DIGBY WELLS
ENVIRONMENTAL

# Environmental Impact Assessment for proposed Future Developments within the Sun City Complex

# Surface Water and Groundwater Impact Assessment Report

**Project Number:**

SUN4642

**Prepared for:**

Sun International (Sun City Resort)

September 2018

Digby Wells and Associates (South Africa) (Pty) Ltd
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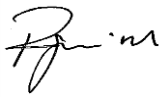
This document has been prepared by Digby Wells Environmental.

| | |
|---|---|
| **Report Type:** | **Surface Water and Groundwater Impact Assessment Report** |
| **Project Name:** | **Environmental Impact Assessment for proposed Future Developments within the Sun City Complex** |
| **Project Code:** | **SUN4642** |

| Name | Responsibility | Signature | Date |
|---|---|---|---|
| Simamkele Baqa | Report Writer |  | April & June 2018 |
| Robel Gebrekristos | Reviewer: Senior Hydrogeologist |  | April 2018 |
| Mashudu Rafundisani | Review: Hydrologist |  | June 2018<br>September 2018 |
| Andre van Coller | Review: Divisional Manager |  | June 2018 |

# EXECUTIVE SUMMARY

Digby Wells Environmental has been appointed by Sun City Resort to undertake an Environmental Impact Assessment (EIA) in relation to proposed future developments within the Sun City Resort Complex located near Rustenburg, North West Province. This groundwater and surface water assessment report forms part of the environmental regulatory process to assess the baseline groundwater and surface water conditions, potential impacts and mitigation plans pertaining to the groundwater and surface water environment during the construction, operation and post closure of the Sun City Report Complex.

The following conclusions and recommendations were made from the impact assessment:

- The Sun City Resort Complex is characterised by two types of aquifers; a shallow near surface weathered zone and a deep unconfined fractured rock aquifer. The shallow near surface weathered zone correlates with the shallow circulating low fluoride cold groundwater overlying the deep confined fractured rock aquifer characterised by deep circulating thermal groundwater enriched with fluoride. Groundwater flow mimics the topographic relief and as result flows radially or outward from the centre of the PARC.
- The surface and groundwater quality indicates that there is an impact on quality of water and this is mainly due to discharged wastewater, landfill (waste facility), and natural processes of the underlying geology.
- Previous construction and/ or development activities are not believed to have impacted surface water and groundwater except for the treated wastewater discharged in to the dams and the landfill facility which is in a decommissioning process. Therefore, it is deemed that the proposed new activities and developments will also similarly have a negligible impact on the environment if managed in a similar of even better manner. This can be achieved through compliance with the DWS guidelines including good monitoring programs and implementing mitigation options.
- Based on the above conclusion it is deemed that both the current surface water and groundwater environment is not sensitive to the proposed activities if managed well.

Further hydrogeological assessments are recommended to gain site specific rock permeability values through borehole drilling and aquifer testing, particularly in the shallow weathered aquifer. This will also enable to collect more groundwater samples for a more accurate groundwater quality analysis as well as to collect groundwater level measurement to construct a potentiometric surface map.

The recommended mitigation plans include:

- Site clearing should be restricted to areas of absolute necessity and the activity should be conducted over a short duration, if possible;
- Natural vegetation should be restored where possible to maintain site specific hydrological conditions. This will minimise flood occurrences and also maintain surface water quality conditions within the project area;
- Site clearance and construction activities should take place above the water table, at the unsaturated zone, (if possible). No impact on the groundwater quantity will then be expected;
- If drains are going to be excavated below the water level, dewatering of the aquifer to lower the water table locally should be considered to ensure that the construction takes place above the groundwater level;
- Surface and groundwater monitoring should be conducted to assess the time series water level, water quality impacts and to observe trends as to aid decision making. Surface water monitoring is recommended to be implemented particularly downstream from the Recreational dam as well as downstream from the vacation club development (LG2) and the development footprint area (RL4). Groundwater monitoring is recommended to be implemented particularly downstream of the landfill site which has shown to be a source of groundwater contamination; and
- Investigations on the shallow weathered aquifer such as Borehole GPCC3 are recommended as it was dry during the time of sampling and it is only recharged during rainy season.

During the closure/post-closure phase, management solutions should be sought in agreement with the farmers or communities and/ or with interested and affected parties within the area particularly those utilising groundwater and surface water for both domestic and commercial purposes

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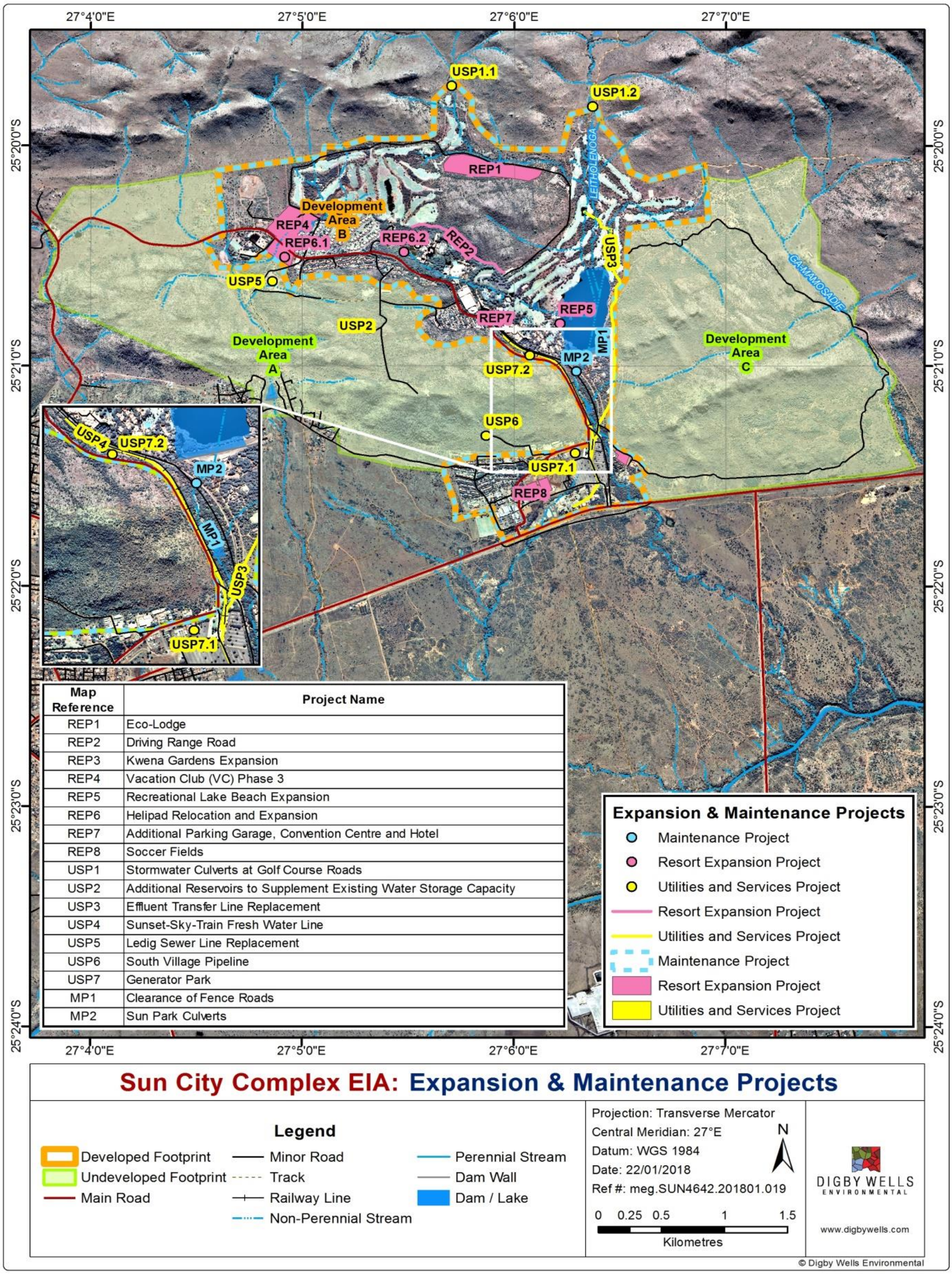
# 1 Introduction

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Sun City Resort to undertake an Environmental Impact Assessment (EIA) in relation to proposed future developments within the Sun City Resort Complex (Figure 1-1) located near Rustenburg, North West Province. The proposed activities involve the following:

- Resort Expansion Projects:
  - Development of a Bush Lodge / Eco-Lodge at Bakubung - West gate;
  - Construct a Road to connect the Driving Range at Lost City Golf Course (LCGC) to the Gary Player Golf Course (GPGC) via the Palace garden road and Valley of Waves (VOW) road;
  - Construct 20 additional Rustic Chalets at Kwena Gardens;
  - Construct an additional 150 simplex units, 2-3 bed units and associated infrastructure to expand capacity at the Vacation Club (VC Phase 3);
  - Expand the existing artificial beach at the Lake and construct an additional shallow swimming pool at Waterworld Beach;
  - Decommission the existing helipad, to make space for VC Phase 3, and construct a new helipad with increased bays closer to the Palace;
  - Construct an additional parking garage, Convention Centre and Hotel (250 rooms) including a bridge link from Sun Central to the new Hotel; and
  - Develop 2 soccer fields at the Warehouse, on the old Motocross track.
- Utilities and Services Projects:
  - Install Stormwater pipes / culverts at both Golf Course Roads to allow water to flow under the roads and maintain the road surface for fence inspections by security (prevent floods washing away the road);
  - Construct 2 x 10Ml reservoirs or alternatively 1x 20Ml Reservoir on Telkom Hill next to existing Upper Reservoir, to supplement water storage capacity;
  - Currently there is an effluent transfer line (old asbestos line) through Sunset Drive to Hole 2. This line will be decommissioned (shut down) but remain in place. A new line will then be installed against the fence of Letsatsing;
  - Construct a main water line from the Welcome Centre to Sky Train (pipe will be attached to skytrain route)
  - Currently the sewer line running through Ledig (old asbestos line) is leaking. The line will be decommissioned (shut down but remain in place). A new Waste Water Treatment Works (WWTW) will be established to manage sewage from VC and The Palace;

- Construct an additional pipeline for water supply to South Village; and
- Consolidate the generators throughout the site into one area for effective monitoring and control.

- Maintenance Projects:
  - Vegetation Clearance at perimeter fences to serve as maintenance roads and Fire Breaks (25 km); and
  - Clear the Culverts under the road at Sun Park from debris and siltation. Construct maintenance road to facilitate future maintenance.




| Map Reference | Project Name |
|---|---|
| REP1 | Eco-Lodge |
| REP2 | Driving Range Road |
| REP3 | Kwena Gardens Expansion |
| REP4 | Vacation Club (VC) Phase 3 |
| REP5 | Recreational Lake Beach Expansion |
| REP6 | Helipad Relocation and Expansion |
| REP7 | Additional Parking Garage, Convention Centre and Hotel |
| REP8 | Soccer Fields |
| USP1 | Stormwater Culverts at Golf Course Roads |
| USP2 | Additional Reservoirs to Supplement Existing Water Storage Capacity |
| USP3 | Effluent Transfer Line Replacement |
| USP4 | Sunset-Sky-Train Fresh Water Line |
| USP5 | Ledig Sewer Line Replacement |
| USP6 | South Village Pipeline |
| USP7 | Generator Park |
| MP1 | Clearance of Fence Roads |
| MP2 | Sun Park Culverts |

**Figure 1-1: Infrastructure Development Plan**

Activities that are listed in terms of the Environmental Impact Assessment (EIA) Regulations[1] require environmental authorisation prior to commencing. The proposed Projects at Sun City constitute Listed Activities in terms of GN R 983 (Listing Notice 1); GN R 984 (Listing Notice 2) and GN R 985 (Listing Notice 3) as amended.

This specialist ground- and surface water impact assessment study has been compiled in terms of Appendix 6 of the NEMA EIA Regulations, 2014, (as amended) in terms of the Scoping and EIA process which is being followed in applying for Environmental Authorisation.

The requirements of Appendix 6 are presented in Table 1-1 and cross-referenced to the relevant sections of this Report.

**Table 1-1: Structure of this report in accordance with the EIA Regulations**

| Regulatory Requirement for EIA Reports | Relevant Section of this report |
|---|---|
| 1. (1) A specialist report prepared in terms of these Regulations must contain - | |
| (a) details of—<br>(i) the specialist who prepared the report; and<br>(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae; | Please refer to Section 2 of this Report |
| (b) a declaration that the specialist is independent in a form as may be specified by the competent authority; | Please refer to Section 2 of this report: |
| (c) an indication of the scope of, and the purpose for which, the report was prepared; | Please see Section 3 |
| (cA) an indication of the quality and age of base data used for the specialist report; | Please see Section 4 |
| (cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change; | Please see Section 6 and Section 7 |
| (d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment; | Please see Section 4 |
| (e) a description of the methodology adopted in preparing the report inclusive of equipment and modelling used; | Please see Section 5 |
| (f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives; | Please see Section 8 |

[1] As published in Government Notices R982; 983; 984 and 985 on 4 December 2014, as Amended 7 April 2017.

| Regulatory Requirement for EIA Reports | Relevant Section of this report |
|---|---|
| (g) an identification of any areas to be avoided, including buffers; | Please see Section 8 |
| (h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | Please see Section 8 |
| (i) a description of any assumptions made and any uncertainties or gaps in knowledge; | Please see Section 10 |
| (j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities; | Please see Section 7 |
| (k) any mitigation measures for inclusion in the EMPr; | Please see Section 11 |
| (l) any conditions for inclusion in the environmental authorisation; | |
| (m) any monitoring requirements for inclusion in the EMPr or environmental authorisation; | Please see Section 11 |
| (n) a reasoned opinion—<br>(i) whether the proposed activity, activities or portions thereof should be authorised;<br>(i) (A) regarding the acceptability of the proposed activity or activities; and<br>(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; | Please see Section 11 |
| (o) a description of any consultation process that was undertaken during the course of preparing the specialist report; | No consultation required for Groundwater and Surface water. |
| (p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | |
| (q) any other information requested by the competent authority. | No additional information was requested. |

## 1.1 Site Description

Sun City is located approximately 40 kilometres (km) northwest of Rustenburg adjacent to the Pilanesberg National Park (Figure 1-2). The Sun City Resort Complex is a family holiday resort which provides entertainment to guests who visit the Resort from all over the world on a daily bases. The resort (Sun City) comprises of various business ventures which include, but is not limit to four hotels, a crocodile sanctuary, the Valley of Waves and sporting and recreational facilities of which the Nedbank Golf Challenge is a very high profile event.

The Sun City Resort Complex comprises features such as recreational dams, a landfill site and a WWTW which treats all sewage generated on the complex. Treated effluent is then used for irrigation of the Gary Player and Lost City Golf Courses. Further, surface water runoffs including the effluent generated during the back washing of the swimming pools on site, water leaking from pipelines runoff to the Recreational Dam from where it can be used as make up water for irrigation of the Golf Courses and Vacation Club Gardens.

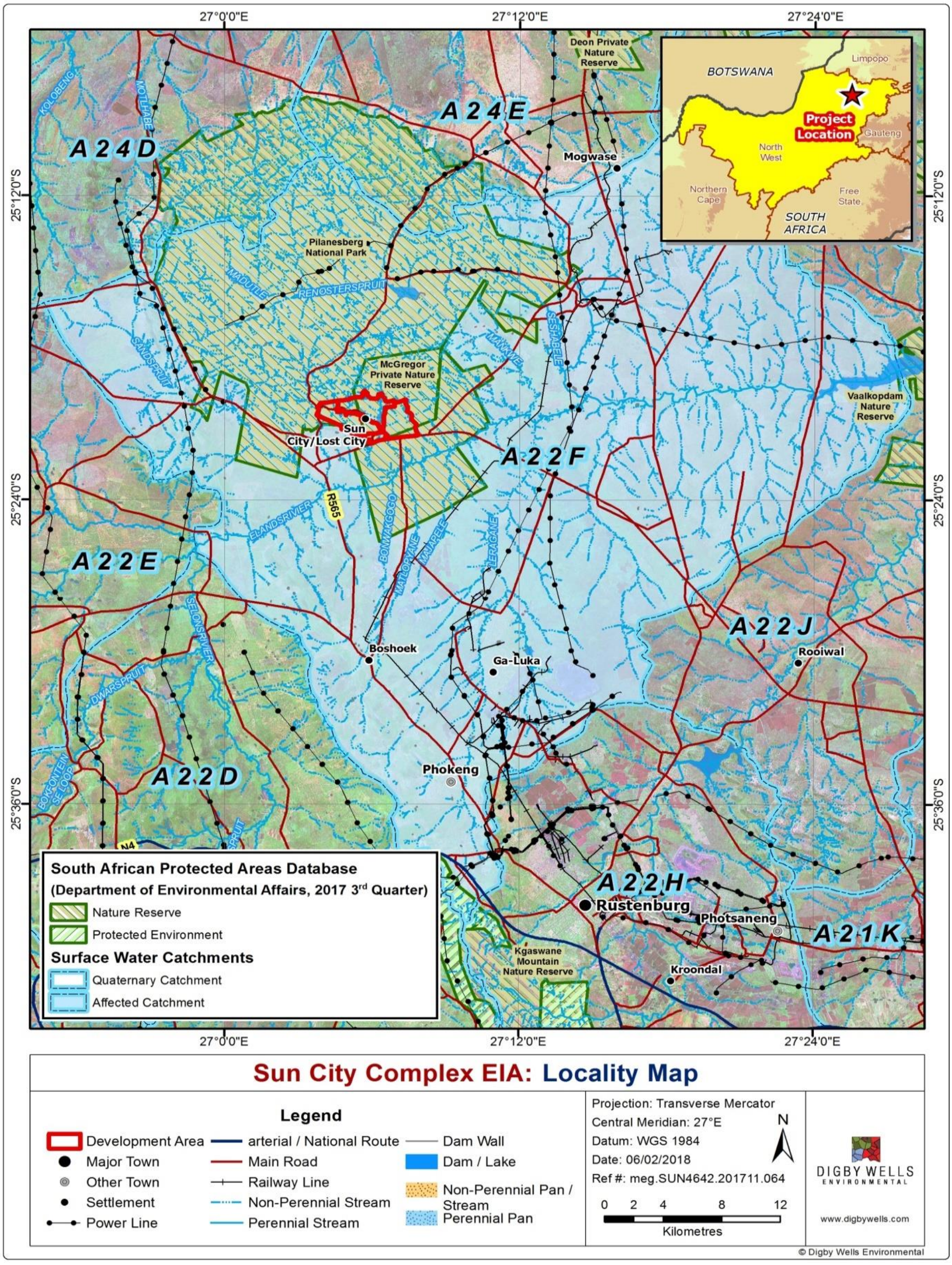



**Figure 1-2: Local Setting**

### 1.1.1 Topography and Drainage

The project area falls within the Pilanesberg Mountain range within the Moses Kotane Local Municipality; a category B municipality located within the Bojanele District Municipality in the North West Province. The Pilanesberg mountain range forms within the world`s largest and best preserved alkaline ring dykes. The Pilanesberg Ring Complex delineates an almost perfect circle with east-west diameter of 27.96 km and north-south diameter of 23.1 km. The near concentric rings of hills are formed from various rocks of igneous origin (Pantshi, 2006; Jones and Wagener, 2017).

The Pilanesberg area is located within the Limpopo River Basin (Primary Catchment A) within the Crocodile West and Marico Water Management Area (WMA). The project area falls within quaternary catchment A22F (Figure 1-2). The A22F catchment surface area covers about 151 423 ha with mean annual run-off 16.3 mm and mean annual recharge of 2.7 % of mean annual precipitation (Pachnoda Consulting, 2013). The catchment is characterised by a series of non-perennial[2] and ephemeral[3] rivers with limited surface water resources such as small dams and wetlands. Such small dams and wetlands play a significant role to attenuate floods, improve on the water quality and maintain stream flow (DWAF, 2010). All surface flows (including effluent discharge) originate within the region and follows a radial pattern outward. Generally, an eccentric or radial river pattern is indicative of geological control such as an igneous intrusion or volcanic event. Mostly, riverbeds are confounded through bedrocks consisting of sand and gravel configurations sited within the pools which are linked with wide-ranging alluvial flood planes or fine-grained over-bank deposits (Jones and Wagener, 2017).

According to the 1:50 000 topographical maps, the following non-perennial streams drain the development area:

- An unnamed stream to the west that drains the landfill site, Lost City Golf Course (LCGC) and Vacation Club;
- The Leitholenoga that drains the central areas such as the Lost City, Cascades, Valley of the Waves, Cabanas, Gary Player Golf Course (GPGC) and Kwena Gardens; and
- The Ga-Mamosadie to the east that mostly drains a natural undeveloped area.

The above streams drain into the Elands River located 5 km south of Sun City. At the time of the site visit, the Elands River was found to be dry. The Elands River is a tributary of the Crocodile River, which flows into the Limpopo River.

[2] Non-perennial is known to have no flow for at least part of the year. Such rivers are also known as periodic rivers and include semi-permanent, ephemeral and episodic rivers.

[3] Ephemeral rivers are known as rivers that flow for short period of time in response to unpredictable high rainfall events.

### 1.1.2 Climate

The project area falls within the semi-arid climate region of Southern Africa, where rainfall is sparse with seasonal variations during wet and dry seasons. Wet (or rainy) seasons occur during summer months, October to March and is characterised by short, intense convective storms. Dry seasons occur during winter time (April – September) and are characterised by dry cold weather conditions.

Average annual rainfall varies from 550 to 650 mm/yr (Pachnoda Consulting, 2013; Jones and Wagener, 2017). Average daily temperatures during summer months vary from 27˚C to 30˚C while in winter vary from 20˚C to 24˚C. The mean annual temperature is 18.6˚C (Mucina and Rashford, 2006 in Pachnoda Consulting, 2013). In general, the mean annual evaporation surpasses the mean annual rainfall by a factor of 2 to 3 times and which makes groundwater one of the most significant water resources not only for water supply but also for sustainable livelihood.

## 2 Details of the Specialist

This Specialist Report has been compiled by the following specialists (CVs of the Project Team are included in Appendix A):

**Table 2-1: Details of the Specialist(s) who prepared this Report**

| | |
|---|---|
| **Responsibility** | Report Writing |
| **Full Name of Specialist** | Simamkele Baqa |
| **Highest Qualification** | MSc Hydrogeology |
| **Years of experience in specialist field** | 0-1 |
| **Responsibility** | Report Review |
| **Full Name of Specialist** | Mashudu Rafundisani |
| **Highest Qualification** | BSc Environmental Management |
| **Years of experience in specialist field** | 5 |
| **Responsibility** | Report Review |
| **Full Name of Specialist** | Robel Gebrekristos |
| **Highest Qualification** | PhD Hydrogeology |
| **Years of experience in specialist field** | 16 |
| **Responsibility** | Report Review |
| **Full Name of Specialist** | Andre van Coller |
| **Highest Qualification** | MSc Geohydrology |

| | |
|---|---|
| **Years of experience in specialist field** | 10 years |

## 2.1 Declaration of the Specialist

I, **Simamkele Baqa**, as the appointed specialists hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
- other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity; or
- am not independent, but another specialist that meets the general requirements set out in Regulation 13 have been appointed to review my work (Note: a declaration by the review specialist must be submitted);
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application;
- have ensured/will ensure that information containing all relevant facts in respect of the application was/will be distributed or was/will be made available to interested and affected parties and the public and that participation by interested and affected parties was/will be facilitated in such a manner that all interested and affected parties were/will be provided with a reasonable opportunity to participate and to provide comments;
- have ensured/will ensure that the comments of all interested and affected parties were/will be considered, recorded and submitted to the Department in respect of the application;
- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant;

- have kept/will keep a register of all interested and affected parties that participate/d in the public participation process; and
- I am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Simamkele Baqa

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

April and June 2018

Date

I, **Mashudu Rafundisani**, as the appointed specialists hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
- other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity; or
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- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant;
- have kept/will keep a register of all interested and affected parties that participate/d in the public participation process; and
- I am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Mashudu Rafundisani

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

June 2018

Date

I, **Dr Robel Gebrekristos**, as the appointed specialist hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
- other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity;
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
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- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant;
- have kept/will keep a register of all interested and affected parties that participate/d in the public participation process; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Dr Robel Gebrekristos

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

April 2018

Date

I, **Andre van Coller**, as the appointed specialists hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
- other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity;
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- have kept/will keep a register of all interested and affected parties that participate/d in the public participation process; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Andre van Coller

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

June 2018

Date

# 3 Study Objectives

An essential to attain the required authorisation for the Sun City Resort Complex project is undertaking a detailed surface and groundwater impact assessment study.

The objective of the study includes the assessment of the potential impacts and mitigation plans for the proposed Sun City Resort Complex development project on the groundwater and surface water resources.

The specific objectives of the study include:

- Detailing the baseline surface water and groundwater characteristics. This represents the baseline surface water and groundwater quality, and flow characteristics within the proposed project area;
- Identifying potential impacts that can arise as part of the proposed activity; and
- Recommend on the potential mitigation measures to be implemented.

This specialist surface water and groundwater impact assessment study was undertaken in line with the Department of Water and Sanitation (DWS) Best Practice Guideline for Impact Prediction and is guided by following legislative requirements: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA); Regulation 636 under the National Environmental Management: Waste Act; National Water Act (Act 36 of 1998) (NWA); and NWA amendment of Regulation 704 (GN R 704) of 1999.

# 4 Data used in this report

Quantitative and qualitative research approaches were utilized in the acquisition of all relevant hydrological and hydrogeological background data. This included the following:

- Field work data
  - Field work was conducted in November 2017 as part of the screening process. Groundwater and surface water samples were collected to characterise baseline groundwater and surface water quality. Further, groundwater level measurements were made in order to characterise groundwater flow system. Due to limited number of measurements made the potentiometric surface map could not be constructed.
- Desktop study
  - A review of the literature conducted within the greater Pilanesberg area was made to provide an understanding of the baseline hydrological and hydrogeological background. The reviewed literature included geological, hydrogeological and surface water hydrology maps, reports and other database from various sources.

## 4.1 Details of the site visit

Sampling sites were selected based on the proposed project area and the existing surface geology maps within the Sun City Resort Complex. Groundwater and surface water samples were collected to obtain the baseline water quality parameters within the project area.

# 5 Methodology

This section of the report describes the methodology adopted in determining the status quo of the Sun City Resort Complex's hydrological system.

### 5.1.1 Desktop Study

In depth analyses of all relevant and available data such as reports, data sheets, proposals and maps was undertaken to develop a conceptual understating on the groundwater and surface water characteristics (i.e. quality, occurrence and flow regimes). Ultimately, the reviewed literatures were utilised to compile baseline information to feed into the EIA report.

### 5.1.2 Field Work

A hydrocensus was conducted in November 2017 to provide an understanding of the baseline environment in the area. The following information was collected for each site:

- The status of the sampling site or borehole;
- Sampling site coordinates (X, Y and Z position) using a GPS;
- Field pH, EC and TDS values; and
- Primary use and/ or abstraction rates.

A total of three boreholes (Kwena BH, Landfill BH and GPCC3BH) and five surface water sampling site were identified as shown in Figure 5-1 and Figure 5-2, respectively. Borehole Kwena BH and Landfill BH were sampled, while GPCC3BH was dry. All surface water sampling sites were sampled.

The samples were sent to a SANAS accredited laboratory (Aquatico) for analysis. The analysis was performed for inorganic constituents as show in Table 5-1.

**Table 5-1: Inorganic constituents analysed**

| | |
|---|---|
| pH | Sulphate ($SO_4$) |
| Electrical Conductivity (EC) | Ammonium ($NH_4$) |
| P-Alkalinity (PALK) | Potassium (K) |
| Total Alkalinity (TALK) | Nitrate ($NO_3$-N) |
| Iron (Fe) | Chromium (Cr) |
| Manganese (Mn) | Phosphate ($PO_4$-P) |
| Chloride (Cl) | Fluoride (F) |
| Magnesium (Mg) | Arsenic (As) |

| | |
|---|---|
| Sodium (Na) | Cadmium (Cd) |
| Aluminum (Al) | Lead (Pb) |
| Calcium (Ca) | Copper (Cu) |
| Zinc (Zn) | Cobalt (Co) |
| Nickel (Ni) | Total cations |
| Total anions | Ionic balance |

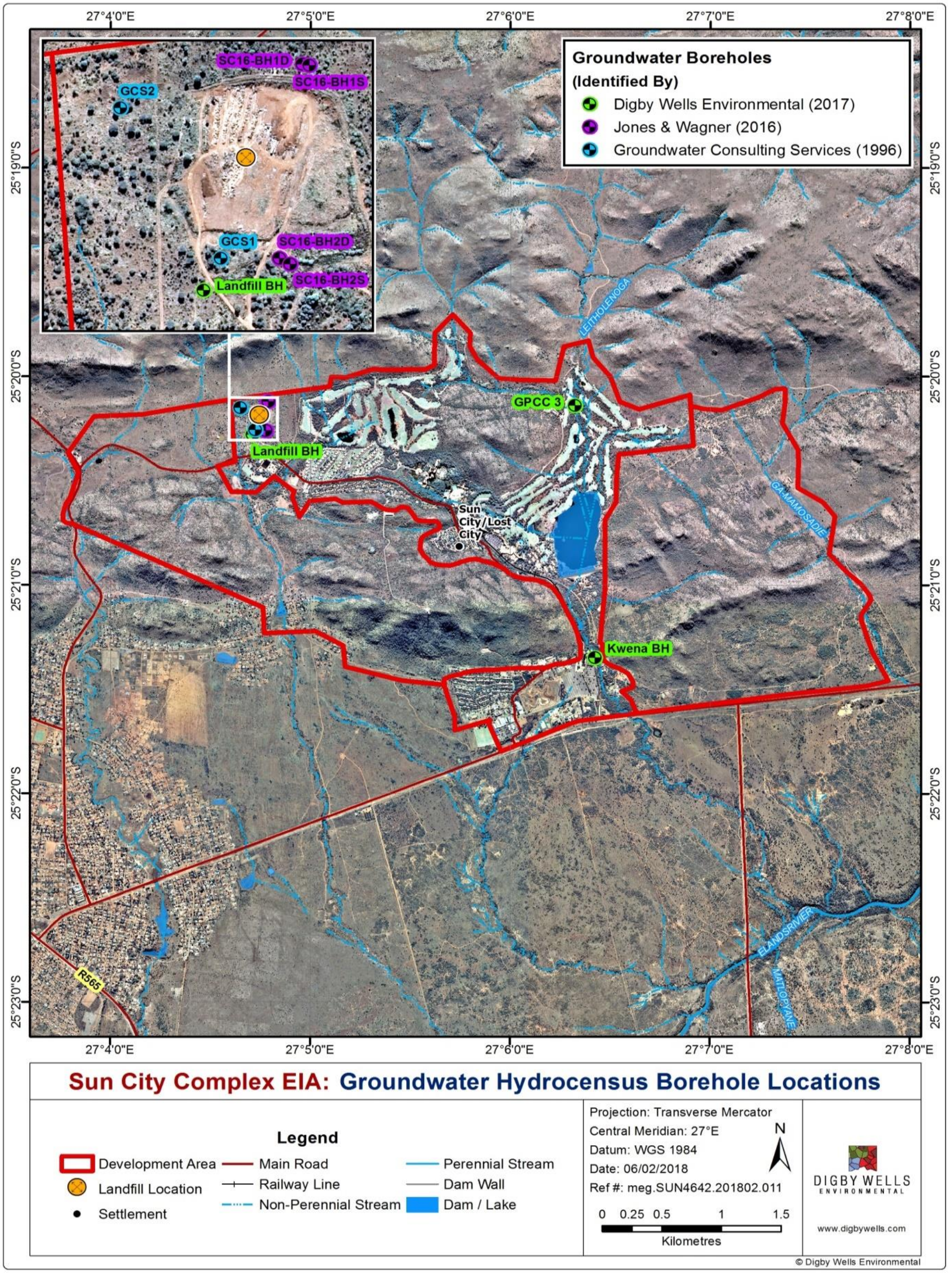


**Figure 5-1: Groundwater sampling sites**

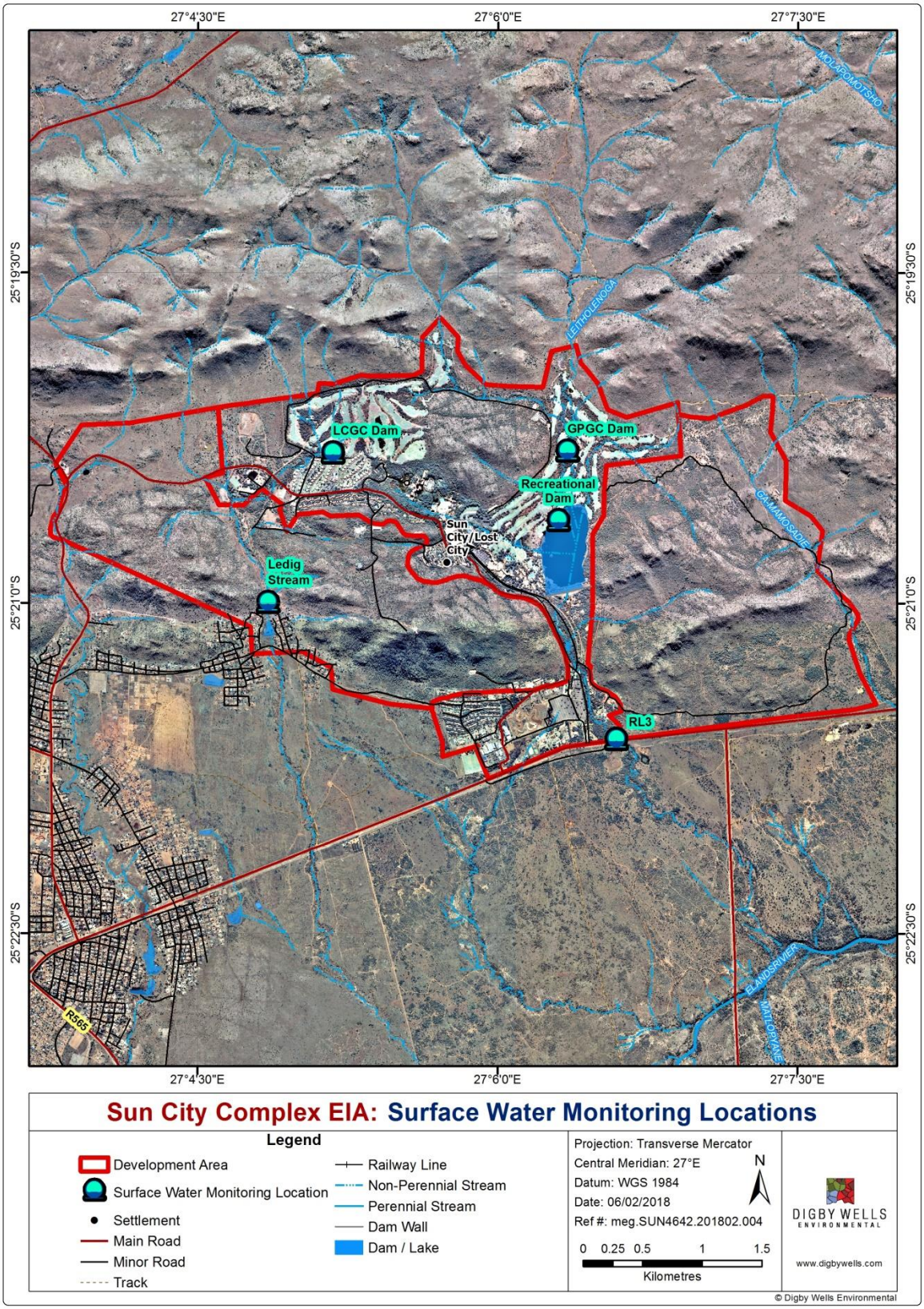


**Figure 5-2: Surface water sampling sites**

## 5.2 Impact Assessment Methodology

Impacts and risks were identified based on a description of the activities to be undertaken. Once impacts were identified, a numerical environmental significance rating process was undertaken which utilises the probability of an event occurring and the severity of the impact as factors to determine the significance of a particular environmental impact.

The severity of an impact was determined by taking the spatial extent, the duration and the severity of the impacts into consideration. The probability of an impact was then determined by the frequency at which the activity takes place or is likely to take place and by how often the type of impact in question has taken place in similar circumstances.

Following the identification and significance ratings of potential impacts, mitigation and management measures were incorporated into the EMP.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = CONSEQUENCE X PROBABILITY X NATURE

Where

Consequence = intensity + extent + duration

And

Probability = likelihood of an impact occurring

And

Nature = positive (+1) or negative (-1) impact

The matrix (Table 5-3) calculates the rating out of 147, whereby intensity, extent, duration and probability are each rated out of seven as indicated in Table 5-2. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation has been applied; post-mitigation is referred to as the residual impact. The significance of an impact is determined and categorised into one of seven categories (The descriptions of the significance ratings are presented in Table 5-4).

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, (i.e., there may already be some mitigation included in the engineering design). If the specialist determines the potential impact is still too high, additional mitigation measures are proposed.

## Table 5-2: Impact assessment parameter ratings

| Rating | Intensity/ Replicability | | Extent | Duration/Reversibility | Probability |
|---|---|---|---|---|---|
| | **Negative Impacts (Nature = -1)** | **Positive Impacts (Nature = +1)** | | | |
| 7 | Irreplaceable loss or damage to biological or physical resources or **highly** sensitive environments.<br>Irreplaceable damage to **highly sensitive** cultural/social resources. | Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline. | International<br>The effect will occur across international borders. | Permanent: The impact is irreversible, even with management, and will remain after the life of the project. | Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability. |
| 6 | Irreplaceable loss or damage to biological or physical resources or **moderate to highly** sensitive environments.<br>Irreplaceable damage to cultural/social resources of **moderate to highly** sensitivity. | Great improvement to the overall conditions of a large percentage of the baseline. | National<br>Will affect the entire country. | Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management. | Almost certain / Highly probable: It is most likely that the impact will occur.>65 but <80% probability. |

| Rating | Intensity/ Replicability | | Extent | Duration/Reversibility | Probability |
|---|---|---|---|---|---|
| | **Negative Impacts (Nature = -1)** | **Positive Impacts (Nature = +1)** | | | |
| 5 | Serious loss and/or damage to physical or biological resources or **highly** sensitive environments, limiting ecosystem function.<br>Very serious widespread social impacts. Irreparable damage to highly valued items. | On-going and widespread benefits to local communities and natural features of the landscape. | Province/ Region<br>Will affect the entire province or region. | Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management. | Likely: The impact may occur. <65% probability. |
| 4 | Serious loss and/or damage to physical or biological resources or **moderately** sensitive environments, limiting ecosystem function.<br>On-going serious social issues. Significant damage to structures / items of cultural significance. | Average to intense natural and / or social benefits to some elements of the baseline. | Municipal Area<br>Will affect the whole municipal area. | Long term: 6-15 years and impact can be reversed with management. | Probable: Has occurred here or elsewhere and could therefore occur. <50% probability. |

| Rating | Intensity/ Replicability | | Extent | Duration/Reversibility | Probability |
|---|---|---|---|---|---|
| | **Negative Impacts (Nature = -1)** | **Positive Impacts (Nature = +1)** | | | |
| 3 | Moderate loss and/or damage to biological or physical resources of **low to moderately** sensitive environments and, limiting ecosystem function.<br>On-going social issues. Damage to items of cultural significance. | Average, on-going positive benefits, not widespread but felt by some elements of the baseline. | Local<br>Local including the site and its immediate surrounding area. | Medium term: 1-5 years and impact can be reversed with minimal management. | Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability. |
| 2 | **Minor loss and/or effects** to biological or physical resources or low sensitive environments, not affecting ecosystem functioning.<br>Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected. | Low positive impacts experience by a small percentage of the baseline. | Limited<br>Limited extending only as far as the development site area. | Short term: Less than 1 year and is reversible. | Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability. |

| Rating | Intensity/ Replicability | | Extent | Duration/Reversibility | Probability |
|---|---|---|---|---|---|
| | **Negative Impacts (Nature = -1)** | **Positive Impacts (Nature = +1)** | | | |
| 1 | **Minimal to no loss** and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures. | Some low-level natural and / or social benefits felt by a very small percentage of the baseline. | Very limited/Isolated Limited to specific isolated parts of the site. | Immediate: Less than 1 month and is completely reversible without management. | Highly unlikely / None: Expected never to happen. <1% probability. |

## Table 5-3: Probability/consequence matrix

| Significance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -147 | -140 | -133 | -126 | -119 | -112 | -105 | -98 | -91 | -84 | -77 | -70 | -63 | -56 | -49 | -42 | -35 | -28 | -21 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 | 84 | 91 | 98 | 105 | 112 | 119 | 126 | 133 | 140 | 147 |
| -126 | -120 | -114 | -108 | -102 | -96 | -90 | -84 | -78 | -72 | -66 | -60 | -54 | -48 | -42 | -36 | -30 | -24 | -18 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 | 78 | 84 | 90 | 96 | 102 | 108 | 114 | 120 | 126 |
| -105 | -100 | -95 | -90 | -85 | -80 | -75 | -70 | -65 | -60 | -55 | -50 | -45 | -40 | -35 | -30 | -25 | -20 | -15 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 |
| -84 | -80 | -76 | -72 | -68 | -64 | -60 | -56 | -52 | -48 | -44 | -40 | -36 | -32 | -28 | -24 | -20 | -16 | -12 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | 80 | 84 |
| -63 | -60 | -57 | -54 | -51 | -48 | -45 | -42 | -39 | -36 | -33 | -30 | -27 | -24 | -21 | -18 | -15 | -12 | -9 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 | 48 | 51 | 54 | 57 | 60 | 63 |
| -42 | -40 | -38 | -36 | -34 | -32 | -30 | -28 | -26 | -24 | -22 | -20 | -18 | -16 | -14 | -12 | -10 | -8 | -6 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 |
| -21 | -20 | -19 | -18 | -17 | -16 | -15 | -14 | -13 | -12 | -11 | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| -21 | -20 | -19 | -18 | -17 | -16 | -15 | -14 | -13 | -12 | -11 | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |

Consequence

**Table 5-4: Significance rating description**

| Score | Description | Rating |
|---|---|---|
| 109 to 147 | A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change | Major (positive) (+) |
| 73 to 108 | A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment | Moderate (positive) (+) |
| 36 to 72 | A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment | Minor (positive) (+) |
| 3 to 35 | A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment | Negligible (positive) (+) |
| -3 to -35 | An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment | Negligible (negative) (-) |
| -36 to -72 | A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment | Minor (negative) (-) |
| -73 to -108 | A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes. | Moderate (negative) (-) |
| -109 to -147 | A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable. | Major (negative) (-) |

# 6 Baseline Environment

The sub-sections below provide environmental background of the Sun City Resort Complex area including the Pilanesberg area.

## 6.1 Geology

### 6.1.1 Regional Geology

The Sun City Resort Complex is located in Pilanesberg Ring Complex, one of the world`s largest and best preserved alkaline ring dyke known as the Pilanesberg Alkaline Complex (PAC). The PAC is located within the western limb of the Bushveld Complex and on the Kaapvaal Craton with the gabbro-norite of the Rusternburg Layered Suite (Figure 6-1) and red granite of the Lebowa granite suite (Pantshi, 2006; Lee *et al*., 2013).

The Pilanesberg Complex intruded approximately between 1200 and 1400 Ma through the Mesoproterozoic era during an interplated extension event (Lee *et al*., 2013). The Pilanesberg Complex is characterised by alkaline igneous rocks (Abiye et el., 2018); constructed on a base of intrusive rocks and a cover of volcanic rocks (Pantshi, 2006). The intrusive rocks are made up of denoting circle or rings of foyaite and syenite, while the volcanic cover consist of lavas and tuffs and very coarse breccias (Shad, 1932 in Pantshi, 2006). The intrusion of these igneous rocks existed through regional tensional forces which similarly fashioned the N-NW orientated dykes of syenite and alkali gabbro that long-drawn-out from the Witwatersrand to Botswana (Jones and Wagener, 2017).

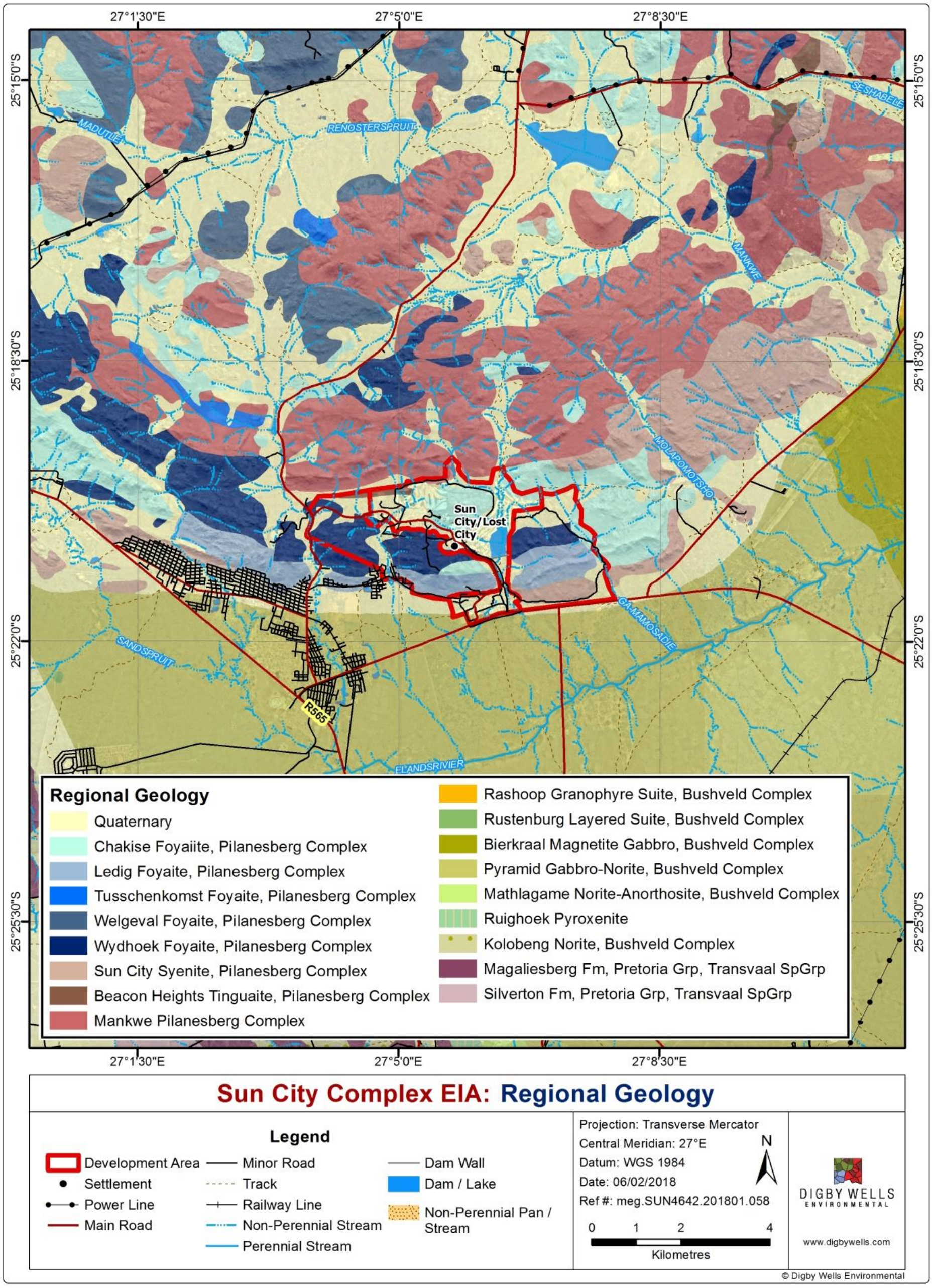


**Figure 6-1: Regional Geology Map**

### 6.1.2 Local Geology

Local geology of the study area is based on the geological logs on the boreholes drilled by Jones and Wagener (2017) in a study conducted within the landfill site to investigate the hydrogeological characteristics as part of the Sun City`s plan to decommission the landfill facility.

The study area is virtually covered by slightly moist, orang-brown, silty medium and fine sand with abundant, black, ferruginised gravels (also known as reworked residual foyaite/hillwash (0 m – 3 m)) overlying the residual foyaite. The residual foyaite (3 m – 7 m) comprises slightly moist with pale brown, silty medium, and fine sand with abundant, rounded, highly weathered gravel. The interval consisting of residual foyaite is considered to be representing the weathered aquifer. Underlying the residual foyaite is also the slightly moist, light grey, coarse and medium sand with moderately weathered, angular fragments (2 - 5 mm) of foyaite. The moderately to slightly weathered hard rock foyaite represents a transitional zone between the overlying residual material and the bedrock.

Further, underlying the moderately to slightly weathered hard rock is the slightly moist, light grey to grey, coarse and medium sand with abundant angular fragments (5 - 10 mm) of foyaite. This is considered to be slightly weathered to unweathered, fractured, hard rock foyaite representing a fractured rock aquifer. The depth of the fractured hard rock foyaite varies between 7 m and 50 m, and at about 23-25 m depth, slight discolouration of pale brown material is moderately weathered, possibly indicating water bearing fracture zone.

## 6.2 Hydrogeology

Generally, the project area is characterised by surface weathering, fracturing and faults in igneous rocks, permeable tuff aquifers and lava aquitards (McCaffrey, 1993 in McCaffrey 1998). Two types of aquifers have been identified within the Pilanesberg area; a shallow circulating low fluoride cold groundwater overlying the deep circulating thermal groundwater enriched with fluoride (McCaffrey 1993 in Abiye et al,. 2018). Details on fluoride-rich deposits and influences on groundwater quality can be found on McCaffrey (1998).

Similarly and according to Jones and Wagener (2017), the project area is characterised by two types of aquifers; a shallow near surface weathered zone and a deep confined fractured rock aquifer. The shallow weathered zone aquifer consists of transported colluvium and in-situ weathered sediments underlain by the consolidated foyaite rock of the Pilanesberg Alkaline Complex. This zone is directly recharged by rainfall and as a result is only recharged during rainy season. The deep fractured rock aquifer consists of “fresh” foyaite of the PAC which is overlain by the weathered zone. The primary porosity of the foyaite is considered to be negligible (Cawthorn et al., 2015 in Jones and Wagener, 2017) and as a result, groundwater occurrence is predominantly associated with secondary porosity such as fractures and joints (Jones and Wegner, 2017). Further, aquifers within the project area are considered as the d2 aquifer types of South Africa which are characterised by low borehole yields of 0.1 to 0.5 ℓ/s (Jones and Wegner, 2017).

Generally, according to Vegter (1995), aquifers within the study area are classified or mapped as both fractured and intergranular. The fractured rock aquifer is believed to have formed by igneous rocks of the Bushveld Complex with a low medium potential (DWAF, 2010). The groundwater table is characterised with steep water gradients due to very low transmissivity of the rock mass as a whole (McCaffrey, 1998). Groundwater flow in the shallow weathered aquifer mimics the topographic relief, thus, it is understood to flow radially or outward from the centre of the PARC.

## 6.3 Water Use

Water use at Sun City can be divided into water required for potable use and water required for irrigation. Magalies Water provides the required potable water that is mostly used for domestic purposes and for the filling of swimming pools, while purified effluent from the Sun City WWTW is used for irrigation of both golf courses and the gardens.

## 6.4 Water Quality Analysis

Water quality results of the samples collected during the hydrocensus are described below. Table 6-1 provides the sampling point name, guideline limits used for comparisons, sampling date, coordinates and sampling site photos. The sampling site positions are indicated in Figure 5-1 and Figure 5-2. The following guideline limits were used for comparisons with the water quality results:

- The limits specified in the 2015 Water Use Licence (WUL) for Sun International;
- The South African Water Quality Guidelines (SAWQG), Volume 2, Recreational Use;
- The SAWQG, Volume 4, Agricultural Use: Irrigation; and
- The SAWQG, Volume 5, Agricultural Use: Livestock Watering.

### 6.4.1 Surface Water

The water quality results are shown in Table 6-2. The results are summarised as follows:

- RL3 – EC, Turbidity, Ammonium and Dissolved Oxygen (DO) exceeded the WUL 2015 as well as the SAWQG for livestock watering. It is noted that the majority of the runoff from the Sun City Resort Complex is drained to this point. *E.coli*, Total Coliforms and Heterotrophic plate count were fairly high, however, there are no available comparison limits. These parameters are indicators of faecal contamination from both humans and animals. The exceedance of these parameters is most likely due to faecal matter from the upstream crocodile farm located at the Kwena Gardens. A further possibility is potential seepage from sewage lines; however, this was not confirmed on site. It is recommended that sewage lines be checked regularly and serviced if required. It is noted that this sampling point is located at the outlet of the Sun City Resort on the Letholenoga stream with various adjoining tributaries,

therefore, the observed water quality may also be influenced by other surrounding land uses including mining, residential areas and agricultural activities.

- LCGC Dam – pH, EC, TDS, Turbidity, Cl, Na, Cd, Alkalinity and DO exceeded the WUL 2015 as well as the SAWQG for Irrigation. *E.coli*, total coliforms and heterotrophic plate count were also found to be high. It was noted that a large number of birds use the rocks in the middle of this dam for roosting. The exceedance of these parameters is likely to be due to bird droppings and fish activity. A stormwater culvert was also noted to be draining into this dam. According to the WUL, this dam receives treated effluent from the WWTW which may also be contributing to the elevated levels.
- Ledig Stream – EC, Alkalinity and DO exceeded WUL 2015 limits. It was noted during the site visit that the tributary draining the LCGC and LCGC Dam contained water at the point directly below the nursery. No water was noted in the stream to the north and north-west of the nursery. It is therefore likely that the source of water in this stream is runoff emanating from the nursery and potentially seepage from the LCGC Dam. The Ledig Sewer pipeline runs within close proximity to the stream above the selected sampling point, although unconfirmed, any leaks from this line which is planned to be decommissioned could be a source of contamination. Therefore, the elevated *E.coli*, total coliforms and heterotrophic plate count is likely due to seepage and runoff from the LCGC Dam and nursery area, as well as possibly from the Ledig Sewer pipeline. Furthermore, a large number of livestock were noted along the stream and it is possible that their faeces are also contributing to these elevated levels.
- Recreational Dam – pH, EC, TDS, Cl, *E.coli*, Na, Alkalinity and DO exceeded the WUL 2015 limits for wastewater used for irrigation, SAWQG for Irrigation as well as the SAWQG for Recreational Water Use. The Recreational Dam also contained high bacterial counts when compared to the other sampling points (especially *E.coli*). This dam receives runoff and seepage from most of the Sun City Resort Complex areas (Lost City, Cascades, Soho, Cabanas and the GPGC). This is assumed to be a major contributing factor to the elevated levels.
- GPGC 2 Dam – pH, EC, TDS, turbidity, Cl, Na, Alkalinity and DO exceeded the limits for WUL 2015, WUL 2015 for the wastewater used for irrigation as well as the SAWQG for Irrigation. Purified effluent is pumped from the WWTW into this dam for irrigation of the GPGC. The exceedance of turbidity is likely to be from the mixing of water that takes place as a result of a water feature in the middle of the dam. This prevents any settling of water and the high TSS levels found confirm this assumption. The high bacterial constituents are possibly from animal sources as well as from the effluent water, although small in comparison to the other sampling points.

### 6.4.2 Groundwater

The groundwater quality results for the tested sites were compared with the results from previous studies within the study site. The water quality results are shown in Table 6-2 and form as the baseline water quality. Further, the results from the samples collected during the hydrocensus were compared with the Sun City Family Resorts Water Use Licence 2015, SAWQG for irrigation, livestock watering and recreational water use.

Based on the water quality results presented in Table 6-2, the following summary can be made:

- The results show that all boreholes contain elevated Fluoride (F) concentration above the maximum allowable concentrations for irrigation and livestock watering limits of less than 2 mg/ℓ. The elevated F concentration can be attributed to the Pilanesberg Complex and its intrusions due to its fluorite-rich deposits in its outer ring foyaite (McCaffrey, 1998; Jones and Wagener, 2017).
- Further, both Kwena BH and the Landfill BH showed elevated chloride (Cl) and sodium (Na) above the recommended concentrations for irrigation. Attributed to the dissolved constituents Na and Cl is the elevated electrical conductivity (EC) and total dissolved solids (TDS).
- The results show that prior to the landfill site development at GCS1 (downstream from the landfill facility) no elevated Cl, N and Na was detected except for the F concentration. Thus, the elevated Cl, Na and N at Landfill BH are indicative of contamination from the landfill facility (Figure 5-1). This further suggests that the contaminant plume is migrating downstream from the landfill facility. However, it is expected that such elevated concentration of Cl, N and Na might decrease once landfill rehabilitation programme has been implemented as stipulated by Jones and Wagener (2017).

**Table 6-1: Sampling point name, guideline limits, sampling date, coordinates and sampling point photo**

| Sampling ID | Description & Water Use | Guideline Limits Used for Comparisons | Date of Sampling | Photo of Sampling Point |
|---|---|---|---|---|
| Kwena BH | This borehole was not in use at the time of the site visit but is likely to be used for irrigation | WUL 2015, SAWQG: Recreational Use, SAWQG: Livestock Watering and SAWQG: Irrigation. | 21/11/2017 |  |
| Landfill BH | This borehole was not in use at the time of the site visit but is likely to be used for irrigation | WUL 2015, SAWQG: Recreational Use, SAWQG: Livestock Watering and SAWQG: Irrigation. | 21/11/2017 |  |

| | | | | |
|---|---|---|---|---|
| RL3 (stream) | This sampling point is located at the outlet of the Sun City complex on the Leitholenoga stream. This stream drains the central areas of the Complex. The water use downstream of this point is mostly for livestock watering | WUL 2015 & SA Water Quality Guidelines: Livestock Watering | 22/11/2017 |  |
| LCGC Dam | This sampling point is located at the Lost City Golf Course (LCGC) Dam. Water from this dam is used for irrigation | WUL 2015: Wastewater Used for Irrigation & SA Water Quality Guidelines: Irrigation | 22/11/2017 |  |

| | | | | |
|---|---|---|---|---|
| Ledig Stream | This sampling point is located on an unnamed stream draining the western side of the Sun City Complex. The stream flows through the settlement of Ledig, and is mostly used for livestock watering | WUL 2015 & SA Water Quality Guidelines: Livestock Watering | 22/11/2017 |  |
| Recreational Dam | The Recreational Dam is located at the centre of the Sun City Complex. The water in this dam is used for recreational purposes and irrigation (indirectly by topping up the GPGC 2 Dam) | WUL 2015: Wastewater Used for Irrigation, SA Water Quality Guidelines: Irrigation & SA Water Quality Guidelines: Recreational Water Use | 22/11/2017 |  |

| | | | | |
|---|---|---|---|---|
| GPGC 2 Dam | The Gary Player Golf Course (GPGC) 2 Dam is located at the Gary Player Golf Course, towards the north of the Sun City Complex. Water in this dam is used for irrigation | WUL 2015: Wastewater Used for Irrigation & SA Water Quality Guidelines: Irrigation | 22/11/2017 |  |

**Table 6-2: Water quality from the site visit**

| Parameter | Units | WUL 2015 | WUL 2015: Wastewater Used for Irrigation | SA Water Quality Guidelines: Recreational Water Use | SA Water Quality Guidelines: Irrigation | SA Water Quality Guidelines: Livestock Watering | Sampling Points & Water Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Limit/s | Limit/s | Limit/s | Limit/s | Limit/s | Kwena BH (Borehole) | Landfill BH (Borehole) | RL3 (Stream) | LCGC Dam | Ledig Stream | Recreational Dam | GPGC 2 Dam |
| pH – Value at 25°C | pH Units | ≥ 6 to ≤ 8.5 | ≥ 5.5 to ≤ 7.5 | ≥ 6.5 to ≤ 8.5 | ≥ 6.5 to ≤ 8.4 | - | 7.36 | 7.02 | 8.25 | 8.95 | 8.19 | 8.46 | 8.64 |
| Electrical Conductivity at 25°C | mS/m | < 50 | ≤ 15 | - | ≤ 40 | - | 85.2 | 178 | 69.3 | 70.7 | 80.7 | 81 | 80.6 |
| Total Dissolved Solids (TDS) at 180°C | mg/l | - | - | - | ≤ 260 | ≤ 1000 | 637 | 1318 | 473 | 460 | 424 | 494 | 496 |
| Turbidity | NTU | < 3 | - | - | - | - | 0.474 | 36.2 | 3.59 | 10 | 0.668 | 1.74 | 15.7 |
| Free Residual Chlorine as $Cl_2$ | mg/l | - | - | - | - | - | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 |
| Chloride as Cl | mg/l | - | - | - | ≤ 100 | ≤ 1500 | 159 | 305 | 82.8 | 133 | 93.3 | 165 | 155 |
| Sulphate as $SO_4$ | mg/l | - | - | - | - | ≤ 1000 | 50.6 | 163 | 79.6 | 75 | 75.7 | 78.7 | 81.2 |
| Fluoride as F | mg/l | - | - | - | ≤ 2 | ≤ 2 | 2.92 | 2.01 | 0.98 | 1.11 | 1.13 | 1.45 | 1.28 |
| Nitrate as N | mg/l | < 6 | ≤ 1.5 | - | - | ≤ 443 | 0.735 | 43.5 | 2.44 | 0.273 | 0.462 | 0.268 | 0.488 |
| Nitrite as N | mg/l | < 6 | - | - | - | - | 0.131 | 0.346 | 0.181 | 0.11 | 0.11 | 0.11 | 0.098 |
| Total Coliform Bacteria | Count/100ml | - | - | - | - | - | 18 | <1 | 410 | 190 | 2900 | 2300 | 6 |
| *E. coli* | Count/100ml | - | - | ≤ 130 | - | - | 13 | <1 | 190 | 90 | 400 | 1400 | 6 |
| Heterotrophic Plate Count | Count/1ml | - | - | - | - | - | 57 | 50000 | 2500 | 7790 | 26600 | 27000 | 5330 |
| Free & Saline Ammonia as N | mg/l | - | ≤ 1 | - | - | - | <0.005 | <0.005 | 0.011 | 0.025 | 0.005 | 0.012 | 0.013 |
| Sodium as Na | mg/l | - | - | - | ≤ 70 | ≤ 2000 | 136 | 204 | 84.1 | 80.4 | 64.7 | 86.8 | 88.2 |
| Potassium as K | mg/l | - | - | - | - | - | 4 | 12.6 | 16.6 | 10.8 | 6.09 | 8.01 | 10 |
| Calcium as Ca | mg/l | - | - | - | - | ≤ 1000 | 74.2 | 177 | 53.6 | 57.9 | 52.7 | 54 | 55.2 |
| Magnesium as Mg | mg/l | - | - | - | - | ≤ 500 | 14.4 | 38.3 | 20.8 | 21.3 | 21.2 | 23.3 | 23.4 |
| Aluminium as Al | mg/l | - | - | - | ≤ 5 | ≤ 5 | <0.002 | <0.002 | <0.002 | 0.013 | <0.002 | <0.002 | <0.002 |
| Boron as B | mg/l | - | - | - | ≤ 0.5 | ≤ 5 | 0.04 | 0.02 | 0.106 | 0.057 | 0.045 | 0.133 | 0.06 |
| Cadmium as Cd | mg/l | - | - | - | ≤ 0.01 | ≤ 0.01 | <0.002 | <0.002 | <0.002 | 0.013 | <0.002 | <0.002 | <0.002 |
| Total Chromium as Cr | mg/l | - | - | - | - | - | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Copper as Cu | mg/l | - | - | - | ≤ 0.2 | ≤ 0.5 | 0.003 | 0.012 | 0.01 | 0.01 | <0.002 | <0.002 | <0.002 |
| Iron as Fe | mg/l | - | - | - | ≤ 5 | ≤ 10 | <0.004 | <0.004 | <0.004 | <0.004 | <0.004 | <0.004 | <0.004 |
| Lead as Pb | mg/l | - | - | - | ≤ 0.2 | ≤ 0.1 | <0.004 | <0.004 | <0.004 | <0.004 | <0.004 | 0.01 | <0.004 |
| Manganese as Mn | mg/l | - | - | - | ≤ 0.02 | ≤ 10 | 0.061 | 0.082 | 0.12 | <0.001 | 0.034 | <0.001 | <0.001 |
| Nickel as Ni | mg/l | - | - | - | ≤ 0.2 | ≤ 1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |

| Parameter | Units | WUL 2015 | WUL 2015: Wastewater Used for Irrigation | SA Water Quality Guidelines: Recreational Water Use | SA Water Quality Guidelines: Irrigation | SA Water Quality Guidelines: Livestock Watering | Sampling Points & Water Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Limit/s | Limit/s | Limit/s | Limit/s | Limit/s | Kwena BH (Borehole) | Landfill BH (Borehole) | RL3 (Stream) | LCGC Dam | Ledig Stream | Recreational Dam | GPGC 2 Dam |
| Zinc as Zn | mg/l | - | - | - | ≤ 1 | ≤ 20 | 0.041 | 0.044 | 0.003 | <0.002 | 0.009 | 0.011 | 0.015 |
| Total Alkalinity | mg CaCO3/l | < 100 | - | - | - | - | 208 | 229 | 171 | 130 | 143 | 118 | 128 |
| Ammonium (NH4) as N | mg/l | - | - | - | - | - | 0.082 | 0.165 | 0.126 | 0.083 | 0.065 | 0.086 | 0.073 |
| Orthophosphate (PO4) as P | mg/l | < 0.5 | ≤ 1 | - | - | - | <0.005 | 0.038 | 1.83 | 0.046 | <0.005 | <0.005 | 0.206 |
| Hexavalent Chromium as Cr6+ | mg/l | - | - | - | ≤ 0.1 | ≤ 1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| Cobalt as Co | mg/l | - | - | - | ≤ 0.05 | ≤ 1 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Total Hardness | mg CaCO3/l | - | - | - | - | - | 245 | 599 | 219 | 232 | 219 | 231 | 234 |
| Chemical Oxygen Demand (COD) | mg/l | - | ≤ 30 | - | - | - | 31.6 | 36.4 | 51 | 45.3 | 29.2 | 23.6 | 23 |
| Total Suspended Solids (TSS) | mg/l | < 25 | ≤ 10 | - | ≤ 50 | - | <4.5 | 122 | 5 | <4.5 | <4.5 | <4.5 | 25 |
| Dissolved Oxygen (DO) | mg/l | > 6 | - | - | - | - | 3.78 | 2.08 | 5.72 | 4.7 | 5.02 | 5.26 | 5.05 |
| Bicarbonate Alkalinity | mg CaCO3/l | - | - | - | - | - | 208 | 229 | 168 | 120 | 141 | 115 | 123 |
| Carbon Alkalinity | mg CaCO3/l | - | - | - | - | - | 0.445 | 0.225 | 2.81 | 10.1 | 2.03 | 3.11 | 5.08 |
| Temperature | °C | - | - | - | - | - | 22.9 | 22.9 | 22.8 | 23 | 22.9 | 23.3 | 22.9 |

Light green highlighted values/cells indicate concentrations exceeding/below the permissible limits for WUL 2015, light purple highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Irrigation, light blue highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Recreational Water Use, light orange highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Irrigation, light tan highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Livestock Watering. In cases where more than one of the above guideline limits applies, the guideline limit with the highest value is taken. Further, the light red highlighted values/cells indicate concentration exceeding the SAWQG for irrigation as well the livestock watering limits.

# 7 Identified Potential Surface and Groundwater Impacts and Mitigations

The potential surface water and groundwater impacts were assessed considering the project lifetime: construction, operation phase. It is unlikely that the constructed infrastructure will be decommissioned in the foreseeable future and the decommissioning phase is therefore not assessed.

### 7.1.1 Construction Phase

Activities during the construction phase that may have potential impacts on the surface water resources are described and the appropriate management/mitigation measures are provided below.

**Table 7-1: Interactions and Impacts of Activity**

| Interaction | Impact |
|---|---|
| Exposure of soils due to loss of vegetation (site clearing for infrastructure establishment.). | Runoff causing siltation of surface water resources, leading to deteriorated water quality. |
| Construction of the various housing units/ blocks and internal roads network. | Contamination of runoff emanating from the construction areas |

#### *7.1.1.1 Impact Description: Siltation of Surface Water Resources*

Clearing or removal of vegetation exposes the surface and leaves the soils prone to erosion during rainfall events and as a result, runoff from these areas (which will be high in suspended solids and sediments) can lead to increased Total Suspended Solids and sedimentation in the nearby water course.

Dust generated during the construction activities and caused by increased vehicular movements can also be deposited into the water course, thereby contributing to the accumulation of suspended solids in the water course, leading to the siltation of the water course.

There is no anticipated impact on the groundwater as the site clearance is expected to take place above the water table.

#### *7.1.1.2 Impact Description: Water Contamination*

Dirty or contaminated runoff emanating from construction activities, such as the cement mixing areas, fuels storage areas, other liquid waste and general waste have the potential to contaminate the nearby water courses.

Human activity will generate waste which includes general wastes (paper, glass, plastic and cans) and biological sewage waste that may be either exposed or spilled during construction. The handling and disposal of such waste must be managed appropriately, as this poses a risk to the surface water resources.

Although there are elevated levels of certain parameters which exceeds the WUL limits, further impacts or deterioration of water quality on the natural water course may occur as a result of the proposed development and its associated activities.

#### *7.1.1.3 Management/ Mitigation Measures*

The following mitigation measures are recommended:

- Clearing of vegetation must be limited to the development footprint;
- Any soil stockpile during necessary excavation should be moderately compacted to prevent erosion of the soils into the nearby water resources;
- Dust suppression measures must be undertaken on the cleared areas during construction;
- If possible, construction activities should be prioritized during dry seasons to avoid potential erosion during high rainfall events.
- Concrete batching and mixing should not occur directly on the ground to avoid washing of this material into the stream;
- All storage areas (fuels, paints, chemicals, etc.) should be appropriately bunded and spill kits should be in place, and construction workers trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills;
- Ensure that all oil changes, refuelling and lubrication of equipment's is done away from the waterbody and in a manner such that any spillage will not enter the waterbody;
- Mobile chemical ablutions for construction workers and general waste bins should be provided and regularly maintained.
- Environmental Control Officer (ECO) should be appointed to ensure implementation of the recommended mitigation/management measures during construction.

**Table 7-2: Impact significance rating for the construction phase**

| Impact: Siltation of surface water resources leading to deteriorated water quality | | | |
|---|---|---|---|
| **Dimension** | **Rating** | **Motivation** | **Significance** |
| Duration | 2 | The impact may only occur during construction of infrastructure | 32-Negligible (negative) |
| Intensity | 3 | This will have minor to medium-term intensity resulting in reduction of proximal watercourse flow capacity and poor water quality for immediate downstream users and the aquatic life | |

| | | | |
|---|---|---|---|
| Spatial scale | 3 | The impacts will be localised to the nearby watercourses from where the silt is being generated to the immediate downstream | |
| Probability | 4 | Without appropriate mitigation, it is probable that this impact will occur | |
| **Post-mitigation** | | | |
| Duration | 2 | The impact will likely occur during the construction phase only | 16-Negligible (negative) |
| Intensity | 3 | Should the impact occur, it will have minor medium-term impacts resulting in a reduction in water quality for downstream users and the aquatic life | |
| Spatial scale | 3 | The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream | |
| Probability | 2 | With mitigation measures in place. It will be rare/improbable for this impact to occur. | |

| **Impact: Water Contamination** | | | |
|---|---|---|---|
| **Dimension** | **Rating** | **Motivation** | **Significance** |
| Duration | 2 | The impact will likely only occur during the construction phase | 40- Minor (negative) |
| Intensity | 4 | This will moderately impact the water quality and the ecosystem functionality for downstream users | |
| Spatial scale | 4 | The impacts may extend in the greater surrounding area from where the impact occurred | |
| Probability | 4 | Without appropriate mitigation, it is probable that this impact will occur | |
| **Post-mitigation** | | | |
| Duration | 2 | The impact will likely only occur during the construction phase | 20-Negligible (negative) |
| Intensity | 4 | This will moderately impact the water quality and the ecosystem functionality for downstream users | |
| Spatial scale | 4 | The impacts may extend in the greater surrounding area from where the impact occurred | |
| Probability | 2 | With the existing measures already in place. It will be rare/improbable for this impact to occur. | |

### 7.1.2 Operational Phase

Activities during the operational phase that may have potential impacts on the surface water resources are described and the appropriate management/mitigation measures are provided below.

**Table 7-3: Interactions and Impacts of Activity**

| Interaction | Impact |
|---|---|
| General maintenance of the service infrastructure. | No surface and groundwater impacts are anticipated for this activity. |
| Presence of increased impermeable surface area (paving, roads, roofs) leading to increased runoff velocity | Alteration of natural hydrology due to increased runoff. |

#### *7.1.2.1 Impact Description: Changes in stream hydrology and morphology due to increased runoff*

Development of infrastructure, pavements, compacted soils, and roads reduces the natural surface infiltration potential and increases surface runoff. Due to these developments, more runoff will collect and hence increase in runoff flow.

This may potentially impact on the natural water course by altering the natural hydrology, generally leading to more frequent, larger magnitude, and shorter duration peak flows. High runoff volume may alter the natural stream channel morphology, leading to changes such as increased channel width, increased down cutting/vertical erosion, and reduced bank stability.

#### *7.1.2.2 Management/ Mitigation Measures*

The following mitigation measures are recommended:

- It would be helpful to construct attenuation infrastructure (gabion, rock or rubble surfaces, etc.) at the outlet of the runoff or storm water drain. This will attenuate the flows and prevent the identified high flows impact on the natural water course.

**Table 7-4: Impact significance rating for the construction phase**

| **Impact: Water Contamination** | | | |
|---|---|---|---|
| **Dimension** | **Rating** | **Motivation** | **Significance** |
| Duration | 7 | The impact will likely occur for as long as the project life | 60- Minor (negative) |
| Intensity | 4 | This will moderately impact the water quality and the ecosystem functionality for downstream users | |

| | | | |
|---|---|---|---|
| Spatial scale | 4 | The impacts may extend in the greater surrounding area from where the impact occurred | |
| Probability | 4 | Without appropriate mitigation, it is probable that this impact will occur | |
| **Post-mitigation** | | | |
| Duration | 7 | The impact will likely only occur during the construction phase | 30-Negligible (negative) |
| Intensity | 4 | This will moderately impact the water quality and the ecosystem functionality for downstream users | |
| Spatial scale | 4 | The impacts may extend in the greater surrounding area from where the impact occurred | |
| Probability | 2 | With mitigation measures place. It will be rare/improbable for this impact to occur. | |

## 7.2 Cumulative Impacts

Observing the project area and its surroundings (within 5 km radius of the project area) the area consists of mixed land uses ranging from undeveloped rural areas, national park, mining activities in the south as well as agricultural activities (Figure 7-1).

The potential cumulative impacts include:

- Possible depletion of natural water resources, or contamination of groundwater and surface water should the development not be managed properly (such as if wastewater treatment plant plan and monitoring programme is not implemented);
- The proposed project is known to attract tourist thus it is likely to increase the water usage which has a potential to increase the water demand to the Magalies water board;
- Increased waste generation (including wastewater generation) which could result on groundwater and surface water contamination; and
- Water usage at the project site can have a potential negative drawdown and quality impacts on existing water supplies.

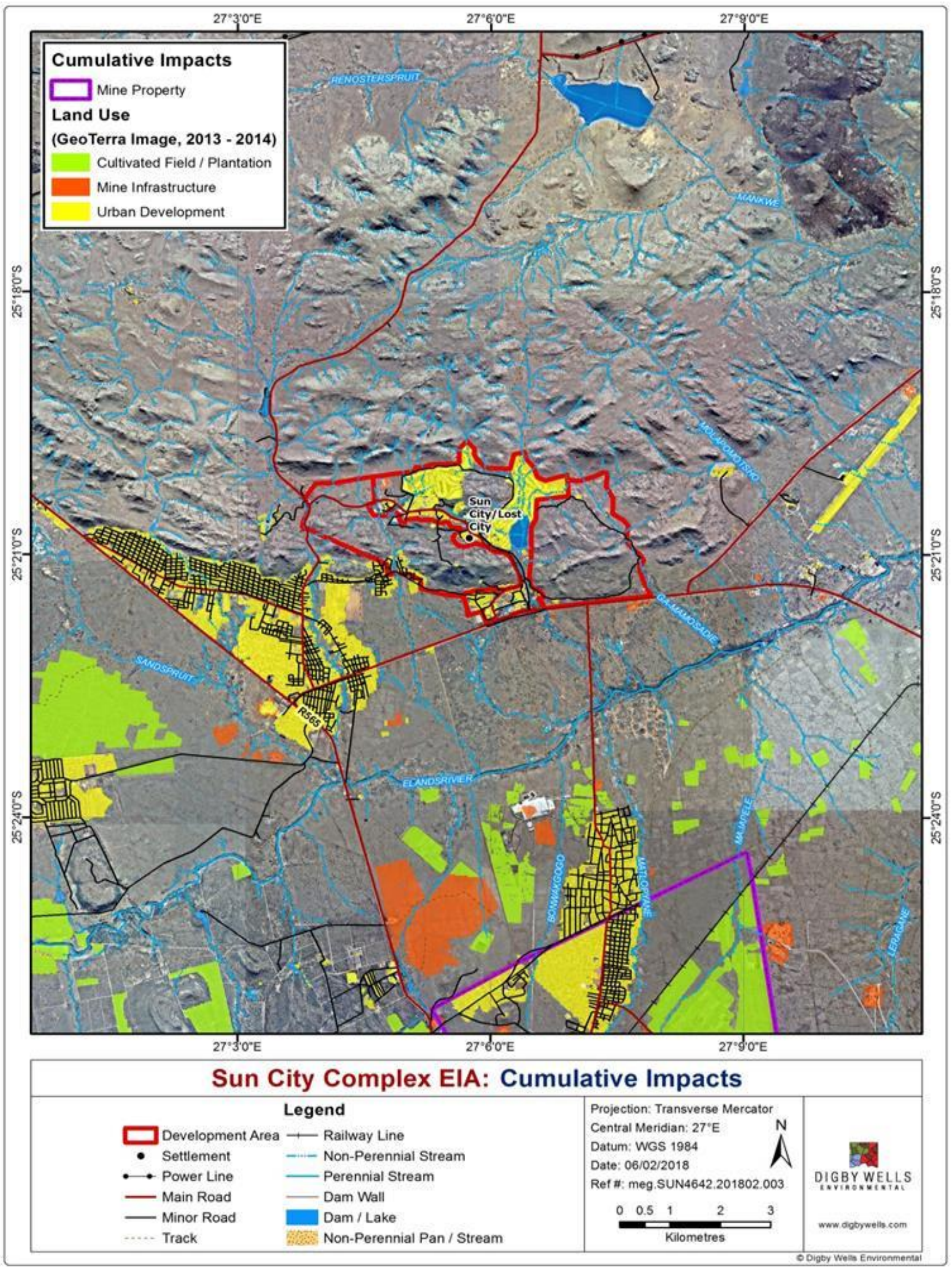


**Figure 7-1: Cumulative Impacts Map**

# 8 Surface and Groundwater Monitoring Plan

Surface and groundwater monitoring should be undertaken to establish the impact of the proposed activities on the streams and local aquifers, through the following:

- Water quality trends through sampling; and
- Water usage through groundwater level.

The recommended surface and groundwater monitoring locations are presented in Table 8-1 and Figure 8-1. A total of 8 surface water and 14 boreholes are proposed for the monitoring network.

**Table 8-1: Proposed surface and groundwater monitoring points**

| Monitoring Site | Latitude | Longitude | Monitoring Status | | |
|---|---|---|---|---|---|
| | | | Sampling/Monitoring Site Status | Monitoring type | Monitoring Purpose |
| LCGC Dam | -25.33857258° | 27.08624700° | Existing Monitoring Site | Water quality | Continue with the current surface water quality monitoring at the Lost City Golf Course dam to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| GPGC Dam | -25.33843780° | 27.10579125° | Existing Monitoring Site | Water quality | Continue with the current surface water quality monitoring at the |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Garry Player Golf Course dam to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| RD1 (Recreational Dam (upstream)) | -25.34369049° | 27.10506077° | Existing Monitoring Site | Water quality | Continue with the current surface water quality monitoring at the Recreational dam upstream to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | stages. |
| RD2 (Recreational Dam (downstream)) | -25.348468° | 27.104217° | Proposed Monitoring Site | Water quality | Initiate a new surface water quality monitoring downstream at the Recreational dam to assess impacts related to discharge treated waste water into the dam. Further this will aim to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| Ledig Stream (LDG1) | -25.3499091° | 27.08084956° | Existing Monitoring Site | Water quality | Continue with the current surface water quality monitoring at Ledig |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | stream to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| Ledig Stream2 (LDG2) | -25.344041° | 27.063274° | Proposed Monitoring Site | Water quality | Initiate a new surface water quality monitoring downstream from phase 4 development to assess water quality impacts related to the development. Further this will aim to assess compliance with water quality standards and to serve as an early |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | detection system to allow remedial measures to be taken at early |
| RL3 | -25.3602469° | 27.10987818° | Existing Monitoring Site | Water quality | Continue with the current surface water quality monitoring at RL3 stream to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| RL4 | -25.367760° | 27.098481° | Proposed Monitoring Site | Water quality | Initiate a new surface water quality monitoring downstream from the development footprint area to assess water quality |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | impacts that may arise to the proposed development. |
| GPCC3 | -25.33563816 | 27.10538884 | Existing Borehole | Groundwater quality and groundwater level. | Continue with the current groundwater quality and groundwater level monitoring at the Garry Player Golf Course area to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| KwenaBH | -25.35580234 | 27.10706505 | Existing Borehole | Groundwater quality and groundwater level. | Continue with the current groundwater quality and groundwater level monitoring |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | downstream from the proposed development area to assess compliance with water quality standards and to serve as an early detection system to allow remedial measures to be taken at early stages. |
| Landfill BH | -25.33799951 | 25.33799951 | Existing Borehole | Groundwater quality and groundwater level. | Groundwater quality and water level monitoring downstream from the landfill facility to assess contaminant migration from the landfill facility. |
| SC16-BH2D | -25.337600° | 27.079450° | Existing Borehole | Groundwater quality and groundwater level. | Groundwater quality and water level monitoring on the deep aquifer downstream from |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | the landfill facility to assess contaminant migration from the landfill facility. |
| SC16-BH2S | -25.337500° | 27.079580° | Existing Borehole | Groundwater quality and groundwater level. | Groundwater quality and water level monitoring on the shallow aquifer downstream from the landfill facility to assess contaminant migration from the landfill facility. |
| GCS1 | -25.337601° | 27.078736° | Existing Borehole | Groundwater quality and groundwater level. | Groundwater quality and water level monitoring downstream from the landfill facility to assess contaminant migration from the landfill facility. |
| GCS2 | -25.335840° | 27.077505° | Existing Borehole | Groundwater level. | Groundwater level monitoring upstream from the landfill site |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | to assess groundwater level flow direction. |
| SC16-BH1D | -25.335320° | 27.079732° | Existing Borehole | Groundwater level. | Groundwater level monitoring on the deep aquifer upstream from the landfill site to assess groundwater level flow direction. |
| SC16-BH1S | -25.335330° | 27.079823° | Existing Borehole | Groundwater level. | Groundwater level monitoring on the shallow aquifer upstream from the landfill site to assess groundwater level flow direction. |
| LG-BH5 | -25.354650° | 27.066184° | Existing Borehole | Groundwater quality and water level | Groundwater quality and water level monitoring downstream from development area. |
| LG-BH13 | -25.355120° | 27.087649° | Existing Borehole | Groundwater quality and | Groundwater quality |

| | | | | | |
|---|---|---|---|---|---|
| | | | | water level | and water level monitoring downstream from development area. |

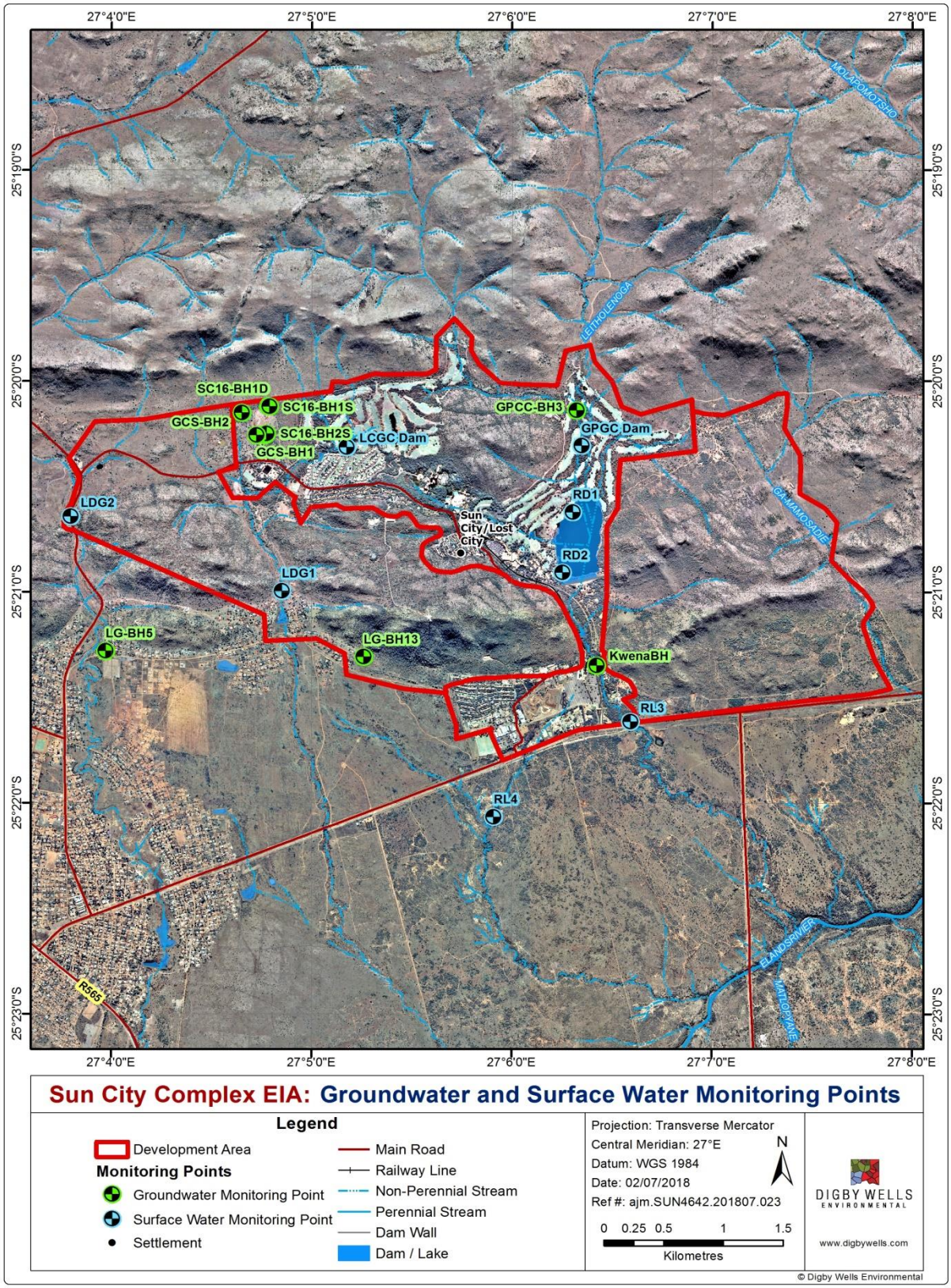


**Figure 8-1: Positions of the proposed surface water and groundwater monitoring points within the project area**

### 8.1.1 Groundwater Level

Groundwater levels must be recorded on a quarterly basis to detect any changes or trends in groundwater elevation and flow direction.

### 8.1.2 Surface water and Groundwater Quality Sampling Frequency

Surface water quality should be monitored on a monthly basis during construction of the proposed development and the frequency can be reduced to quarterly post development. This will assist to detect any changes or impacts on the downstream surface water quality and to assess compliance with DWS water quality standard and/ or guidelines and to serve as an early detection system to allow remedial measures to be taken at early stages on any impacted area.

Groundwater is a slow-moving medium and drastic changes in the groundwater composition are not normally encountered within days. Considering the proximity of private boreholes and streams to the proposed development, monitoring (water quality and water level) should be conducted quarterly to reflect influences of wet and dry seasons. The sampling frequency could be further adjusted following the trend analysis and absence of any impact from the project area.

Samples should be collected by using best practice guidelines and should be analysed by a SANAS accredited laboratory.

### 8.1.3 Water Sampling and Preservation

When sampling the following procedures are proposed:

- One (1) litre plastic bottles with a cap are required for the sampling exercises;
- Glass bottles are required if organic constituents are to be tested;
- Collected samples must be stored in cooler box or fridge while on site; and
- Sample bottles should be marked clearly with the borehole name, date of sampling, sampling depth and the sampler's name and submitted to a SANAS accredited laboratory.

### 8.1.4 Parameters to be monitored

- TDS, EC, pH, Alkalinity;
- Major ions i.e. Ca, Mg, Na, K, $SO_4$, $NO_3$, F, Cl; and
- Minor and trace metals, including As, Al, Co, Cr, Zn, Cd, Cu, Fe, Ni, V, Mn.

### 8.1.5 Data Storage

During any project, good hydrological and hydrogeological decisions require good information developed from raw data. The production of good, relevant and timely information is the key to achieve qualified long-term and short-term plans. To minimize surface and groundwater contamination, it is necessary to utilize all relevant surface water and groundwater monitoring data.

The generation and collection of this data is very expensive as it requires intensive investigations and therefore the data has to be managed in a centralised database for to optimize on cost efficiency. Digby Wells has compiled a WISH-based database during the course of this investigation and it is highly recommended that the applicant utilise this database and continuously update and manage it as new data becomes available.

# 9 Sensitivity of the Site

Over the years a large area of construction and development within the boundaries of the Sun City Resort and greater project area has caused various impacts. The water quality of the aquifers indicates that groundwater contamination has already taken place and this is mainly due to landfill (waste facility) and natural processes of the underlying geology.

Further, surface water quality indicates that contamination has also taken place and this is mainly due to the discharge of treated waste water. This is observed at GPGC dam and LCGC dam which are used as discharge facilities for treated wastewater. Further this (contamination) is observed at streams and dams which receives water from the two dams (GPGC and LCGC).

Based on the current results, previous construction and/ or development activities are not believed to have impacted surface water and groundwater except for the treated wastewater discharged in to the dams and the landfill facility which is in a decommissioning process. Therefore, it is deemed that the proposed new activities and developments will also similarly have a negligible impact on the environment if managed in a similar of even better manner.

Based on the above conclusion it is deemed that both the current surface water and groundwater environment is not sensitive to the proposed activities if managed well.

# 10 Assumptions and Limitations

The following gaps were identified during the study;

- Surface water quality monitoring is required particularly downstream at recreational dam as well as LG2 (Ledig stream) and RL4 downstream from the development area; and
- Groundwater monitoring boreholes are required, particularly downstream or at the Lost City Golf Course as well as upstream and downstream from the recreational dam.

# 11 Conclusions and Recommendations

## 11.1 Conclusions

### 11.1.1 Baseline Hydrogeological Findings

The project area is made up of two types of aquifers; a shallow near surface weathered zone and a deep unconfined fractured rock aquifer. The shallow near surface weathered zone correlates with the shallow circulating low fluoride cold groundwater overlying the deep confined fractured rock aquifer characterised by deep circulating thermal groundwater enriched with fluoride. Groundwater flow appears to mimic the topographic relief, and as result flows radially or outward from the centre of the PARC.

The water quality of the surface water and the aquifers indicates that groundwater contamination has already taken place and this is mainly due to discharged wastewater, landfill (waste facility), and natural processes of the underlying geology.

Based on the current results, previous construction and/ or development activities are not believed to have impacted surface water and groundwater except for the treated wastewater discharged in to the dams and the landfill facility which is in a decommissioning process. It is therefore recommended that the effectiveness of the WWTW be investigated to ensure that the quality of treated water is within the acceptable WUL 2015 standards. Therefore, it is deemed that the proposed new activities and developments will also similarly have a negligible impact on the environment if managed in a similar of even better manner. This can be achieved through compliance with the DWS guidelines including good monitoring programs and implementing mitigation options.

Based on the above conclusion it is deemed that both the current surface water and groundwater environment is not sensitive to the proposed activities if managed well.

### 11.1.2 Impact Assessment

Observing the project area and its surroundings (within a 5 km radius of the project area), the following impacts might prevail:

- Possible depletion of natural water resources, or contamination of groundwater and surface water should the development not be managed properly (such as if wastewater treatment plant plan and monitoring programme is not implemented);
- The proposed project is known to attract tourist thus it is likely to increase the water usage which has a potential to increase the water demand to the Magalies water board;
- Increased waste generation (including wastewater generation) which could result on groundwater and surface water contamination; and

- Water usage at the project site can have a potential negative drawdown and quality impacts on existing water supplies.

## 11.2 Recommendations

Further hydrogeological assessments are recommended to gain site specific rock permeability values through borehole drilling and aquifer testing. The drilling of additional boreholes will also enable to collect more groundwater samples for a more accurate groundwater quality analysis as well as to collect groundwater level measurement to construct a potentiometric surface map. These will assist in improving the baseline hydrogeological characteristics (hydrogeological conceptualization).

The recommended mitigation plans include:

- Site clearing should be restricted to areas of absolute necessity and the activity should be conducted over a short duration, if possible;
- Natural vegetation should be restored where possible to maintain site specific hydrological conditions. This will minimise flood occurrences and also maintain surface water quality conditions within the project area;
- Site clearance and construction activities should take place above the water table, at the unsaturated zone, (if possible). No impact on the groundwater quantity will then be expected;
- If drains are going to be excavated below the water level, dewatering of the aquifer to lower the water table locally should be considered to ensure that the construction takes place above the groundwater level;
- Surface and groundwater monitoring should be conducted to assess the time series water level, water quality impacts and to observe trends as to aid decision making. Surface water monitoring is recommended to be implemented particularly downstream from the Recreational dam as well as downstream from the vacation club development (LG2) and the development footprint area (RL4). Groundwater monitoring is recommended to be implemented particularly downstream of the landfill site which has shown to be a source of groundwater contamination; and
- Investigations on the shallow weathered aquifer such as Borehole GPCC3 are recommended as it was dry during the time of sampling and it is only recharged during rainy season.

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# Appendix A: Specialist CVs