quality and biotic requirements and objectives have been set, consequences to various operational flow scenarios were not determined. The Reserve template for the Orange River was completed and submitted to CD: RDM as part of a study for a Concentrating Solar Power (CSP) plant for Abengoa during 2010/2011, but has not yet been signed or gazetted.

Table 8: EcoClassification results for EFR02

Driver Components	PES	TREND	REC	AEC↓
IHI HYDROLOGY	E			
WATER QUALITY	C		C	D
GEOMORPHOLOGY	C	0	C	C
INSTREAM IHI	C/D			
RIPARIAN IHI	B/C			
Response Components	**PES**	**TREND**	**REC**	**AEC↓**
FISH	C	0	C	D
MACRO INVERTEBRATES	C	0	C	D
INSTREAM	C	0	C	D
RIPARIAN VEGETATION	B	0	A/B	B/C
RIVERINE FAUNA	C	0	B	C
ECOSTATUS	C	0	B/C	C
EIS	HIGH			

Table 9: EcoClassification results for EFR03

Driver Components	PES	TREND	REC	AEC↓
IHI HYDROLOGY	E			
WATER QUALITY	C		C	D
GEOMORPHOLOGY	C	0	C	C-
INSTREAM IHI	D			
RIPARIAN IHI	C/D			
Response Components	**PES**	**TREND**	**REC**	**AEC↓**
FISH	C	0	B	D
MACRO INVERTEBRATES	C	0	B	D
INSTREAM	C	0	B	D
RIPARIAN VEGETATION	B/C	-	B	C
RIVERINE FAUNA	C	0	B	C
ECOSTATUS	C	0	B	C*
EIS	HIGH			

* The focus for setting EFRs will be on the instream EC of a D

8. SENSITIVITY ASSESSMENT

A number of sensitive areas were identified within the Karoshoek study area. From an aquatic systems point of view most were associated with dry river beds and riparian zones. The conservation importance of these systems are presented in the *Terrestrial Fauna and Botanical Specialist Report* for the EIA (Todd, 2012).

Thus from a habitat and ecosystem point of view, all the dry river beds and the associated riparian systems (Figure 8) would be rated as extremely sensitive to development, in particular the mainstem systems such as Klein-leerkransspruit and Matjies River. The Matjes River runs through a section of Site 3. When mapping these systems, it became evident that the active channel could not be used to define the lateral extent of the river system. Due to the nature of the soils and geomorphology, these systems are able to form various meanders or fans within the greater landscape. Placing a buffer of, for example 100 m onto such a system, would still not capture the entire system and therefore not adequately ensure the protection of the riparian zone.

9. IMPACT ASSESSMENT

This impact assessment deals with three separate components, i.e. riparian vegetation, flow and quality, and fish fauna (Sections 9.2 – 9.4). ***Note that impact statements cover all sites, unless listed separately per site.*** Section 9.1 provides general information on impacts. Generic information is taken from the Project Ilanga report.

9.1 Generic impacts

In generic terms, many of the potential environmental impacts on the Orange River due to construction activities associated with the water abstraction infrastructure on the banks and riparian zones are similar, and will be applicable to any construction activity in or adjacent to rivers. A general description of the possible causes of these common impacts on aquatic habitats and biota (particularly on the fish fauna), as well as a description of their ecological consequences, is provided below.

9.1.1. Sedimentation and Elevated Turbidity

Potential causes

There is a risk of elevated sediment input into the Orange River during the establishment or extension of the water abstraction facilities on the banks and floodplains of the Orange River. In addition, although relatively far from the river itself, sediment-laden runoff from the proposed sites of the Karoshoek Solar Valley Development could occur, particularly if flash floods occur during the site clearing and construction phases of the project. Sediment mobilisation could result from, among others:

» Disturbance of existing flood protection embankments.

» Inadequate erosion control or containment of sediment-laden runoff during site clearing and construction activities for infrastructure at both the abstraction points (e.g. pipe lines and reservoirs) and at the solar plant site.

» Backwash water discharged from the sand filters could result in sediment laden water reaching the Orange River, with a resultant impact on habitat availability for instream biota.

Consequences

Increased siltation and sedimentation has been described as one of the biggest threats facing some rivers in South Africa and could result in a number of negative impacts, including:

» Reducing the depth of pools in the river channel causing these sanctuary habitats to become too shallow during low flows to support fish life or other aquatic biota.

» Fine sediment could be washed downstream and smother important fish spawning areas, such as gravel and cobble riffles used by Largemouth yellowfish and rock catfish.

- Sediment deposits would further encourage reed invasion in the river channel and thus degrade preferred fish habitats.

Elevated turbidity levels associated with increased sediment washing into the river has a number of negative impacts on aquatic biota, including fish. These include:

- The whole food web can be disrupted due to reduced light penetration and photosynthesis, resulting in reduced primary production, a reduction in submerged plant life, including phytoplankton.
- Reduced number of bottom organisms (e.g. benthic algae, crabs, small aquatic invertebrates) due to smothering by layers of silt.
- The smothering of incubating eggs (fish, tadpoles, etc.) and larval fish.
- Clogging, abrading and damage to fish gills, leading to reduced oxygen absorption, damage to gill filaments, resulting in increased stress, disease and even death, (Whitfield and Paterson, 1995).
- Reduced feeding efficiency – a major impact on visual predators such as Largemouth yellowfish, as they are unable to see and find enough food in the turbid water.

The above impacts could eliminate sensitive species from the affected areas and cause fish species and other biota to vacate the area. Fish species such as the near threatened Largemouth yellowfish that require silt-free gravel and/or cobble habitats for spawning, would be particularly affected by elevated sediment inputs.

The ecological functioning of the potentially impacted reach of the Orange River could therefore be seriously impacted by high sediment inputs associated with the proposed construction activities, particularly of the water abstraction facilities.

9.1.2 Water pollution

Potential causes

During both pre-construction and construction activities, chemical pollutants (hydrocarbons from equipment and vehicles, cleaning fluids, cement powder, wet cement, shutter-oil, etc.) associated with site-clearing machinery and construction activities could wash into the rivers. In addition, washing soap, faeces, and other waste material from workers, particularly those working near the river, could contaminate surface run-off and pollute the river water.

Consequences

These pollutants could be harmful to aquatic biota, particularly during low flows when dilution is reduced, and could pose a health risk to locals using the river water for domestic purposes. Larval fish, which often utilise shallow productive habitats near the river bank as nursery areas, are usually more sensitive than adult fish to poor water quality. In addition, the important and rare rock catfish is thought to be particularly sensitive to poor water quality.

Lime-containing (high pH) construction materials such as concrete, cement, grouts, etc., deserve a special mention, as they are highly toxic to fish and other aquatic biota. If dry cement powder or wet uncured concrete is exposed to surface run-off or river water, these compounds can elevate the pH to lethal levels – note that pH levels of over 10 are considered toxic to fish.

9.2. Impact assessment: Riparian zones

The riparian zone component includes the functional or ecosystem services importance of the dry river beds and riparian zones on site and how the proposed development would affect the riparian environment. At this point the development footprint has been positioned to avoid the majority of the drainage lines.

During the impact assessment study a number of potential key issues / impacts were identified and these were assessed based on the methodology supplied by Savannah Environmental. Two main issues are highlighted and these are listed below, together with related impacts that have the potential to arise should the project go-ahead.

Issue – Biological environment (e.g. vegetation)

- Impact 1: Loss of riparian systems

Issue - Physical environment

- Impact 2: Impact on dry riverbeds and localised drainage systems
- Impact 3: Impact on riparian systems through the possible increase in surface water runoff on riparian form and function
- Impact 4: Increase in sedimentation and erosion
- Impact 5: Physical disturbance by the supporting infrastructure (pipelines, power lines and pump stations) on the riverine environment

The impacts were assessed as follows:

Nature: Impact 1 - Loss of riparian systems: _Sites 1.1, 1.3, 1.4, 2, 4 and 5_

The physical removal of the narrow strips of woody riparian zones, being replaced by hard engineered surfaces. Although the biological impact would be localised per site, there would also be a cumulative impact across the area due to the large number of sites impacted in the area.

Site 3: The impact on this site is considered slightly higher than the other sites, due to the presence of the Matjes River running through the site; but not high enough to alter scores.

	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)

Magnitude	Moderate (6)	Low (4)
Probability	Definite (5)	Definite (5)
Significance	**High (55)**	**Medium (45)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources	No	No
Can impacts be mitigated	Yes	
Mitigation: The most significant form of mitigation would be to select a development area per site, which contains no drainage lines. All sites are also a significant distance from the main drainage systems, and is thus unlikely to be flooded or in itself pose a risk to the aquatic systems should there be any major spills (coolants).		
Cumulative impacts: Some cumulative impact due to the number of sites to be developed, but not considered high due to current land use impacts (e.g. grazing) on riparian zones. Little natural habitat remains along the Orange River.		
Residual impacts: Changes in run-off characteristics within the development area will cause residual impacts.		

Nature: Impact 2 - Impact on dry riverbeds and localised drainage systems: *All sites* The physical removal of narrow strips of woody riparian zones being replaced by hard engineered surfaces will alter the hydrological nature of the area, by increasing the surface run-off velocities, while reducing the potential for any run-off to infiltrate the soils. Although this impact would extend to a large section of the Karoshoek Solar Valley farms, the extent of the impacts would still be considered local.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Low (4)
Probability	Definite (5)	Probable (3)
Significance	**Medium (45)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources	No	No
Can impacts be mitigated	Yes	
Mitigation: The most significant form of mitigation would be to select a development area which contained no or the least number of drainage lines. This is particularly relevant to Site 3, where the Matjes River should be avoided. Storm water within each site should be handled in a suitable manner, i.e. separate clean and dirty water streams around the plant, and install stilling basins to capture large volumes of run-off, trap sediments and reduce flow velocities.		

Cumulative impacts: The increase in surface run-off velocities and the reduction in the potential for groundwater infiltration is unlikely to occur, considering that the sites are not near the main drainage channel and the annual rainfall figures are low. Care should be taken with the placement of the Site 3 facility.	
Residual impacts: Diversion of run-off away from downstream systems is unlikely to occur as the site is not near the main drainage channel and the annual rainfall figures are low. i.e. the overall hydrological regime will be altered in a limited fashion.	

Nature: Impact 3 - Impact on riparian systems through the possible increase in surface water run-off on riparian zone form and function: *All sites*		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (2)	Low (2)
Probability	Definite (5)	Probable (3)
Significance	**Medium (35)**	**Low (19)**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources	No	No
Can impacts be mitigated	Yes	
Mitigation: Any storm water within the site will be handled in a suitable manner, i.e. separate clean and dirty water streams around the plant. It is also recommended that stilling basins to capture large volumes of run-off, trap sediments, and reduce flow velocities (e.g. water used when washing the mirrors) are installed. The project should also try to capture and recycle any form of run-off created by the daily operations. This would minimise the amount of water required by the project, but also serve to limit the downstream impacts on the riparian systems through an increase in run-off, a situation that these systems are currently unaccustomed too.		
Cumulative impacts: Downstream alteration of hydrological regimes due to the increased run-off from the area, particularly when all plants are operational.		
Residual impacts: Possible impact on the remaining catchment due to changes in run-off characteristics in the development area.		

Nature: Impact 4 - Increase in sedimentation and erosion within each development footprint: *All sites*		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (1)	Low (1)
Probability	Definite (5)	Probable (3)
Significance	**Medium (30)**	**Low (18)**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources	No	No
Can impacts be mitigated	Yes	
Mitigation: Any storm water within each site should be handled in a suitable manner, i.e. separate clean and dirty water streams around the plant, and install stilling basins to capture large volumes of run-off, trap sediments and reduce flow velocities (e.g. water used when washing the mirrors).		
Cumulative impacts: Downstream erosion and sedimentation of the irrigation canal systems. During flood events, any unstable banks and sediment bars will be washed into the Orange River. It is also therefore recommended that storm water is not released directly into the Orange River.		
Residual impacts: Expected runoff volumes from the 1 GW developed area could potentially increase the amount of erosion and or sedimentation, but with appropriate mitigation per site, amounts of sediment transported should not be significant.		

Nature: Impact 5 - Physical disturbance by the supporting infrastructure (pump stations) on the riparian environment The proposed pipeline route, power line and pump infrastructure will have limited to no impact on the functioning of any riparian systems.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Low (3)
Probability	Definite (5)	Probable (3)
Significance	**Medium (55)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources	No	No
Can impacts be mitigated	Yes	
Mitigation: The current placement is within an area of dense reed growth (*Phragmites australis*), and would		

not be considered a severe impact as the related infrastructure is already in place and the pipeline and power line will follow the existing road. Suitable erosion protection will be installed were the pipeline and power line does cross any drainage lines, which will later become vegetated.
Cumulative impacts: Additional downstream erosion and sedimentation of the Orange River.
Residual impacts: During flood events, the unstable banks (eroded areas) and sediment bars (sedimentation downstream) will further increase the suspended sediment loads within the Orange River system.

9.3. Impact assessment: Orange River - Flow and quality issues

The flow and quality component focuses on the impact of the development on the availability of the water resources of the area, particularly from the regional context of the Lower Orange River system.

The distance of the proposed solar facilitiesfrom the Orange River will reduce the risk of contaminated run-off from the solar facility polluting the Orange River. However the well-defined drainage lines or ephemeral streams such as those adjacent to Site 3 would increase this risk during rainstorms and local flash floods, which normally occur during the summer months.

9.4. Impact assessment: Orange River – Fish fauna (biotic study)

The fish fauna component focuses on the impact of the development on the biota of the water resources of the area, i.e. the Orange River as the water source for the development.

Note that the impact assessment for flow and quality, and fish fauna, are dealt with together. As fish surveys were not undertaken specifically for this study, the assessment is a desktop study. This is particularly relevant when assessing the potential impact of water abstraction from the Orange River.

There is a low risk of impacts to the Orange River resulting from elevated sediment loads and polluted run-off from the solar facilities reaching the river during site preparation and construction, if appropriate mitigation is taken. The construction of infrastructure associated with the abstraction point also poses a low risk of impacting negatively on aquatic habitats and biota in the adjacent Orange River, due to the distance of the sites from the river. These impacts are assessed in detail below.

Nature: Impact 1 - Sediment input into the Orange River: *All sites* Vegetation clearing and earthmoving operations at the sites during pre-construction and construction of the infrastructure (including access roads, water pipelines, reservoirs, etc.) will increase the risk of soil erosion and sediment being washed into the Orange River during heavy rains. The risk will obviously be lower for sites further away from the river, e.g. Sites 4, 5, 1.3

and 1.4, and possibly a bit higher for Site 3 due to the link between the Matjes and Orange rivers.		
	Without mitigation	**With mitigation**
Extent	Site (2)	Local (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Moderate (6)	Minor (2)
Probability	Highly probable (4)	Improbable (2)
Significance	**40 (medium)**	**10 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Low
Irreplaceable loss of resources	Medium	Low
Can impacts be mitigated	High	
Mitigation: » Site clearing and preparation for the construction of the solar facilities should take steps to avoid surface run-off and storm-water erosion of cleared areas where practicable. » A comprehensive Storm Water Management Plan (SWMP) incorporating anti-erosion measures on site should be put in place. » All surface run-off should be discharge via detention dams to allow sediment to settle out before leaving the site.		
Cumulative impacts: Man-induced erosion and sedimentation in this area from intensive farming activities along the Orange River is expected to be unnaturally high. The cumulative impact on the Orange River could thus exceed the tolerances of the aquatic biota, including sensitive fish species, should appropriate mitigation not be conducted.		
Residual Impacts: Residual Impacts should be minimal with appropriate mitigation.		

Nature: Impact 2 - Chemical and other pollutants into the Orange River: <u>*All sites*</u> During both pre-construction, construction and operational activities, chemical pollutants (hydrocarbons from equipment and vehicles, cleaning fluids, cement powder, wet cement, shutter-oil, etc.) associated with site-clearing machinery and construction activities could be washed downslope via the ephemeral streams into the Orange River. During the operational phase, spills and leaks from the evaporation or blow down ponds could be washed by storm water run-off via the natural drainage lines into the Orange River. Appropriate ablution facilities should be provided for construction workers during construction and on-site staff during the operation of the facility.		
	Without mitigation	**With mitigation**
Extent	Site (2)	Local (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**30 (medium)**	**10 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Yes (high)	Yes (high)
Irreplaceable loss of resources	Yes (medium)	Yes (low)
Can impacts be mitigated	Yes (high)	
Mitigation: » Strict use and management of all hazardous materials used on site. » Strict management of potential sources of pollution (e.g. litter, hydrocarbons from vehicles		

and machinery, cement during construction, etc.). » Containment of all contaminated water by means of careful run-off management on the development site. » Strict control over the behaviour of construction workers. » Working protocols incorporating pollution control measures (including approved method statements by the contractor) should be clearly set out in the Construction Environmental Management Plan (CEMP) for the project and strictly enforced.
Cumulative impacts: The widespread use of chemicals in farming activities (fertilizers, insecticides, herbicides, etc.) means that any chemical pollution from the solar facilities will have a marked cumulative impact on aquatic biota.
Residual impacts: Residual impacts will be negligible after appropriate mitigation.

Nature: Impact 3 - Abstraction of water from the Orange River: timing and volume: *All sites cumulatively*

The proposed constant abstraction of large volumes of water from the Orange River (ca 1.5 million m^3/a for the Solar Valley Park) may reduce present day flows and impact negatively on aquatic biota. This impact would be particularly evident in summer when high river flows are required for fish spawning migrations and egg incubation. It is anticipated that constant pumping during droughts may impact on drought flow requirements needed to meet the EWR. Cognisance will therefore have to be taken of other user requirements.

	Without mitigation	**With mitigation**
Extent	Region (3)	n/a
Duration	Long term (4)	n/a
Magnitude	Moderate (6)	n/a
Probability	Probable (3)	n/a
Significance	**39 (medium)**	n/a
Status (positive or negative)	Negative	n/a
Reversibility	Moderate	n/a
Irreplaceable loss of resources	Yes (moderate)	n/a
Can impacts be mitigated	Low/none	

Mitigation:

Mitigation measures may be difficult and expensive, however, the possible measures to reduce volumes of water abstracted from the Orange River could include the following:

» Optimise the design or technology of the each solar power facility to reduce consumptive water requirements as far as possible.
» Adapt the abstraction regime to meet the EWR and requirements of other users where required.
» Implement the proposed dry cooling process

Cumulative impacts:

Cumulative impacts due to water abstraction in the Lower Orange River are already considered to be high and will be exacerbated by the abstractions for the Karoshoek project.

Residual impacts:

No residual impacts expected if water use is reduced as much as possible.

<table>
<tr><td colspan="3">Nature: Impact 4 - Water abstraction facility: Sediment input due to erosion and river bank damage

Increased sediment input could result from:
» Inadequate erosion control or containment of sediment-laden runoff during site clearing and construction activities for infrastructure at the abstraction points (e.g. pipelines and reservoirs).
It is assumed that refurbishment of the abstraction facility will be required, but that the current facility will be used.</td></tr>
<tr><td></td><td>Without mitigation</td><td>With mitigation</td></tr>
<tr><td>Extent</td><td>Site (2)</td><td>Local (1)</td></tr>
<tr><td>Duration</td><td>Short-term (2)</td><td>Very short-term (1)</td></tr>
<tr><td>Magnitude</td><td>Low (4)</td><td>Minor (1)</td></tr>
<tr><td>Probability</td><td>Probable (3)</td><td>Improbable (2)</td></tr>
<tr><td>Significance</td><td>24 (low)</td><td>6 (low)</td></tr>
<tr><td>Status (positive or negative)</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Reversibility</td><td>Yes (medium)</td><td>Yes (high)</td></tr>
<tr><td>Irreplaceable loss of resources</td><td>Yes (low)</td><td>Yes (low)</td></tr>
<tr><td>Can impacts be mitigated</td><td>Yes (high)</td><td></td></tr>
<tr><td colspan="3">Mitigation:
Mitigation measures can readily be implemented and include:
» Appropriate hard-engineered bank erosion protection structures.
» Careful rehabilitation using natural riparian vegetation to stabilize the riverbanks and all disturbed areas in the riparian zone.
» Storm water drains should be correctly located and designed with appropriate erosion-control features to ensure local storm water run-off over the flood embankments and natural riverbanks do not cause erosion and subsequent bank slumping.
» During construction, adjacent riparian habitats outside the “footprint” of the new infrastructure should be declared sensitive habitats and out of bounds for all construction activities and for all construction workers.
» Construction work should preferably take place in the dry winter months to avoid storm-water erosion of cleared areas and damage due to untimely river flooding.</td></tr>
<tr><td colspan="3">Cumulative impacts:
Cumulative impacts due to artificial elevation of the river banks, embankment construction and earthmoving activities in the floodplain of the Orange River has severely impacted on ecological functioning of the system. Further manipulation will exacerbate these impacts, but to a very limited degree with a localised impact.</td></tr>
<tr><td colspan="3">Residual impacts:
There will be a low residual impact due to the alteration of the river banks at the abstraction point.</td></tr>
</table>

<table>
<tr><td colspan="3">Nature: Impact 5 - Operation of the reservoir and high pressure sand filtration plant

The discharge of sediment-laden backwash water from the sand filter into a natural drainage line about 500 m from river could have a potential impact by discharging into and raising the turbidity of the Orange River, particularly due to the volumes expected when all plants are operational.</td></tr>
<tr><td></td><td>Without mitigation</td><td>With mitigation</td></tr>
<tr><td>Extent</td><td>Site (3)</td><td>Local (1)</td></tr>
</table>

Duration	Long-term (4)	Short (2)
Magnitude	Moderate (6)	Minor (2)
Probability	Highly probable (4)	Improbable (2)
Significance	**52 (medium)**	**10 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Yes (high)	Yes (high)
Irreplaceable loss of resources	Yes (low)	Yes (low)
Can impacts be mitigated	Yes (high)	
Mitigation: Mitigation measures could be readily applied and include the following: » The backwash water should be directed into a suitably designed retention pond to allow most of the sediment to settle out before the clear water is allowed to flow back to the river.		
Cumulative impacts: This will be a cumulative impact as it will add to the already elevated sediment load into the river due to agricultural activities.		
Residual impacts: Residual impacts should not be apparent if mitigation is correctly carried out.		

10. ENVIRONMENTAL MANAGEMENT PLAN (EMP) MEASURES

Project component/s	Site selection with regard to minimising the overall impact on the functioning of the riparian environment	
Potential impact	Loss of important habitat and fragmentation of the riverine systems	
Activity risk source	Placement of hard engineered surfaces	
Mitigation: Target / Objective	Select a favourable section of each site, having the least impact or within an area that is least sensitive	
Mitigation: Action/control	**Responsibility**	**Timeframe**
Minimise the loss of riparian habitat, i.e. physical removal	Developer	Planning and design phase
Performance indicator	N/A	
Monitoring	N/A	

Project component/s	Alteration of sandy substrata into hard surfaces impacting on the local hydrological regime	
Potential impact	Poor storm water management and alteration of the hydrological regime, particularly if all sites are managed poorly and a cumulative impact occurs	
Activity risk source	Placement of hard engineered surfaces	
Mitigation: Target / Objective	Conduct effective storm water management so as to reduce changes to the hydrological regime of the area	
Mitigation: Action/control	**Responsibility**	**Timeframe**
Reduce the impact of increased	Developer / Operator	Planning, design and operation phase

surface flow velocities on dry riverbeds by properly designed and implemented SWMPs		
Performance indicator	Indicators for water quantity management: flow monitoring	
Monitoring	Monitoring of flows leaving the plants according to specifications in DWA's water use license conditions	

Project component/s	Poor storm water management	
Potential impact	Risk of river system erosion and downstream sedimentation, resulting in changes in instream habitat	
Activity risk source	Placement of hard engineered surfaces	
Mitigation: Target / Objective	Any storm water within the site should be handled in a suitable manner, i.e. clean and dirty water streams around the plant and install stilling basins to capture large volumes of run-off, trapping sediments and reduce flow velocities (e.g. water used when washing the mirrors).	
Mitigation: Action/control	**Responsibility**	**Timeframe**
Minimise the potential impact by the supporting infrastructure in the riparian systems and properly designed and implemented SWMPs	Developer / Operator	Planning, design and operation phase
Performance indicator	Water quantity management criteria, e.g. monitoring flows as specified by DWA	
Monitoring	Surface water monitoring plan, to be developed along the requirements specified in the license conditions provided by DWA	

Project component/s	Placement and operation of access roads, pipelines and storage dams
Potential impact	Risk of river system erosion and downstream sedimentation, resulting in changes in instream habitat. This will be exacerbated if backwash water Is discharged from the sand filters back into the Orange River
Activity risk source	Placement of hard engineered surfaces and expansion of the abstraction point
Mitigation: Target / Objective	The placement of pump inlets and the supporting infrastructure so as to prevent the potential for scour / erosion and downstream sedimentation of the Orange River. The current abstraction point placement is within an area of dense reed growth (*Phragmites australis*), and would not be considered a severe impact. The risk of erosion and bank slumping or collapse during both pre-construction, construction work can readily be prevented by careful design and planning. Mitigation measures include: • Appropriate hard-engineered bank erosion protection structures. • Careful rehabilitation using natural riparian vegetation to stabilize the riverbanks and all disturbed areas in the riparian zone. • Local storm water run-off over the flood embankments and natural riverbanks could potentially cause erosion and subsequent bank slumping, unless storm water drains are correctly located and designed with appropriate erosion-control features. • During construction, adjacent riparian habitats outside the "footprint" of

	the new infrastructure should be declared sensitive habitats and out of bounds for all construction activities and for all construction workers. • Construction work (including site clearing and preparation for the solar power plants) should only take place in the dry winter months to avoid storm water erosion of cleared areas and damage due to untimely river flooding. • Storage dams should be lined in a suitable manner so as to prevent any groundwater contamination	
Mitigation: Action / control	**Responsibility**	**Timeframe**
Minimise the potential increase in sedimentation and erosion	Developer / Operator	Planning, design and operation phase
Performance indicator	Water quality and quantity management criteria, e.g. monitoring of instream biota downstream of the abstraction point – as specified by DWA	
Monitoring	Surface water monitoring plan, to be developed along the requirements specified in the license conditions provided by DWA	

Project component / s	The use of chemicals and hazardous substances during construction and operation	
Potential impact	These pollutants could be harmful to aquatic biota, particularly during low flows when dilution is reduced, and could also pose a health risk to locals using the river water for domestic purposes. Lime-containing (high pH) construction materials such as concrete, cement, grouts, etc. are highly toxic to fish and other aquatic biota.	
Activity risk source	Design, placement and operation of infrastructure	
Mitigation: Target / Objective	Management actions that are applicable to all the construction sites (particularly at the abstraction points) include: • Strict use and management of all hazardous materials used on site • Strict management of potential sources of pollution (hydrocarbons from vehicles and machinery, cement during construction, etc.) • Containment of all contaminated water, which includes any 'backwash" or process water that could be released back into the Orange River • Strict control over the behaviour of construction workers • Any current erosion or destabilization of the river banks due to existing structures in the vicinity of the abstraction sites should be repaired and stabilized as part of the present project • All areas adjacent to the hard-engineered erosion-control structures provided for this project, which are (accidently) disturbed and where riparian vegetation was destroyed during the construction activities, should to be rehabilitated using appropriate indigenous vegetation	
Mitigation: Action / control	**Responsibility**	**Timeframe**
Minimise the potential impact of pollutants entering the Orange River	Developer / Operator	Planning, design and operation phase
Performance indicator	Water quality management criteria, e.g. water quality monitoring of any waste streams on site and downstream in the Orange River; possibly including monitoring of instream biota – as specified by DWA	
Monitoring	Surface water and biological monitoring plan, to be developed along the requirements specified in the license conditions provided by DWA	

Project component/s	Impact of potential waste streams on rivers, particularly the Orange River	
Potential impact	Pollutants could be harmful to aquatic biota, particularly during low flows when dilution is reduced, and could also pose a health risk to locals using the river water for domestic purposes. Potential contaminants include brine from the evaporation ponds and sewage from the Sewage Treatment Works (STW)	
Activity risk source	Design, placement and operation of evaporation ponds and STW	
Mitigation: Target / Objective	Management actions that are applicable to all the construction sites (particularly at the abstraction points) include: • Strict management and effective operation of STW and evaporation ponds • Strict management of potential sources of pollution • Containment of all contaminated water	
Mitigation: Action/control	**Responsibility**	**Timeframe**
Minimise the potential impact of pollutants entering the Orange River	Developer / Operator	Planning, design and operation phase
Performance indicator	Water quality management criteria, e.g. water quality monitoring of any waste streams on site and downstream in the Orange River; possibly including monitoring of instream biota - as specified by DWA	
Monitoring	Surface water and biological monitoring plan, to be developed along the requirements specified in the license conditions provided by DWA	

11. CONCLUDING COMMENTS/IMPACT STATEMENT

With suitable mitigation and careful placement of the proposed plants, the development should have limited impact on the overall status of the riparian systems within the region. This desktop assessment of the potential impacts of the proposed development on the fish biota of Orange River also did not reveal any significant impacts on the fish fauna and associated aquatic habitats, provided the appropriate mitigation measures are taken. All impacts that were assessed as being of moderate significance could readily be reduced to low significance by appropriate mitigation, apart from the moderate impact of water abstraction from the Orange River. Note that little is known of the pattern of water abstraction. Should the abstraction be at a constant rate, impacts during low flows will be higher. It is anticipated that appropriate flow monitoring will be specified in DWA's water use license.

Impacts on the Orange River system due to water abstraction, and site-specific impacts on instream biota are difficult to quantify due to the highly regulated nature of the system. Releases from the Vanderkloof Dam would affect the site, although release patterns are re-evaluated every year to provide for irrigators and is therefore well known. Eskom requirements also play a role in release strategies. A 280 million m^3/a

release for the estuary is also made as variable base flows over 12 months, although it is unknown as to whether this water actually reaches the estuary. A study is currently underway on the Lower Orange River in Namibia which may be able to confirm flows reaching the estuary. Operating losses and requirements (such as to top up the upstream Boegoeberg Dam after draining it for cleaning) are also included in this allocation. Note that Boegoeberg Dam (upstream of Upington) is not used to operate flows into the river, but rather as a diversion weir for the canal systems. The only flows from this dam into the Orange River are spills and when bottom releases are made (approximately once a year) to clean the dam (WRP Consulting, pers. comm., September 2010, for the ORASECOM EFR study).

In conclusion, the facility is deemed to have a **limited to moderate** potential impact on the aquatic environment, considering the highly regulated nature of the Orange River system. The only significant risk to the project is the water use license not being granted by the Department of Water Affairs. Although dry cooling will be practiced, the Orange River system is under pressure in terms of water requirements.

11. REFERENCES

COLLOTY, B.M. & SCHERMAN, P-A. (2011). Project Ilanga Solar Thermal Power Plant, Northern Cape Province. EIA Phase Report: Water Resources Assessment Specialist Report. Produced for Savannah Environmental by Scherman Colloty & Associates.

DWAF (2005). A practical field procedure for identification and delineation of wetland and riparian areas Edition 1. Department of Water Affairs and Forestry, Pretoria

DWAF (2008). Methods for determining the water quality component of the Ecological Reserve. Report prepared for Department of Water Affairs and Forestry, Pretoria, South Africa by P-A Scherman of Scherman Consulting.

GERMISHUIZEN, G. & MEYER, N L. (eds) (2003). Plants of southern Africa: an annotated checklist. Strelitzia 14, South African National Biodiversity Institute, Pretoria.

HAMPEL, M. (2011). Technical Report. Part 1: Site Assessment Report: Summary. Ilangalethu Solar Power (Pty.) Ltd. Technical consulting services for CSP technology. Lahmeyer International.

IMPSON, D. & SWARTZ, E. (2007). *Labeobarbus kimberleyensis*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.3. <www.iucnredlist.org>. Downloaded on 18 April 2010.

IUCN (2010). The IUCN Red List of Threatened Species. Version 2010.2. www.iucnredlist.org.

LORMS (2005). Lower Orange River Management Strategy, Specialist Report on the Environmental Flow Requirements - Riverine PB D000/00/4503. Department of Water Affairs, Pretoria.

LOUW, M. D. (2010). Work package 5: Assessment of Environmental Flow Requirements. Deliverable 10: Resource Unit delineation. Draft Report prepared for ORASECOM, July 2010.

LOUW, M. D. and KOEKEMOER S. (editors) (2010). Deliverable 12: Volume 1: Environmental Flow Requirements produced for WRP. Support to Phase II ORASECOM Basin Wide Integrated Water Resources Management Plan, November 2010.

MUCINA, L. & RUTHERFORD, M.C. (2006). South African vegetation map. South African National Biodiversity Institute – Accessed: http:// bgis.sanbi.org/vegmap/map.asp, 15 September 2010.

ORASECOM (2007). Water quality in the Orange River: Orange River Integrated Water Resources Management Plan. Prepared by Coleman, T and van Niekerk, A. ORASECOM Report 007/2007.

SAVANNAH ENVIRONMENTAL (2010). Final Environmental Impact Assessment Report: Proposed Upington Solar Thermal Plant and associated infrastructure on a site near Upington, Northern Cape Province, for Khi CSP South Africa (Pty) Ltd. Appendix H: Water resources assessment study. Authored by Scherman P-A, Colloty BM and Bok A.

SCHERMAN, P-A. (2010a). Coega Ridge housing development: Environmental Impact Assessment – hydrological specialist study. Report produced for SRK Consulting. September 2010.

SCHERMAN, P-A. (2010b). Work package 5: Assessment of Environmental Flow Requirements. Water quality draft report: Orange River. October 2010.

SKELTON, P. H. (2003). *A Complete Guide to the Freshwater Fishes of Southern Africa*. Struik Publishers, Cape Town, South Africa. 395 pp.

SWARTZ, E., BILLS, R. & IMPSON, D. (2007). *Austroglanis sclateri*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on May 2011.

SWARTZ, E. & IMPSON, D. (2007). *Barbus hospes*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 18 April 2010.

WHITFIELD, A.K. and PATERSON, A.W. (1995). Flood-associated mass mortality of fishes in the Sundays Estuary. *Water SA* **21**: 385-389.

WORLEYPARSONS (2011). Ilangalethu Solar Power: Preliminary Design and Scoping Report for Bulk Water Supply. 254660JN0 – Document Number.